

MYCOM

Compound 2-stage Screw Compressor 2016**C Instruction Manual

2016LLC / 2016LMC / 2016LSC
/ 2016MSC / 2016SSC



ATTENTION

Before operating, servicing, or inspecting this product, read this manual thoroughly to fully understand the contents.

Keep this Instruction Manual in a safe, designated place for future reference whenever the manual is needed.

Specifications of this product is subject to change without prior notice.

株式会社 前川製作所

Preface

Thank you for purchasing the **MYCOM** compound 2-stage screw compressor 2016**C (hereinafter referred to as "this product").

This Instruction Manual (hereinafter referred to as "this manual") provides safety information and operation and maintenance procedures, so that users correctly understand how to handle this product and, as a result, can use it safely and efficiently. This manual is applicable to the following models:

2016LLC-*B*-51, 2016LMC-*B*-51, 2016LSC-*B*-51, 2016MSC-*B*-51, 2016SSC-*B*-51
2016LLC-*B*-61, 2016LMC-*B*-61, 2016LSC-*B*-61, 2016MSC-*B*-61, 2016SSC-*B*-61

* -51 (-61) may not be written. For more information, see 2.2 "Model designation of the compressor" in this manual Chapter 2.

Before installing or using this product, make sure you read this manual.

Keep this manual in a safe place near this product for quick reference.

Revision History

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Warranty and Disclaimer

Warranty Clauses

Mayekawa shall repair or replace parts of this product for no charge if any failure resulting from defects in design or manufacture occurs, under normal use with the purpose and method that are in accordance with the specifications of this product and this manual, within the warranty period.

The warranty period is "12 months from factory shipment of this product". If there is a separate agreement, that agreement shall prevail in principle.

Disclaimer Clauses (Exclusion of Warranty Clauses)

In no event will Mayekawa be liable to you for any of the following damages or claims arising out of the use or inability to use this product:

- Malfunction or damage caused by acts of nature (storms, heavy rains, floods, high tides, earthquakes, subsidences, lightnings, fires, etc.)
- Malfunction, damage or deterioration caused by misuse or improper use of this product (outdoor storage or storage under high temperature and humidity, excessively frequent liquid flow-back operation, extreme start-stop repetition, etc.)
- Malfunction or damage caused by devices or equipments not provided by MAYEKAWA including operation control methods of those devices.
- Malfunction or damage caused by the use of refrigerant (or gas) or lubricant that is not applicable to this product
- Malfunction or damage caused by maintenance or inspection not recommended by MAYEKAWA
- Malfunction or damage caused by parts that are not Mayekawa genuine
- Malfunction or damage caused by remodeling this product without approval of MAYEKAWA
- Lost profits or other incidental or consequential damages arising directly or indirectly out of the malfunction or damage of this product

Important Information

Intended Use of This Product

This product is a general-purpose screw compressor for refrigeration and cold storage. Do not use this product for any other purposes that are not intended for or which depart from the specifications. For specifications of this product, refer to "2.3 Compressor Specifications".

Please perform the maintenance items described in this manual by using safe and assured procedures.

Important Information for Safe Use of This Product

Although MAYEKAWA has paid a lot of attention to safety measures for this product, all hazards including potential hazards caused by human errors, or due to environmental conditions can not be anticipated.

As there are too many items to be strictly observed or prohibited when using this product, it is impossible to inform all of them through this manual or warning labels. Therefore, when operating this product, pay extreme caution on personnel safety as well as on items described in this manual.

Important rules for safety work with this product that apply to all workers including managers and supervisors are listed below.

Please read this manual before using this product. Fully understand the instructions provided there, and be sure to perform the safety procedures described in this manual.

- Operation, maintenance, and inspection of this product should be performed by qualified personnel educated about the fundamentals of this product and trained about hazards involved and measures to avoid danger.
- Do not allow any person other than those educated on the fundamental expertise of this product and trained about hazards involved and measures to avoid dangers to approach this product while it is operating or during maintenance.
- Observe all related federal/national and local codes and regulations.
- To prevent accidents, do not carry out any operation or maintenance other than those described in this manual. Do not use this product for any purpose other than intended.
- Replace the parts with **MYCOM** genuine parts.
- Not only workers but also managers should actively participate safety and health activities in the workplace to prevent accidents.
- When closing or opening a valve during work, make sure to apply lockout/tagout to prevent the valve from being accidentally closed or opened during the work.

[Lockout] To lock with a key in order to keep people, except the workers involved, from operating the product.

Lockout means disconnecting or keeping disconnected machines and devices by locking their energy (power) sources. Lockout is not just simply turning off the power switches to stop the supply of power, but includes immobilizing them with a key or similar device to keep any blocked switches from being operated.

Lockout devices are devices such as keys, covers, and latches, to immobilize switches, valves, opening and closing levers, etc., with a state of being locked.

[Tagout] To prevent any inappropriate work by hanging tag plates indicating "work in progress".

Tagout means to clearly indicate, by hanging tag plates, that a device is in lockout and that operation of the device is prohibited. Tag plates forbidding operation, starting, opening, etc. are warnings clearly stating to not operate energy (power) sources, and are not for stopping blocking devices.

Observe the following precautions when performing maintenance work on electrical control.

- Electrical maintenance of the product must be performed by certified/qualified personnel and only those educated about the electrical control of the product.
- Before servicing or inspecting the electrical equipment or devices, turn "OFF" the motor main power and control power, and perform lockout/tagout to prevent the power from being turned on during work.

Even when the motor main power and control power are turned "OFF", this product may be turned on if the power is supplied from outside the refrigeration system or cold storage unit. Make sure the power supply on the power source side is shut off, and perform lockout/tagout to prevent the product from being turned on during work.

About This Manual

- This product may be modified without prior notice. Therefore, the appearance of actual machine may differ from the descriptions in this manual. If you have any questions, contact our sales offices or service centers in your area.
- This manual is in English. If any other language is required, it is the customers responsibility to prepare a manual for safety education and operation instructions.
- This manual is copyrighted. Drawings and technical references including this manual shall not, in whole or part, be copied, photocopied, or reproduced into any electronic medium or machine-readable form without prior permission from MAYEKAWA.
- Photographs or drawings included in this manual may differ from the appearance of actual product.
- If this manual is lost or damaged, immediately request our local sales offices or service centers for a new manual. Using this product without the manual may result in safety issues.
- If you resell this product, never fail to attach this manual to this product.

Construction of This Manual

Title of section and chapter	Description details
Preface	Describes the outline of this manual and how to read this manual.
Warranty and Disclaimer	Describes what Mayekawa warrants and what are covered by the warranties. Warranty exemption is stated as disclaimer.
Important Information	Describes important information related to this product and this manual.
1. Safety	Describes safety information for the worker, safety rules for this product, and management details regarding the work safety that is required for handling this product.
2. Configuration and Specifications of Compressor	Describes the main components of this product, functional information, specification, and operating limits.
3. Installation	Describes the installation procedure of this product.
4. Operation of compressor and unit	Describes the precautions for operating this product.
5. Maintenance	Describes sections and period for inspecting, and assembly and disassembly of this product.
6. Troubleshooting	Describes troubleshooting methods for this product in case problems occur during operation of this product.
7. Related Documents	Describes documents such as development views and parts list.
8. Contact Information	Describes contact information for our local sales offices or service centers, which are for ordering MYCOM genuine parts.

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Chapter 1 Safety

1.1 Observation/Prevention (DOs and DON'Ts)

1.1.1 DOs

1.1.1.1 DOs on Operation

- Make sure to attach safety and protective devices on the unit.
- Regularly inspect the safety and protective devices if they function properly.
- If the safety or protective devices do not work properly or if this product operates abnormally, immediately stop the operation and report to the supervisor. Obtain his/her approval and direction before restarting the compressor.
- If this product stops for unknown reasons, immediately inform your supervisor of it. Obtain his/her approval before restarting the compressor.
- Some types of refrigerants emit bad smell or toxic gases when they leak. Make sure to ventilate the air during operation.
- For the properties of refrigerant and lubricant (corrosiveness, decomposability or toxicity), be sure to obtain the Safety Data Sheet (SDS) and follow the relevant information.
- When stopping the operation of this product, close the suction and discharge side shut-off valves and turn "OFF" the motor (main power), heater power, and control power.

1.1.1.2 DOs on Maintenance

- Prepare work procedures based on a work schedule. Be sure to perform danger forecasting before starting the work.
- Before performing the work together with at least one other person, thoroughly confirm each other's work details and procedures to acknowledge the other worker's movement.
- When troubleshooting during operation or before performing setup, cleaning or maintenance/inspection of this product, always turn OFF the main power to the motor and control power and other devices. Also, lock and tag out them to prevent the power from being supplied erroneously during operation.
- When troubleshooting during operation or before performing setup, cleaning or maintenance/inspection of this product, confirm that the pressure inside this product and the refrigerating/cold storage unit is at atmospheric pressure.
- Some refrigerants in use generate bad smell or toxic gases, or may cause deficiency of oxygen. Before starting work, measure oxygen concentration in the work area as necessary. Ventilate the area well. Be sure to keep the area well ventilated until the work is finished.
- For the properties of refrigerant and lubricant (corrosiveness, decomposability or toxicity), be sure to obtain the Safety Data Sheet (SDS) and follow the relevant information.
- After using tools always restore to designated place and never leave tools in the compressor.

1.1.1.3 DOs on Lockout/Tagout after Shutting Off the Power

- Attach lockout/tagout mechanism to the main breakers of motor main power and control power. Lockout/tagout after power off is a very effective means to secure safety. It can prevent the power source from being turned on by accident by two or more workers which may cause injury to other worker(s).
- If there are any possibilities of danger during works (especially during cleaning, maintenance and inspection, and troubleshooting), turn "OFF" the motor main power and control power, and perform lockout/tagout.

- In the following situations, workers may neglect to perform power source shutoff or lockout/tagout. Clearly notify the workers of the necessity of lockout/tagout.
 - It is assumed that workers do not perform lockout/tagout before starting work because it is troublesome, and only turn "OFF" the main motor and control power.
 - It is assumed that workers only turn off the main motor and control power and do not lockout/tagout the main motor and control power, because they judge that there is no danger.

1.1.1.4 DOs about Personal Protective Gear

- Prepare and use protective gear complying with the safety standards of the regulations.
- Check the function of each protective gear before using.
- Wear designated clothes such as work outfits, with their cuffs tightly closed.
- Do not wear any neckties or jewelry as there is a risk of being entangled by a movable part or rotating part. Put on a helmet as your hair may get entangled.
- Do not have anything in your pocket to prevent objects from falling into the machine.

1.1.1.5 DOs about Handling of Hazardous and Toxic Substances

- Obtain the Safety Data Sheet (SDS) from manufacturers of hazardous and toxic substances. Check the SDS and follow the handling instructions recommended by the manufacturers to handle and store those substances.

1.1.1.6 DOs about Handling Emergency Situations

- Formulate an emergency action plan complying with the regulations, and post it on a safe place.

1.1.1.7 DOs about Waste Oil, Fluid, and Materials

- Disposing of refrigerant and oil used for this product are subject to a number of regulations for the environmental protection purposes. Follow the local, state, federal acts and regulations and your company's rules when disposing of such waste oil, fluid and materials.

1.1.1.8 Other DOs

- Clean the floor around the entire refrigerating/cold storage unit. Provide a safety passage.
- Walk only on the areas set up as a work floor. Also, do not leave tools and cleaning solutions in that area.
- If water or oil is spilled on this product or the floor, immediately wipe it off to prevent workers from slipping and getting injured.

1.1.2 DON'Ts

- Do not remove or relocate any safety device, including electrical interfaces.
- Do not disable any safety device by short-circuiting or bypassing without any permission.
- Do not leave this product unsafe and unattended, by removing a safety cover or some other measures.
- Do not touch, clean or lubricate any part of this product which is moving.
- Do not touch relays or electric systems such as terminal block with bare hands when turning on the power.

1.2 Warnings

The following two measures are taken for this product to let workers pay attention to possible dangers.

- Warnings described in this manual
- Safety labels affixed on the product main body

* No safety labels are affixed to the compressor itself which this manual is intended for.

For details about the warning labels affixed to the unit, refer to the instruction manual of the unit.

1.2.1 Types and Meanings of Warnings

The warning messages described in this manual warn dangerous situations that may arise during work by using the following four categories.

Neglecting such warnings may cause accidents, resulting in personal injury or even death.

Also, this product or its auxiliary equipment may be heavily damaged. Therefore, be sure to always observe the instructions of the warnings.

Table 1-1 Types and Meanings of Warnings

 DANGER	Indicates a hazardous situation which, if not avoided, could very likely cause serious injury or death.
 WARNING	Indicates a potentially hazardous situation which, if not avoided, may cause serious injury or death.
 CAUTION	Indicates a potentially hazardous situation which, if not avoided, may cause minor or moderate injury.
CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in property damage.

1.3 Residual Risks

The following information assumes that this product is operated or inspected/maintained while being used in general refrigerating/cold storage units. It is impossible to predict all the risk sources involved in actual use of the refrigerating/cold storage units.

Devise appropriate countermeasures for hazardous sources in your systems.

Table 1-2 Hazardous Sources

	Hazardous sources	Predicted hazard	Countermeasures in operation	Countermeasures in cleaning, inspection, and parts exchange
A	Motor and compressor coupling	<ul style="list-style-type: none"> Caught in due to contact 	<ul style="list-style-type: none"> Install coupling cover and prohibit opening. Keep away. 	<ul style="list-style-type: none"> Turn off motor main power and control power, and conduct lockout/tagout.
B	Motor terminals	<ul style="list-style-type: none"> Electric shock caused by contact with live wires or electrical leakage 	<ul style="list-style-type: none"> Keep away. Do not open terminal boxes. Do not touch terminal boxes. 	<ul style="list-style-type: none"> Turn off motor main power and control power, and conduct lockout/tagout.
C	Compressor low-stage side suction casing	<ul style="list-style-type: none"> Frostbite due to contact Contact with or inhalation of hazardous substances generated by leakage of refrigerant or the like 	<ul style="list-style-type: none"> Keep away and do not touch. Wear protective gear. Detect gas leakage. 	<ul style="list-style-type: none"> Wear protective gear. Work under room temperature.
D	Compressor high-stage side discharge casing and discharge piping	<ul style="list-style-type: none"> Burn injury due to contact Contact with or inhalation of hazardous substances generated by leakage or spout of refrigerant or the like 	<ul style="list-style-type: none"> Keep away and do not touch. Wear protective gear. Detect gas leakage. 	<ul style="list-style-type: none"> Wear protective gear. Work at a temperature of not higher than 40°C.
E	Check valves/service valves and joints on each section of the unit	<ul style="list-style-type: none"> Contact with or inhalation of hazardous substances generated by mishandling or leakage Frostbite or burn due to contact 	<ul style="list-style-type: none"> Sufficient ventilation Indicate valve open/close state. Keep away and do not touch. Wear protective gear. 	<ul style="list-style-type: none"> Sufficient ventilation Wear protective gear. Tagout for controlled valve
F	Solenoid valves/motor operated valves on each section of the unit	<ul style="list-style-type: none"> Electric shock caused by contact with live wires or electrical leakage Pinched due to contact with driving part 	<ul style="list-style-type: none"> Install protective cover on terminals, and prohibit opening. Keep away and do not touch. Wear protective gear. 	<ul style="list-style-type: none"> Turn off each breaker and the control power, and conduct lockout/tagout. Wear protective gear.
G	Electric components in each section of the unit (oil heater, protective switch, etc.)	<ul style="list-style-type: none"> Electric shock caused by contact with live wires or electrical leakage Pinched due to contact with driving part 	<ul style="list-style-type: none"> Install protective cover on terminals, and prohibit opening. Keep away and do not touch. Wear protective gear. 	<ul style="list-style-type: none"> Turn off each breaker and the control power, and conduct lockout/tagout. Wear protective gear.
H	Unit oil drains	<ul style="list-style-type: none"> Contact with hazardous substances generated by leakage or spout Burn caused by contact with high-temperature fluid 	<ul style="list-style-type: none"> Sufficient ventilation Keep away and do not touch. Wear protective gear. 	<ul style="list-style-type: none"> Sufficient ventilation Wear protective gear. Work at a temperature of not higher than 40°C.
I	Noises	<ul style="list-style-type: none"> Damage caused by noise 	<ul style="list-style-type: none"> Wear protective gear. 	—

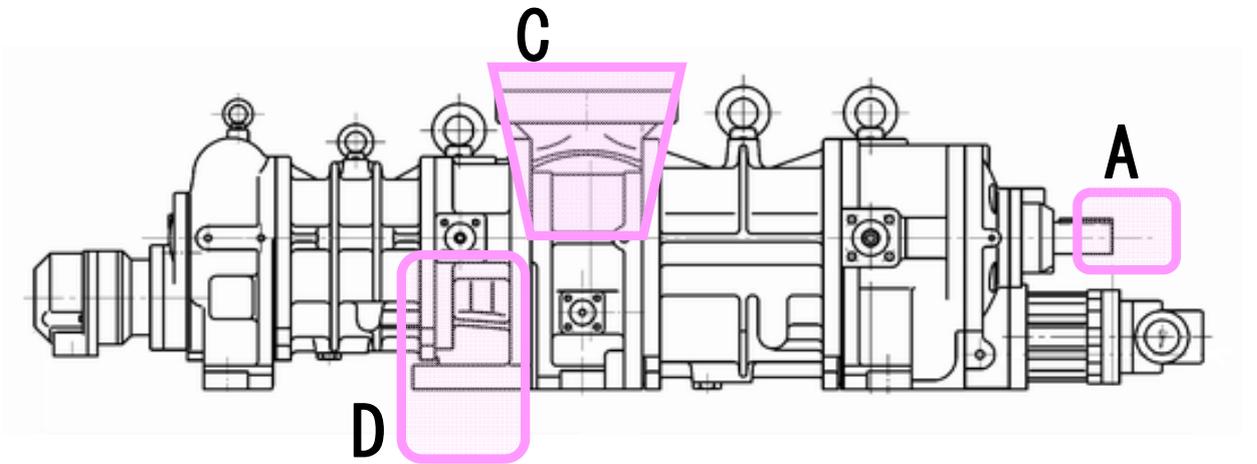


Figure 1-1 Locations of Hazardous Sources (compressor)

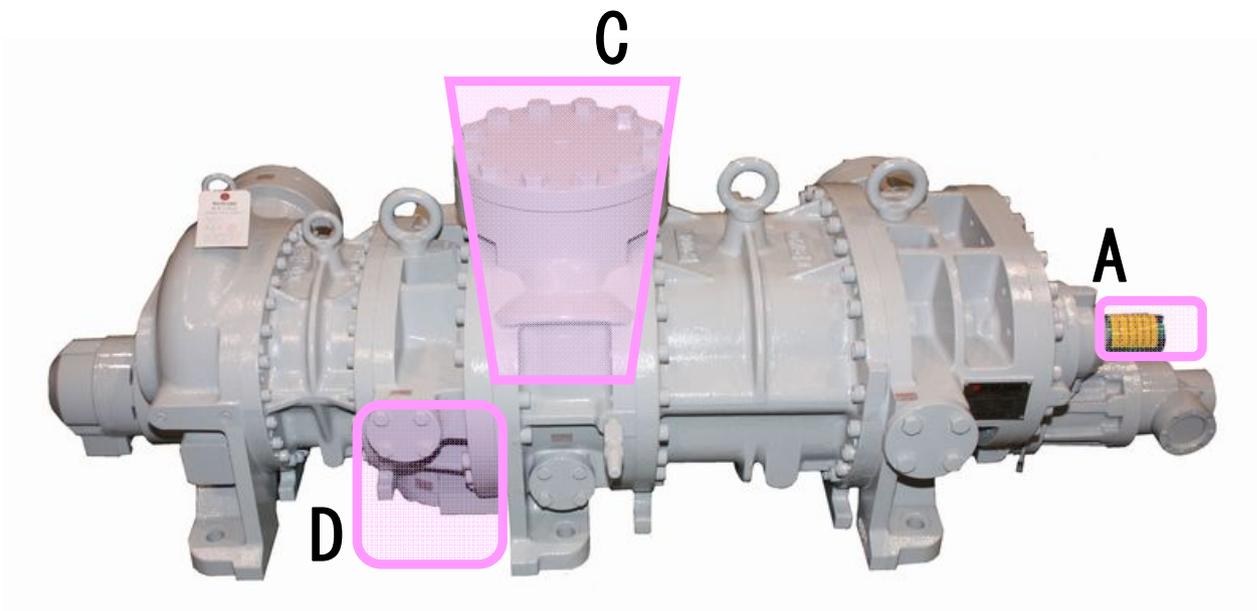


Photo 001 Locations of Hazardous Sources

1.4 Safety Devices

For safe use and protection of this product, make sure to attach safety devices to this product in accordance with the regulations and the following instructions.

Safety devices cannot be kept in normal condition unless inspected and maintained at regular intervals. Their maintenance and inspection need to be performed as an important part of the maintenance/inspection work project. Provide users of this product with necessary information on the safety devices, for example, types of the safety devices, installation position, function, and inspection method of safety related devices.



- **Check the safety devices after turning on the power and before operation of the compressor. If they do not operate normally, immediately take repair or replace safeties before starting compressor.**

1.4.1 Emergency Stop Button

■ Overview/Function/Purpose

The emergency stop buttons are used to stop the compressor operation immediately if an emergency occurs in this product.

■ Installation Positions

On the control board and in the operation control room

■ Stop/Restoration Methods

For information on how to stop or restore the emergency stop button, refer to the instruction manual of the unit.

■ Inspection Method/Cycle

The emergency stop buttons must be tested before commissioning and must also be periodically re-tested after that. For the inspection method and frequency for the emergency stop button, refer to the instruction manual of the unit.

1.4.2 Breakers of Motor Main Power and Control Power (with Lockout/Tagout Mechanism)

■ Overview/Function/Purpose

Turn off the main motor and control power, and if there is any possibility of danger during work (especially during cleaning, maintenance, inspection, or troubleshooting), lockout/tagout devices must be used on the breakers of the main motor and control powers to prevent injuries to workers in case the power is turned on accidentally during work.

■ Methods of Performing and Releasing Lockout/Tagout

Make sure to clearly notify methods of performing and releasing lockout/tagout referring to the regulations created by Occupational Safety & Health Administration (OSHA) or local governing body.

■ Inspection Method/Cycle

For the inspection method and cycle for the lockout/tagout mechanism, refer to the instruction manual of the unit.

1.4.3 Compressor Protective Devices



- **Be sure to adjust the set values and check operation of the protective devices at the test run.**

■ Overview/Function/Purpose

These protective devices are used to protect this product.

- **Protecting from discharge temperature rise (DT)**
This device stops the compressor operation when the discharge temperature of the compressor exceeds the set value.
Install a temperature sensing port to the discharge pipe.
- **Protecting from oil temperature rise (OT)**
This device stops the compressor operation when the oil temperature of the compressor exceeds the set value.
Install a temperature sensing port to the unit's oil supply pipe (after the oil cooler).
- **Protecting from high pressure (HP)**
This device stops the compressor operation when the discharge pressure abnormally rises due to compressor misoperations or stoppage of cooling water supply to the condenser.
This device prevents explosion of the equipment and components.
Install a pressure sensing port to the discharge pipe.
- **Protecting from intermediate pressure (IP)**
This device controls the compressor appropriately when the intermediate pressure exceeds the set value. In some cases, this device stops the compressor operation.
Install a pressure output port to the unit's intermediate gas pipe (or compressor's intermediate gas pressure output port).
- **Protecting from suction pressure drop (LP)**
This device stops the compressor operation when the suction pressure becomes below the set value.
Install a pressure sensing port to the suction pipe.
- **Protecting from oil pressure (OP)**
This device stops the compressor operation when refrigerant oil supply is not sufficient, the oil filter is clogged, the refrigerant is mixed into the lubricant, and oil supply pressure difference (from discharge pressure) becomes below the set value.
This device is to protect the compressor from wear and burnout.
Install a pressure sensing port to the unit's oil supply pump (after the oil pump) and the discharge pipe.
- **Protecting from motor overcurrent (OCR)**
This device controls the compressor appropriately when the current exceeds the set value. In some cases, this device stops the compressor operation.
This device is normally installed in the compressor operation controller.

■ Connection Positions and Settings

For connection position and setting for each compressor protective device, refer to the instruction manual of the unit.

Make sure that the set values do not exceed the operating limits shown in Chapter 2, section 2.3.2 and Table 2-2 of this manual.

■ Inspection Method/Cycle

Compressor protective devices require operation tests and confirmation of the settings calibration before test run as well as at regular intervals. For information on inspecting procedure and frequency for the compressor, refer to the instruction manual of the unit.

 CAUTION

- In the operation test, check that alarms and protective devices operate normally by using devices such as pressure tester. Do not operate the compressor with all the valves closed, or in any other dangerous conditions.
- If the protection from oil pressure (OP), high pressure (HP) activates, do not restart operation until the cause of activation is removed.

Chapter 2 Configuration and Specifications of Compressor

2.1 Features of the **MYCOM** Compound 2-stage Screw Compressor 2016**C

The 2-stage compression system, which has hitherto required two units of standard-type screw compressor for its embodiment, can now be realized by a single unit of compound 2-stage screw compressor.

Generally, screw compressors use oil injection to keep discharge temperature at a low level during operation without loss of volumetric efficiency even at high compression ratios. It can, therefore, be operated with a single-stage compression system even at evaporative temperatures near -40°C.

However, for normal use at low temperatures, a 2-stage compression system is applied in order to improve KW/RT (ratio of power consumption versus cooling ability). If the 2-stage compression system is configured with standard-type screw compressors, at least two screw compressor units need to be installed, one on the high-stage and the other on the low-stage, which inevitably requires double installation of the entire system including machinery, motors, utilities, etc.

This 2-stage screw compressor is produced to solve this problem. It is a single unit that has two single-stage compressor units combined into one.

The 2016**C model has a capacity control mechanism for startup load reduction on the high-stage, and a capacity control mechanism for coping with load change on the low-stage.

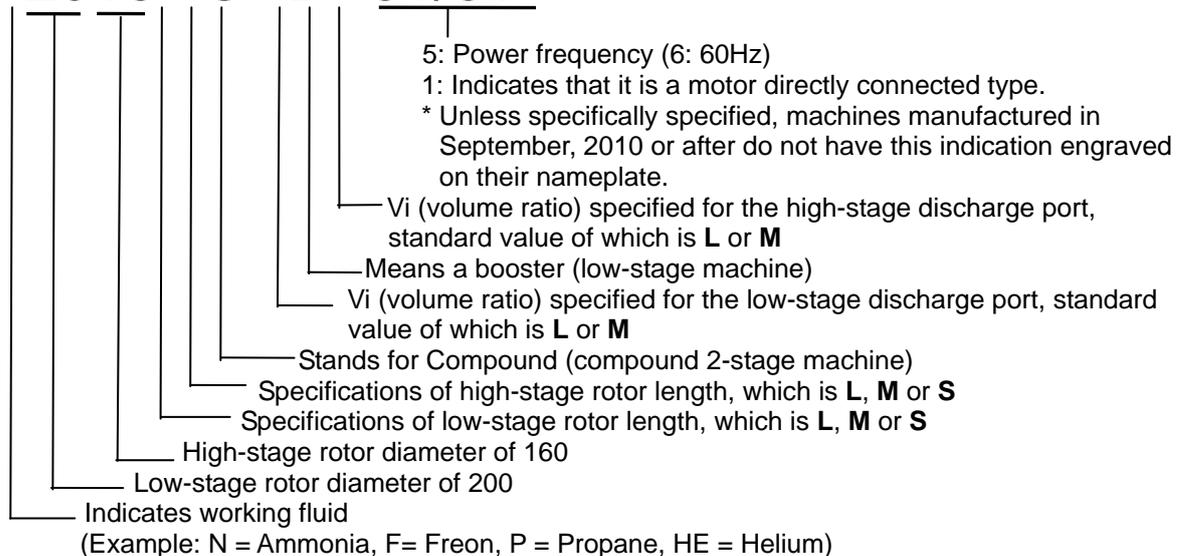
There are various combinations of machine control methods/capacity control methods. However, as they are not directly related to the inspection of the compressor, they are omitted here.

2.2 Model Designation of the Compressor

This manual describes 2016**C-*B*-51 and 2016**C-*B*-61 models.

The meaning of the type designation, which is engraved on the MODEL column of the compressor nameplate, is as follows.

***2016**C-*B*-51/61**



2.3 Compressor Specifications

2.3.1 Specifications

Table 2-1 2016**C Screw Compressor Specifications

Items		2016				
		LLC	LMC	LSC	MSC	SSC
Weight	kg	1180	1140	1100	1050	1000
Low-stage theoretical displacement @3550 rpm /2950 rpm	m ³ /h	1460/1210	1460/1210	1460/1210	1220/1020	975/810
High-stage theoretical displacement @3550 rpm /2950 rpm	m ³ /h	749/622	624/519	499/415	499/415	499/415
Refrigerant	-	NH ₃ , HFC, etc.				
Design pressure	MPa	2.6				
Capacity control (Actual load)	-	10 to 100%				
Rotation direction	-	Counterclockwise viewed from motor				
Connected pipe size	Low-stage suction flange	-	JIS 20K 150A (6")			
	Low-stage discharge flange	-	JIS 20K 100A (4")			
	High-stage suction flange	-	JIS 20K 100A (4")			
	High-stage discharge flange	-	JIS 20K 80A (3")			
	Journal lubrication (low-stage)	-	JIS 20K 25A (1")			
	Journal lubrication (high-stage)	-	JIS 20K 20A (3/4")			
	Oil injection lubrication	-	JIS 20K 15A (1/2")			
	Low-stage capacity control	-	Load: Rc1/4, Unload: Rc3/8			
	High-stage capacity control	-	Load: Rc3/8, Unload: Rc1/4			

- Unless otherwise noted, the pressure unit MPa represents the gauge pressure in this manual.
- For limits of working temperature and pressure, see "2.3.2 Operation Limits" in this manual.

2.3.2 Operation Limits

Table 2-2 Operation Limits of 2016C**

Items	Operation Limits	Remarks
Maximum discharge pressure	1.96 MPa *Note 1	Casing design pressure: 2.6 MPa
Minimum suction pressure	-0.080 MPa	Shaft seal, inherent properties
Maximum intermediate pressure	0.588 MPa	Bearing
Minimum intermediate pressure	> Suction pressure	Recommended condition: > Suction pressure + 0.1 MPa
Oil supply pressure	Ps: Suction pressure, Pd: Discharge pressure	
1) Journal lubrication pressure	Pd + (0.049 to 0.39) MPa	Balance piston lubrication (Pressure lubrication)
2) Bearing and oil injection minimum lubrication pressure	Ps + 0.49 MPa *Note 2	Check valve must be installed.
3) Balance piston minimum lubrication pressure	Pd + 0.049 MPa	
Suction temperature	max. 85°C min. -60°C	Clearance allowed between rotor and casing Casing design
Maximum discharge temperature	Low-stage 90°C High-stage 100°C	Clearance allowed between rotor and casing
Maximum oil supply temperature	60°C	Oil viscosity should be not less than 13mm ² /s. (Optimally, oil viscosity should be between 13 and 40 mm ² /s.)
Minimum oil supply temperature	30°C	Oil viscosity should be not higher than 60mm ² /s.
Maximum M rotor rotation speed	4000 rpm	Bearing, inherent properties, seal
Minimum M rotor rotation speed	1450 rpm	Bearing

Note 1: Unless otherwise noted, the pressure unit MPa represents the gauge pressure in this manual.

Note 2: When it is required that pressure difference between Pd and Ps should be not greater than 0.49 MPa, oil pump needs to be installed.

If a combination of "NH₃ + compatible oil (PN46)" is used for working fluid (refrigerant) and lubricating oil, oil pump must be installed.

CAUTION

- If operation at partial load, which is not greater than 30% of the indicated load, is continued for a long time except when starting up the machine, abnormal noises or vibration may be generated. So avoid such operation.
- Repeated startup and stop in a short period is harmful not for the startup devices and electric machinery but also for the compressor itself. For information on the start/stop limitations, refer to each instruction manual. Wait at least 15 minutes after stopping the compressor before restarting it.

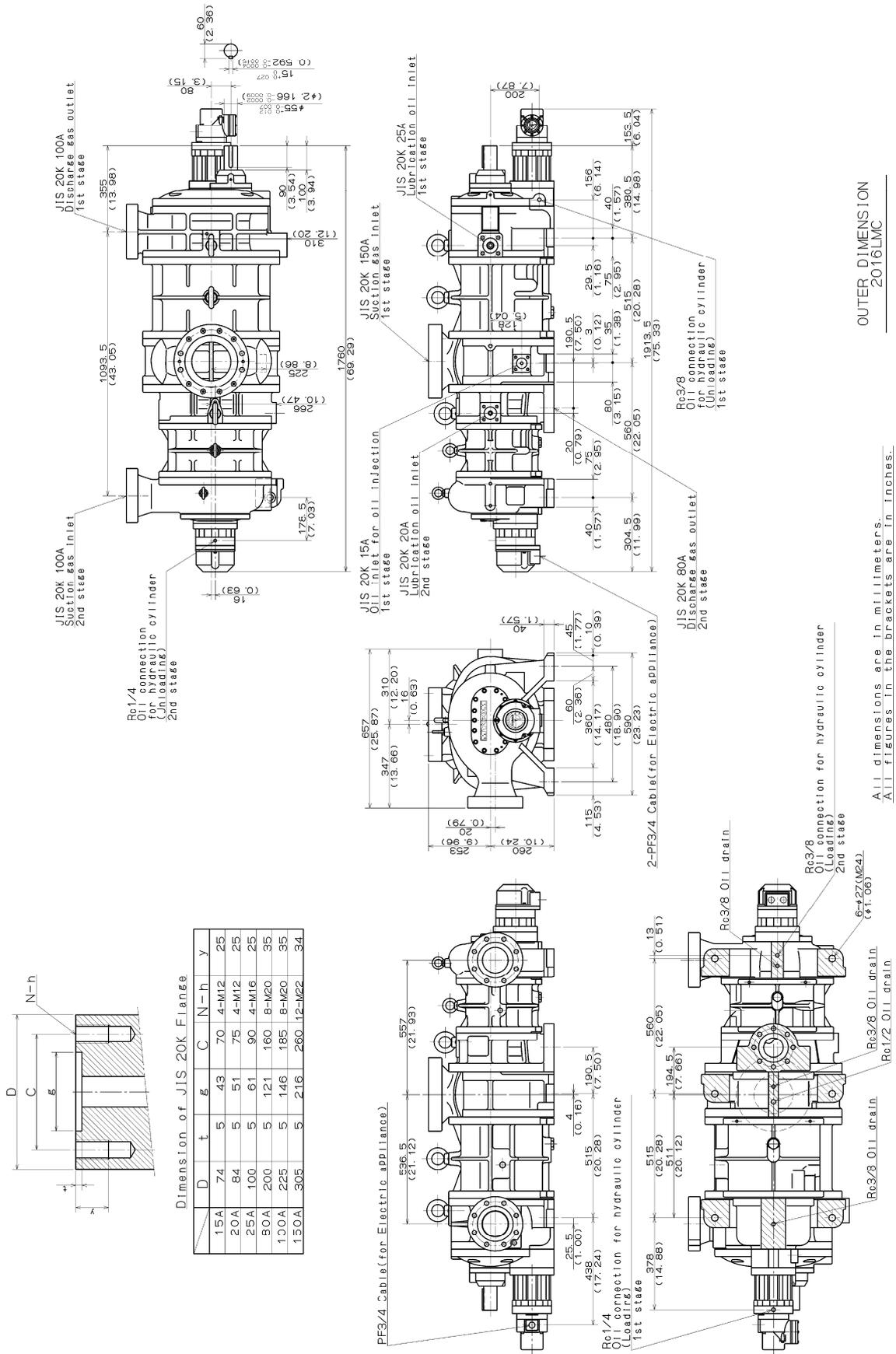


Figure 2-2 Outer Dimensions 2016LMC

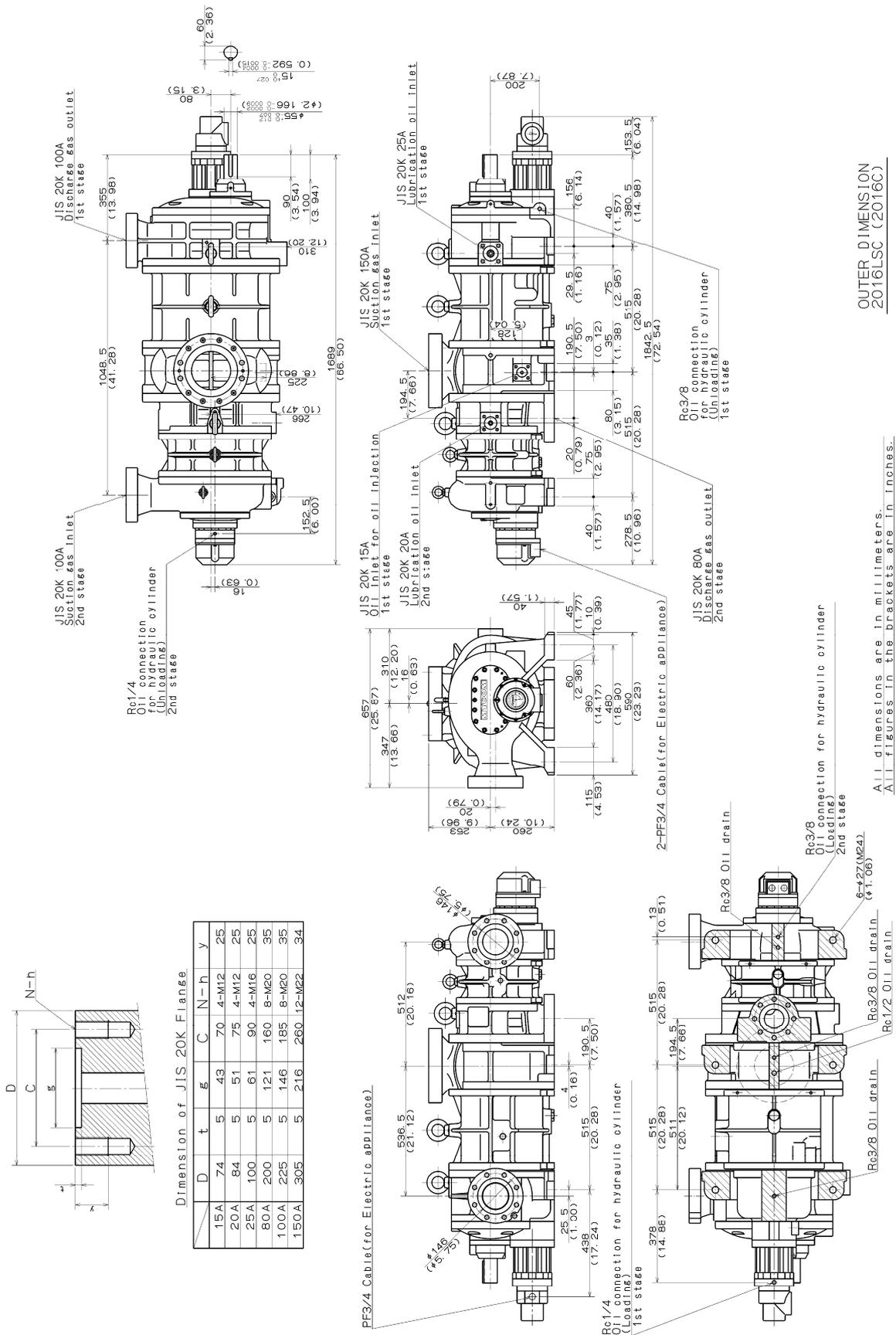


Figure 2-3 Outer Dimensions 2016LSC

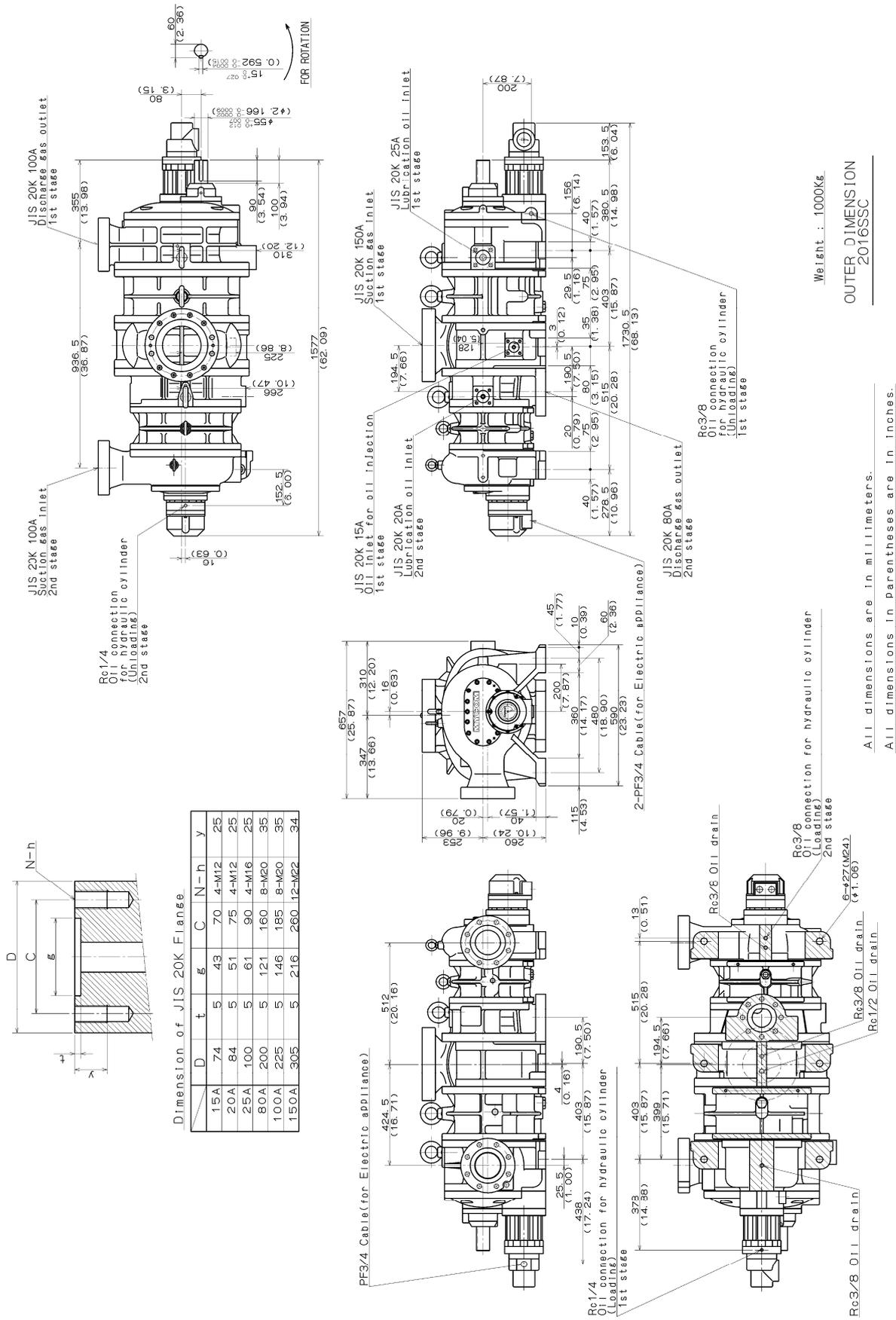


Figure 2-5 Outer Dimensions 2016SSC

2.4 Configuration of Compressor

[POINT]

- For names of each part of the compressor, refer to "7.1 Development Views, Assembly Sectional Views", and "7.2 Parts Configuration Table".

2.4.1 Sectional View

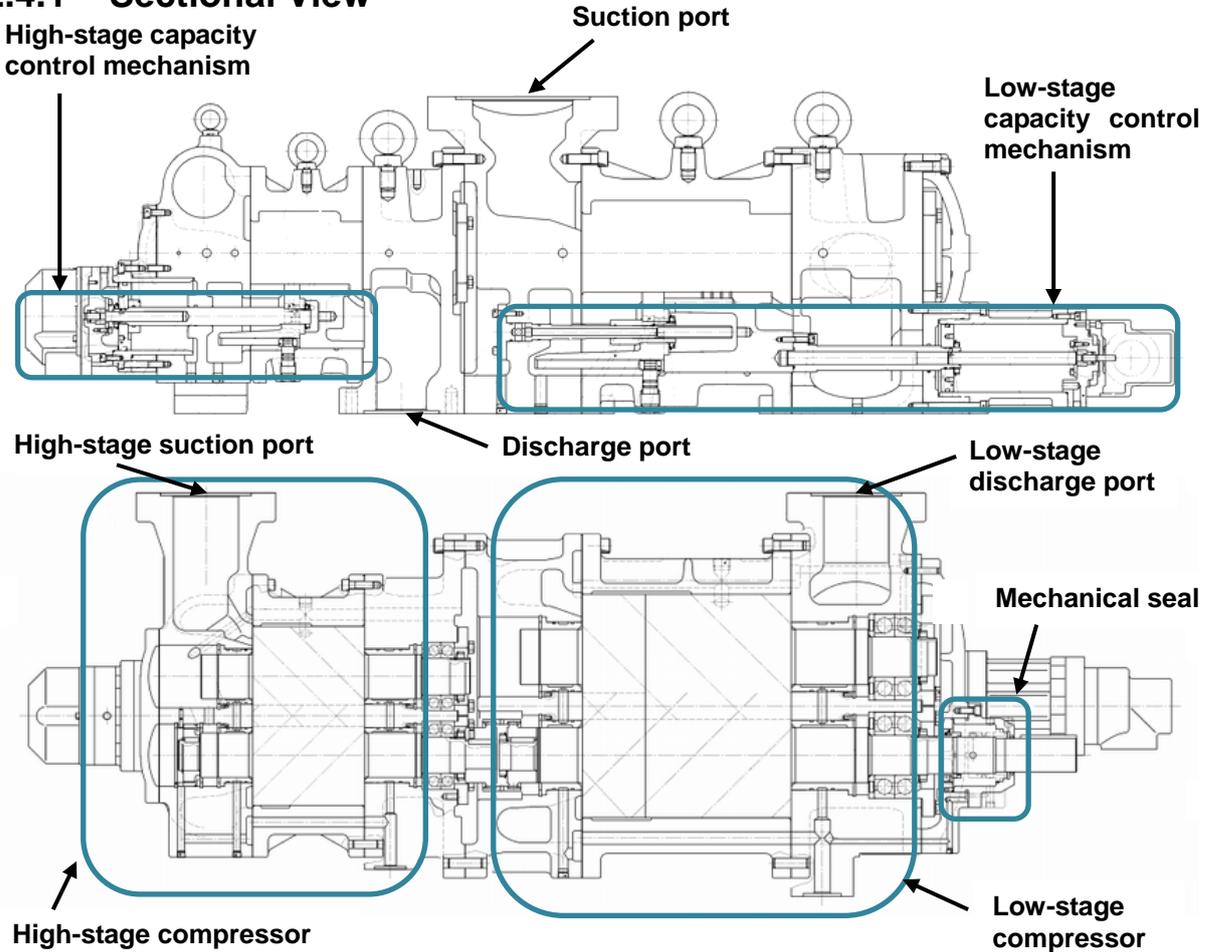


Figure 2-6 2016**C Screw Compressor Sectional View

The 2016**C model, a compound 2-stage compressor, consists of two compressors, (i) a low-stage compressor which suctions gas, working fluid, from the refrigerating unit and compresses (pressure-raises) the gas and (ii) an high-stage compressor which furthermore compresses the gas that has been pressure-raised by the low-stage compressor and sends the resulting gas to the equipment side.

In each casing (low-stage, high-stage), two screw rotors with long leads are supported on both ends by bearings. They are meshed with each other in a joint assembly. These two screw rotors are a set of a male rotor having 4 protruding tooth profiles (M rotor) and a female rotor having 6 concave profiles (F rotor). They conduct compressing according to the mechanism explained below.

The standard compressor's M rotor is driven by a 2-pole motor; it operates at 3000 rpm (50 Hz) or 3600 rpm (60 Hz). F rotor operates at 2000 rpm (50 Hz) or 2400 rpm (60 Hz), conforming to the operation of M rotor.

* The actual speed of a motor is less than its calculated speed (synchronous speed). This difference is caused by slipping of the motor rotor.

The shaft of the low-stage compressor's M rotor which is linked with the motor has a mechanical seal that keeps gas and lubricating oil from escaping from inside the compressor.

For high efficient operation, the 2016**C model has a capacity control mechanism for coping with load change on the low-stage, and a capacity control mechanism for reducing startup load on the high-stage.

2.5 Mechanisms

2.5.1 Basics of the Screw Compressor

The screw compressor is categorized as a positive displacement rotary compressor. It has features of both reciprocating and centrifugal compressors.

As shown in Figure 2-7, the refrigerant (gas) is continuously compressed by the 3-dimensional spaces that are formed by a pair of male and female screw rotors (with different sectional profiles) and the casing, as the spaces change continuously.

The rotor having 4 protruding tooth profiles is called a male or M rotor, and the rotor having 6 concave profiles is called a female or F rotor. In this manual, they are referred to as M rotor and F rotor.

The compressor is driven by the motor connected to the shaft of the M rotor.

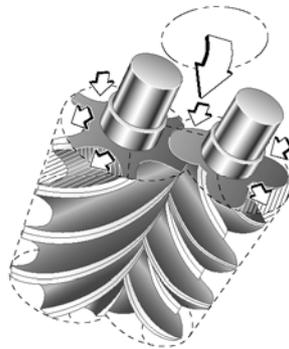


Figure 2-7 Compressor Mechanism

2.5.2 Suction Process

As shown in Figure 2-8, the rotors with different tooth profiles are engaged. As the rotors turn, the volume between the M and F rotor tooth profiles and the compressor casing gradually increases starting from the suction side.

As the rotation continues, at a certain point when the volume reaches its maximum, the rotors isolate the gas (volume), which is enclosed by the rotors and the compressor casing, from the suction port and then continues rotation.

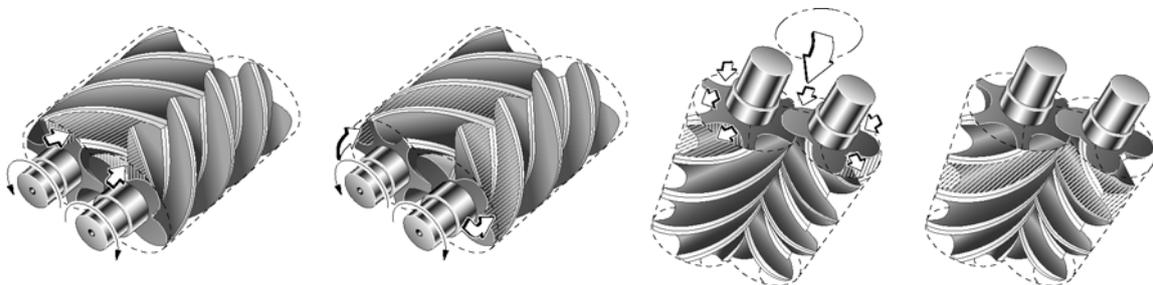


Figure 2-8 Suction Process

2.5.3 Compression Process

As the rotors rotate further, the volume between the rotor teeth and grooves decreases while the sealing line moves toward the discharge side, which compresses the trapped refrigerant gas.

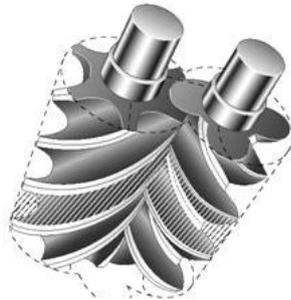


Figure 2-9 Compression Process

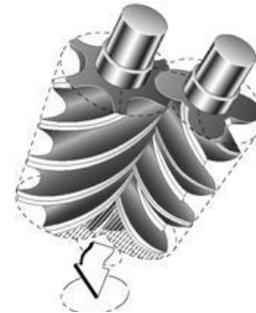


Figure 2-10 Discharge Process

2.5.4 Discharge Process

The volume between the rotor teeth and grooves decreases to a level predetermined by the discharge port. With the rotations of the rotors, the compressed refrigerant gas is pushed out to the discharge port.

2.5.5 About Volume Ratio (Vi)

Volume ratios (Vi) are indicated in property tables or catalogs by using port symbols L, M and H.

The volume ratio represented by each symbol (**MYCOM** screw compressor) is as follows:
L=2.63, M=3.65, H=5.80.

$$V_i = \frac{\text{Volume of suctioned refrigerant gas immediately before the start of compression}}{\text{Volume of refrigerant gas just before pushed out to discharge port}}$$

Which volume ratio (L, M or H) should be used is decided according to operating conditions. If the compressor is used with a volume ratio that does not match operating conditions, operation will go inefficiently wasting the power.

The relationship between volume ratios and generally used compression ratios is as follows:

$$V_i = \left(\frac{P_d}{P_s} \right)^{\frac{1}{K}} \quad \text{or} \quad V_i^K = \frac{P_d}{P_s}$$

$$(V_i)^K = \pi_i = P_d/P_s \quad K = C_p/C_v \text{ of refrigerant gas}$$

V_i = Design volume ratio π_i = Design compression ratio

As V_i is affected by the constant of the refrigerant gas, its value that corresponds to the compression ratio will change depending on the refrigerant gas.

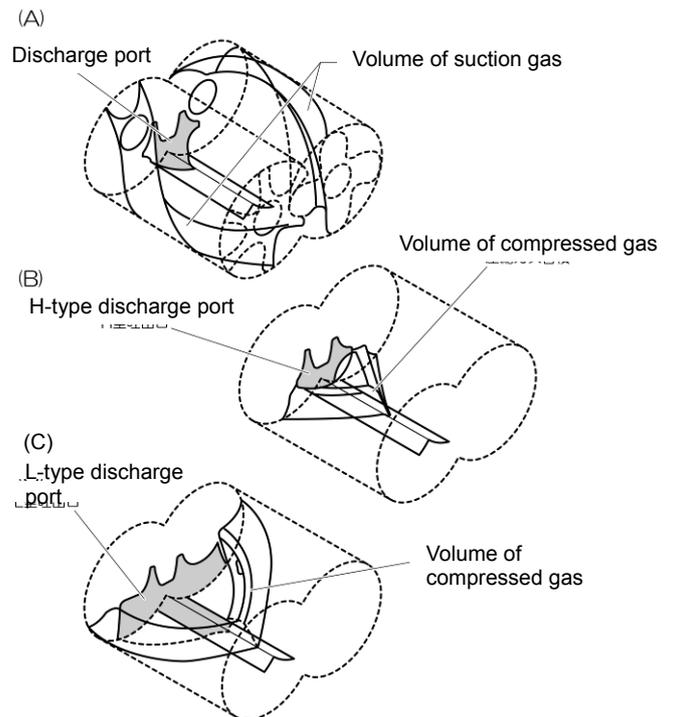
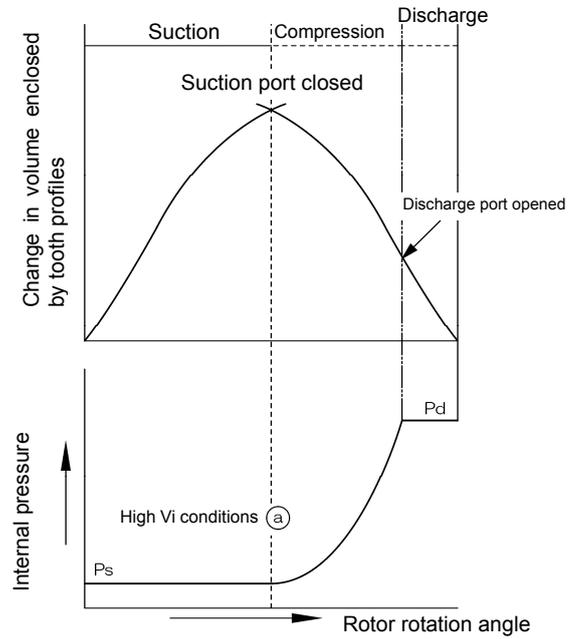
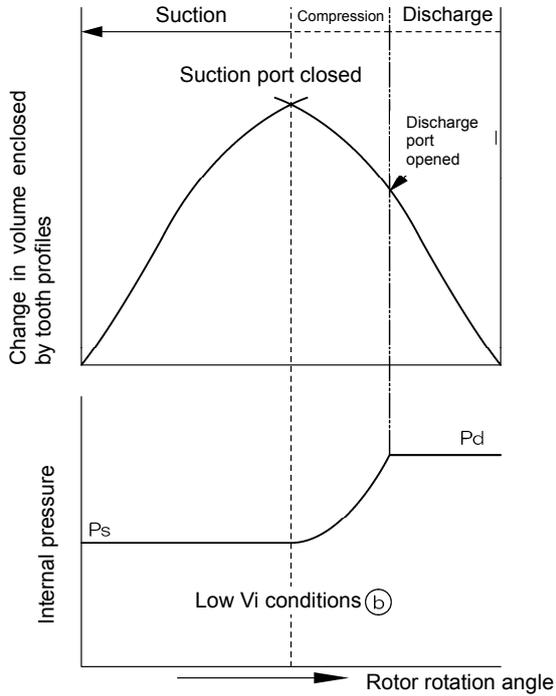


Figure 2-11 Volume Ratio

(A) Properly adapted V_i to load condition

Both the required compression ratio and V_i are low.

Both the required compression ratio and V_i are high.



(B) Improperly adapted V_i to load condition

V_i is too low compared to the required compression ratio.

V_i is too high compared to the required compression ratio.

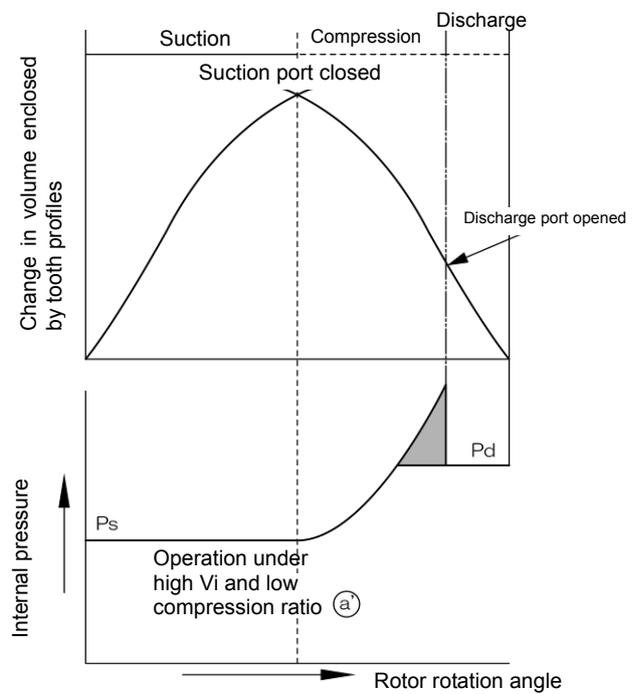
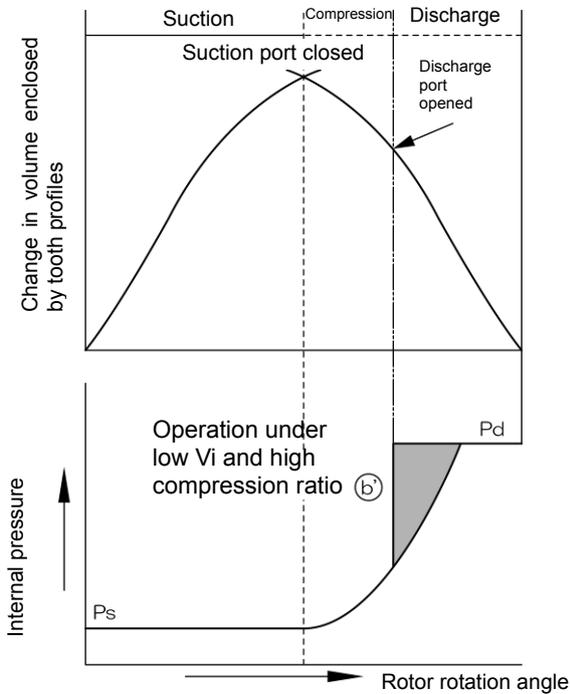


Figure 2-12 Relationship between Volume ratio (V_i) and Operation Conditions

2.5.6 Capacity Control Mechanism

The capacity control mechanism, by moving a slide valve, lets suction gas (immediately before compressed) bypass and advance to the suction side, to help shorten the rotor portion used for compression. The slide valve is located at the bottom of the casing in which the rotors mesh together, and is constructed to move parallel to the rotor shaft. This movement is changed by a cam mechanism into rotation movement. Its position (namely, capacity control ratio) is indicated externally and, at the same time, fed back to the automatic control circuit by changing the electric resistance.

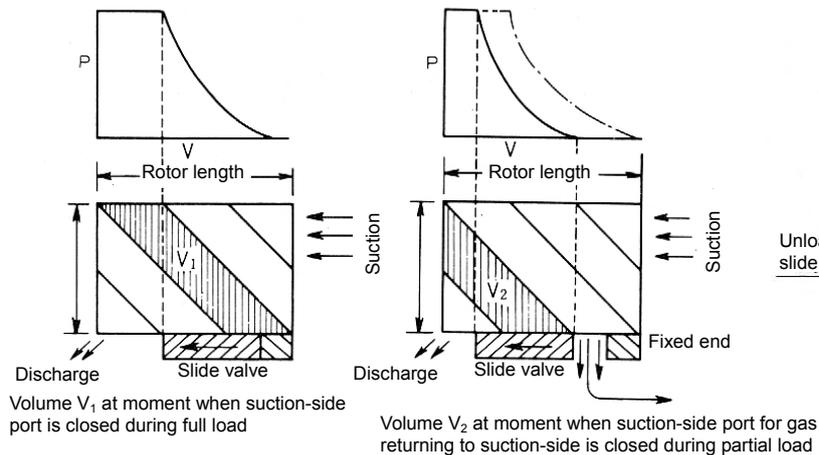


Figure 2-13 Capacity Control Mechanism

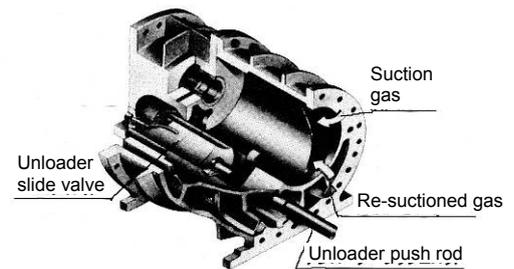


Figure 2-14 Slide Valve in the Rotor Casing

2.5.7 Bearing

For the load acting on the rotor perpendicular to the shaft, sleeve-type white metal-lined bearings are used. For the load acting along the shaft direction, face-to-face combination type of angular contact ball bearings are used.

Special care is taken to cope with the load acting along the shaft direction. Because the M rotor is a kind of helical gear and also because the thrust force produced by discharge pressure is larger than that for F rotor, the load applied onto the M rotor is reduced by using not only a thrust bearing but also a balance piston that applies pressure from the opposing direction.

2.5.8 Seal

A seal which is generally called a mechanical seal is used. The mechanical seal, fully immersed in oil, rotates and provides complete sealing function and cooling effect.

For example, the BBSE (Balance Bellow Single Seal) which is currently used as standard seal, employs a stationary ring (mating ring) made of cast metal, a rotating ring made from carbon, and O-rings for the packing.

2.6 Gas and Oil Flow

The compression process of the screw compressor is as described in the preceding paragraphs.

Gas of the compound 2-stage screw compressor 2016**C is sent from the evaporator, and passes through the strainer and check valve. It is drawn in from the upper central area (1) of the compressor, compressed at the lower side near the driving shaft (2), and then discharged at (3).

(3) and (4) are connected with a pipe.

At the mid point of the pipe, that gas is mixed with the gas from liquid cooler which was used for supercooling.

Lubricant injected at the low-stage is, while kept mixed with gas, suctioned from (4) into the high-stage.

After being compressed at (5), the lubricant is discharged from (6), and is sent from the oil separator to the condenser.

Even if without intermediate gas cooling, oil provides cooling effect.

So, the high-stage discharge temperature is maintained at a temperature not higher than 90°C.

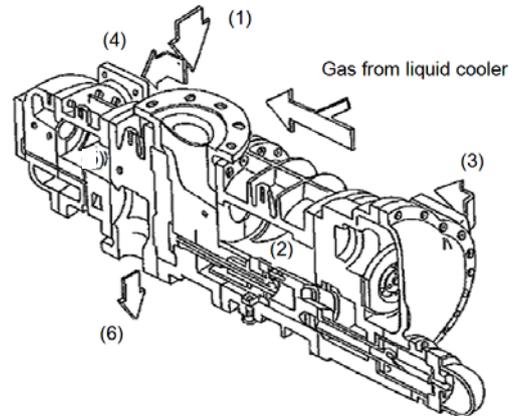


Figure 2-15 Gas Flow

Oil Supply Mechanism

As shown in Figure 2-16, lubricant is split into five flows. After completing each role, the oil is mixed with discharge gas and leaves the compressor. In standard configuration, oil injection is not performed at the high-stage.

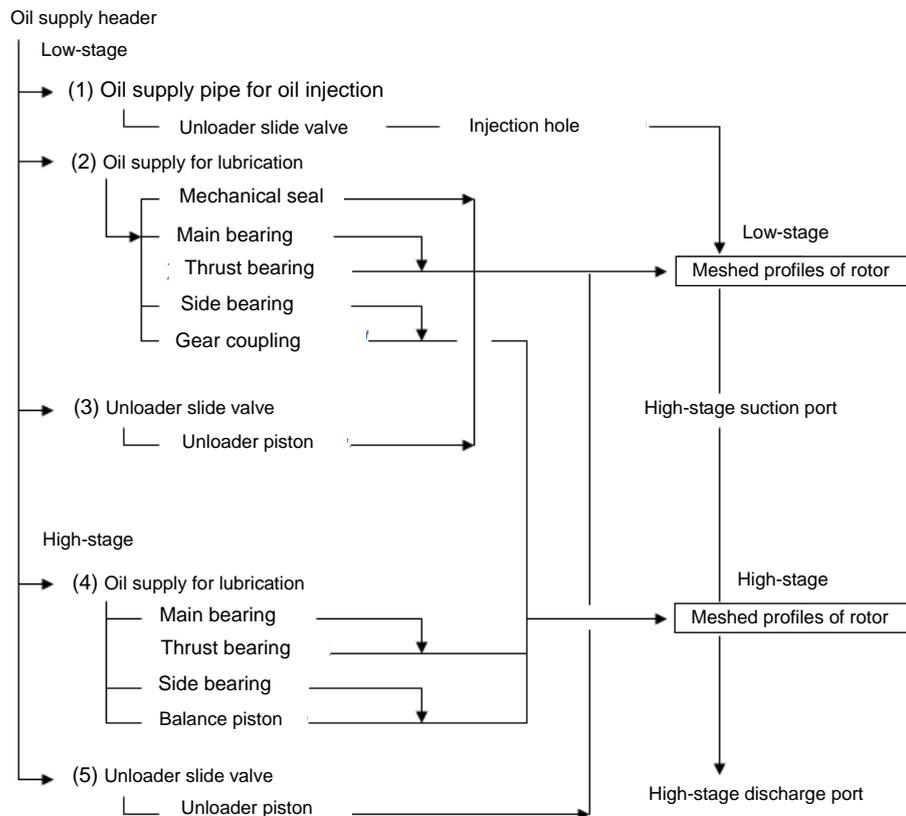


Figure 2-16 2016**C Oil Supply Route

Chapter 3 Installation

3.1 General Precautions for Installation

[POINT]

- This chapter (Installation) assumes that the compressor is installed to a standard refrigeration / cold storage unit.
If the unit you are actually using is not the standard type refrigeration/cold storage unit, prepare a proper installation manual by referring to the description in this chapter and paying due consideration to safety, before installing the compressor.
If there are any questions, please contact our local sales offices or service centers.

- In some cases, it may be required that installation is performed by qualified personnel. Make sure that the work is performed by qualified personnel in compliance with local laws, ordinances and other regulations/requirements.
- Before installing the compressor, please read this chapter and related documents attentively and fully understand their contents.
- Electrical works should be performed only by electrical engineers.

3.2 Installation Works

3.2.1 Unpacking

Check that there are no abnormalities such as damage on the compressor.

[POINT]

- If there are abnormalities or deficient parts on the compressor, please contact our sales offices or service centers immediately.
- Unnecessary packing materials should be discarded according to the laws and ordinances, or your company's rules.

3.2.2 Storage

Perform the followings to store the compressor before installation.

- Store it indoors.
- Infuse nitrogen gas into the compressor and seal it. (Pressure: Approximately 0.15 Mpa)

3.2.3 Transfer



- **Dropping of the lifted compressor may cause death or serious injury. Do not stand under the lifted compressor.**

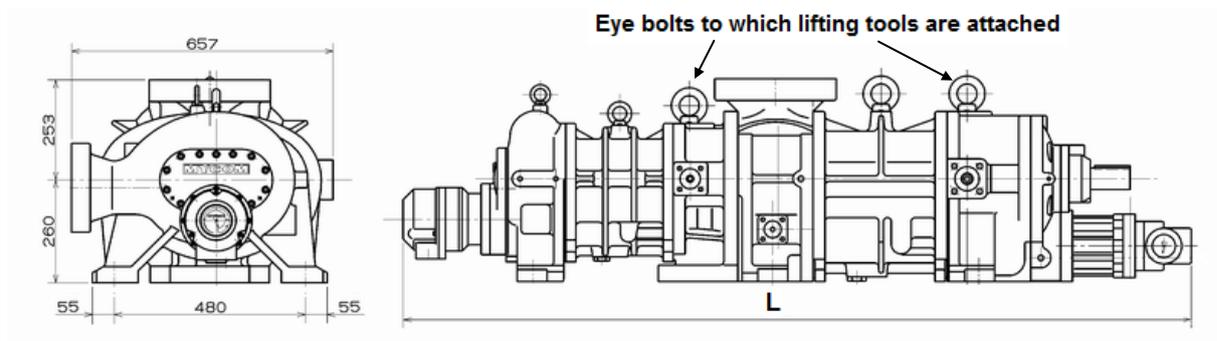
1. For lifting the compressor within the safety limit, use lifting equipment and tools appropriate for the weight of compressor.
2. Secure sufficient space for safe lifting.
3. Always check the wire ropes before using them. Thoroughly check the wire ropes for problems such as kinks, knots and broken strands. Do not perform lifting before checking the wire ropes. If you cannot make a correct evaluation or judgment, entrust an expert to check.
4. To lift the compressor, attach the wire ropes to the appended eye bolts by using appropriate shackles and hooks. Use the eye bolts only for lifting the compressor. Do not use the eye bolts when lifting the compressor together with additive equipment.

CAUTION

- **The compressor eye bolts must not be used for lifting the unit. To lift the unit, use the lifting chains provided around the base or other lifting means provided on the base.**

5. Check path of compressor installation to make sure it is free of obstacles in consideration of the compressor size.
6. Before lifting, check that the hook is located above the gravity center of the compressor.
7. Direct all the workers to stay clear of the work site before lifting.
8. Before lifting the compressor, alert all workers in area of dangers during lifting process by signal (such as calling at the beginning of the work or making a signal by hand). Do not lift the compressor unless the signals (such as calling out or hand signals) are completely understood by the workers at site.
9. Slowly reel up the wire ropes until immediately before the compressor leaves the ground.
10. Then, reel up the wire ropes a little further until the compressor is slightly up away from the ground. Check that the compressor is not tilted. If the compressor is tilted, return the compressor to the ground and correct the tilt by adjusting the wire ropes. After that, restart the lifting operation.
11. Be sure to lift up the compressor slowly. If it is lifted rapidly, it may damage the lifting tools such as wire ropes or a part of the compressor.
12. When the lifting work starts, observe to see if wire ropes and lifting tools are normal. Be sure that the compressor is not tilted.
13. When moving the lifted compressor, always use guiding ropes.
14. When moving the compressor, turn away workers from the movement direction and check safety.
15. Do not lift the compressor above the safety passage unless absolutely necessary.
16. Do not lower the compressor on the safety passage. Always keep the safety passage free of obstacles.
17. Remove any obstacles before lowering the compressor onto the ground. The compressor should not be tilted or unstable.
18. Before lowering the compressor, announce to the workers around the working area in advance.
19. When lowering the compressor onto two or more blocks, align the tops of blocks so that the compressor becomes stable horizontally on them.
20. Slowly lower the lifted compressor so that it is not damaged by shock.

■ Outer Dimensions, Weight and Lifting Position



	2016LLC	2016LMC	2016LSC	2016MSC	2016SSC
Weight (kg)	1180	1140	1100	1050	1000
L (mm)	1980.5	1913.5	1842.5	1787.5	1730.5

Figure 3-1 Outer Dimensions, Weight and Lifting Position of Compressor



Photo 002 Lifting Position

3.2.4 Preparation for Installation

■ Installation Space

Secure sufficient working space for easy operation, cleaning, maintenance, and inspection.

■ Illumination

Prepare illumination devices which allow easy operation, cleaning, maintenance, and inspection.

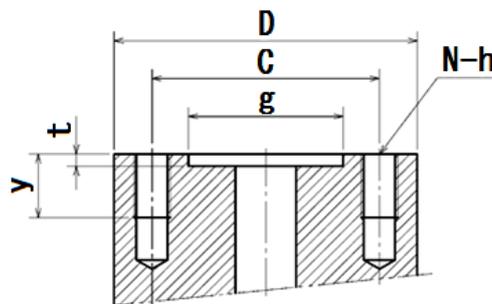
■ Ventilation

If natural ventilation is insufficient, install ventilation fans according to the relevant regulations.

■ Piping

Table 3-1 List of Connecting Pipes (Compressor)

Item	Dimensions	Remarks
Suction gas inlet	JIS 20K 150A (6")	See Figure 3-2.
Low-stage gas outlet	JIS 20K 100A (4")	See Figure 3-2.
High-stage gas inlet	JIS 20K 100A (4")	See Figure 3-2.
High-stage discharge gas outlet	JIS 20K 80A (3")	See Figure 3-2.
Lubrication oil supply port for low-stage bearing (journal)	JIS 20K 25A (1")	
Lubrication oil supply port for low-stage capacity control (increased side)	Rc1/4	
Lubrication oil supply port for low-stage capacity control (decreased side)	Rc3/8	
Oil supply port for oil injection	JIS 20K 15A (1/2")	
Lubrication oil supply port for high-stage bearing (journal)	JIS 20K 20A (3/4")	
Lubrication oil supply port for high-stage capacity control (increased side)	Rc3/8	
Lubrication oil supply port for high-stage capacity control (decreased side)	Rc1/4	



	D	t	g	C	N-h	y
15A	□ 74	5	43	70	4-M12	25
20A	□ 84	5	51	75	4-M12	25
25A	□100	5	61	90	4-M16	25
80A	200	5	121	160	8-M20	35
100A	225	5	146	185	8-M20	35
150A	305	5	216	260	12-M22	34

Figure 3-2 Dimensions of the Joint

3.2.5 Installation

3.2.5.1 Installation

Check that the surface of the refrigeration/cold storage unit, where the compressor is to be installed, is even and horizontal. If it is uneven and non-horizontal, tightening the bolts may lead to compressor deformation, which may prevent normal operation.

3.2.5.2 Piping Connection

■ Refrigerant Piping

Observe the following when connecting the refrigerant piping.

- The compressor is one of the few devices installed within the refrigerating/cold storage unit that have moving components. These moving components are adversely affected by foreign substances within the system (scale, dust, spatter, etc.). Therefore, when connecting the piping, do not allow any of such foreign substances to enter inside.
- Some compressors (mainly those for export) are charged with nitrogen gas to prevent rust. Be sure to release the pressure before starting piping work.
- Be sure not to allow moisture to enter the piping. There is a high probability that it will cause trouble after the start of operation. Be sure to assemble piping when it is dry.
- Cover flanges are attached to the compressor's low-stage gas outlet and high-stage gas inlet. After installation, be sure to attach piping (intermediate piping) that links the both connection ports.
- Improper piping may cause operating problems such as oil not returning to the compressor or liquid flow-backs.
- When connecting the piping to the compressor, use piping that is the same size as the compressor connection port. If the pipe size of the piping is smaller than the compressor connection port, the flow of lubricant or refrigerant will be obstructed leading to problems.
- Do not let the weight of the piping connected to the compressor applied onto flanges or joints. Be sure to prepare proper supports for piping.

3.2.5.3 Equipment and Devices for Protection of the Compressor

■ Oil Filter

Use an oil filter with filtration accuracy of 15µm or smaller and install it in front of the oil inlet of the compressor.

The oil filter may be clogged just after test operation. We recommend installing two oil filters in parallel. This will enable replacement of either filter during operation.

■ Oil Heater for Oil Separator

To preserve the temperature of the lubricant before starting the compressor, install an oil heater on the oil separator. Make sure to install a protection function (thermostat, etc.) to prevent overheating.

■ Suction Strainer

When inter-soluble oil is used, the mesh size of suction strainer should be not less than 200 meshes. When non-miscible oil is used, it should be not less than 100 meshes.

For details about inter-soluble and non-inter-soluble oils, see "4.1 Lubricant (Refrigerant Oil)" in this manual.

During test operation, small particles and scale may come from the system. We recommend to install a finer filter temporarily.

■ Compressor Protective Devices (Safety Devices)

To protect the compressor, install the protective devices as indicated in "1.4.3 Compressor Protective Devices" in this manual.

3.2.6 Airtightness Test

Perform an airtightness test on the refrigerating/cold storage unit.

3.2.7 Lubricant Charge

CAUTION

- When refilling lubricant, ensure that it is clean and does not contain foreign matters.
- Be careful that air and water are not mixed in when refilling.
- To ensure that the lubricant does not absorb air moisture, keep it indoors in an airtight container until use.

3.2.7.1 Initial Charge of Lubricant

At initial test operation or after periodical inspection, the compressor's moving parts such as bearings and mechanical seals may not be sufficiently lubricated. So, charge the compressor with lubricant according to the following procedure.

1. Thoroughly evacuate the compressor and oil separator (approximately 40 Torr). At this moment, open all the solenoid valves used for the unloader, and evacuate the unloader cylinders.
2. Close the oil separator outlet valve in the oil supply line. Also close the oil injection adjusting valve.
3. Charge lubricant from the drain valve on the oil cooler (or the drain valve on the oil filter).
4. When the oil level reaches the lower limit of the oil level gauge of the oil separator, finish supplying lubrication oil from the oil line. (Minimum amount to be charged of lubricant should be "the volume of the oil cooler and oil filter + approximately 20 liters".)
5. Then, supply lubricant from the oil-supply valve of the oil separator until the oil reaches the specified oil level.
6. Start the oil pump. By checking the discharge pressure of the oil pump, confirm that the lubricant is flowing.
If possible, check that the oil level of the oil separator goes down.
7. Adjust the oil differential pressure of the oil pump. (Differential pressure should be "0.2±0.05 MPa".)
8. After adjusting the differential pressure, run the oil pump for approximately 2 minutes. Check that the motor main power is turned off, and then turn the compressor's drive shaft. (Turn the shaft about 10 times, by using the coupling.)
9. If the above work steps have made you confirm that lubrication oil is flowing normally through the oil supply line, the initial charge for refrigerating machine is finished.

【POINT】

- Be sure to conduct the initial charge of lubricant in such a way that the oil cooler and oil filter are filled with lubricant.
 - For details about lubricant to be used, see "4.1 Lubricant (Refrigerant Oil)" in this manual.
 - For the specified amount of initial charge of lubricant, refer to the instruction manual of the unit.
-

3.2.7.2 Additional Charge of Lubricant

For additional charge of lubricant during operation the procedures of charging defer depending on the systems and operating conditions therefore follow the procedures described in the instruction manual of the unit.

3.2.8 Charge of Refrigerant

Charge refrigerant by referring to the instruction manual of the unit.

3.2.9 Check after Installation

Check the compressor after installation according to the check items of the unit.

Chapter 4 Operation of Compressor and Unit

4.1 Lubricant (Refrigerant Oil)

Lubrication management is very significant to keep the compressor in a good operating condition. Take the following notes when managing lubricant.

4.1.1 Precautions for Selecting the Lubricant

- Selection of the lubricant should depend on the type of the refrigerant, the type of the evaporator used with the compressor, and the conditions under which the compressor is operated. Also to be considered when selecting lubricant are the properties of the oil that include not only the viscosity but also such characteristics as solubility in refrigerant, separability from refrigerant, low temperature fluidity, high temperature thermal stability, etc. We therefore recommend to contact our sales offices or service centers for choice of a specified brand for your system.
- Lubricant used for compressors must have a viscosity appropriate for lubricating the bearings and other components in the compressors. The viscosity to be considered in this case should be the viscosity the oil shows at the oil inlet of the compressor. The viscosity of the lubricant significantly changes depending on the type of the refrigerant used in combination with the oil. If the refrigerant dissolves in the oil (or the oil and refrigerant are inter-soluble), the viscosity of the oil drops to a level remarkably below the level required for operation of the compressor under some operating conditions. On the contrary, if the refrigerant does not dissolve in the oil (or the oil and refrigerant are non-inter-soluble), the viscosity may become too high when the supply oil temperature is low. For this reason, the lubricant must be selected such that it is supplied to the compressor with an appropriate viscosity (kinematic viscosity of 13 - 40 mm²/s) in the operating state.
- The circulation of the lubricant for the entire system must be considered. After lubricating and cooling each part of the compressor, the lubricant is discharged with refrigerant gas. Most of the oil which is discharged from this compressor is trapped by the oil separator and is cycled to the compressor. A small quantity of refrigerant oil goes to the condenser and the evaporator. The lubricant is required to have sufficient fluidity and stability inside parts with different temperatures.

CAUTION

- **Be careful since polyolester synthetic oil (POE) cannot be used with ammonia refrigerant.**

4.1.2 Recommended Lubricants

When selecting lubricant, not only compatibility with refrigerant but also effects on O-rings must be considered. To prevent compressor malfunctions, we recommend the lubricant described below.

4.1.2.1 Recommended Lubricants for Ammonia Refrigerant

■ Polyalkylene Glycols (PAG) based synthetic oils

Brand	Kinematic viscosity (40°C) mm ² /s	Manufacturer	Type
JOMO Freol PN46	46	JX Nippon Oil and Energy Corporation	PAG

"JOMO Freol PN46" is the only type of inter-soluble oils that can be used with an ammonia refrigerant.

■ Mineral oils (non-inter-soluble oils)

Brand	Kinematic viscosity (40°C) mm ² /s	Manufacturer	Type
SUNISO 3GS	30	Sun Oil	Naphthene base
SUNISO 4GS	55	Sun Oil	
REFOIL NS 3GS	30	Nippon Oil	
GARGOYLE ARCTIC C HEAVY	46	Exxon Mobil	
GARGOYLE ARCTIC 300	68	Exxon Mobil	
CAPELLA WF46	46	Texaco	
CAPELLA WF68	64	Texaco	
CP-1009-32	34	CPI	Hydrotreated paraffinic base
CP-1009-68	69	CPI	
REFLO 46A	46	Petro Canada	
REFLO 68A	58	Petro Canada	
CAPELLA PREMIUM	67	Texaco	
RHT-68	68	Kluber	
REFLO XL	59	Petro Canada	

■ Synthetic oils (non-inter-soluble oils)

Brand	Kinematic viscosity (40°C) mm ² /s	Manufacturer	Type
Acemire 300	59	Acemire	AB
Mycold AB68	53	BVA	
ZERICE S46	46	Exxon Mobil	
ZERICE S68	68	Exxon Mobil	
BERREL FREEZE 46S	46	Matsumura Oil Co., Ltd.	
CP-4700-32	31	CPI	
CP-4700-68	56	CPI	
Gold-Cold 300	53	Golden West	
GARGOYLE ARCTIC NH68	64	Exxon Mobil	PAO+AB
REFLO SYNTHETIC 68A	62	Petro Canada	
Gargoyle arctic SHC 224 ^{Note}	30	Exxon Mobil	PAO
Gargoyle arctic SHC 226(E) ^{Note}	68	Exxon Mobil	

Note: Use only a seal of the standard BBSE type.

4.1.2.2 Oils for systems using HFC refrigerants

Polyolester synthetic oil (POE) for R404A, R507A and R410A: Inter-soluble synthetic oil

Brand	Kinematic viscosity (40°C) mm ² /s	Manufacturer	Type
SUNISO SL-68S	67	Sun Oil	POE
EMKARATE RL68H	72	Lubrizol	

■ **Polyolester Synthetic Oil (POE) for R134a: Inter-soluble synthetic oil**

Brand	Kinematic viscosity (40°C) mm ² /s	Manufacturer	Type
JOMO Freol α100	107	JX Nippon Oil and Energy Corporation	POE

CAUTION

- **When using lubricant of a brand not described in this section, or when using lubricant along with refrigerants or gases not described in this section, please contact us.**

4.1.3 Change of Lubricant Brand

- Lubricant contains various additives to fulfill necessary lubricating conditions. Types of additives and their mixing ratio depend on each oil brand. We, therefore, recommend to avoid mixed use of different brands of lubricant. If mixed brands of lubricant are used, the different additives in the lubricant may react with each other and produce foreign substances like slurry.
- If it is necessary to change the brand of lubricant, collect as much as oil as possible from the compressor as well as from the condenser, evaporator, and all other refrigerating unit components before charging the new lubricant. After 100 to 200 hours of operation, replace the oil again.
- If lubricant manufacturers differ, contact both of them and inquire whether the changing is appropriate. The same confirmation is required for changing the brand even if it is of the same manufacturer.
- There is no problem in changing the viscosity level within the same brand. However, make sure that the viscosity grade will not cause problems during operation. (Example : SUNISO 3GS→SUNISO 4GS)

CAUTION

- **Unit composition differs depending on the characteristics of lubricant (inter-soluble/non-inter-soluble with ammonia). As a general rule, changing inter-soluble oil to non-inter-soluble oil or vice versa is not allowed. Recommendable inter-soluble oil is JOMO Freol PN46 only. Changing the brand is not allowed.**

4.1.4 Precautions for Handling lubricant

- When refilling lubricant, ensure that it is clean and does not contain foreign matters.
- Be careful that air and water are not mixed in when refilling.
- To ensure that the lubricant does not absorb air moisture, keep it indoors in an airtight container until use.

4.1.5 Precautions for Handling JOMO Freol PN46 (Ammonia-inter-soluble Oil)

As PN46 is extremely hygroscopic compared with mineral oils, moisture, if mixed in, may cause corrosion or corrosive wear. So pay attention especially to the following:

CAUTION

- Charge oil as quickly as possible after opening the pail can (within 15 min if possible).
- Avoid replenishing oil on a rainy day or when the workplace is humid to prevent absorption of moisture.
- Do not use the oil that is left in the container after charge.
- If JOMO Freol PN46 drops on a painted surface, wipe it off as quickly as possible. Otherwise the paint may come off.

For management of lubricant, see "5.3 Management of Lubricant" in this manual.

4.2 Precautions for Operation

4.2.1 Prevention of Liquid Flow-back

Liquid flow-back is a phenomenon where refrigerant that did not completely evaporate with the gas reaches the compressor. Liquid flow-back may cause insufficient lubrication of the compressor, abnormal vibrations and noises, and abnormal foaming of lubricant (too much entry of oil). To prevent liquid flow-back, properly adjust the expansion valve of each liquid cooler. For details, see "Troubleshooting" in chapter 6 of this manual.

4.2.2 Purging of Non-Condensable Gases



- **Some types of refrigerants emit bad smells or toxic gases. Make sure to ventilate the air during work.**

If there is a leak on the low-pressure side of the unit, air may enter the unit.

If non-condensable gas like air enters the unit, the condensing pressure rises and the energy consumption increases. This leads to uneconomical operation.

Follow the procedure below to check for non-condensable gases.

1. When the compressor is stopped, allow the cooling water to flow to the unit's condenser for at least 15 minutes. Check the condensing pressure by using the pressure gauge of the compressor.
2. Check the cooling water temperature.
3. Compare the condensing pressure checked in step 1 above with the refrigerant saturation pressure that depends on the cooling water temperature (as shown in the table below).

Table 4-1 Typical Refrigerant Temperature and Saturation Pressure

Temperature °C	Pressure MPa				
	Ammonia	R404A	R507A	R410A	R134a
0	0.328	0.509	0.523	0.699	0.192
4	0.396	0.590	0.606	0.807	0.237
8	0.472	0.678	0.696	0.924	0.287
12	0.557	0.775	0.795	1.053	0.342
16	0.652	0.881	0.903	1.193	0.403
20	0.756	0.996	1.021	1.346	0.471
24	0.871	1.121	1.148	1.513	0.545
28	0.998	1.256	1.286	1.693	0.626
32	1.137	1.401	1.435	1.887	0.714
36	1.289	1.559	1.595	2.098	0.811
40	1.454	1.728	1.768	2.324	0.916

- Unless otherwise noted, the pressure unit MPa represents the gauge pressure in this manual.

4. When the pressure inside the condenser and the refrigerant saturation pressure that depends on the cooling water temperature are approximately equivalent, non-condensable gases do not exist. When the pressure inside the condenser is 0.05 MPa or more higher than the refrigerant saturation pressure that depends on the cooling water temperature, there is a possibility of non-condensable gases entering the unit. In that case, purge the non-condensable gases from the condenser.

4.2.3 Actions for Stopping the Compressor for Long Period of Time

Before stopping the compressor for a long time, make sure to perform the following steps.

- Turn off the motor main power.
- Turn off the oil heater power and the control power.
- Close the suction stop valve and discharge stop valve.

If the operation stop period is 1 month or longer, perform the following checks once per month.

- Measure the system pressure.
- Check for refrigerant leak.
- Operate the oil pump for 5 minutes. After that, rotate the compressor shaft (10 rotations or more).

When restarting the compressor after an operation stop period of 1 year or longer, check the system for refrigerant leak and replace the refrigerant oil. Also check the motor insulation resistance.

Supply power to the oil heater at least 1 hour before operation start. Before starting the operation, confirm that the refrigerant is not condensed in the package by checking the package temperature and pressure.

Chapter 5 Maintenance

5.1 Precautions for Maintenance

- Before starting maintenance after completely recovering the refrigerant from the unit, make sure that the main motor power, control power and power for instruments and valves are turned off and that the turned-off switches are protected from any unauthorized access. In addition, attach a tag to inform other workers that the turned-off switches must not be turned on (lockout/tagout).
- Also when a manual valve is closed, take proper actions so that it cannot be operated by other workers and attach a tag stating that the device must not be opened (tagout).
- When disassembling, inspecting or handling the compressor, be sure to fully understand the procedures before starting the work. This manual does not provide complete procedures for disassembly and assembly of the compressor. It just explains the points for servicing the compressor.
- If complete assembly and disassembly of the compressor has to be done, consult our local offices or service centers.
- When replacing any parts of the compressor, use **MYCOM** genuine parts. If you do not use genuine parts, unexpected problems may occur.
- Do not modify the compressor or any of its parts without prior permission of Mayekawa. It may cause the compressor to be damaged or disabled from maintaining its normal functions.
- When disassembling the compressor, remove it from the unit frame and place it on a work bench. Before removing the compressor from the unit frame, recover the refrigerant from the unit properly and check that the pressure inside the compressor is atmospheric.
- Prior to the removal of the compressor from the unit frame, check that the high temperature side (discharge side) is cooled down to at least 40°C or lower.
- Disassemble the compressor on a rigid and flat work bench.
- When removing the compressor from the unit frame and placing it on the work bench, follow the instructions in "3.1 General Precautions for Installation" and "3.2.3 Transfer" in this manual.
- Do not allow anyone other than qualified personnel to lift and carry the compressor or the package.
- For compressor disassembly/assembly, use specified tools that are properly functioning.
- When handling heavy objects, exercise extreme care and use safe auxiliary tools such as safety bolts.
- When handling a heavy object, use a lifting apparatus such as a crane or work together with other people.
- When working as a team, ensure that all workers have clear understanding of the work procedure.
- Let qualified personnel turn on/off each power supply, taking care to avoid electrical shocks.
- Any other electrical or manufacturing work that requires qualification must be done by qualified personnel.

5.2 Maintenance List

5.2.1 Daily Management

As daily management, check the items listed in Table 5-1 "Daily Inspection Items" and record the results.

Logging these operation data on a daily basis aid in finding out any abnormal conditions of the compressor. This is significantly effective in preventing compressor failures.

It is particularly important to check whether the temperature/pressure correlations related to the refrigerant evaporation and condensation is proper. This makes it possible to quickly find out problems in the compressor or the system.

If a failure or accident should occur in the compressor or the system, the operation logbook will help determine the cause and take prompt and proper actions.

In addition to the items listed in Table 5-1, it is necessary to record and manage refrigerating unit components and load side conditions on a daily basis. For their details, refer to the instruction manual of the refrigerating unit.

Table 5-1 Daily Inspection Items

Inspection Items		Inspection Contents	Check Items/Actions	
Compressor	Operating hours	h	Total operating hours	<ul style="list-style-type: none"> Judgment of periodic maintenance timing
	Suction pressure	MPa Note 1	Difference from the set value of evaporation temperature equivalent pressure	<ul style="list-style-type: none"> Contamination on the cooling pipe surface Temperature, flow rate, etc. of the object to be cooled
	Intermediate pressure	MPa	Pressure difference from rated operation (normal value)	<ul style="list-style-type: none"> If it is too large, check high-stage. If it is too small, check low-stage.
	Discharge pressure	Mpa	Difference from cooling water temperature equivalent condensing pressure	<ul style="list-style-type: none"> Contamination on condenser cooling pipes Non-condensable gases mixed into the system Quantity, temperature, etc. of cooling water
	Oil supply pressure	MPa	Difference from discharge pressure	<ul style="list-style-type: none"> Whether differential pressure is decreasing Operation with liquid flow-back Whether compressor parts are worn
	Oil filter pressure loss	MPa	Pressure difference between oil filter inlet and outlet	<ul style="list-style-type: none"> Contamination of lubricant Clogging of oil filter
	Suction temperature	°C	Whether within upper and lower limits	<ul style="list-style-type: none"> Temperature, flow rate, etc. of the object to be cooled
	Degree of superheat for suction	°C	Whether degree of superheat is proper	<ul style="list-style-type: none"> Adjust expansion valve Insufficient refrigerant flow
	Intermediate temperature	°C	Whether within upper and lower limits	<ul style="list-style-type: none"> Adjust intermediate expansion valve
	Discharge temperature	°C	Whether within upper limit	<ul style="list-style-type: none"> Non-condensable gases mixed into the system Oil supply temperature, insufficient oil supply Compressor failure

Inspection Items		Inspection Contents		Check Items/Actions
Compressor	Oil supply temperature	°C	Whether within upper and lower limits	• Contamination on cooling pipes of oil cooler
	Capacity control Indicated load	%	Whether operation is normal	• Damage to solenoid valve coil • Improper adjustment of manual control valve of electromagnetic assembly
	Leak from mechanical seal	ml	Leak per hour	• Mechanical seal failure
	Noise and vibration		Abnormal noise/vibration	• Compressor failure
Others	Motor current	A	Whether it is higher than the current at test run	• Compressor failure
	Oil level of oil separator	-	Oil level	• Oil entry • Replenish oil
	Fluid level in the receiver	-	Fluid level	• Replenish refrigerant
	Check for refrigerant leak	-	leak or not	• The machine room and the load side facilities

Note 1 : Unless otherwise noted, the pressure unit MPa represents the gauge pressure in this manual.

■ Daily Maintenance Items

1. Lubrication oil level

When the oil level in the oil separator reaches the lower limit, charge lubricant by referring to the instruction manual of the unit.

2. Replacing oil filter

When the differential pressure between the lubrication oil supply pressure and the discharge pressure is 0.15 MPa or higher, replace the oil filter. At the beginning of the operation, the differential pressure of the oil filter may increase quickly.

3. Cleaning of suction strainer

When the compressor operating hours exceeds 500, check the suction strainer. If a temporary filter is installed for the initial stage of operation, remove it.

At the beginning of the operation or after periodical check, the differential pressure between the front and back of the suction strainer may increase quickly. If the differential pressure becomes large, check and clean the suction strainer.

4. Lubricant leak rate from mechanical seal

If much oil leaks from the mechanical seal, determine the leak rate per hour. The following table shows guidelines for allowable leak rate and the rate at which inspection must be done.

If any problem (damage, etc.) is found in mechanical seal, replace the mechanical seal.

Table 5-2 Guideline for Leak from Mechanical Seal

	2016**C
Allowable leak rate	≤ 3 ml/h
Rate at which inspection must be done	≥ 9 ml/h

Note: The specifications above are just guidelines. They are not guaranteed values.

5. Contamination on the cooling water side of the cooling pipes of condenser and oil cooler

Clogging and contamination of the cooling pipe is largely affected by the quality of cooling water. When the oil temperature and discharge pressure gradually rise during the initial stage of operation, inspect and clean the cooling water side of oil cooler and condenser even when the time has not yet come at which inspection must be done.

5.2.2 Periodical Inspection

Check the following items at specified intervals.

Table 5-3 Periodical Inspection Items

Item	Frequency of inspections	Remarks
Pressure gauges /pressure sensors	Check once per year.	
Thermometers /temperature sensors	Check once per year.	
Protective devices and safety valves	Check once per year.	
Suction strainer	Check after 500 hours from the start of operation.	If the differential pressure between the front and back of the suction strainer increases, check and clean the suction strainer.
	Check and clean once per year.	
Lubricant	Replace lubricant after 500 hours from the start of operation.	When the analysis results do not meet the management criteria provided in "5.3 Management of Lubricant" of this manual, replace oil.
	Analyze oil every 6 months.	
Oil filter	Replace once per year.	Replace oil filter when the differential pressure between the discharge pressure and oil supply pressure exceeds 0.15 MPa.
Cooling water side of oil cooler	Check once per year.	Clean if excessively contaminated.
Cooling water side of condenser	Check once per year.	Clean if excessively contaminated.
Mechanical seal	Check once per year or per 8,000 operating hours. Note*	To be replaced if any abnormality is found However, in the case that it is difficult to stop the operation not at regular inspection, replace the mechanical seal assembly at every inspection.
Coupling	Check once per year or per 8,000 operating hours. Note*	

Note*: Inspection frequency is the specified period after delivery or operating hours, whichever comes first.

5.2.3 Guidelines for Compressor Overhaul Frequency

When servicing or overhauling the compressor, follow the instructions and guidelines described below. The compressor overhaul frequency is largely affected by the compressor operating conditions, type and status of refrigerant and oil, and the system/equipment in which the compressor is operated. The table below lists overhaul frequencies recommended by Mayekawa which are categorized based on the compressor operating conditions.

Table 5-4 Standard Package Operation Conditions and Overhaul Frequency Guidelines

Category of operating condition	Application example	Recommended Overhaul Frequency
Relatively stable operating condition	Cold storage and refrigeration	Every 5 years or 40,000 operating hours
Relatively changing operating condition	Ice maker/chiller	Every 4 years or 30,000 operating hours
Frequently started/stopped, and relatively changing operating conditions	Heat pump	Every 3 years or 20,000 operating hours

Note 1: The above guidelines are only applicable when the compressor is operated within the operation limits specified separately.
(See "2.3.2 Operation Limits" in this manual.)

Note 2: The above guidelines are only applicable when the compressor undergoes daily and periodical inspections specified separately.
(See "5.2.1 Daily Management" in this manual.)

Note 3: Inspect the compressor at the intervals of specified period or operating hours, whichever comes first.

Note 4: The above guidelines do not constitute any warranty.

5.3 Management of Lubricant

5.3.1 Lubricant Management Criteria

Lubricants, to which the management criteria applies, are classified as follows.

1. Synthetic oils : Polyalkylene glycols (PAG)
2. Mineral oils : Naphthenic base and paraffinic base
3. Synthetic oils : Alkyl benzene (AB) and Polyalphaolefine (PAO)
4. Synthetic oils : Polyolesters (POE)

- **We recommend performing sampling oil analysis every six months.**
- **If the oil does not satisfy the management criteria below, replace the oil.**

* This does not apply to water contents in PAG oil. See Note 1 of the table below.

Items and criteria are as follows. The management criteria may be changed without notice.

Table 5-5 Synthetic Oil (PAG)

Item	Management Criteria
(a) Color	ASTM color standard: 4.0 or less
(b) Total acid number (TAN)	Max. 0.1 mg·KOH/g
(c) Kinematic viscosity	Within $\pm 10\%$ in variation when compared with fresh oil
(d) Water content	Max. 2000 ppm ^{Note 1}
(e) Contamination level	Max. 15 mg/100 ml as measured by gravimetric (Millipore filter) method ^{Note2}

Table 5-6 Mineral Oils and Synthetic Oils (AB, PAO)

Item	Management Criteria
(a) Color	ASTM color standard: 6.0 or less
(b) Total acid number (TAN)	Max. 0.3 mg·KOH/g
(c) Kinematic viscosity	Within $\pm 15\%$ in variation when compared with fresh oil
(d) Water content	Max. 100 ppm ^{Note 1}
(e) Contamination level	Max. 15 mg/100 ml as measured by gravimetric (Millipore filter) method ^{Note2}

Table 5-7 Synthetic Oil (POE)

Item	Management Criteria
(a) Color	ASTM color standard: 4.0 or less
(b) Total acid number	Max. 0.2 mg·KOH/g
(c) Kinematic viscosity	Within $\pm 10\%$ in variation when compared with fresh oil
(d) Water content	Max. 200 ppm
(e) Contamination level	Max. 15 mg/100 ml as measured by gravimetric (Millipore filter) method ^{Note2}

Note 1: Synthetic oils (inter-soluble with ammonia) are so highly hygroscopic that they can absorb moisture at the time of sampling. In addition, the ammonia content they have absorbed may be detected as the water content at the time of the analysis, making it difficult to precisely measure the water content. Therefore, use the criterion value only as a reference.

Note 2: This assumes the use of an oil filter with nominal mesh size at 15 μ m or finer.

5.3.2 Lubricant Replacement Frequency

5.3.2.1 First system startup

When the system is started up for the first time, since the lubricant may get contaminated or deteriorated due to scale inside the piping and vessels, sample and analyze the lubricant 500 hours after starting operation.

If the results do not meet the management criteria for each oil type detailed in Tables 5-5 through 5-7, replace the lubricant.

5.3.2.2 During regular operation

Lubricant deteriorates gradually as the system is operated over time.

The deterioration rate depends on the operating conditions, oil type, and any foreign substances or water in the oil. Sample and analyze the lubricant every 6 months and if the results do not meet the management criteria for each oil type detailed in tables 5-5 through 5-7, replace the lubricant.

If oil filters frequently clog or the oil has turned dark and unclear, replace oil after removing the cause of problem.

5.4 Compressor Disassembly Preparation

As explained in Chapter 2, screw compressors are very reliable compressors. However, it is necessary to disassemble and inspect parts after a certain period of operation. This chapter describes the sequence and method of disassembly, and locations of and methods for inspecting parts.

As a general rule, periodic inspections where the compressor is completely disassembled should be done at the manufacturing factory. However, when work must be done at the installation location from unavoidable circumstances, follow the procedures described below.

When doing a full-scaled overhaul, the compressor must be removed from its frame.

* Some sections of the compressor can be overhauled with the compressor installed on its frame.

For the disassembly sequence and handling of parts, follow the instructions given in this manual. Otherwise, unexpected failure may occur when the system is restarted, due to damage to the parts or improper assembly.

Read this manual thoroughly and fully understand the system before starting work.

Numbers denoted by [] that follow part names refer to the numbers used in assembly cross-section views or development views.

DANGER

- Before starting inspection/maintenance, be sure to cut off the main power supply and control power supply. Be careful that the power will not be turned on during inspection/maintenance.
- If the power is turned on during inspection/maintenance, the compressor or oil pump may start moving, which may cause the operator to be caught in or the devices to be damaged. In addition, there is a risk of receiving an electric shock through contact with live parts.

WARNING

- After turning off the main motor power, control power and the power of each device, conduct lockout/tagout to prevent the power from being turned on accidentally during work.
- After closing the suction, discharge and fluid supply shut-off valves, conduct lockout/tagout to prevent the valves from being opened accidentally during work.
- The worker who enters the equipment should perform lockout/tagout.
- The worker who performed lockout/tagout should release them after checking that all work procedures have completed.
- If refrigerant gas or a mixture of refrigerant and oil remains in the compressor, refrigerant gas may blow off when the closed circuit is opened. This may result in injury such as frostbite or loss of vision. Be sure to confirm that there is no residual pressure before opening any pipe connections.

5.4.1 Tools for Disassembly and Work Place



- For compressor disassembly/assembly, use specified tools that are properly functioning. Using tools that are worn or damaged or that are unsuitable for the work can result in injury.

Prepare tools to be required for the work referring to “7.5 Tools for Disassembly.” It is also recommended to prepare general hand tools, green silicon carbide grinding stone, emery paper(#80-#100), emery paper(over #800), parts cleaning oil, lubrication oil, a lubricator, an oil can for oil sump, waste cloth and so on.

A work bench with a large surface plate is useful to perform work accurately and with ease. If the surface plate cannot be prepared, use a commercially available steel plate. The steel plate should be approximately 1200 mm × 2400 mm in size and have a thickness of approximately 1.5 mm if the work location is flat.

To safely perform bolts and plugs removal used in the lower side of the compressor, an exclusive frame for placing the compressor is required. Refer to the article 5.4.5 in this chapter.

Perform the work in a dry place with as little sand and dust as possible, with a sufficiently wide space around there.

5.4.2 Replacement Parts

Prepare **MYCOM** genuine replacement parts based on the table 7-1 " Parts Configuration Table " in this manual Chapter 7.

Because O-rings and gaskets which are removed for the inspection are easy to be damaged, replace all with new ones.

When purchasing any part, inform its (a) model, (b) serial number, (c) part name, (d) code No. and (e) necessary number to our sales office or service center. Especially when the (b) serial number of the compressor is not identified, it will be difficult to decide the required parts because we can not specify the design and manufacturing specifications.

5.4.3 Recovering the Refrigerant

After stopping the compressor unit, internal pressure of the compressor is high. Before disassembling the compressor, it is necessary to lower the internal pressure to atmospheric pressure. The following methods are available.

- By using the bypass valve, release the high pressure gas in the unit to the low pressure side.
- If there is another compressor unit connected by bypass piping (or which can be temporarily installed), operate the other compressor and lower the pressure through the bypass piping.
- Operate the refrigerating unit, close the fluid supply master valve, and collect the liquefied gas in the receiver.
- By using a refrigerant recovery machine, recover the liquefied refrigerant in the receiver.

For any of the above methods, prepare a flow sheet describing the operations of the work. Verify valve operations that are necessary for each method, according to the flow sheet and on the actual unit. Specify control valves as well as connected devices and tubes on the flow sheet.

Prepare one flow sheet for the foreman and another one for display at the work area.

In addition, prepare a refrigerant collection procedure with the workplace situation considered. Be sure that all the personnel related to the work will read it together for confirmation, before starting the work.

 **WARNING**

- Be sure to confirm and make known the work contents and procedures described in the work procedure, and inform the estimated risks to the related personnel, before the work. Neglecting these efforts will increase the industrial accident occurrence rate to a level that cannot be ignored.
- After closing (opening) a valve for work, conduct lockout/tagout to prevent it from being handled accidentally during work.

5.4.4 Removing Parts Connected to the Unit

 **DANGER**

- If refrigerant gas or a mixture of refrigerant and oil remains in the compressor, refrigerant gas may blow off when the closed circuit is opened. This may result in injury such as frostbite or loss of vision. Be sure to confirm that there is no residual pressure before opening any pipe connections.

When removing the compressor from the unit frame, disconnect the following parts.

- (1) Coupling that is connecting the compressor and electric motor
- (2) Compressor's suction pipe flange and discharge pipe flange (if the suction strainer is connected directly with the compressor, remove the strainer, too), and the intermediate (inter-unit) pipe connecting low-stage discharge port and high-stage suction port
- (3) Compressor's lubrication piping
(journal lubrication (2 sets), oil injection (1 set) and capacity control increase/decrease (2 sets for each))
- (4) Electric wiring for operating capacity control
(Depending on the situation of the workplace, unloader indicator assembly may be used. See "5.7.14 Unloader Indicator" in this manual.)
- (5) Bolts for installing compressor (leg bolts)
- (6) Oil escape piping at the bottom of low-stage bearing head

[POINT]

Before removing the intermediate (inter-unit) pipe which is used to transfer oil/gas from low-stage discharge port to high-stage suction port, extract all oil from the oil escape valve of the low-stage bearing head.

Since remaining oil may leak out when disconnecting the oil piping from the compressor, slightly warm the piping and then disconnect it while checking the state of oil spillage, or disconnect it after extracting the oil from the oil temperature gauge of the lubrication header.

The unloader cylinder is full of oil. When removing pipe(s), prepare a container for receiving oil. 18 liter-size empty can for lubricating oil is suitable as the container.

When disconnecting electrical wiring, put markings so that it can be reconnected easily. Unless reconnected correctly, the compressor may not start up or the capacity control system may not operate.

5.4.5 Removing and Lifting the Compressor

⚠ WARNING

- Do not allow anyone other than qualified personnel to lift and carry the compressor. Entrusting the work to unqualified personnel may result in fall accident.
- Be sure not to assemble/disassemble the compressor while it is being lifted. There is a risk that the compressor's main body or parts may drop on human body.

【POINT】

The suction piping is located immediately above the compressor. Hold the piping or remove it in part, so that the compressor lifting work is not hindered.

For the compressor locations where lifting tools should be attached, see Figure 3-1 and Photo 002 in 3.3 of this manual, or Photo 003 shown below.

If you are going to perform work step(s) other than steps ⑩ and ⑪ when performing work steps ⑤ and onwards (see "Figure 5-1 Illustrated Disassembly Sequence" in 5.5 of this chapter), **do not disassemble while lifting the compressor**, put the compressor on a table as shown in Photo 004 below, and remove approximately 8 bolts from the lower side of the flange as necessary. These bolts cannot be removed after the compressor is brought down on the work bench.



Photo 003 Lifting the Compressor



Photo 004 Lower-side Bolts for
Fastening Rotor Casing

5.4.6 Removing Oil from Compressor

Remove oil in advance, since a large quantity of oil remains inside the compressor.

There is plug 【10】 under suction covers 【5-1】 【5-2】 and plug 【15】 under bearing head 【11-1】.

Most of the oil will flow out of these plug holes. Remove the remaining oil as it appears, while disassembling the compressor on the surface plate.

Oil mainly resides inside a) unloader cylinders 【60-1】 【60-2】, b) balance piston cover 【22】 , c) seal cover 【51】 and d) suction covers 【5-1】 【5-2】.

Prepare a receiving tray and waste cloth for oil that will spill during disassembly.

5.5 Disassembly Sequence

Generally compressors are disassembled in the order shown in Figure 5-1 Illustrated Disassembly Sequence but the order in the figure is just an example and the actual order may differ according to individual situations.

For instance when overhauling it is no problem to start separation of high-stage part from low-stage part after removing the compressor from the unit frame and putting it on the work bench prepared beforehand.

In addition it is often the case that the disassembly of unloader cover/unloader cylinder part from mechanical seal part is performed in the reverse order of shown in the Figure 5-1.

Shown in the steps in the Figure 5-1, ① through ⑤, ⑩ and ⑪, you can disassemble the compressor with the compressor attached on its frame.

When conducting steps ⑦ through ⑳, perform each step after removing the compressor and placing it on the work bench.

When conducting steps ⑦ through ⑳, the compressor should be removed from its frame and placed on a work bench prepared in advance.

When disassembling high-stage or low-stage side only, start from step ⑦ and disassemble necessary parts only.

Parts which have no problem should be left as they are. Do not disassemble such parts unless during periodical inspection.

Since it is difficult to completely eliminate the risks of performing inaccurate work at the field, disassemble the minimum required parts only.

Table 5-8 Compressor Disassembly Sequence Examples

Part to Be Disassembled	Disassembly Sequence (See Figure 5-1.)
(1) Mechanical seal	①—②
(2) Unloader indicator	③
(3) Unloader cylinder cover	③—④
(4) Unloader piston and unloader cylinder	④
(5) Bearing cover	⑤
(7) Separating high-stage and low-stage.	⑦
<u>High-stage parts</u>	
(8) Gear coupling	⑦—⑧
(9) Thrust bearing	⑦—⑧—⑨
(10) Balance piston cover	⑩—⑪
(11) Balance piston	⑩—⑪
(12) Suction cover and side bearings	⑩—⑪—⑫
(13) Rotors and main rotor casing	⑬—⑭
(14) Bearing head and main bearing	⑭
<u>Low-stage parts</u>	
(15) Bearing head, thrust bearings, etc.	⑮
(16) Gear coupling	⑯
(17) Suction cover and side bearings	⑰
(18) Rotors and main rotor casing	⑱—⑲
(19) Bearing head and main bearings	⑲
(20) Unloader slide valve and guide block	⑲

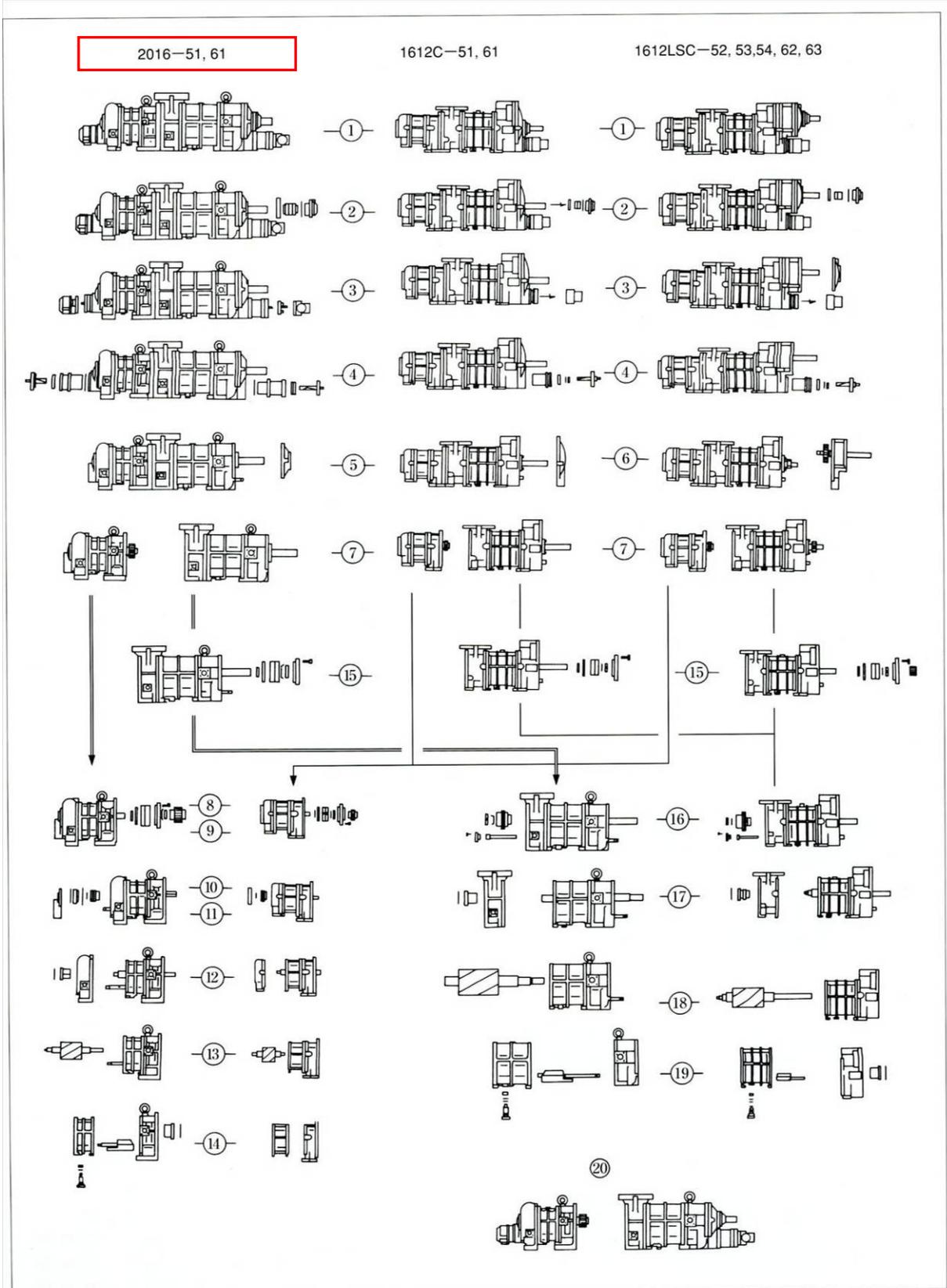


Figure 5-1 Illustrated Disassembly Sequence

5.6 Overhaul

DANGER

- Before starting inspection/maintenance, be sure to cut off the main power supply and control power supply. Be careful that the power will not be turned on during inspection/maintenance.
If the power is turned on during inspection/ maintenance, the compressor or oil pump may start moving, which may cause the operator to be caught in or the devices to be damaged. In addition, there is a risk of receiving an electric shock through contact with live parts.

WARNING

- Be careful so as not to receive an electrical shock when turning on/off the power supplies.
- When handling heavy objects, exercise extreme care and use apparatus such as crane as necessary. There is a risk that the compressor's main body or parts may drop on human body.
- When using a crane, allow only qualified personnel to operate it. Entrusting the work to unqualified personnel may result in fall accident.
- Replace the parts with **MYCOM** genuine parts. If parts other than genuine parts are used, there is a risk of the compressor and equipment being damaged or ruptured.

CAUTION

- For compressor disassembly/assembly, use specified tools that are properly functioning. Using tools that are worn or damaged or that are unsuitable for the work, can result in injury.

Be careful with handling of the parts during overhaul work. Since the compressor rotates at a very high speed, even the slightest handling error could cause a situation that requires replacement of the rotor and all other important parts. Such errors can also cause problems or performance deterioration after the compressor is reassembled.

Be sure to fully understand the following before starting the work.

5.6.1 Mechanical Seal

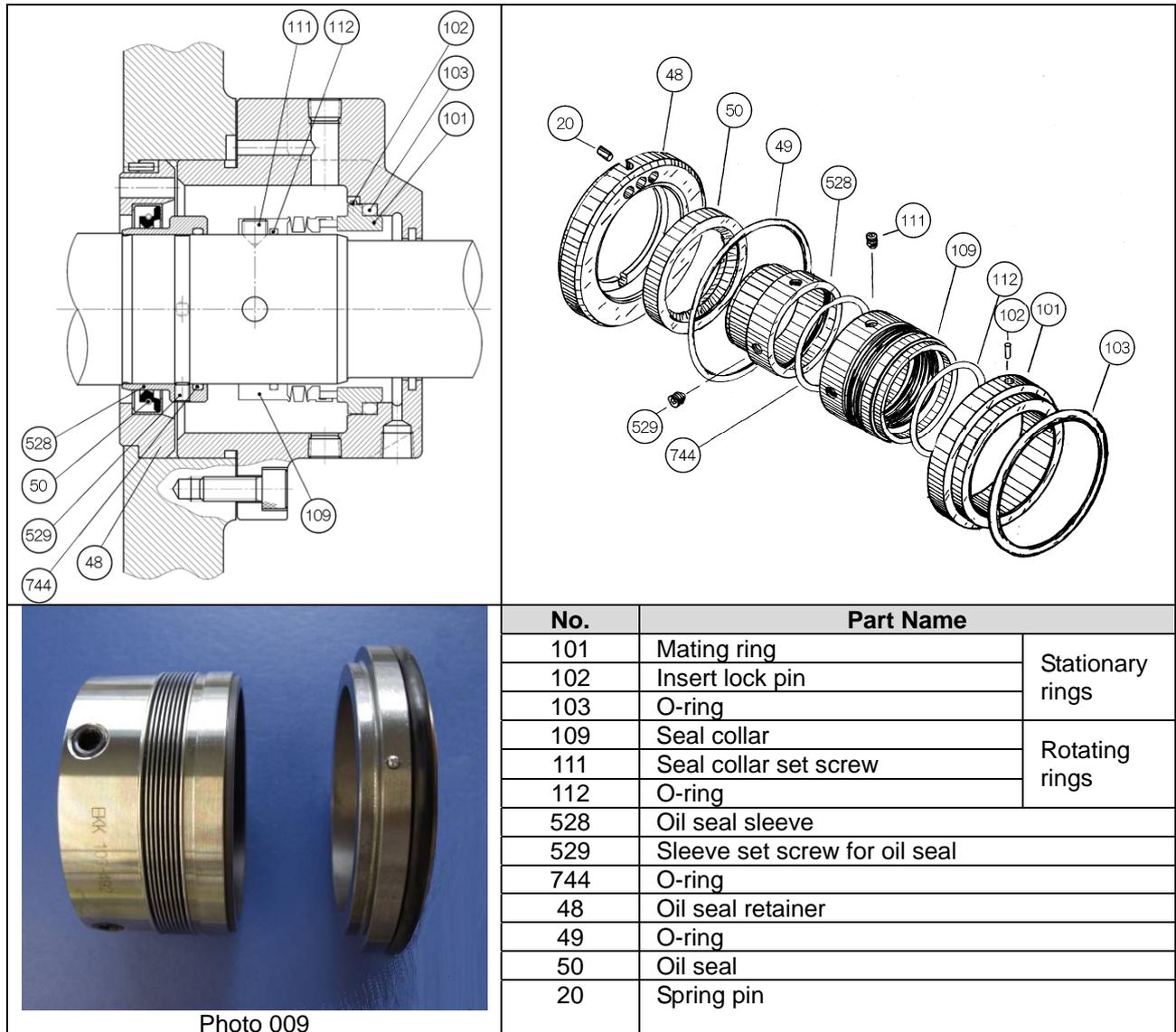


Figure 5-2 Details of BBSE Type Mechanical Seal

5.6.1.1 Disassembly

- Of the eight hexagon socket head cap screws [53] securing the seal cover [51], remove six and leave two on the opposing sides.
- Loosen the remaining two screws alternately and evenly, a little at a time. After loosened to some extent, the seal cover of the mechanical seal will be raised slightly by the force of the inside spring, creating a gap under the cover. The gap will not be created if the gasket is sticking to both surfaces. In this case, free the cover by screwing the 8 mm eye bolts into the forcing screw holes in the seal cover to separate it.
- Use a container to catch the oil that will leak from the gap in the seal part.
- Pull out the seal cover, while keeping it parallel with the shaft (rotor shaft). The mating ring is attached inside the seal cover by using an O-ring. Be careful not to let the mating ring and the shaft damaged by contact.
- Remove the O-ring [49] from between the seal cover and oil seal retainer.

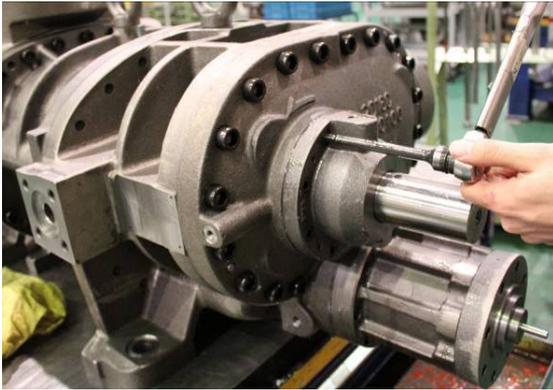


Photo 005 Removing Seal Cover



Photo 006 Seal Cover and Mating Ring

- f) After removing the seal cover, wipe clean and inspect the shaft surface. If there are scratches, use fine sandpaper to smooth them over. This is done to prevent damage to the internal O-ring when pulling out the mechanical seal.
- g) Loosen the set screws 【111】 of the seal collar 【109】 by turning them approximately three times (Photo 007). Do not remove the set screws completely, but leave them so that their ends are below the surface of the seal collar. These screws are located in two places 90 degrees apart from each other.



Photo 007 Loosening the Seal Collar Set Screws



Photo 008 Oil Seal Retainer

- h) Pull out the seal collar with your fingers. While pulling out, make sure that the ends of the set screws do not touch the shaft surface. Axial-direction scratches on the shaft can cause leaks.
- i) By removing the two set screws, pull out the oil seal sleeve.
- j) Screw two eye bolts into the jacking screw holes in the oil seal retainer and pull out the oil seal retainer while keeping it at a right angle against the shaft.

5.6.1.2 Inspection

- a) Mechanical seal should be replaced if any defect is found during inspection. Actually, however, it is sometimes difficult to find out defects on the sliding surface only through visual inspection. In such circumstances, Mayekawa recommends to replace it with a new one in the same manner as with O-rings or gaskets.
The contact between the sliding surfaces of the mating ring and seal collar must be checked even when replacing the seal. If there are obvious traces of uneven contact or damage, find out the cause (degradation over time, problems such as heating operation, etc.) and take necessary actions.
- b) Replace the O-rings every time the mechanical seal assembly is inspected because they normally swell and deform over time.
A total of four O-rings are used for the sealing section. They are located between the seal cover and oil seal retainer 【49】; between the mating ring and seal cover 【103】; between the seal collar and shaft 【112】; and between the shaft and oil seal sleeve 【744】.

- c) Inspect the oil seal sleeve for wear in its section rubbing against the oil seal lip.
If wear is evident, replace both the oil seal 【50】 and oil seal sleeve 【528】 with new parts. Since the oil seal is made of a special material, only a genuine oil seal must be used for replacement.
<About the O-rings attached to oil seal sleeve 【744】>
In the design modification applied in March, 2010, O-ring 【744】 is attached to the inner diameter of the oil seal sleeve.
- d) Replace the seal cover gasket with a new one.



Photo 010 Oil Seal Retainer and Oil Seal Sleeve attached with O-ring

5.6.2 Unloader Indicator

As the 2016**C model has a capacity control also on the high-stage side, it has two separately-placed indicators. Normally, the low-stage capacity control only is used during operation. The high-stage control capacity is used to reduce the startup load.

As various control methods are employed depending on the equipment, refer to the separate electrical control wiring diagram (provided for each plant).

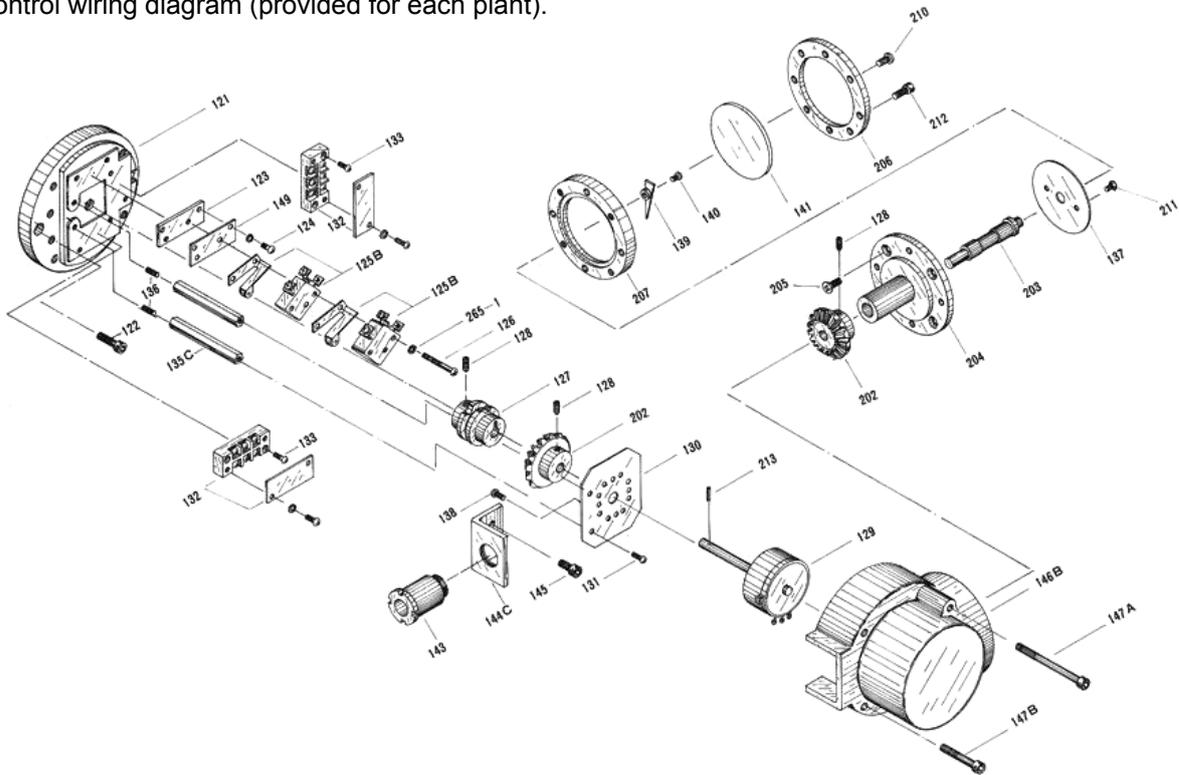


Figure 5-3 Development View of the 2016**C Standard-type Low-stage Indicator

5.6.2.1 Disassembly

■ When removing the compressor, the wiring of the unloader indicator has to be pulled out. As the indicator has a terminal board for wiring, remove the cover from the indicator. Follow the procedure below. After the wiring is removed, attach the cover again for protection.

○ Low-stage

- Loosen the hexagon socket head cap screws [212] fastening the indicator glass [141]. Do not by mistake loosen the crosshead screw [210] on the same surface. Remove assemblies [141], [202 to 207], [210] and [211].
- Remove hexagon socket head cap screws [147A] [147B] (two each) that fasten the indicator cover [146B]. Then the cover gets removable.
- There is a terminal block. Remove the plastic plate on the surface, and loosen the screws.

○ High-stage

- Remove three hexagon socket head cap screws [147] that fasten the indicator cover [146]. Then the cover gets removable.
- The indicator cover comes off with glass [141] and indicator glass spacer [142] attached. The glass and the spacer are pasted together, however, take care not to drop them as they may come apart.
- Remove the wiring.

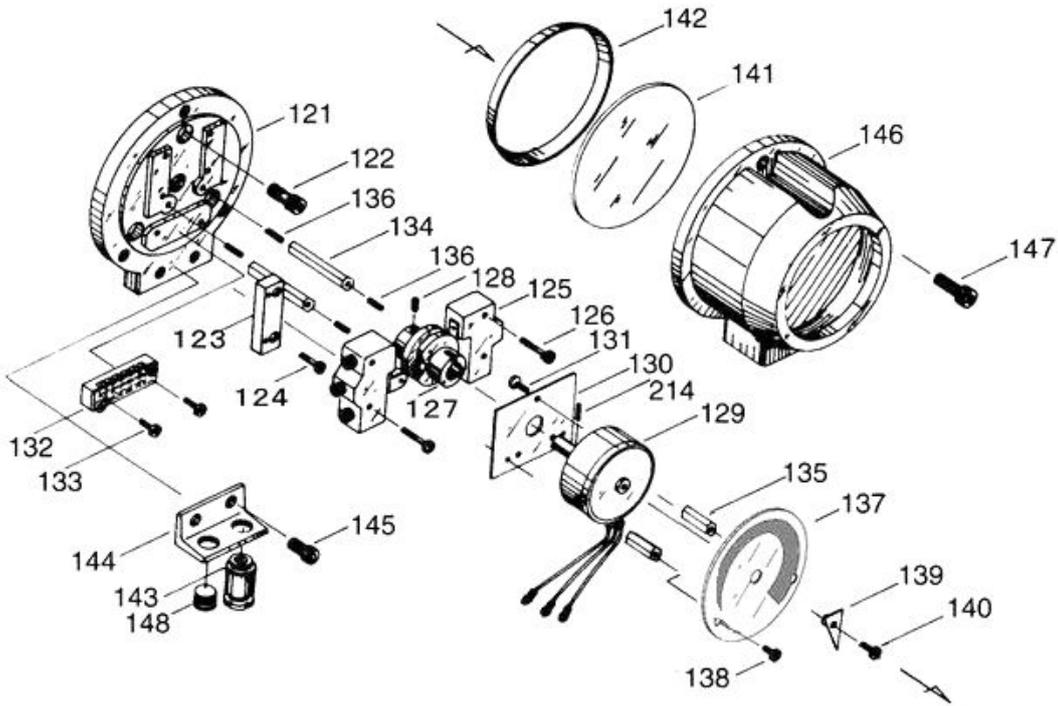


Figure 5-4 Development View of the 2016**C Standard-type High-stage Indicator

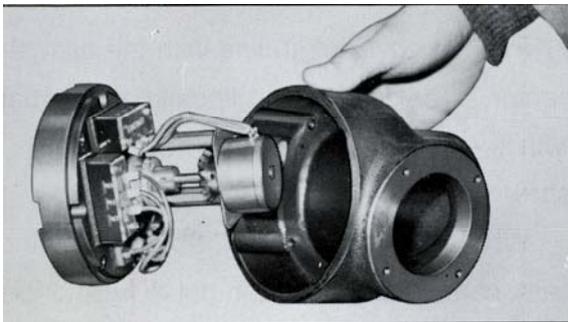


Photo 011 Removing Low-stage Indicator Cover

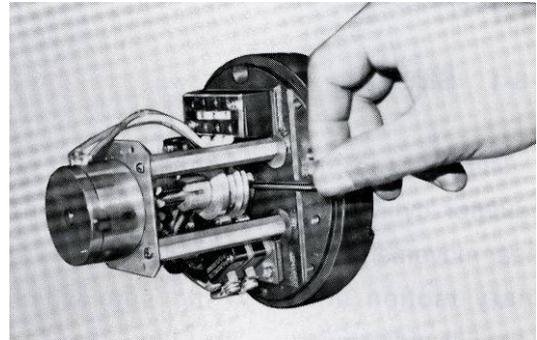


Photo 012 Loosening Low-stage
Micro-switch Cam Set Screw

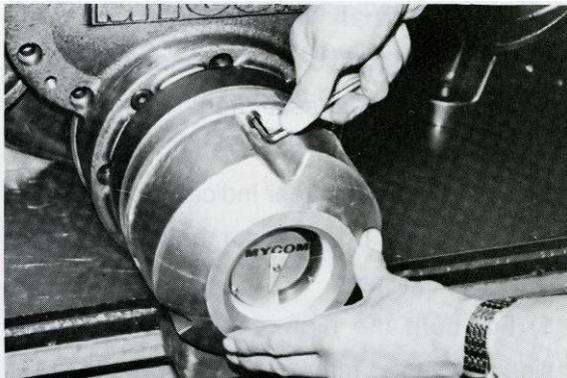


Photo 013 Removing High-stage Indicator Cover

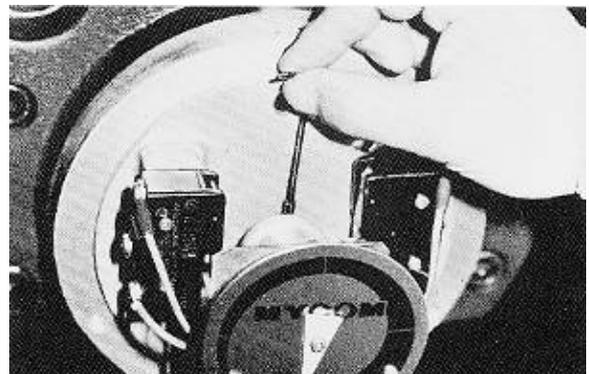


Photo 014 Loosening High-stage
Micro-switch Cam Set Screw

- When further disassembly is necessary
The indicator is an assembly. Unless it needs to be disassembled, remove it as a unit and do not disassemble it into smaller parts.

- High-stage/Low-stage

- a) As a result of the disassembly process conducted above, (i) the internal potentiometer, (ii) micro-switch and (iii) micro-switch base plate [121] attached with micro-switch cam get removable.
- b) Remove hexagon socket head cap screws [122].
- c) Loosen the micro-switch cam set screw [128].
- d) Now, the assembly can be pulled out as it is if pulled out in the axial direction.

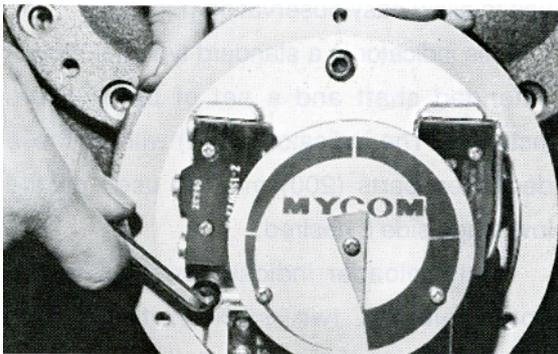


Photo 015 Loosening the Screws
Securing High-stage

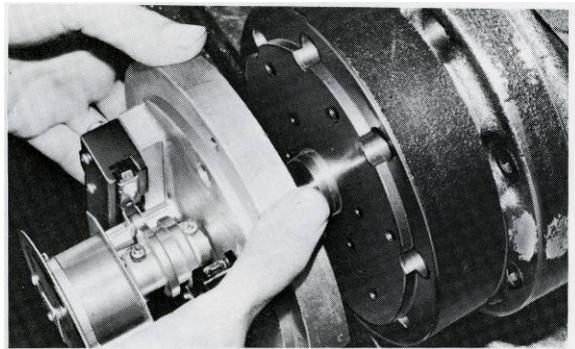


Photo 016 Removing High-stage Indicator
Micro-switch Base Plate

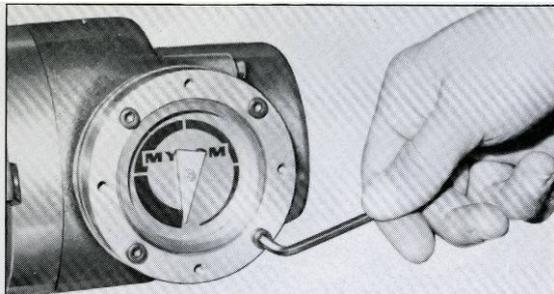


Photo 017 Removing Low-stage Indicator

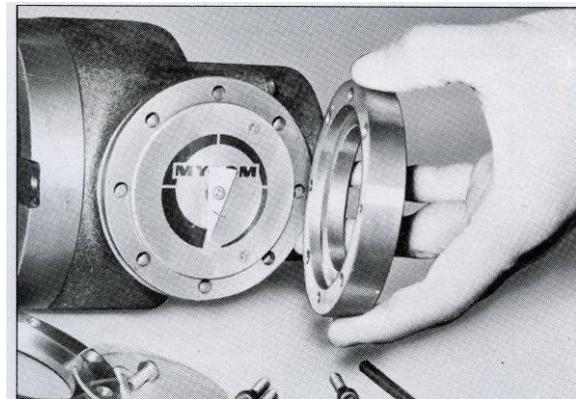


Photo 018 Removing Low-stage
Indicator Cover

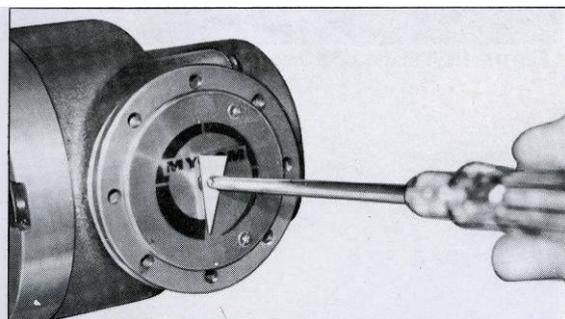


Photo 019 Removing Low-stage Indicator Pointer

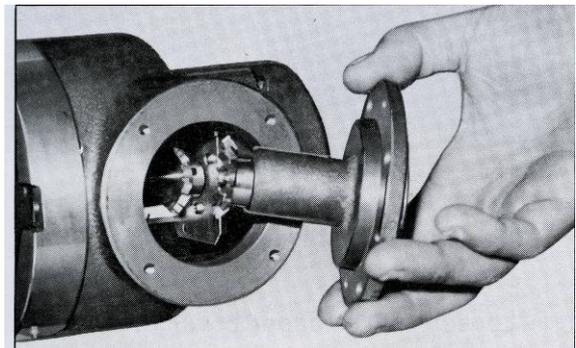


Photo 020 Low-stage Indicator Inside

5.6.3 Unloader Cylinder Cover

Unloader cylinder covers [74-1] [74-2] contain indicator cams [77-1] [77-2] for converting the linear position of the unloader slide valve into a rotation angle, as well as parts for attaching the cam.

5.6.3.1 Disassembly



Photo 021 Loosening Bolts of Unloader Cylinder Cover



Photo 022 Removing Unloader Cylinder Cover

- a) Remove the hexagon socket head cap screws [76] used to attach the unloader cylinder cover.
- b) The indicator cam [77], which is attached to the unloader cylinder cover, is fit to the inner side of the unloader push rod [67] which is inside the unloader cylinder. The guide pin [68] at the tip end of the push rod is engaged with the groove of the indicator cam. So the unloader cylinder cover can be pulled out straight as it is (Photo 022).
If the unloader cylinder cover should be bent obliquely, the shaft of the indicator cam will also be bent. So take care.

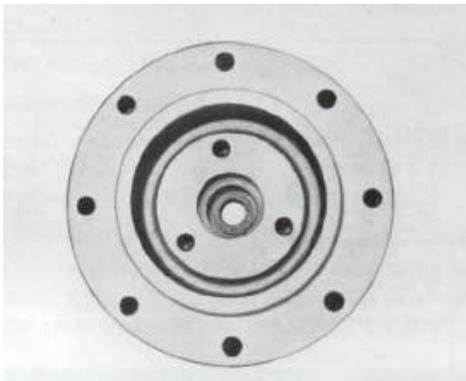


Photo 023 Main Body of Unloader Cylinder Cover



Photo 024 Sealed Portion of Indicator Cam

- c) If the indicator cam does not move properly, check the groove of the indicator cam, bearings and guide pin. Disassembly sequence is as shown below.
 - c-1) The bearing gland [80] that holds the indicator cam is secured to the cylinder side of the unloader cylinder cover. Remove the three hexagon socket head cap screws [81] that are securing the bearing gland.
 - c-2) Now, the indicator cam can be pulled out as it is, together (attached to its shaft) with its ball bearing [78] and stop ring [79] securing the bearing.
 - c-3) The spring retainer [84], spring [83] and Teflon V-rings [82] are attached, in this sequence, to the inside of the unloader cylinder cover.
The outer diameter of the Teflon V-rings is attached tightly to the holes of the unloader cylinder cover. These V-rings, once removed, cannot be reused because their tongue portion gets damaged. So be careful.



Photo 025 Teflon V-rings

5.6.3.2 Inspection

- a) Check for damage on the packing portion of the indicator cam shaft. If refrigerant leaks even when there is no damage here, the V-rings are defective. Replace the V-rings.
- b) Check the groove of the indicator cam. If defect such as damage or wear is found, replace it with a new one.

5.6.4 Unloader Piston and Unloader Cylinder

5.6.4.1 Disassembly

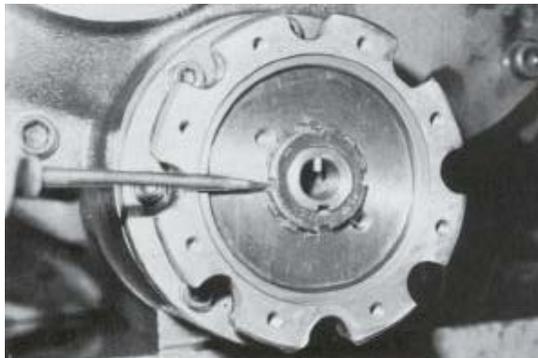


Photo 026 Disengaging the Lock Washer Claw

- a) Pull out the unloader piston [64] to the utmost front position. Then, lift off the rotation stopper claw of the lock washer [70] that secures the piston to the push rod and loosen the lock nut [69]. Remove the unloader piston by screwing eye bolts into the two screw holes.
- b) The low-stage unloader cylinder [60-1] is, together with the bearing cover [16], attached to the low-stage bearing head [11-1] by using eight long bolts [62-1]. Remove those bolts [62-1], and pull out the unloader cylinder.



Photo 027 Removing Lock Nut



Photo 028 Removing Low-stage Unloader Cylinder

- c) The upper side unloader cylinder 【60-2】 is, likewise, fastened by using two hexagon socket head cap screws 【61】 and six hexagon socket head cap screws 【62-2】. Pull out the unloader cylinder in the same way as described in b) above. If, after disassembly of the cylinder portion, further process of disassembly has to be done, leave the two screws 【61】 fastened as they are and remove the bolts 【62-2】 and bolts 【24】 that fasten the balance piston cover, so that the unloader cylinder can be removed as a unit, combined with the balance piston cover. At this moment, there is oil accumulated at the balance piston and side bearings. So pay attention to the oil that will flow out when removing the balance piston cover. When the gasket 【23】 is stuck, remove it by tapping the balance piston cover with a hammer.



Photo 029 Removing High-stage Unloader Cylinder

5.6.4.2 Inspection

- a) Be sure to replace the cap seal 【66】, which is attached to the outer circumference of the unloader piston 【64】, as well as the O-ring 【65】.
- b) The unloader cylinder often has damage or oil refuse stuck to its inner surface. Clean it thoroughly, and smoothen its surface by using fine emery paper (#400 or finer).



Photo 030 Removing the Cap Seal of the Unloader Piston

5.6.5 Bearing Cover

The bearing cover 【16】 should be removed when pulling out the low-stage thrust bearings or rotors for inspection.

5.6.5.1 Disassembly

- Remove all the hexagon socket head cap screws 【18-1】. The bearing cover remains attached to the bearing head 【11-1】 with alignment pins 【19-1】.
- Screw holes are provided in symmetric positions. Screw the two bolts that have been removed 【18-1】 into the right and left holes. This will cause the bearing cover to separate from the bearing head. When a small gap is created, peel up one side of the gasket 【17-1】 by using a thin knife or a spatula-shaped tool.
- Screw the bolts further, until the cover comes off the alignment pins.

CAUTION

- At this time, be sure to support the bearing cover. Otherwise, it may fall over or fall down, causing the shaft (rotor shaft) to get damaged. Protect in advance the shaft with a cloth.



Photo 031 Removing Bearing Cover



Photo 032 After the Bearing Cover is Removed

5.6.6 Separating High-stage and Low-stage

Separate the high-stage and low-stage when pulling out the high-stage thrust bearings or rotors of each stage.

Structurally, they can be separated at the initial step of disassembly.

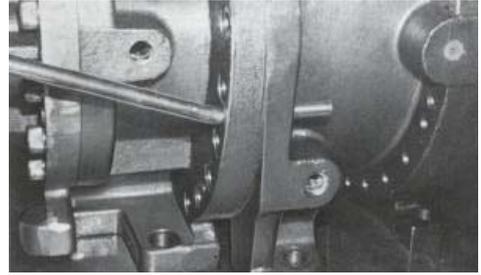


Photo 033 Separating High-Stage and Low-Stage

5.6.6.1 Disassembly

- a) As explained under **【POINT】** at 5.4.5 in this manual, put the compressor on a special table and remove the bolts from the lower side. Then, remove the remaining hexagon socket head cap screws **【18-2】**.

At this moment, the upper side of the compressor is spaced apart the surface plate.

Brace the upper side with a rectangular piece of wood or the like to prevent it from falling when disassembled.

As the screws **【18-2】** of the 2016**C model are 5 mm longer than other screws, they cannot be used for other purposes. Distinguish these from others.

- b) Drive alignment pins **【19-2】** into suction cover **【5-1】**.
- c) The bearing head **【11-2】** and suction cover are stuck together by gasket **【17-2】**. Tap the suction cover at its leg portion or screw in screws **【18-2】** (which have been removed) into the holes on the bearing head, to separate the suction cover evenly by pushing. Do not drive a screwdriver or chisel into the gap.
- d) The power transmission gear couplings **【151 to 161】** are attached to the inside of M rotor shaft. Move the main body in parallel with the shaft to separate the drive side and the driven side in the direction of the shaft.



Photo 034 Low-stage After Separation



Photo 035 Removing the Driven Hub

5.6.7 High-stage Side Gear Coupling

As known by seeing the parts/components separated in the previous chapter, the coupling as a power transmission part is separated into the high-stage side and low-stage side, each one of which is fixed to each shaft (rotor shaft).

5.6.7.1 Disassembly

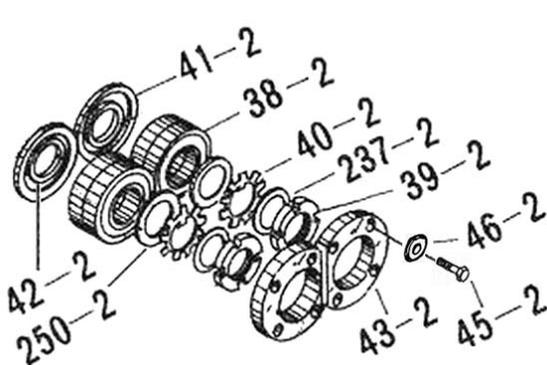
Loosen the set screw **【159】** of the key attached to the driven hub **【153】**, and then remove the driven hub. As it is clearance-fitted, it can be removed easily.

The set screw **【159】** should be with looseness stop and tooth to set firmly for the sure loothness stop.

5.6.7.2 Inspection

Check for abnormal deformation and/or wear on the tooth profiles and tooth surfaces. If there is any of such defect, find the cause and replace the part.

5.6.8 High-stage Thrust Bearings



No.	Part name	Qty.
38-2	Thrust bearing (2)	2
39-2	Lock nut (2)	2
40-2	Lock washer (2)	2
41-2	Thrust bearing outer race spacer (2)	2
42-2	Thrust bearing alignment spacer (2)	2
43-2	Thrust bearing gland (2)	2
45-2	Hexagon head bolt, M10x30	8
46-2	Conical spring washer for M10	8
237-2	Torsional slip washer for 160***	2
250-2	160*** thrust washer	2

Figure 5-5 High-stage Thrust Bearing

Thrust bearing is a component of the screw compressor that is playing the most important role. This component's assembly/adjustment quality could affect the compressor performance or cause problems. Be very careful when assembling/adjusting this part.

Thrust bearing [38-2] is a face-to-face angular contact ball bearing. This bearing only receives thrust load and does not receive the radial load perpendicular to the shaft because there is a gap between the outer ring of the thrust bearing and the bearing head. Apart from receiving the thrust load, the bearing has the important role of securing the position of the gap between the rotor and the discharge side of the bearing head. This gap (end clearance) is significantly linked with performance.



Photo 036 Thrust Bearing

5.6.8.1 Disassembly

- Lift off the rotation stopper claw of the lock washer [40-2] that secures the inner ring of the thrust bearing to the rotor shaft. After that, remove the thrust washer [250-2], torsional slip washer [237-2] and lock nut [39-2].
- Remove the hexagon head bolt [45-2] and its conical spring washer [46-2] holding the thrust bearing gland [43-2], and then remove the gland.
In case of a former model which uses a rotation stopper fitting instead of a conical spring washer, extend the claw of the rotation stopper and remove it from the hexagon head blot [46-2], and then remove the hexagon head bolt and the gland.
- There is a gap between the outer ring of the thrust bearing and the bearing head. Since the inner ring of the bearing slides on to the rotor axis, bend the tip of a wire with diameter of 2 to 3 mm, insert it between the outer ring and the ball retainer, and hook it onto the thrust bearing to pull it out.
- Attached to the inside of the thrust bearing are; thrust bearing outer race spacer [41-2] for the bearing head-side outer ring, and the thrust bearing alignment spacer [42-2] for the rotor shaft side inner ring.

To identify where to set, the thrust bearing outer race spacers and thrust bearing alignment spacers have a stamped mark of "M" or "F" which means "for M rotor" or "for F rotor".

The bearing glands, thrust bearing outer race spacers and thrust bearing alignment spacers, which have been removed, should be divided into two groups (M rotor group and F rotor group).

Incorrect assembly can change the dimensions of the end clearance (gap between the rotor's end face and the bearing head), which may deteriorate the performance or cause a galling accident due to the heat generated by excessive adhesion between sliding surfaces.



Photo 037 Pulling Out Thrust Bearing



Photo 038 Stamp Marks on Spacer and Thrust Bearing Alignment Spacer

5.6.8.2 Inspection

- a) After thoroughly cleaning the thrust bearing, there is no problem if all bearing balls are shiny. If the ball surfaces are dull, contact us for confirmation.
Next, check the gap between the retainer and the balls. If there is burr in the retainer area where the balls are held, or if the gap between the balls and the retainer is excessive, there is a problem.
- b) Rotate the outer ring while supporting the inner ring with your hand. If you feel an abnormal vibration, the ball contact surface of the inner/outer ring or the balls themselves are defective. Make a closer check. Even a tiny piece of dirt that entered during removal can cause a rough feel. In such case, blow off the dirt with high pressure air after cleaning. If the problem persists, be sure to replace the part with new one.
- c) Moving the cleaned bearing with your hand will make a rattling sound. This is due to the gap between the balls and the retainer. This sound will not be heard if you rotate the bearing while holding it level.
If you lubricate the bearing after cleaned, this sound will not be emitted. If the sound is still heard, the bearing should be checked for details.
- d) Even if an abnormality is not identified by the above-mentioned check in the case of thrust bearings with more than 20,000 hours compressor operation, the thrust bearings should be replaced with new ones, in consideration of security of the continuation operation until the next overhaul.

CAUTION

- As a bearing is a combination of specifically designed parts, even if a bearing with the same number is found in a bearing manufacturer's catalog, the accuracy or material may not be identical. Replace the parts with **MYCOM** genuine parts. Parts other than genuine parts are not covered by the warranty.

5.6.9 Balance Piston Cover

Disassemble this part when pulling out the rotor or when inspecting the side bearing [28-2] or balance piston.

The balance piston cover [22] is removed, combined together with the unloader cylinder [60-2]. If the unloader cylinder is pulled out and disassembled further, follow the procedure below.

- a) Loosen all of the hexagon socket head cap screws [24] by turning them three or four times, and tap the side face of the cover with a hammer, to release the balance piston cover gasket [23] that is stuck.
- b) In this state, drain the oil from the balance piston and side bearings inside the suction cover. When the oil has been drained, remove all the screws except for the one on the upper side. While holding down the balance piston cover, remove the remaining screw and remove the balance piston cover.

5.6.10 Balance Piston

When the screw compressor is operated, the thrust load applied to the M rotor is large and the M rotor rotates very fast compared with the F rotor. Therefore, the life of thrust bearing on the M rotor would normally be much shorter than that of those attached on the F rotor. To reduce the bearing load on the M rotor, a hydraulic piston is installed at the end of the rotor drive shaft in order to cancel the load.

* Balance piston is not required on the low-stage, because the low pressure conditions on the low-stage do not shorten the life.



Photo 039 Balance Piston and Stop Ring

5.6.10.1 Disassembly

- a) By using stopring plier, remove the stop ring [32] which retains the balance piston [30] on the shaft. Screw in eye bolts, and pull out the balance piston. It is not necessary to remove the balance piston key [31] fitted in the rotor shaft.

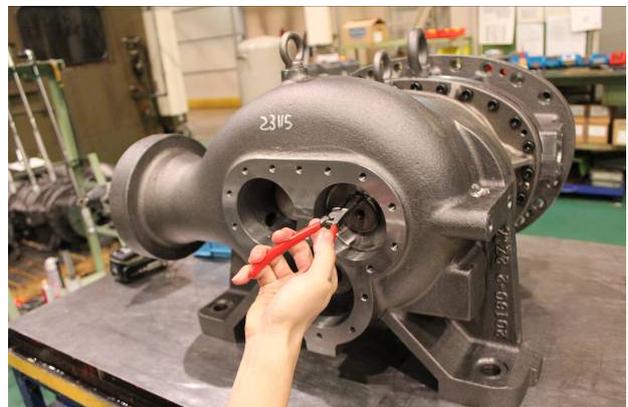


Photo 040 Removing Stop Ring



Photo 041 Pulling Out Balance Piston

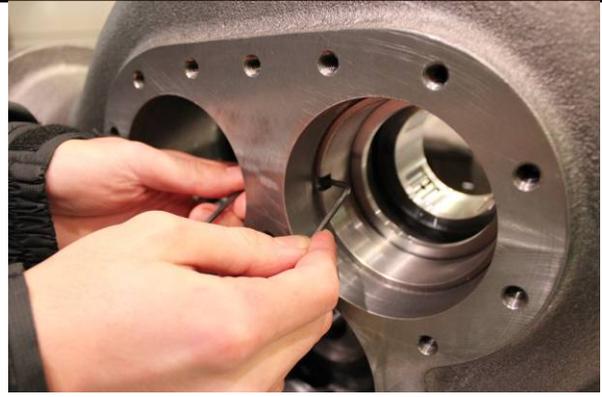


Photo 042 Loosening Set Screws Used for Stopping Rotation of Balance Piston Sleeve

- b) Then, retract the hexagon socket head cap set screws **【34】** which are used for locking rotation of the balance piston sleeve **【33】**.
Two set screws are used. Loosen the F rotor-side set screw, and get the balance piston-side set screw under the suction cover.
- c) Remove the stop ring **【37】** which retains the balance piston sleeve. As the stop ring is pushed out by the force of the inner O-ring, it can be removed easily by pushing in gently.
- d) Pull out the balance piston sleeve. As the outer diameter of the sleeve is clearance-fitted with the suction cover, it can be pulled out easily.
Remove the balance piston sleeve, O-ring and O-ring spacer **【36】**.
- e) The stop ring **【29】** attached inside the O-ring spacer need not be removed, except when removing the side bearing **【28】**.

5.6.10.2 Inspection

Although there are signs of wear on the inner surface of the balance piston sleeve, this is not a problem. They result from the fact that the gap between the balance piston and the piston sleeve is smaller than the gap between the rotor shaft and the bearings.

These wears will not develop further, because a large gap is created around the outer circumference of the balance piston sleeve in order to prevent the bearing load from being applied to the balance piston.

5.6.11 High-stage Suction Cover and Side Bearings

The high-stage suction cover is an important part; it has an intermediate pressure gas inlet, provides the function for sealing the casing's suction face, and is equipped with the side bearings for holding the rotors.

5.6.11.1 Disassembly

- a) Loosen and remove the hexagon socket head cap screws [2-2] that fasten the high-stage suction cover [5-2] and high-stage rotor casing [1-2].
- b) The suction cover gasket [6-2] is stuck to the flange surface. Screw two hexagon socket head cap screws [2-2] (which have been removed) into the holes on the rotor casing flange, to push the suction cover evenly. When a small gap is created, peel up one side of the gasket by using a thin knife or a spatula-shaped tool (Do not drive a screwdriver or chisel into the gap).
- c) At the position where the alignment pins can be disengaged, draw out the suction cover all at once in parallel with the axis. As the thrust bearings are disconnected, the rotors will be simultaneously pulled out. Let the rotors stay in the casing.



Photo 043 Pulling Out Suction Cover

- d) The side bearing [28-2] is press-fit from the balance piston cover side of the suction cover. Release the stop ring [29-2], and push it out from the rotor side. It is not subject to disassembly unless it has to be replaced.

5.6.11.2 Inspection

- a) The suction cover itself does not cause problems. As the side bearing is a sliding part, check the metal surface. If a foreign matter is embedded or any defect is found, replace the part. As the inner diameter of the side bearing is interrelated with the rotor shaft, make judgment based on the correlative gap.
- b) The inner surface of the rotor casing is supposed to have no problem as there is a gap. If, however, there are signs of sliding wear or the like on the rotor side face, it is considered that thrust bearings are defective.
- c) In the standard specifications, oil injection is not used at the high-stage.
- d) The high-stage suction cover of 2016**C has a hole into which the unloader push rod is drawn. Check the O-ring [9] in there, and replace it.

5.6.12 Pulling out High-stage Rotor

The 2016**C uses the 160SU, MU or LU as the high-stage rotor.

5.6.12.1 Disassembly

- a) The upper side rotor comes off during disassembly of the suction cover. So it can be pulled out easily. Either the M rotor or F rotor may be removed first. However, as the M rotor is longer, it is easier to remove the M rotor first.

While holding and slightly lifting the shaft, pull out the rotor while rotating it clockwise. When approximately two thirds of the rotor has been pulled out, draw the rest out slowly while attaching the other hand to the outer circumference of the rotor.

CAUTION

- If you pull out the M rotor without rotating it, the F rotor will also be pulled out simultaneously.



Photo 044 Before Pulling Out Rotors

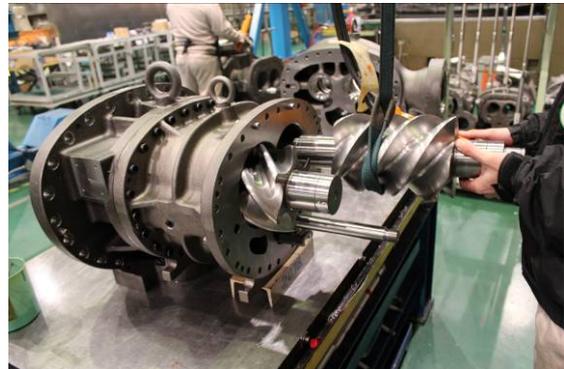


Photo 045 Pulling Out M Rotor



Photo 046 Pulling Out F Rotor

- b) Do not place the pulled-out rotor directly on the floor. Cover the floor with wooden pieces or the like as a cushion. Otherwise, rest the bearing portion on a V block made of square timber to add a small amount of lift.
- c) Pull out the F rotor in the same way. Take care not to get the main bearing damaged with the edge of rotor shaft during removal.

5.6.12.2 Inspection

- a) During normal use, the surface of the rotor's tooth profiles should not get damaged at all. The surface of the meshed tooth profiles are shiny black (around the base of the teeth on the M rotor, and at the tip ends of the teeth on the F rotor).
Sometimes, small linear scars are found developed perpendicular to the shaft, due to small pieces of dirt mixed into suction gas or oil. However, this is not galling. Smoothen the surface by using a grinding stone or fine emery paper.
If ammonia refrigerant is used for the rotor which has been disassembled after a long operation stop, there may be rust generated on the rotor tooth surface. Clean it off softly with emery paper.
- b) Check the bearings. These bearings (of standard machines) are high frequency hardened. They scarcely get worn unless extremely dirty oil is used or hard pieces of dirt are embedded in the metal (due to a broken filter, etc.).
- c) Check if there are signs of inner race rotation in the thrust bearing assembly. If any sign is found, read the precautions for assembly carefully.
- d) Check the rotor casing inside. There is a small gap between the rotor outer circumference and the rotor casing. Signs of slight damages to the rotor teeth ends and the rotor casing inner surface, which may have been caused by dirt or the like, are no notable problem.
However, signs of damage caused by the teeth ends hitting against the rotor casing surface indicate abnormality. Measure the bearing inner diameter and the shaft diameter. If the situation is left as it is, it could cause an accident such as seizure.



Photo 047 High-stage Rotor Casing

5.6.13 High-stage Bearing Head and Main Bearings

The side surface of the bearing head 【11-2】 where the rotor is attached has a gas discharge port which is determined based on the compressor's operating conditions.

This discharge port affects the performance of the compressor.

The bearing head also has a main bearing which supports one end of the rotor.

5.6.13.1 Disassembly

- a) Remove all the hexagon socket head cap screws 【2-2】 that fasten the casing and bearing head. Drive an alignment pins 【3-2】 into the rotor casing.
- b) Tap the bearing head with a hammer at its leg portion to peel up the bearing head gasket 【12-2】. If the gasket is stuck fast, screw the hexagon socket head cap screws 【2-2】 (which have been removed) into the holes on the rotor casing and then push the gasket (in the same way as with the suction cover).
As the rotor has been removed, this work will be easy.
- c) The main bearing 【27-2】 is gently press-fit to the bearing head.
To take out the main bearing, remove the stop ring 【29-2】 and tap the rotor side.
- d) The unloader slide valve is incorporated into the high-stage of the 2016**C. Draw it toward the bearing head and out.
- e) The guide block 【87-2】 and guide block stem 【88-2】 of the unloader slide valve are screwed from under the rotor casing. When there is no problem, they need not be disassembled unless otherwise specified.



Photo 048 After Removal of Stop Rings and Main Bearings

5.6.13.2 Inspection

- a) Check the bearing surface of the main bearing 【27-2】 which is attached inside. If hard pieces of dirt are embedded in the inner surface or white metal gets worn, replace the part.
- b) Check the rotor-side surface where discharge port is provided. If there is a defect such as damage, correct it. If the entire surface is severely damaged, the thrust bearing is faulty or the end clearance is adjusted improperly.
Damages can also be caused by dirt in the piping. Make a thorough check by referring to the description about assembly.
- c) Check for wear of the sliding portion of the unloader slide valve, guide block on the casing's outer circumference, and the guide groove.
If the wear is excessive, the rotor and slide valve are hitting against each other, which will cause the rotor outer circumference to get worn. Measures should be taken to protect the outer circumference from wear. Please contact us.

5.6.14 Low-stage Thrust Bearings



Photo 049 Low-stage Thrust Bearing Part



Photo 050 Conical Spring Washer for Hexagon Head Bolt

5.6.14.1 Disassembly

- Remove the hexagon head bolts 【45-1】 that fasten the thrust bearing glands 【43-1】. Be careful not to lose the conical spring washers 【46-1】.
- Remove the thrust washers 【250-1】, lock washers 【40-1】, torsional slip washers 【237-1】 and lock nuts 【39-1】, in the same way as for the high-stage.
- Remove the thrust bearings 【38-1】 in the same way as with the high-stage.



Photo 051 Thrust Bearing Glands are Just Removed



Photo 052 Bearings are Just Removed

5.6.14.2 Inspection

For inspection of the low-stage thrust bearings, follow the inspection procedure prepared for the high-stage thrust bearings (see 5.6.8.2 in this manual).

5.6.15 Low-stage Gear Coupling

The drive side of the gear coupling is attached to the M rotor low-stage, in order to transmit power from the low-stage to the high-stage.

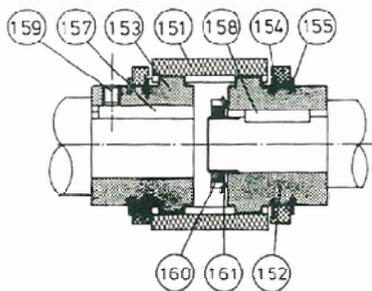
<About the Change of the 2016**C Gear Coupling Method>

In March 1982, after exchanging approval drawings with the manufacturer, the coupling method was changed from the initial type (coupling hub is directly connected using hexagon head screws) to the method called "Φ125 special sleeve-type method" (coupling hub and sleeve are used).

This method was used for a long time. In October 2010, however, according to a design modification notification, it was changed so as to attach a stopper inside the sleeve (compatible with the former method).

* Date on which design was changed: The new method was applied first to assembly in oct. 19. 2010.
"Model: N2016SSC-LBM Serial number: 2023130".

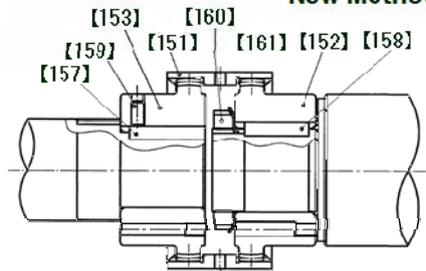
Old Method



151+152+153+154*2+155*2+159 constitutes an gear coupling assembly

No.	品名
159	Hexagon head cap screw with tooth
157	Key, driven hub
153	Driven hub
151	Driven sleeve
158	Key, drive hub
154	Stopper, driven sleeve
155	Stop ring
152	Drive hub
161	Rock washer
160	Rock nut

New Method



151+152+153+159 constitutes an gear coupling assembly

Figure 5-6 Gear Coupling Assembly Drawing
(before and after Design Modification in October, 2010)

5.6.15.1 Disassembly

- Driven sleeve [151] can be removed with hands. Remove the drive hub [152]. Lift off the lock washer [161] claw, and loosen the lock nut [160].
- Two screw holes are provided on the drive hub. Screw in eye bolts, and pull out the drive hub. As it is clearance-fitted, it can be removed easily.
- Leave the key embedded in the rotor shaft as it is.



Photo 053 Current Parts of Gear Coupling

5.6.15.2 Inspection

Check for deformation of tooth profiles and wear on the tooth surfaces of the hub and sleeve, respectively. Mate it with the high-stage driven hub [153], and check for gap. If there is any problem, replace the parts as a set. Find the cause at the same time.

5.6.16 Low-stage Suction Cover and Side Bearings

5.6.16.1 Disassembly

- a) While the compressor is being lifted for disassembly, remove 6 to 8 screws 【2-1】 from its bottom.
- b) To pull out the oil injection pipe 【85】 that supplies lubricant for injection to the unloader slide valve, remove the fastening bolts 【166】 of the oil injection pipe retainer 【164】 located at the lower area of the high-stage.
- c) Remove the oil injection pipe retainer.



Photo 054 Removal of Oil Injection Pipe Retainer

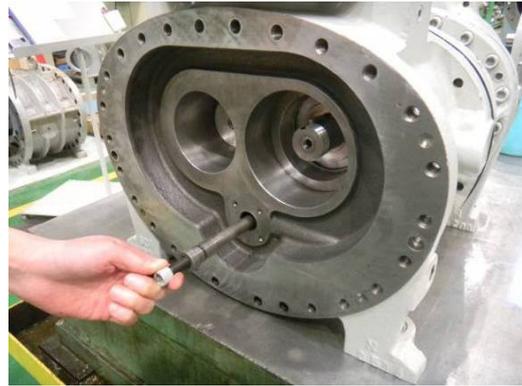


Photo 055 Pulling Out Oil Injection Pipe

- d) The oil injection pipe hole is tapped. Insert a screw 【2-1】, and pull out the pipe.
- e) Remove all the hexagon socket head cap screws 【2-1】. Then, drive alignment pins 【3-1】 into the rotor casing 【1-1】.
- f) Screw hexagon socket head cap screws 【2-1】 into the two screw holes on the rotor casing flange, to push the suction cover flange evenly.
- g) When a gap is created, peel up the gasket by using a knife or a spatula. Attach it to the suction cover.
- h) When a gap gets spread to a full length of the screws, release the engagement of the rotor shaft and side bearing by sliding on the surface plate parallel with the axis. The rotor may also be pulled out simultaneously. Take care.
- i) To take out the side bearing 【28-1】, remove the stop ring 【29-1】 and tap the rotor side.

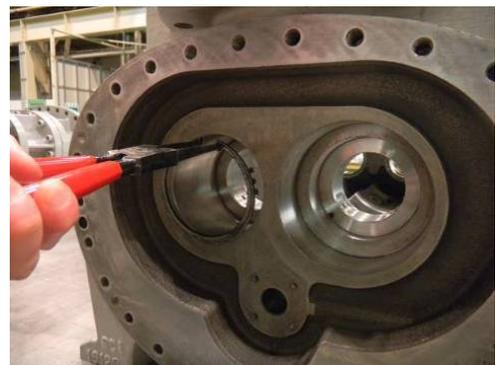


Photo 056 Removing the Stop Ring

5.6.16.2 Inspection

Check for wear or embedded foreign matter on the sliding surface inside the side bearing.

If the mating rotor shaft is worn, even when the inner diameter of the side bearing is dimensioned properly, hard pieces of foreign matter are embedded. Replace the bearing with a new one.

5.6.17 Low-stage Rotors and Rotor Casing

In the same way as with the high-stage, the rotors can be removed easily. Take care because the low-stage rotors are heavy.

Check rotor's teeth ends and the rotor casing in the same way as with the high-stage. Be aware that there is an unloader slide valve on the low-stage which may hit against the tooth ends. If the hitting is strong, scrape off the contact areas with a scraper or file. Finally, make the surface smooth with emery paper. When the surface is smoothed, flush thoroughly so that no iron powder remains inside.



Photo 057 Low-stage Rotor Casing

5.6.18 Low-stage Bearing Head and Main Bearings

The low-stage bearing head [11-1] and rotor casing [1-1] need not be separated, except when overhauling the unloader slide valve. To separate them, follow procedure steps a) to d) in 5.6.18.1 below.

5.6.18.1 Disassembly

- a) Remove all the hexagon socket head cap screws [2-1].
- b) Drive an alignment pins [3-1] into the rotor casing flange.
- c) Separate the bearing head and rotor casing by using the screw holes in the flange.
- d) Since the unloader push rod [67-1] is fit, separate by moving parallel to the axis.
- e) To take out the main bearings [27-1], remove the stop rings [29-1] and tap the rotor side.
- f) The slide valve should be dealt with in the same way as with the high-stage.

5.6.18.2 Inspection

- a) Check the bearing surface on the rotor's discharge-side end face. Severe damage on the surface will affect the performance.
In that case, contact our service center.
- b) Check for wear and embedded foreign matter on the inner surface of main bearing.
- c) Check it in the same way as with the high-stage slide valve.

5.6.19 Low-stage Unloader Slide Valve and Guide Block

When the bearing head and rotor casing are separated, you will find that the slide valve is attached to the lower area of the rotor casing. The valve moves in parallel with the axis, position-controlled by the guide block 【87-1】 attached inside and by the outer circumference.

The slide valve consists of slide valve [1] 【54-1】, slide valve [2] 【55-1】, hexagon socket head cap screw 【58-1】, push rod 【67-1】, oil injection pipe guide 【168】, etc.



Photo 058 Unloader Slide Valve

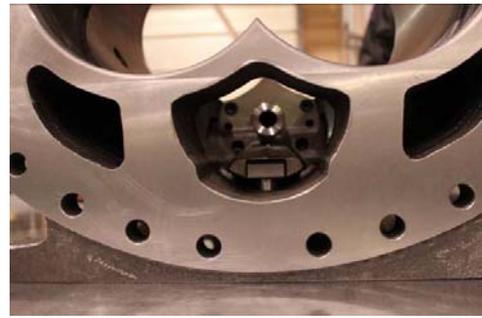


Photo 059 Unloader Slide Valve and Guide Block

5.6.19.1 Disassembly

- If pulled in the discharge direction, the push rod 【67-1】 can be removed easily.
- When replacing the push rod, remove the hexagon socket head cap screw 【162】.
- The oil injection pipe guide 【168】 is fastened from inside by using lock nut. Pull out the hexagon socket head cap screws 【58-1】 and washers 【267-1】 to disassemble the slide valve assembly, so remove the guide.

5.6.19.2 Inspection

- Check the gap between the guide block and the sliding surface of the slide valve guide.
- Check for defects in the grooved pin (dowel pin) at the tip end of the push rod 【67-1】 which engages with indicator cam 【77-1】.
- Check for looseness in the assembled state.
- Thoroughly check the hole into which the oil injection pipe is inserted.

5.7 Reassembly

WARNING

- When turning on/off electric tools, take care to avoid electric shocks.
- When handling heavy objects, exercise extreme care and use apparatus such as crane as necessary. There is a risk that the compressor's main body or parts may drop on human body.
- When using a crane, allow only qualified personnel to operate it. Entrusting the work to unqualified personnel may result in fall accident.
- Replace the parts with **MYCOM** genuine parts. If parts other than genuine parts are used, there is a risk of the compressor and equipment being damaged or ruptured.

CAUTION

- For compressor disassembly/reassembly, use specified tools that are properly functioning. Using tools that are worn or damaged or that are unsuitable for the work, can result in injury.
- When using electric tools, check beforehand that there is no problem with insulation resistance. Otherwise, use double insulated tools.

CAUTION

- When reassembling, ensure that the replaced O-rings are of the correct standard (size, material, use for stationary portion or sliding portion, etc.). Incorrect replacement can lead to defects such as oil leakage.
- Some gaskets are asymmetrical. In that case, ensure that the assembly direction is correct. If the assembly direction is not correct, problems such as blocking of oil passages machined in the casing may occur, resulting in serious defects.

Start assembly when disassembly and inspection are finished.

Recheck the purchased replacement parts before assembly.

Replace all O-rings as well as gaskets with new ones which were removed by overhauling a compressor.

Almost all assembly procedures are reverse to the disassembly procedures. First, clean the work bench and tools to be used.

Clean the assembly parts with cleaning oil (kerosene, etc.) immediately before assembly. Dry these parts by blowing compressed air, and then apply sufficient lubricant over their surfaces. Prepare sufficient amount of clean lubricant for use during reassembly.

Also apply oil to both sides of the gasket.

Assembly is similar for both the upper and lower sides. So a common explanation is given to both. Read and fully understand the instructions before performing the work.

Table 5-9 Standard Tightening Torque for Hexagon Socket Head Cap Screws

Size	M6	M8	M10	M12	M14	M16	M20	M24
N·m	10	25	50	90	140	240	450	750
kgf·cm	100	250	500	900	1400	2400	4500	7500

Tighten each bolt by referring to the torque shown in the above table.

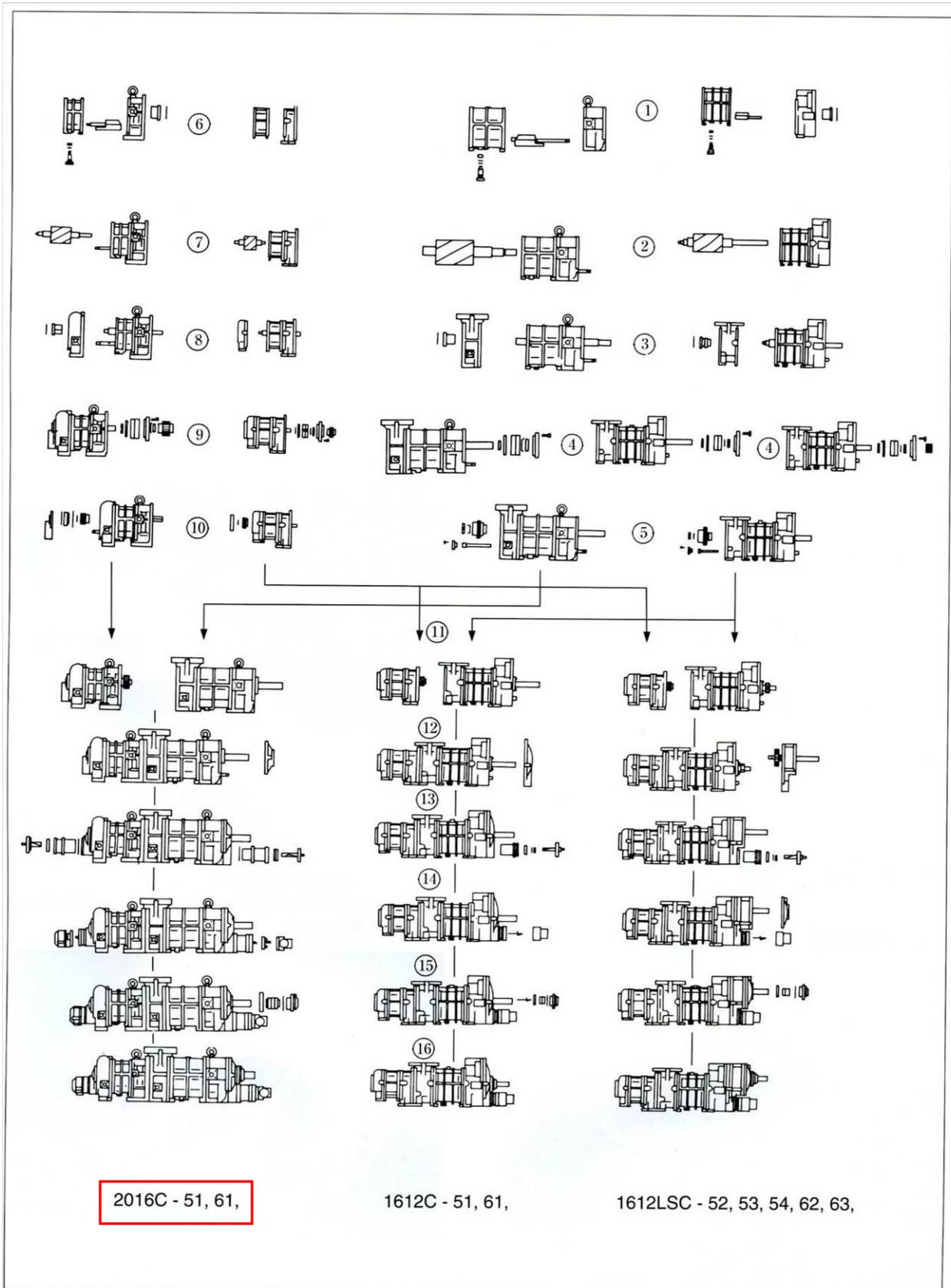


Figure 5-7 Illustrated Assembly Sequence

* The circled numbers in the figure do not correspond to the paragraph numbers used in the steps below.

5.7.1 Low-stage Unloader Slide Valve and Guide Block

- a) First, tightly screw the guide block stem [88-1] into the bottom of the casing, and then mount the guide block [87-1] inside the casing.
- b) When the slide valve assembly has been disassembled, tighten the hexagon socket head cap screws [58-1] to their specified torque (50 N·m) so that the joints are aligned correctly.
- c) Smoothen the outer periphery of the assembly by using a grinding stone or emery paper, and then attach the assembly to the casing. Next, align the guide block with the slide valve groove, and push in gently.
- d) After assembly, hold the unloader push rod and move it several times to check its movement. Inspect the joint with the casing, and confirm that there is no unevenness. Since unevenness indicates improper assembly, reassemble it again. If used without correcting it, the outer periphery of the rotor may hit against the slide valve, causing an unexpected accident.
* Regarding the unevenness between the unloader slide valve and the casing, there is no problem if the slide valve is slightly lower than the casing.

CAUTION

- **If the unloader slide valve is higher than the rotor casing, there is a problem in assembly. Do not leave the problem as it is. Be sure to reassemble. If used without correcting it, the outer periphery of the rotor may hit against the slide valve, which will cause a severe damage accident.**



Photo 060 Guide Block Stem Inside the Casing



Photo 061 High-stage Rotor Casing

5.7.2 High-stage Rotor Casing

For the 2016**C model, deal it in the same way as with the low-stage.

5.7.3 Bearing Head and Main Bearings (High/Low-stage)



Photo 062 Attaching Main Bearing
(High-stage)

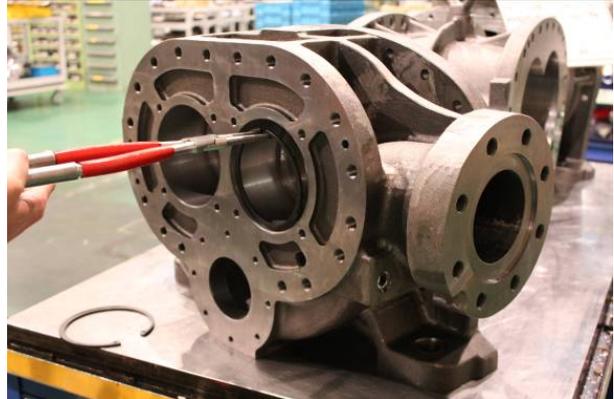


Photo 063 Securing with Stop Ring
(Low-stage)

When attaching the main bearing (O-ring type), press-fit it lightly.

Position the notch of the main bearing in such a way that it aligns with the spring pin 【14】 which is screwed into the bearing head (use of a jig like the guide rod shown in Photo 062 is helpful).

After that, pad the bearing and drive it. If misaligned, pull it out once and then assemble it again.

【POINT】

When press-fitting, using a weight jig and a plastic spacer indicated in the Figure 5-8 makes attaching bearing works easier. The plastic spacer should be just the right size of the bearing inner diameter and hit the spacer inside with the weight jig.

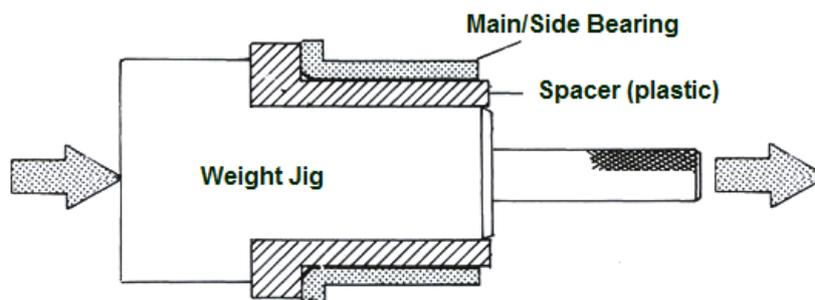


Figure 5-8 Spacer and Weight Jig for press-fitting a Bearing

5.7.4 Bearing Head and Rotor Casing (High/Low-stage)

CAUTION

- As the bearing head gasket is not formed symmetric laterally, pay attention to the installation direction. If it is not oriented correctly, the oil route provided in the casing may be blocked.



Photo 064 Fastening Low-stage Assembly with Bolts



Photo 065 High-stage Assembly

- a) Fit the unloader push rod in the hole of bearing head. Then, slide the bearing head or rotor casing to let them mate together.
- b) Loosely tighten two bolts. Next, drive in the alignment pins 【3-1】 to fix the position, and then screw bolts in opposing positions, and then fasten the bolts evenly in turn.
- c) After fastening the bolts, check that the bearing head gasket is not protruding toward the inside of the casing. New gaskets always protrude toward the inside of the casing. Cut the protruded portion with a sharp knife.
- d) Assemble the high-stage side in the same way.

CAUTION

- After attaching the bearing head and the rotor casing, be sure to check whether the bearing head gasket is protruded. If you omit this check, the gasket could be caught between the rotor end face and the bearing head surface, preventing to obtain accurate measurement values. If you adjust the end clearance under this condition and operate the system, the performance may be deteriorated.

5.7.5 Attaching Rotors (High/Low-stage)

<About Rotor Profiles of the 2016**C>

Regarding the products produced in and after November 1993, the profile has been changed from A-profile to O-profile.

The most significant difference is the existence of the edge on the tooth tip. Edged A-profile has been changed to the edgeless O-profile.

Make the rotor sufficiently adjusted. By using fine Emery paper, remove over any damage on the shaft surface of the bearing and seal.

Both the M and F rotors have certain engagement positions which are indicated by stamp marks.

To facilitate the alignment when attaching to the rotor casing, numbers are stamped on the discharge-side tooth peak of the M rotor and the suction-side tooth peak of the F rotor, respectively.



Photo 066 M Rotor Mating Mark



Photo 067 F Rotor Mating Marks

- Sufficiently lubricate the main bearing inside the bearing head as well as the bearing portion of the rotor shaft.
- In assembly, attach the F rotor first to the casing.
- Insert the M rotor tooth peak (1) between the F rotor tooth peaks (1) and (2). To avoid problems related to engagement and balance, etc., be sure to mate as shown above.
As the M rotor has a stamped mark on the discharge side, it can be easily aligned for assembly.



Photo 068 Attaching F Rotor



Photo 069 Attaching M Rotor

CAUTION

- In this state, the rotor's outer periphery is in contact with the rotor casing. Do not rotate it much. Letting it rotate may cause its tooth tips to get worn.

5.7.6 Suction Cover and Side Bearings (High/Low-stage)

- a) The side bearing (O-ring type) is dimensioned in such a way that it is lightly press-fit to the suction cover.

Align the notch of the bearing with the positioning pin【8】which is driven into the suction cover, and press-fit the bearing. During the press-fit, check the position of the pin and the notch. If the position is misaligned, pull the bearing out once and then press-fit it again.

When the assembly is finished, secure the side bearing by using the stop ring (Photo 071).

On the high-stage too, when the side bearing has been attached, secure it by using the stop ring 【29】.

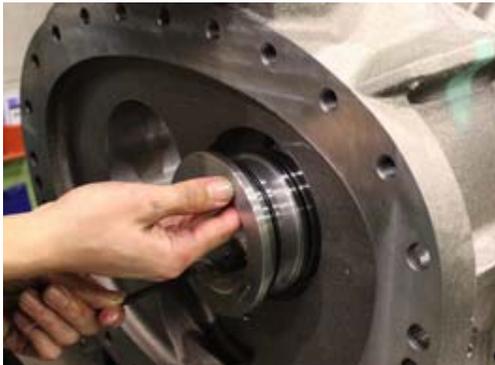


Photo 070 Attaching Side Bearing
(Low-stage)



Photo 071 Securing with Stop Ring
(Low-stage)

- b) After that, attach the balance piston to the high-stage only, by following the procedure below.

After attaching the stop ring 【37】 for O-ring spacer, attach the spacer 【36】.

The size of the O-ring 【35】 for balance piston sleeve is rather small. Extend it slightly all over with your hands before attaching it.

Attach the balance piston sleeve 【33】.

Screw two set screws 【34】 for stopping rotation (Photo 078), and then attach the stop ring 【37】.



Photo 072 Attaching Side Bearing
(High-stage)

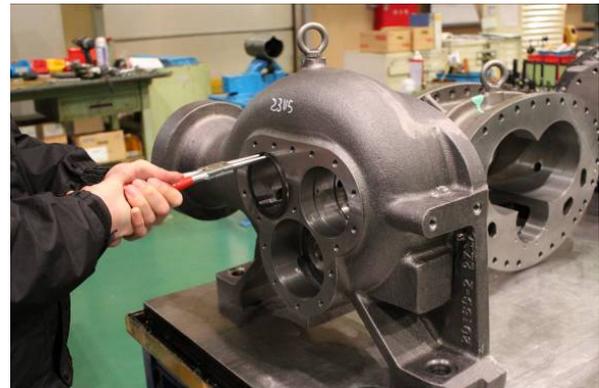


Photo 073 Securing with Stop Ring
(High-stage)



Photo 074 Attaching O-ring Spacer (High-stage)



Photo 075 O-ring for Balance Piston Sleeve



Photo 076 Attaching Balance Piston Sleeve

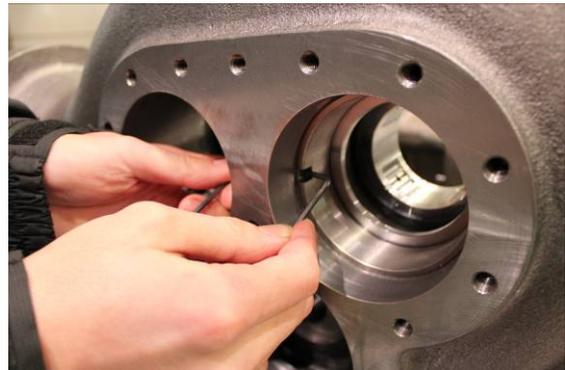


Photo 077 Screwing Set Screws for Stopping Rotation



Photo 078 Two Set Screws Have Been Screwed



Photo 079 Attaching Stop Ring

c) The suction cover gaskets 【6-1】 【6-2】 are not formed symmetric laterally. Thoroughly check the position of the drilled hole for supply oil. Lubricate the side bearing sufficiently.



Photo 080 Assembling Low-stage Suction Cover



Photo 081 Assembling High-stage Suction Cover

- d) Slide the suction cover on the surface plate, and move it to the assembly position. When fitting the side bearing and the rotor shaft, be careful not to let the end of the rotor shaft damage the metal on the inner surface of the side bearing.
- e) When the rotor shaft fits in the side bearing, slide the suction cover parallel with the shaft for assembly. Note that there is unloader push rod in the high-stage of the 2016**C.
- f) First, hammer two alignment pins for positioning. Then, fasten the bolts evenly. The bolts (approximately 6 in quantity) on the lower side should be fastened **during final assembly, placed on the special table** which was used during disassembly.
- g) Rotate the M rotor shaft with your hand, and check the rotors mating condition.
- h) For the low-stage, attach the oil injection pipe [85] and then fasten it by using the oil injection pipe retainer [164].



Photo 082 Driving In Alignment Pin for Positioning



Photo 083 Oil Injection Pipe Retainer

- i) Move the push rod with your hand, and check the movement of the unloader slide valve.
- j) While holding the M rotor shaft with your hand, move it in the axial direction and check that there is allowance in the axial direction.
- k) To the high-stage, attach the balance piston [30] and secure it with the stop ring [32]. Check that the stop ring fits well in the groove.

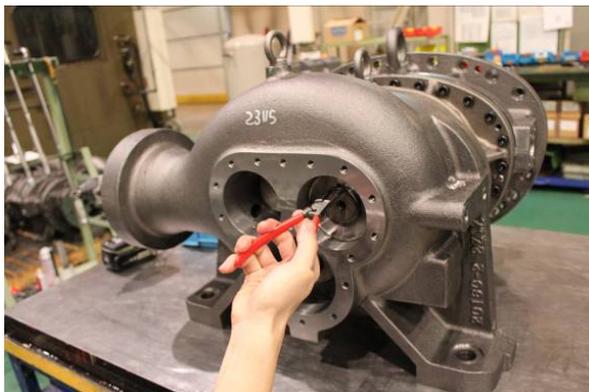


Photo 085 Attaching the Stop Ring



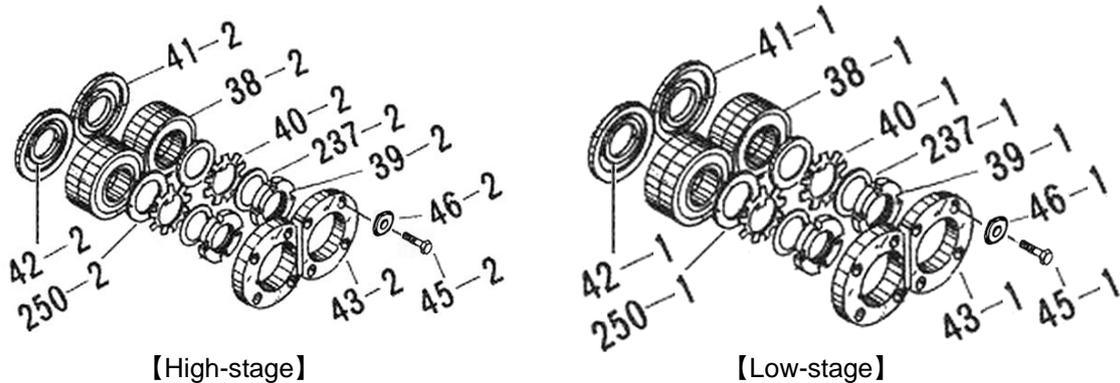
Photo 084 Attaching the Balance Piston

- m) Attach the load capacity adjustment spacer (spacer for 20% load) [420] to the high-stage push rod.



Photo 086 Attaching Load Capacity Adjustment Spacer (Spacer for 20% Load)

5.7.7 Thrust Bearings (High/Low-stage)



No.	Part name	Qty.
42-1, 42-2	Thrust bearing alignment spacer (1), (2)	Two for each
41-1, 41-2	Thrust bearing outer race spacer (1), (2)	Two for each
38-1, 38-2	Thrust bearing (1), (2)	Two sets for each
250-1, 250-2	Thrust washer (1), (2)	Two for each
40-1, 40-2	Lock washer (1), (2)	Two for each
237-1, 237-2	Torsional slip washer (1), (2)	Two for each
39-1, 39-2	Lock nut (1), (2)	Two for each
43-1, 43-2	Thrust bearing gland (1), (2)	Two for each
46-1, 46-2	Conical spring washer (1), (2)	Eight for each
45-1, 45-2	Hexagon head bolt (1), (2)	Eight for each

Figure 5-9 Development View of the Thrust Bearing Part

CAUTION

- When assembling the disassembled thrust bearing without replacing any parts, check the M and F stamp marks on the thrust bearing outer race spacer and thrust bearing alignment spacer, and reassemble them in the same way as before disassembly. This is essential to control the end clearance of the rotor discharge side.
- Even when assembling the same bearing, dimensions may become incorrect if flakes of paint or dirt are caught between spacers and alignment spacers.
- Regarding the direction of thrust bearing assembly, there may or may not be a V-shaped mark for assembly on the outer periphery of the bearing. Follow the instructions below for each case of assembling.

a) The procedure for assembling this portion is described in Figure 5-9. The important points are explained below.

If there is a V-shaped mark for assembly on the outer side of the thrust bearing, assemble with the pointed end of the mark on the inner side of the machine, as there is a slight directional difference that affects end clearance adjustment.

If there is no V-shaped mark, assembly direction does not affect end clearance adjustment. However, to clarify the difference between the inner side and outer side of the machine, assemble the thrust bearing with the bearing number stamped on the outer side. Then, put down a V-shaped mark on the side which is to be attached to the inner side of the machine, by using blue whetstone.

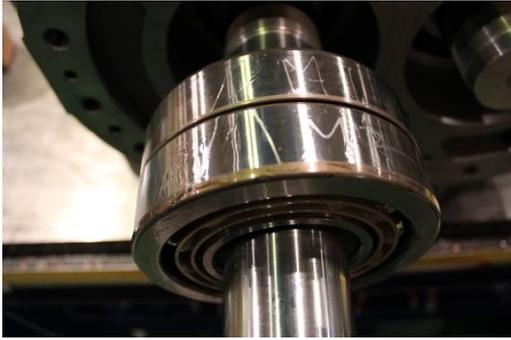


Photo 087 Thrust Bearing Assembly Mark



Photo 088 Attaching Thrust Bearing

- b) After attaching the thrust bearing, attach the thrust washer, lock washer and torsional slip washer. Fasten the lock nut with the specified torque or tightening angle range (see Chapter 7 "7.3 Tightening Torques for Bolts and Nuts" in this manual), so that the inner ring of the thrust bearing is fit in the rotor shaft.

CAUTION

- Since the inner ring of the thrust bearing is clearance-fitted for ease of access at the assembly site and is secured by the tightening force of the nut alone, the tightening work is very important!
- If the thrust bearing has been replaced, the difference between the bearing inner ring and outer ring surfaces will be different even when the parts are manufactured within standard values. Therefore, fully tightening the nut from the initial use may lead to a noticeable reduction in the life of bearing, due to a lack of end clearance between the rotor and the bearing head discharge end face, and also due to indentations on the contact surface formed by ball pressure. To avoid this, check for end clearance while tightening.

5.7.7.1 End Clearance Measurement

At this moment, measure the end clearance on the discharge side of the fully assembled rotor.

In particular, when the thrust bearing has been replaced, the end clearance must be measured. Even when the same bearing is used, measure the end clearance for confirmation.

If the clearance does not fall within the specified range shown in Table 5-10, adjustment is needed.

Table 5-10 End Clearance (Unit : mm)

Model of the compressor	High-stage	Low-stage		
		S	M	L
2016**C	0.04 to 0.05	0.26 to 0.30	0.28 to 0.32	0.31 to 0.35

■ End clearance of 2016**C is the same as A-profile rotor and O-profile rotor.



Photo 089 Pushing Rotor from Suction Side



Photo 090 End Clearance Measurement

The measurement method and adjustment method are explained below.

- a) Push the rotor to the discharge side while the thrust bearing inner ring is secured to the rotor shaft. Push the rotor from the suction side to the discharge side by using a jig (Teflon). Alternatively, by using a chamfered part of the lock nut, pull out the rotor with the edge of a flat blade screwdriver as shown in Figure 5-10.
- b) When the rotor has been pushed to the discharge side, prepare to install the thrust bearing gland. Attach a dial gauge to the edge of the shaft, and match the needle to 0. Dial gauge should be attached to the position near the side bearing, as shown in Photo 090, in order to make the bearing gland tightening work easier and precise.

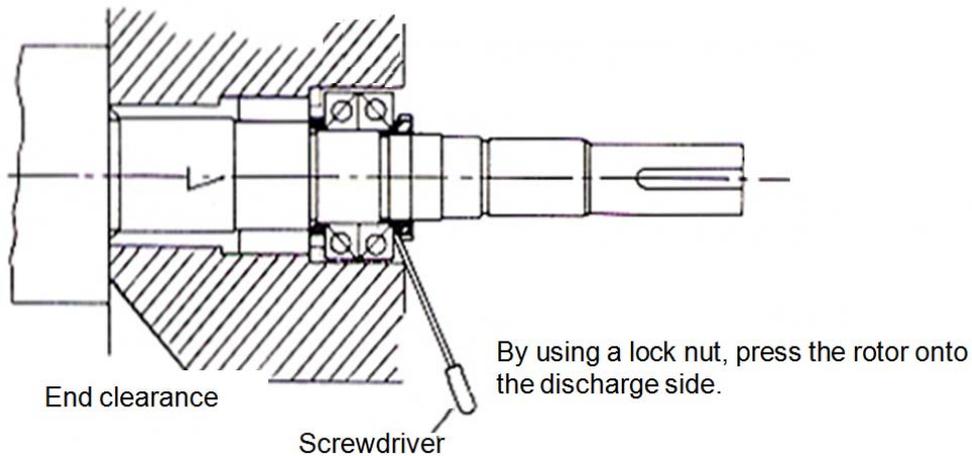


Figure 5-10 End Clearance Adjustment [I]

- c) Fasten the bearing gland by tightening the four bolts (without conical spring washer inserted) evenly and gradually to the specified torque. Tightening each bolt to the specified torque at once will lead to uneven tightening. Tighten bolts in turn and in several steps. Then, read the dial gauge measurement. This value is the actual end clearance.

Table 5-11 Tightening Torques for Thrust Bearing Glands

Model of the compressor		Tightening torque	
		N·m	kgf·cm
2016**C	High-stage	40	400
	Low-stage	50	500



Photo 091 Fastening with Bearing Gland

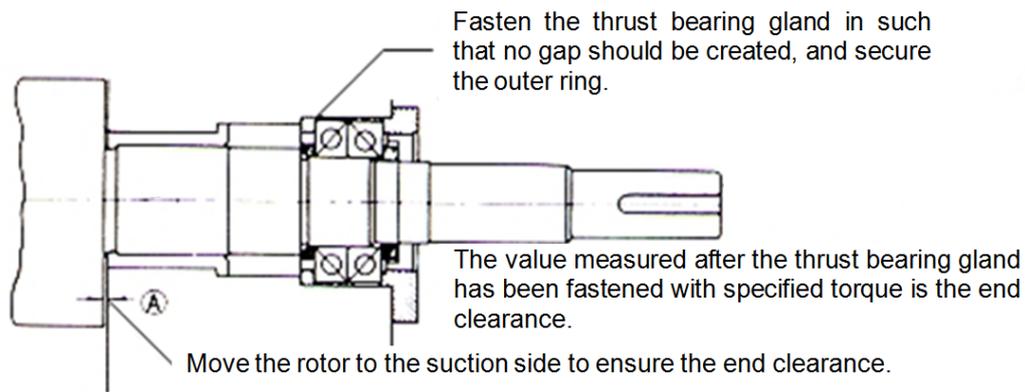


Figure 5-11 End Clearance Adjustment [II]

5.7.7.2 Procedure for End Clearance Adjustment

(1) When end clearance is smaller than the specified value

To deal with this, insert shim material (thrust adjustment liner) of required thickness (difference in thickness from the specified value) between the thrust bearing alignment spacer [42] and thrust bearing inner ring.

* The thrust adjustment liner is not shown in the development view, but available from us. Place an order together with a model name.

Or using a highly accurate surface grinding machine or asking professional service vendors to grind, grind the surface of thrust bearing outer race saucer[41] by the difference from the specified value. After grinding the flat surface, measure the whole circumference of the saucer by using a micrometer, and check that the thickness is even.

(2) When end clearance is larger than the specified value

As the end clearance is excessive, remove shim material (thrust adjustment liner) of a thickness equal to the difference between the measured value and the specified value if the shim material is used between thrust bearing alignment spacer and thrust bearing inner race.

Or if the shim material is not used between thrust bearing alignment spacer and thrust bearing inner race, or even if used but insufficient thickness, grind the surface of thrust bearing alignment spacer [42] by the difference between the measured value and the specified value or ask professional vendors to do so.

After grinding the flat surface, measure the whole circumference of the spacer by using a micrometer, and check that the thickness is even.

(3) Rotor axial runout measurement

When the end clearance has been adjusted to within the specified range, place a dial gauge on the seal attachment part of the M rotor shaft. Measure axial runout by turning the rotor shaft.

The tolerance for axial runout is 0.03 mm or less for all models.

Runout occurs when the thrust bearing alignment spacer and saucer are not parallel or when the thrust bearing mark is not at the correct side.

Small particles of dirt trapped between parts may cause excessive runout.

If axial runout is over the tolerance, even if the end clearance is within the specified range, disassemble and adjust the relative positions of the spacer, alignment spacer and thrust bearing.

This is important because it affects the life of the mechanical seal and its performance.



Photo 092 Measuring Runout of Shaft

5.7.7.3 Tightening after End Clearance Adjustment

- a) Bend the lock washer claw to the notch of the lock nut which is tightening the thrust bearing inner ring, to prevent rotation.
- b) Remove the hexagon head bolts that are tightening thrust bearing gland 【43】 one by one. Insert conical spring washers 【46】 as rotation stoppers, and tighten to the specified torque again.

5.7.8 Bearing Cover

- a) Before attaching the bearing cover 【16】, confirm once again that the lock washer claw of the thrust bearing bended as a rotating stopper and that all the hexagon head bolts for holding the thrust bearing gland have conical spring washer inserted.
- b) Screw the stud bolts into two of the upper holes provided in the flange surface of the bearing head (1) 【11-1】.
- c) Apply oil to the bearing head flange surface and the both surfaces of the bearing cover gasket (1) 【17-1】. Hang the gasket on those stud bolts in such that it is put on the flange surface.
- d) Attach O-ring 【197】 to the part where the pushrod goes through bearing cover 【16】.
- e) Attach lifting tools to the eye bolt of the bearing cover 【16】. Install the bearing cover taking care not to let it touch the M rotor shaft or push rod. After it is hung on the stud bolts, the lifting tools can be removed (Photo 094).
- f) Align the alignment pins with the hole. Tap the flanged part alternately with a hammer to attach. When it becomes possible to screw in bolts, screw in two or three bolts. Evenly narrow the gap until the mating surfaces come in contact, and then tighten the other bolts.



Photo 093 Stud Bots and Gasket

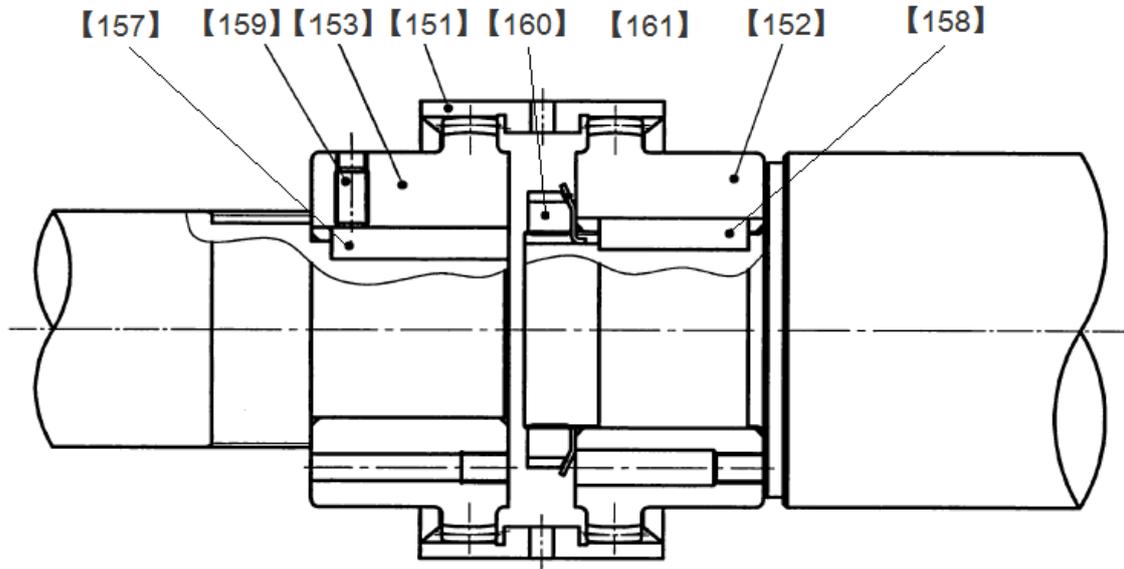


Photo 094 Attaching Bearing Cover



Photo 095 Tightening Bearing Cover

5.7.9 Attaching High-stage and Low-stage



【157】	Key, driven hub	【160】	Lock nut
【159】	Set screw	【161】	Lock washer
【153】	Driven hub	【152】	Drive hub
【151】	Driven sleeve	【158】	Key, Drive hub

Figure 5-12 Assembly Drawing of Gear Coupling

- On the high-stage, attach the driven hub [153] of the gear coupling, and fasten the M8 set screw [159] for securing the driven hub key [157]. This set screw is knurled and provided with anti-loosening.
- On the low-stage, attach the drive hub [152], lock washer [161] and lock nut [160] in this order. Fasten the lock nut with the specified torque or tightening angle range (see Chapter 7 "7.3 Tightening Torques for Bolts and Nuts" in this manual). Align the lock washer claw with the notch of the lock nut, and bend it.
- Set the driven sleeve onto the low-stage drive hub.



Photo 096 Tightening the Set Screw for Securing Driven Hub



Photo 097 Setting Driven Sleeve onto Low-stage

- d) Screw stud bolts into two of the upper holes provided in the low-stage flange surface which is to be attached to the high-stage.
- e) Apply oil to the both surfaces of the bearing cover gasket (2) 【17-2】. Attach the gasket on the flange surface over the stud bolts.
- f) Lift the high-stage by using lifting tools until it is slightly off the surface plate, and move it toward the low-stage. At this moment, on the low-stage, slightly move the M rotor shaft in both directions, so that the gear coupling assembly will fit smoothly.
- g) After the gear coupling is assembled, press the high-stage parallel with the rotor shaft. For both upper and lower sides, gradually and evenly tighten, temporarily, the hexagon socket head cap screws 【18-2】 that are set in the bolt holes, each hole located one hole apart from the left or right alignment pin, until the high-stage and low-stage flange surfaces come into contact.
- h) After the flange surfaces come into contact, slightly loosen the four hexagon socket head cap screws, which have been temporarily tightened, and then drive in the left and right alignment pins.
- i) Tighten the hexagon socket head cap screws to the specified torque (240 N·m). The lower bolts should be tightened on the special table, which was used during disassembly.
- j) Turn the low-stage M rotor (use of a jig for rotating the rotor is helpful), and check that it rotates properly.



Photo 098 Attaching the Gasket onto the Low-Stage Flange Surface



Photo 099 Attaching High-stage and Low-stage

5.7.10 Balance Piston Cover and High-stage Unloader Cylinder

The 2016**C model has the unloader cylinder [60-2] also on the high-stage. To facilitate the assembly work, attach the unloader cylinder [60-2] to the balance piston cover [60-2] first, and then attach the united body to the high-stage suction cover [5-2].

The balance piston cover and unloader cylinder are often omitted from disassembly unless specifically needed. Accordingly, steps a) through d) below shall apply when they have been disassembled.

- a) Attach the O-ring [63] to the O-ring groove provided on the surface of the balance piston cover where the unloader cylinder is to be attached (Photo 100).

[POINT]

According to the design change on October 1996, the place O-ring [63] is attached has been changed from the opening with chamfered to the current position indicated in photo101. At the same time the same design modification was applied to low-stage bearing cover. Refer to the next article 5.7.11 in this chapter.

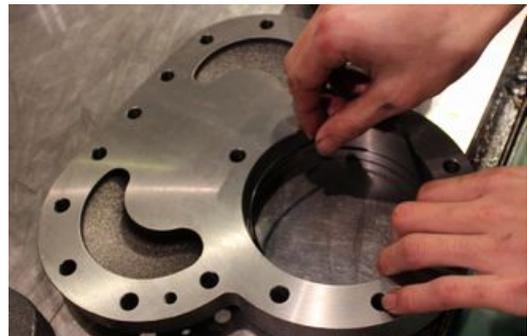


Photo 100

- b) Align the balance piston cover with the unloader cylinder. A gasket cannot be inserted between the aligning flange surfaces of the balance piston cover and unloader cylinder. So, as shown in Photo 101, thinly and evenly apply special synthetic rubber liquid gasket onto the mating flange surface of the unloader cylinder at the inner radius from the center positions of the bolt holes.
- c) As O-ring is inserted, attach the balance piston cover while tapping its flange surface with a soft hammer (as shown in Photo 102).
- d) When mating the both flange surfaces, also align the bolt holes. Fasten the two hexagon socket head cap screws [61], one at the position shown in Photo 103 and the other at the position spaced two bolt holes apart from it.



Photo 101



Photo 102



Photo 103

- e) Fit the O-ring [73-2] in the O-ring groove at the end of the unloader push rod [67-2] where the unloader piston is to be attached.

- f) Before assembly, apply sufficient lubricant. Attach the O-ring [65] to the unloader piston [64-2], and then attach the cap seal [66] on them. Lightly making a mountain fold in the circumferential direction of the cap seal will facilitate the work. Use of a small and smooth spatula-shaped tool (as shown in Photo 104) will aid the assembly.
- g) Attach the unloader piston, which has the O-ring and cap seal attached, to the unloader cylinder. The unloader piston has a surface which has threaded holes for eye bolts and another surface without such holes. First, while exchanging these surfaces alternately several times using the chamfer of the unloader piston, press the unloader piston lightly with the palm to settle the cap seal. Finally, as shown in Photo 106, attach the unloader piston with its surface having threaded holes faced to the unloader cylinder cover. After attaching, check that the cap seal is not broken or pinched.



Photo 104



Photo 105 First Fit in
Reverse Direction



Photo 106

- h) Push the unloader piston into around the midst of the unloader cylinder. With the unloader push rod [67-2] pulled toward you, attach the balance piston cover with gasket attached (as shown in Photo 106), onto the high-stage suction cover (Photo 107). If you push the piston into the push rod and temporarily tighten it with the lock nut [69-2], the work that follows will be easier.



Photo 107

- i) Align the flange surfaces, and tighten the hexagon socket head cap screws to the specified torque (50 N·m).

- j) Pull the piston toward you by using eye bolts, and remove the temporarily tightened lock nut. As shown in Photo 108, attach the lock washer [70-2] and lock nut [69-2] to the push rod, and fasten the lock nut to the specified torque of 80 N·m (Photo 109). To stop rotation, bend the lock washer claw aligned with the notch of the lock nut (Photo 110). Lastly, check the movement of the piston by using eye bolts.



Photo 108



Photo 109



Photo 110

5.7.11 Low-stage Unloader Cylinder

The low-stage unloader cylinder may be attached immediately after attaching the bearing cover (see "5.7.8 Bearing cover" in this manual), or after attaching the mechanical seal (see the description below). The contents of and points for this work are almost the same as the previous section.

- a) Fit the O-ring 【73-1】 in the O-ring groove at the end of the unloader push rod 【67-1】 where the unloader piston is to be attached.
- b) Attach the O-ring 【65】 and cap seal 【66】 to the unloader piston 【64-1】.
- c) Attach the unloader piston, which has the O-ring and cap seal attached, to the unloader cylinder 【60-1】 (Photo 111).
- d) Attach the O-ring to the O-ring groove provided on the portion of the bearing cover 【16】 where the unloader cylinder is to be attached (Photo 112).

* According to the design change on October 1996, the place O-ring 【63】 is attached has been changed from the opening with chamfered to the current position indicated in Figure 5-13.

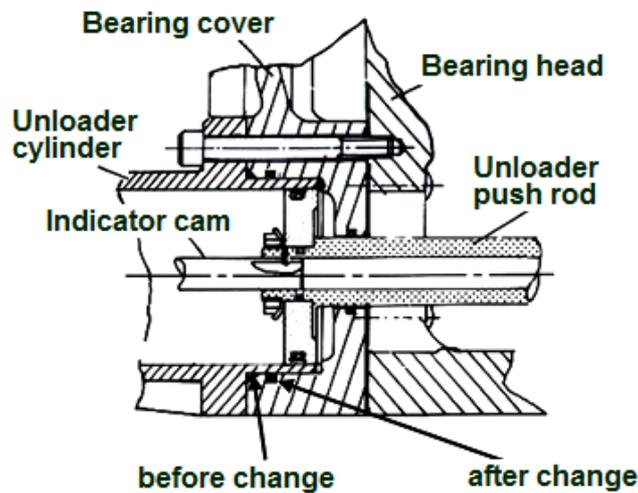


Figure 5-13 Change of The O-ring position for Bearing cover

- e) Attach the unloader cylinder to the bearing cover (Photo 114), and fasten the eight hexagon socket head cap screws 【62-1】 to the specified torque (50 N·m).



Photo 111



Photo 112



Photo 113

- f) Attach the lock washer 【70-1】 and lock nut 【69-1】 to the unloader push rod, and fasten the lock nut to the specified torque of 120 N·m (Photo 114). To stop rotation, align the lock washer claw with the notch of the lock nut in the tightening direction, and bend the claw (Photo 115). Lastly, check the movement of the unloader piston by using eye bolts.



Photo 114



Photo 115

CAUTION

- For the 2016MSC, be sure to attach the spacer for the unloader piston 【423】 and the O-ring 【702】 to the low-stage (see Chapter 7, Figure 7-9 in this manual).

5.7.12 Mechanical Seal

The standard mechanical seal assemblies used in the current **MYCOM** standard screw compressors are of the BBSE (balance bellows single) type.

In addition, the BOS (balance O-ring single) type may be used depending on the specifications of the customer.

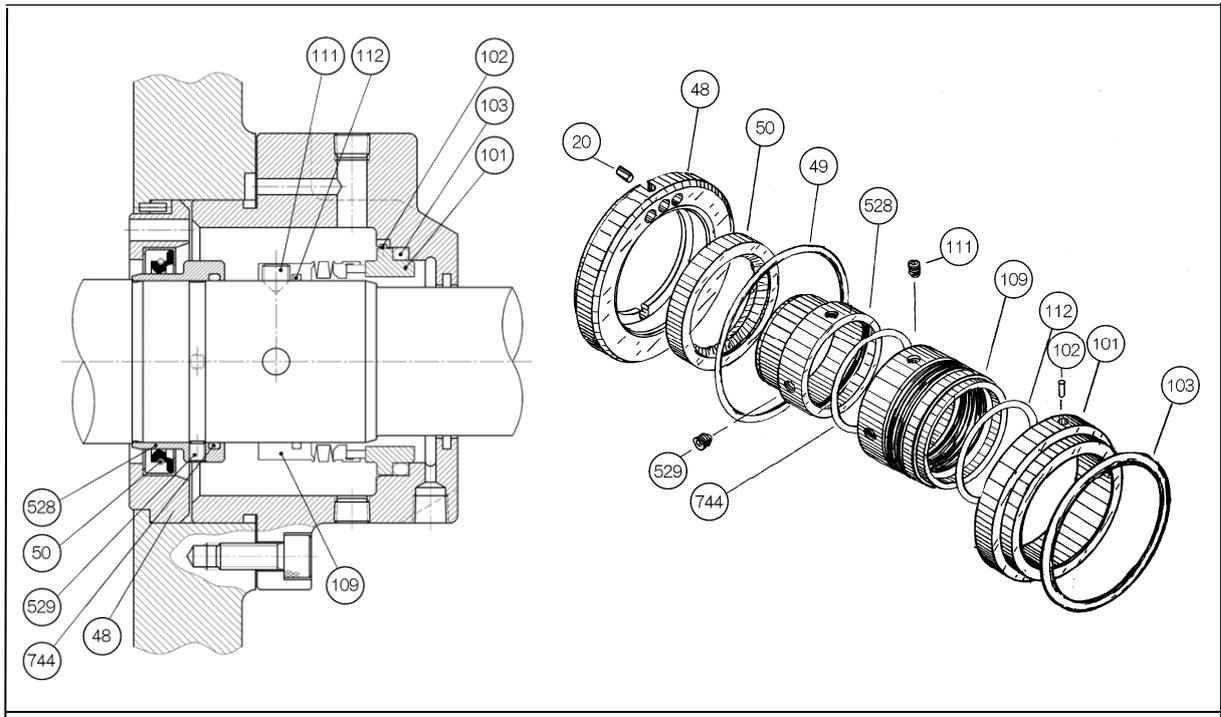


Figure 5-14 BBSE Type Mechanical Seal Assembly

- a) Before assembly, clean the portion where the rotor shaft seal will be installed.
- b) In particular, recheck immediately before assembly that the stepped portion where the axial seal will be mounted is free of damage.
- c) Attach oil seal [50] to oil seal retainer [48].
Since the design change notification issued in November 2002, the oil seal attachment direction has been changed from "facing the atmosphere side" to "facing the opposite side". The purpose of this change is to improve oil flow from inside the seal box so that the pressure will not rise too high. However, in rare cases, assembling the oil seal retainer becomes difficult in the following work. Then, the previous attaching direction is allowed to be used.
Place a Teflon or other kind of resin block on the oil and tap on the block to push the oil seal into the retainer evenly until it bottoms. When it gets fully pushed in, you will know by the change in the tapping sound and feel.
After assembly, check that the step formed at the boundary between the oil seal and the retainer is even. See from the opposite side, and confirm that they are evenly assembled.
- d) Insert the O-ring [744] in the inner periphery of the oil seal sleeve [528], which should then be attached to the oil seal retainer with oil seal inserted (Photo 116).



Photo 116

- e) Attach the oil seal retainer, which has oil seal attached, along the rotor shaft by using two standard 8 mm eye bolts (as shown in Photo 117). At this time, ensure that the retainer's oil hole is on the upper side of the rotor shaft, and accurately align the rotation stop spring pin [20], which has been screwed to the bearing cover, with the notch of the retainer. After assembly, try to turn the retainer's eye bolts to check that they are secure. If they are properly aligned, the retainer will not rotate.
- f) Secure the oil seal sleeve to the rotor shaft by using two set screws [529] (Photo 118).



Photo 117



Photo 118

- g) Then, insert the O-ring [49] for the oil seal retainer (Photo 119).

CAUTION

- **Take special care because users frequently omit to insert the O-ring [49] for oil seal retainer.**

- h) Attach the seal collar [109], which has the O-ring [112] attached to its inner periphery, to the rotor shaft. Before assembly, apply sufficient lubricant (prepared for use during assembly) to the rotor shaft and seal as if intending to wash away dirt. Push in the O-ring [112], while taking care not to get it damaged by the step on the rotor shaft (Photo 120).



Photo 119

- i) By using two seal collar set screws [111], tighten the seal collar against the countersunk holes in the rotor shaft (Photo 121). Tightening the seal collar at other places than the countersunk holes can cause damage to the rotor shaft which can lead to leakage.



Photo 120



Photo 121

- j) Attach the O-ring 【103】 for mating ring and mating ring 【101】 to seal cover 【51】 (Photo 122).
- k) Apply oil to the seal cover gasket 【52】, align the gasket oil hole with the oil hole on the seal cover flange surface, and affix the gasket.

* With the standard internal oil supply type compressors, the bearing cover and the seal cover are connected by an oil supply hole. Oil flows from the notch in the seal cover through the groove to the upper side of the seal cover, and then flows through the drilled oil supply hole to the upper sliding surface of the mechanical seal.

- m) Install the seal cover with the gasket, so that the oil removal piping of the seal cover is on the bottom side.

At this time, assemble it carefully, either at a right angle or by delaying the upper side slightly, while paying attention not to cause the mating ring inside the seal cover hit against the rotor shaft.



Photo 122



Photo 123

- n) The seal ring and the mating ring sliding surface will come into contact midway through attachment. At this moment, check the dimensions between the seal cover gasket and the bearing cover flange surface by using a taper gauge (Photo 124). This value is called tightening allowance for seal. It is used when checking the sliding face pressure between the rotating ring and stationary ring of the seal.

In case of BBSE-type seal of the 2016**C, if this value is not within the range between 2 and 3 mm, measures should be taken, such as replacement of mechanical seal assembly or addition of another gasket.

With the 2016**C compressor, the thickness of the seal cover gasket is 0.5 mm.



Photo 124

- o) When the seal tightening allowance is proper, push the seal cover firmly into the bearing cover. Since there is repulsion force of the seal bellows, keep it pushed firmly and tighten the two hexagon socket head cap screws 【53】 (for tightening the seal cover) evenly at positions 180 degrees apart. When there is no gap between the flange surface and the gasket, tighten all of the remaining bolts to the specified torque (50 N·m).
- p) When tightening of the seal cover is finished, supply oil to the seal cover while rotating the rotor shaft (Photo 125).



Photo 125

5.7.13 Unloader Cylinder Cover

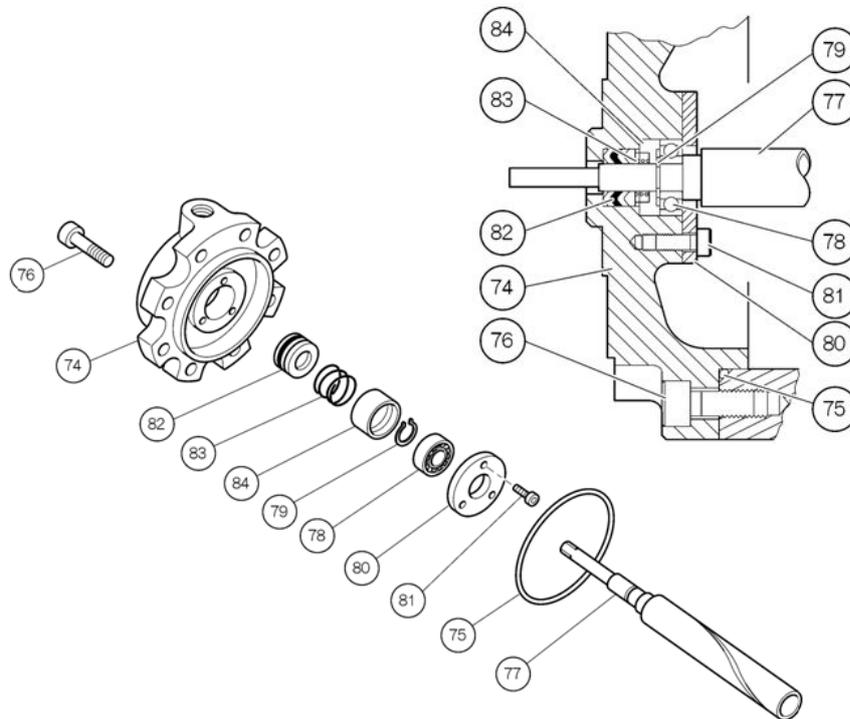


Figure 5-15 Development View of Unloader Cylinder Cover

- a) Attach eye bolts to the unloader piston, and move it back and forth. Check once again that it functions properly. During this manual check, pay attention not to let the piston reach the utmost front position.

CAUTION

- With some model (2016MSC), the slide valve may come off the guide block if you pull the unloader piston excessively toward you.

- b) Attach the ball bearing [78] to the shaft of the indicator cam [77]. When fitting, push the inner ring of the bearing. Pushing the outer ring may damage the bearing. Push the bearing to the stepped portion of the indicator cam and retain the bearing with the stop ring.
- c) Apply sufficient oil to the unloader cylinder cover [74], and attach the V-ring set [82]. One of the V-rings in a set is made of rubber (dark color) to improve sealing performance. As shown in Figure 5-15, it is set at the second position viewed from the outer side of the machine. Set the V-ring in such a way that its ridge faces the machine's outer side and the lip faces the inner side.
- d) Install the spring [83] and spring retainer [84] into position. Then insert the shaft of the indicator cam, which has been assembled in step b) above, into the V-ring. Fasten the bearing to the unloader cylinder cover by using the bearing gland [80].
- e) After making sure that the indicator cam rotates smoothly, attach the O-ring [75] to the unloader cylinder cover.
- f) Attach the unloader cylinder cover to the unloader cylinder [60]. Push the unloader cylinder cover in such a way that the guide pin [68] of the unloader push rod [67] just fits to the spiral groove of the indicator cam. Secure the unloader cylinder cover with the hexagon socket head cap screws [76], with its hole for supplying unloader working oil facing upward.

5.7.14 Unloader Indicator

The unloader indicator contains micro-switches, a micro-switch cam and a potentiometer. Either of them detects the rotational volume change of the shaft of the indicator cam, which converts the axial positional change of the unloader slide valve into circumferential positional change, and sends it as electric signals to the control side of the package unit or refrigerating system.

For confirmation after inspection/adjustment or parts replacement, they need to be linked with the control side. So, even during an overhaul which is conducted with the compressor carried out of the installation site, this portion is often removed from the compressor as an indicator assembly so that inspection/adjustment or parts replacement can be conducted at the site.



- **When removing or inspecting/adjusting the indicator assembly, be sure to turn off the control power and conduct lockout/tagout. Failure to turn off the power supply could cause an electric shock.**

The 2016**C model has, on its high-stage, an indicator which is designed for the standard-type single-stage compressor (however, the dial face which is exclusively designed for the 2016**C high-stage). On the low-stage, it has an indicator designed for the low-stage of 2-stage compressor, which, additively, has a bevel gear for changing the indicator needle and dial from axial direction to lateral direction. The basic functions and inspection procedures are common to both. So, the following explanation is given based on the standard-type high-stage unloader indicator.

5.7.14.1 Micro-switch and Micro-switch Cam

The standard-type unloader indicator has two micro-switches and one micro-switch cam, for sensing that the unloader slide valve is at the 0% position or the 100% position of capacity control (indicated load).

If, for any reason, their assembly gets loose or the micro-switch(es) gets faulty, proper sensing will be disabled, which will cause trouble in operation control of the compressor.

■ Disassembly

- a) Turn off the control power and conduct lockout/tagout. After that, remove the indicator cover [146], indicator glass [141] and indicator glass spacer [142].
- b) Remove the indicator needle screw [140] securing the indicator needle [139] to the shaft.
- c) Remove the indicator dial screws [138] securing the indicator dial [137] to the dial supports.
- d) Remove the electric wiring of the micro-switch. To avoid future assembly errors, put markings to indicate positional relationship of wiring by using different colors of tape or the like, and take a note.
- e) The micro-switch [125] is secured with two long philips screws [126]. The micro-switch can be removed by loosening these screws. Do not remove these screws except when the micro-switch needs to be replaced. Leave them as they are when conducting inspections or positional adjustments.
- f) The micro-switch on the right is for sensing the no-load (0%) position and the micro-switch on the left is for sensing the full-load (100%) position.
Under the left micro-switch, the micro-switch base plate [123] is secured with different philips screws [124] on the micro-switch mounting frame. This is to use the cam which is outside the micro-switch cam [127].

■ Inspection

- a) In a normal state where the compressor's capacity control oil pressure pipe is not opened, pull the unloader piston to the no-load position/full-load position by using the manual capacity control circuit, in order to check, through the control circuit (operation check of related relays and/or contacts), whether the micro-switch senses the 0% /100% position of the micro-switch cam.

- b) Turn off the control power, and conduct lockout/tagout. After that, remove the indicator glass and check for looseness of the philips screw for securing the micro-switch 【126】.
- c) Check for looseness of the set screw for securing the micro-switch cam 【127】.
- d) Check that the wiring of the micro-switch has been removed. After that, turn the switch on and off and check whether it works properly by using a tester.
- e) When the compressor's capacity control oil pressure pipe is opened due to overhaul or the like, pull the unloader piston to the no-load position/full-load position by using nitrogen gas or compressed air pressure, in order to check whether the micro-switch senses the 0%/100% position of the micro-switch cam.
- f) In addition, conduct appearance check to find out any traces of water entry inside the indicator, defects in the switch terminal such as corrosion, wear in the switch roller or micro-switch cam, etc.

■ Reassembly

To reassemble the unloader indicator, follow the disassembly procedure in reverse.

5.7.14.2 Potentiometer

The potentiometer of the standard-type indicator is of the full rotation type. It senses the continuously variable position (indicated load of 0% to 100%) of the unloader slide valve, and feeds the sensed position as electric signals to the control side of the package unit or refrigerating system. Life expectancy of the potentiometer varies significantly depending on the compressor's installation environment (with corrosive gas atmosphere or much moisture) or operating state (frequently operated with partial load, frequently started/stopped, subject to much vibration, etc.). It is a consumable part, and needs to be replaced periodically depending on the situation.

■ Disassembly

- a) Turn off the control power and conduct lockout/tagout. After that, remove the indicator cover 【146】, indicator glass 【141】 and indicator glass spacer 【142】.
- b) Remove the indicator needle screw 【140】 securing the indicator needle 【139】 to the shaft.
- c) Remove the indicator dial screws 【138】 securing the indicator dial 【137】 to the dial supports.
- d) Remove the electric wiring of the potentiometer. To avoid future assembly errors, put markings to indicate positional relationship of wiring by using different colors of tape or the like, and take a note.
- e) The potentiometer set-plate 【130】 is fitted between the potentiometer support arms [1] 【134】 and arms [2] 【135】. Loosen and remove the arms [2] by turning them counterclockwise while holding the arms [1].
- f) When the right and left support arms are removed, the potentiometer 【129】 can be removed together with the potentiometer set-plate.
- g) The potentiometer is secured to the potentiometer set-plate with three philips screws.

■ Inspection

- a) On the terminal block, check whether or not the lead wires of the potentiometer are loose.
- b) Check for defects such as cracks in the welded portion of the potentiometer lead wires.
- c) Rotate the axis of the potentiometer with hand, and check with a tester whether the resistance value changes smoothly.

■ Reassembly

To reassemble, follow the inspection procedure in reverse. Lastly, position the indicator needle correctly by following the procedure below.

- a) When the compressor's capacity control oil pressure pipe is opened due to overhaul or the like, pull the unloader piston to the no-load position by using nitrogen gas or compressed air pressure. Then, align the indicator needle to the start point of the semicircular range drawn on the dial face, and fix it. Next, move the unloader piston to the full-load position, and check that the indicator needle points at the end point of the range drawn on the dial face.

- b) In a normal state where the capacity control oil pressure pipe is not opened, move the unloader piston by using a manual capacity control circuit. When the control power is turned on, keep the indicator cover attached to avoid electrical shock. After the position of the piston is determined, turn off the control power and conduct lockout/tagout. After that, remove the indicator cover and fix the indicator needle.

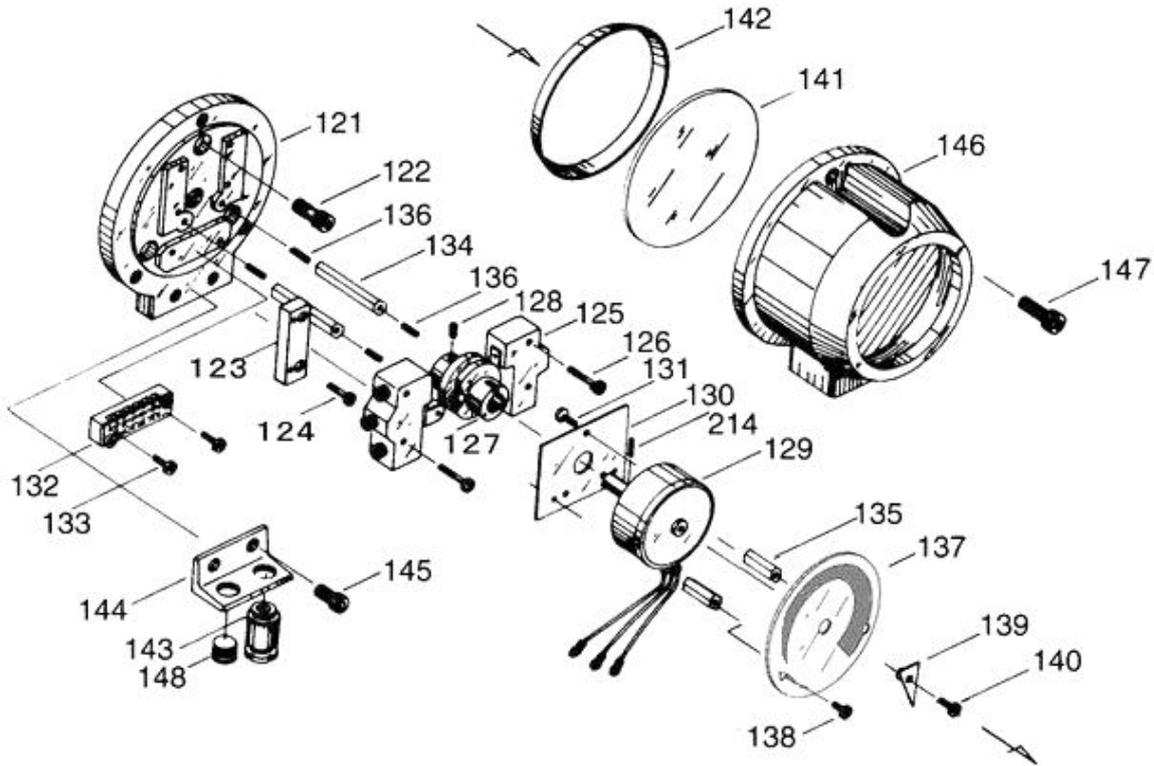


Figure 5-16 Development View of the 2016**C Standard-type High-stage Indicator

Table 5-12 Unloader Indicator Components (Standard type)

No.	Part name	Qty.	No.	Part name	Qty.
121	Micro-switch base plate	1	136	Potentiometer mounting screw	3
122	Hexagon socket head cap screw	3	137	Indicator dial	1
123	Micro-switch set plate	1	138	Indicator dial screw	2
124	Philips screw	2	139	Indicator needle	1
125	Micro-switch	2	140	Indicator needle screw	1
126	Philips screw	4	141	Indicator glass	1
127	Micro-switch cam	1	142	Indicator glass spacer	1
128	Set screw	1	143	Electric wiring connector	1
129	Potentiometer	1	144	Connector support	1
130	Potentiometer set-plate	1	145	Hexagon socket head cap screw	2
131	Philips screw	3	146	Indicator cover (2)	1
132	Terminal block	1	147	Hexagon socket head cap screw	3
133	Philips screw	2	148	Plug	1
134	Potentiometer support arm [1]	2	214	Spring pin	1
135	Potentiometer support arm [2]	2	265-2	Spring washer	7

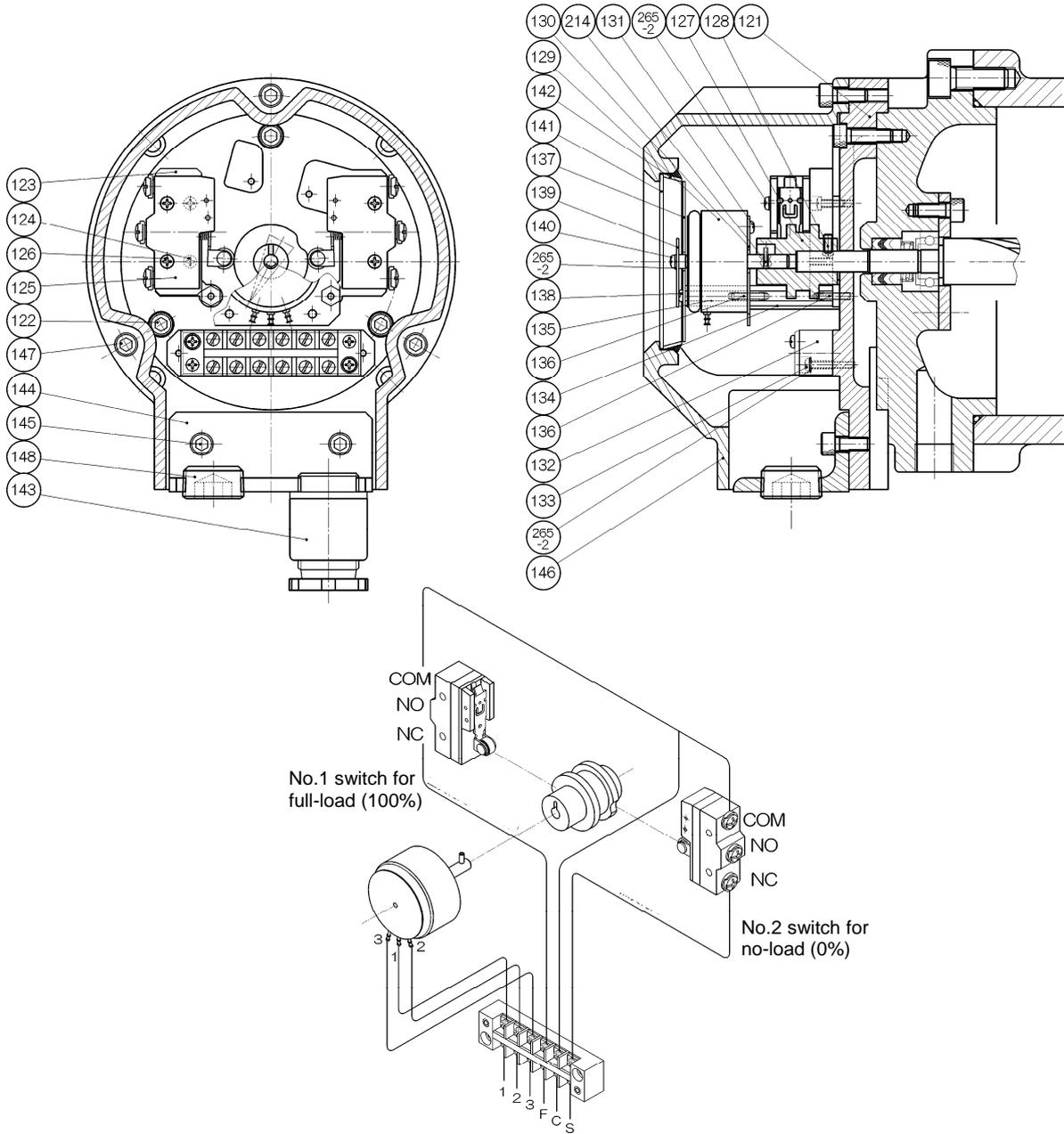


Table 5-17 Assembly Drawing of Unloader Indicator (Standard type)

Chapter 6 Troubleshooting

Table 6-1 describes typical trouble symptoms of compressors, their causes and actions to be taken. For information about troubleshooting for the unit or the whole refrigeration cycle, refer to the instruction manual of the unit.

Table 6-1 Troubleshooting

	Symptom	Direct cause	Root cause	Action
01	Compressor does not start up.	Power source is off.	Mostly caused by forgetting to turn on after inspection.	Use a check sheet for post-inspection actions and implement finger pointing and call check to prevent forgetting.
		Main motor failure	Mostly caused by activation of overload protection circuit.	Refer to the operation manual of the motor for details including other causes and actions.
		"Micro-switch and micro-switch cam" of the indicator do not sense capacity control of 0%.	Micro-switch failure	Replace.
			Loosening of micro-switch or micro-switch cam set screw due to vibration.	Adjust the position of the cam and switch, and tighten them. Use thread locking agent when necessary. When compressor's vibration is unusually high, see Item No. 12 "Compressor generates abnormal vibration and/or sound".
		Defective capacity control oil supply line	Improper adjustment of oil flow control valve (throttled excessively).	Readjust.
			Leak/clogging in piping or solenoid valve	Remove cause, and check oil for contamination/replace oil.
		Oil pressure not detected	Failure of oil pressure protection device, pressure sensor, relay, etc.	Identify defective devices, investigate causes of failure and take necessary actions. Then, replace failed device(s).
			Pressure pipe is clogged.	Remove clogging, and check oil for contamination/replace oil.
		Cooling water circulation is not confirmed.	Failure of devices such as cooling water pump and related circuits	Identify defective devices, investigate causes of failure and take necessary actions. Then, replace failed device(s).
			Circulation route is clogged.	Remove the clogging.
		Failure of magnet, relay, etc. in compressor startup circuit	Aging degradation	Replace with new one.
			Poor installation environment	Replace ventilation fans, etc. if defective. Improve temperature, humidity and ventilation at the installation site.
02	Compressor stops immediately after startup.	Low pressure protection circuit activates.	Insufficient refrigerant flow	To correct insufficient refrigerant, check leak, stop leak and then add refrigerant. * Also pay attention to moisture entering into the system.

	Symptom	Direct cause	Root cause	Action
02	Compressor stops immediately after startup.	Low pressure protection circuit activates.	Insufficient refrigerant flow <ul style="list-style-type: none"> • Insufficient refrigerant • Insufficient liquid supply • Heat exchange failure in heat exchanger 	To correct insufficient liquid supply, inspect expansion valve and liquid supply strainer. Take necessary actions. In addition, inspect devices and parameters (set values) of the expansion valve aperture adjusting mechanism, and take necessary actions.
				If there are any problem (insufficiency) in heat exchange, such as malfunction of defrosting, investigate the cause and take necessary actions.
				In case of malfunction of pressure adjustment valve, replace the valve or remove the cause.
		Failure of low pressure protection device, pressure sensor, relay, etc.	Identify defective devices, investigate causes of failure and take necessary actions. Then, replace failed device(s).	
	Motor overload		Motor overload that occurs just after startup is mostly caused not by the refrigeration cycle but by the motor. Refer to the instruction manual of the motor.	
03	Unusually low pressure (decrease of suction pressure)	Refer to direct cause, "Low pressure protection circuit activates", in Item 02 above.	Same as left	Same as left
04	Low oil pressure (low lubrication oil supply pressure)	Oil filter element is clogged. * Pressure difference between the outlet port and inlet port is large.	Contamination of lubricant	Remove clogging, and check oil for contamination/replace oil.
			Internal defects of compressor	Check for oil contamination and conduct vibration/noise diagnosis. Overhaul compressor if necessary.
		Insufficient oil in oil separator.	Oil heater is not functioning, refrigerant dissolves excessively when the machine is stopped, and oil loss occurs at startup.	Inspect oil heater alone, inspect relays, etc. on related circuits, and replace parts as necessary.
			Insufficient oil return due to insufficient refrigerant circulation	Correct insufficient refrigerant circulation, and return oil from load-side heat exchanger. * Supply lubricant temporarily.
			Troubles such as clogging in oil return passage	Remove causes of the trouble, and restore the system.

	Symptom	Direct cause	Root cause	Action
04	Low oil pressure (low lubrication oil supply pressure)	Insufficient oil in oil separator.	Extensive oil leak	Inspect machine room and around the compressor, and take necessary actions. Check if there is oil floating in cooling water system. →If there is, check for oil leak from heat transmission tube of oil cooler and take necessary actions.
				If piping is damaged due to excessive vibration, take measures to reduce vibration (including measures for resonance vibration).
		Oil pressure detection function is defective.	Failure of oil pressure protection device, pressure sensor, relay, etc.	Identify defective devices, investigate causes of failure and take necessary actions. Then, replace failed device(s).
				Pressure pipe is clogged.
05	Intermediate pressure is unusually high.	High suction pressure	Heat load on load side is higher than design value.	Inspect the conditions on load side (warehousing volume, opening/closing of doors, etc.), and take necessary measures.
			Malfunction of suction pressure adjusting mechanism	In case of pressure sensing failure, replace the pressure sensor. * In some cases, pressure pick-up position is improper. → Change the position.
				If there is a problem in device(s) on the control circuit, find the defective device(s) and replace it.
				If parameter (set value) on the control circuit is improper, optimize it.
				In case of malfunction of pressure adjustment valve, replace the valve or remove the cause.
			Malfunction of compressor's capacity control	See Item No. 11 "Capacity control malfunction".
		Liquid flow-back from intermediate liquid cooler.	Failure or internal leakage of intermediate liquid supply expansion valve	Repair or replace.
		There is problem in compressor's high-stage.	Malfunction of capacity control on compressor's high-stage	See Item No. 11 "Capacity control malfunction".
Excessive wear or sliding damage of the part(s) on compressor's high-stage	Overhaul compressor and replace parts. Replace the whole quantity of lubricant.			
06	Unusually high pressure	Heat exchange failure in condenser (heat exchanger)	Heat transmission tubes and/or fins are contaminated or blocked.	Clean and wash. Depending on the contamination level, use chemical cleaning.

	Symptom	Direct cause	Root cause	Action
06	Unusually high pressure (abnormal discharge pressure)	Heat exchange failure in condenser (heat exchanger)	Failure or water dripping in fan motor, thermo switch, water spraying pipes, cooling water pumps, etc.	Identify defective devices, investigate causes of failure and take necessary actions. Then, replace failed device(s).
			Faulty adjustment of cooling water/brine	In case of manually adjusted valve, readjust the valve. When an automatic control valve (including wax valve) is used, investigate the cause and take necessary actions.
			Other causes of insufficient flow of cooling water, etc.	Inspect filters installed on the circulation route for clogging and contamination, and take necessary actions. Inspect for leaks in circulation routes, and take necessary actions. Inspect water supply routes/mechanisms, and take necessary actions. If frozen, take measures such as improvement of heat insulation or increase of temperature.
			Deficiency in heat exchanger performance	If the symptom is caused by change in operating conditions, re-examine the conditions for improvement. If the symptom is caused by change in installation environment, improve the environment if possible. In either case, if improvement measure is difficult to be made, add more heat exchangers or increase their sizes.
		Non-condensable gases mixed into the system	Leak on low pressure side * There are also cases where the symptom was caused by corrosion in suction temperature gauge protection	Perform a leak check, and take necessary measures. Air-purge the heat exchanger.
		Refrigerant is excessive.	In some cases, insufficient cooling is judged as caused by insufficient refrigerant and, as a result, refrigerant is charged repeatedly.	Properly adjust the refrigerant charge.
			Capacity of heat changer is insufficient.	If the symptom is caused by change in operating conditions, re-examine the conditions for improvement. If improvement is difficult, add heat exchangers or increase their sizes.

	Symptom	Direct cause	Root cause	Action
06	Unusually high pressure (abnormal discharge pressure)	Discharge oil pressure detection function is defective.	Failure of high pressure protection device, pressure sensor, relay, etc.	Identify defective devices, investigate causes of failure and take necessary actions. Then, replace failed device(s).
			Liquid clogging, etc. due to clogged pressure pipe	Remove clogging, and check oil for contamination/replace oil.
		Outlet shut-off valve of oil separator is closed.	Operator forgot to restore after shut down operation. Human error	Open the valve or perform emergent stop. Be sure to conduct tagout while handling valves. Be sure to check valves before starting the compressor.
07	Discharge temperature is abnormally high.	Overheated during operation	Insufficient refrigerant flow	See the causes listed in item 02 above.
			Heat load on load side is higher than design value.	Inspect the conditions on load side (warehousing volume, opening/closing of doors, etc.), and take necessary measures.
			Failure of low pressure protection device, pressure sensor, relay, etc.	Identify defective devices, investigate causes of failure and take necessary actions. Then, replace failed device(s).
		Non-condensable gases mixed into the system	Leak on low pressure side	Perform a leak check, and take necessary measures. Air-purge the heat exchanger.
		Oil supply temperature is high.	Heat exchange failure in oil cooler	For water-cooling system, see "Heat exchange failure in heat exchanger" in 06 above. For liquid cooling system, check liquid supply expansion valve, temperature sensor and related relays/wiring/terminals, and take necessary actions.
			Oil temperature rise protection feature does not function.	Check temperature protection device, temperature sensor and related relays/wiring/terminals, and take necessary actions.
		Defective discharge temperature detection/protection feature.	Failure of temperature protection device, temperature sensor, relay, etc.	Identify defective devices, investigate causes of failure and take necessary actions. Then, replace failed device(s).
Insufficient oil supply	See "Low oil pressure" in Item 04 above.	Same as left		
08	Leak from mechanical seal	Initial leak after replacement until sliding faces settle	In some cases, immediately after replacement, the compressor-specific operating conditions and the pressure receiving conditions of machined sliding surface is unstable.	In case of initial leak, although leak amount might increase temporarily, it will decrease gradually. Check that leak does not increase continuously. Duration of initial leak depends on design/operating conditions. It is approximately 200 hours, as a rough indication.

	Symptom	Direct cause	Root cause	Action
08	Leak from mechanical seal	Sliding surface is roughened due to overheating.	Started and stopped too many times. * In case of standard equipment, "four or more times per hour" is considered "frequent/too many".	If heat load is less than the level set by the equipment's design conditions, review the operating conditions and set control such that equipment is started/stopped less frequently. In case of capacity control malfunction, see "Capacity control malfunction" in item No. 11.
			The amount of lubricant contained in refrigerant gets smaller, resulting in decreased viscosity.	In case of liquid flow-back, remove the cause(s). If oil heater or devices on its control circuit are defective, replace the defective part.
			Overheated operation	See the causes in item 02, "Insufficient refrigerant flow".
			Oil supply temperature is high.	See the causes in item 07, "Oil supply temperature is high".
			Machine is stopped for a long time. (No oil film on sliding surfaces)	User-specific conditions, such as intermittent heat load
		Deteriorated part(s)	Hardened O-ring	If deteriorated over time, replace. For other specific causes, see the causes/action for symptom "Overheating of sliding surface".
			Swelled O-ring * This occurs when the lubricant of refrigerating machine contains large amount of refrigerant.	In case of liquid flow-back, remove the cause(s). If oil heater or devices on its control circuit are defective, replace the defective part.
			Deteriorated seal ring/mating ring	If deteriorated over time, replace. For other specific causes, see the causes/action for symptom "Overheating of sliding surface".
		Incompatibility of lubricant and operating conditions (such as working temperature range or refrigerant)	Unsuitable lubricant was selected, or operating conditions have changed after installation of the equipment.	If possible, review the operating conditions. If not, see "4-1 Lubricant (Refrigerant Oil)" to select suitable lubricant and replace the whole quantity.
		Poor contact of sliding surfaces	Foreign matter attached to sliding surfaces, due to contaminated lubricant.	Replace the whole quantity of lubricant. Install bypass filter to oil supply line.

	Symptom	Direct cause	Root cause	Action
08	Leak from mechanical seal	Poor contact of sliding surfaces	Faulty assembly of parts Human error	Disassemble, replace parts and reassemble. Use assembly check sheet to ensure confirmation.
09	Squeaking	During initial period after exchange for new mechanical seal, squeaks may be heard from sliding surfaces until they fit together.	As the sliding surfaces are very hard and dense, they need time to fit together.	Squeaking itself does not cause leak from seal or deterioration in sealing function. Normally, squeaking is heard for several dozens of hours, however, it may last longer in rare cases. →In this case, contact our service center.
10	Capacity control position is indicated incorrectly.	Inaccurate reading of compressor indicator gauge.	Screw for securing indicator needle is loose.	Manually operate the compressor's capacity control to indicate 0% position, and tighten the screw again.
			Indicator's bevel gear is worn.	If deteriorated over time, replace. If the wear is caused by excessive vibration of the compressor, take measures to reduce vibration and then replace the gear.
		Inaccurate reading of capacity control indicator on the control panel.	The cam groove of compressor's indicator cam is worn.	Often caused by continued operation with load on a certain point.→Replace the indicator cam. * The currently shipped indicator cam has its grooved portion strengthened.
			The guide pin (dowel pin) of the compressor push rod is worn.	Currently, this pin is also improved in resistivity against wear. If the indicator cam is replaced with the improved version, replace the pin with the countermeasure part.
			Failure of potentiometer	If the part is deteriorated over time or loaded at a certain point during operation for a long time, replace it. If the wear is caused by excessive vibration of the compressor, take measures to reduce vibration and then replace the gear.
			Improper zero span adjustment of E/E positioner	Readjust.
			E/E positioner or/and indicator is faulty.	If deteriorated over time, replace. If there are specific causes such as surge current, remove the cause or take proper action.
			Loosened terminals or defective wires	Tighten the terminals if loosened. Replace defective wires.
11	Capacity control malfunction	↑ See the causes for "Inaccurate reading of capacity control indicator on the control panel".	Same as left	Same as left

	Symptom	Direct cause	Root cause	Action
11	Capacity control malfunction	"Micro-switches and micro-switch cam" of the indicator do not sense "100%" position and/or "0%" position.	Micro-switch failure	Replace.
			Loosening of micro-switch or micro-switch cam screw due to vibration.	Adjust the position of the cam and switch, and tighten them. Use thread locking agent when necessary. When compressor's vibration is unusually high, see Item No. 12 "Compressor generates abnormal vibration and/or sound".
		Failure of capacity control (4-way) solenoid valve or related relays	Mostly caused by coil burnout.	If deteriorated over time, replace. If the symptom is caused by water leakage, etc., remove the cause(s) and then replace defective part(s). For details, refer to the instruction manual of solenoid valve.
		Internal leakage of capacity control (4-way) solenoid valve	Liquid clogging, etc. due to temperature rise inside unloader cylinder	If the symptom is caused by long duration of low-load operation, review and improve the operating method. Arrange inline check valve and oil bypass route on the capacity control oil supply line.
		Defective capacity control oil supply line	Improper adjustment of oil flow control valve	Readjust.
			Leak/clogging in solenoid valve gland or oil supply piping	Remove cause, and check oil for contamination/replace oil.
		Unloader piston does not move. (Though this is one of the causes of "Defective capacity control oil supply line", it is listed separately here.)	Damage on the cap seal of the piston	Check oil for contamination/replace oil. Replace O-ring, cap seal, etc.
			Cap seal is pinched.	Replace O-ring, cap seal, etc.
Cap seal is worn.	Check oil for contamination/replace oil. Replace O-ring, cap seal, etc.			
There is residual refrigerant gas inside unloader cylinder.	Stop the compressor. By operating the oil pump, repeat load/unload operation to purge refrigerant gas from unloader cylinder. In case of liquid flow-back, remove the cause(s). If oil heater or devices on its control circuit are defective, replace the defective part.			
12	Compressor generates abnormal vibration and/or sound.	Shaft poorly aligned with motor	If the shaft vibration value of axial direction is high, it may be caused by this.	Conduct shaft alignment again. If this occurs frequently in monocoque unit, perform hot alignment (operate the compressor at rated speed to raise the temperature and make adjustment before it cools down).

	Symptom	Direct cause	Root cause	Action
12	Compressor generates abnormal vibration and/or sound.	M rotor shaft vibrates excessively.	Thrust bearing glands are tightened unevenly.	If lock nuts are not loose and parts such as thrust bearing are free of defects, tighten the glands evenly.
			Thrust bearing glands get loosened.	Lock washer claw not bended, or thrust bearing rolling elements (balls) are worn. → Check the thrust bearing. If any defect is found, replace it, and then reassemble it after adjusting end clearance and checking shaft runout.
			Rotor dynamic balance is disturbed.	If no other causes are found for abnormal vibration, or if on-site overhaul only has been repeatedly performed for a long time, this may be the cause. → Overhaul the compressor at a place where a dynamic balance measurement/adjustment system is available, such as the MAYEKAWA Moriya Factory.
		Oil hammer	Continuous low-load operation with capacity control not greater than 30%	During low-load operation, lubricant is difficult to be discharged. As a result, oil that stays between the engaged rotors increases and gets compressed. → Avoid continuous low-load operation as far as possible. * Especially when the fluid is light gas (He, NH ₃ , etc.), continuous operation of merely 10 minutes can cause bad effect. The maximum limit should be 30 minutes even for fluorocarbon fluids.
		Liquid flow-back during startup * Loud abnormal noise at startup. * If this is heard, the compressor may get damaged instantaneously.	Refrigerant liquefies and stays inside upstream piping when equipment is stopped.	There are many probable causes, such as a leak inside liquid supply solenoid valve on the load side, insufficient heat exchange (refrigerant evaporation) in heat exchanger, or trapping due to mis-piping in the piping line. → Identify the cause(s) and take necessary measures. Then overhaul and inspect the compressor.
Liquid flow-back during operation	Aperture of liquid supply expansion valve is large.	In case of temperature-type expansion valve, check the condition of temperature sensitive cylinder and capillary tube. If any defect is found, take necessary actions. If orifice gets unsuitable due to the change in operating conditions, replace the orifice.		

	Symptom	Direct cause	Root cause	Action
12	Compressor generates abnormal vibration and/or sound.	Liquid flow-back during operation * Notable frosting on the suction side. * In many cases, flow-back of mist (steam) rather than liquid occurs. * Sometimes, gas-liquid separator (accumulator) is attached to prevent this symptom. * See also the causes in item 02, "Insufficient refrigerant flow".	Aperture of liquid supply expansion valve is large.	In case of electronic expansion valve, check devices attached on the expansion valve aperture control mechanism (circuit) such as temperature sensor, converter, controller (overheating regulator). If any of them is found defective, replace it. In the same way as with temperature-type expansion valve, if orifice gets unsuitable due to the change in operating conditions, replace the orifice.
			Rapid change from no-load operation to full-load operation	Set control parameters so as to prevent rapid changes. Otherwise, make adjustment by throttling the aperture of the capacity control increase-side oil quantity adjusting valve.
			Expansion valve aperture control cannot keep up with rapid change in heat load on the load side.	Avoid rapid change in heat load that exceeds the set value of follow-up range of "heat exchanger on load side (evaporator)" and "expansion valve". For details, refer to the instruction manuals related to devices/control on load side.
			Heat exchange failure in heat exchanger on load side • Related to defrosting	In case of frosting (icing), conduct manual defrosting. Set defrosting interval shorter. If a device which is specific to the defrosting type fails, remove the cause(s) and replace the device(s). If a piping route which is specific to the defrosting type gets blocked, remove the cause(s) and take necessary actions. * Especially when handling hot gas defrosting systems, thoroughly read and understand the contents of the instruction manuals for the units associated with devices/control on the load side.
			Heat exchange failure in heat exchanger on load side • Load side conditions	If ventilation around the heat exchanger is obstructed for any reason such as piled up load, improve the conditions. * Ensure the flow of heating medium through the heat exchanger on the load side.
			Heat exchange failure in heat exchanger on load side • Heat exchanger conditions	Check for any blocked heat transmission tubes or fan motor(s) failure. If any problem is found, take necessary actions.

	Symptom	Direct cause	Root cause	Action
12	Compressor generates abnormal vibration and/or sound.	Foreign substances entering the compressor	Welding spatter, etc. flowing from upstream side	Check suction strainer and/or oil filters. Replace element if defective. Overhaul the compressor. Collect foreign substances and identify their sources. Then take necessary actions.
			Tools and/or waste cloth left uncollected after overhauling	
		Damaged thrust bearings.	Deterioration over time (operated beyond recommended time of replacement)	The time for replacement depends largely on operating conditions (low pressure or high intermediate pressure will make the life shorter, etc.) and/or oil management conditions. In case of a typical refrigeration application which basically operates in a stable continuous mode, inspect and replace them every 40,000 hours or 5 years, whichever comes first. For details, see Chapter 5, 5.2.3 in this manual.
			Operation with liquid flow-back	Refer to causes of "Liquid flow-back during startup" and "Liquid flow-back during operation" in item 12.
			Entry of foreign substances	Refer to causes of "Foreign substances entering the compressor" above.
			Excessive thrust stress other than above • High suction pressure/intermediate pressure exceeding the level set by operating conditions	Re-examine operating conditions, and improve if possible. If difficult to improve, review maintenance interval.
			Faulty assembly * Lock nuts tightened insufficiently, lock washer tab not bended, rotation stopper not set to thrust bearing gland, gland not assembled, etc.	Tighten lock nuts by using specified torque or torque angle (see Chapter 7, "7.3 Tightening Torques for Bolts and Nuts" in this manual). Be sure to record data on the assembly check sheet to prevent omission of work steps.
		Resonance vibration	This occurs when the frequency of vibration comes close to the natural frequency of any component in the entire vibrating system, including pipes and supports.	In many cases, this symptom is caused by change in installation environment (such as change in piping routes or additive installation of devices within machine room, oil level change, etc.) → If occurrence of resonance vibration is suspected, contact our service center.

Chapter 7 Related Documents

7.1 Development Views, Assembly Sectional Views

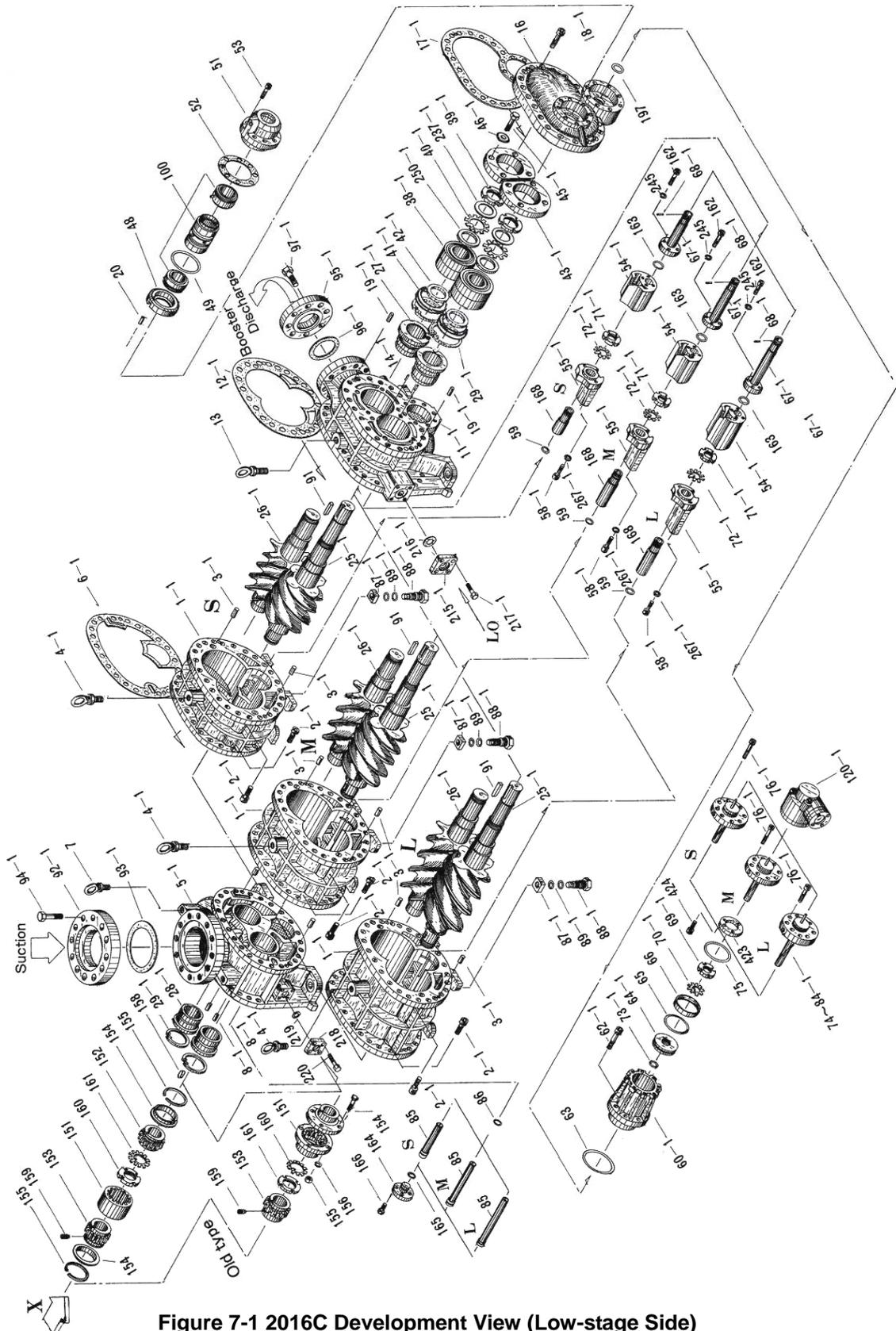


Figure 7-1 2016C Development View (Low-stage Side)

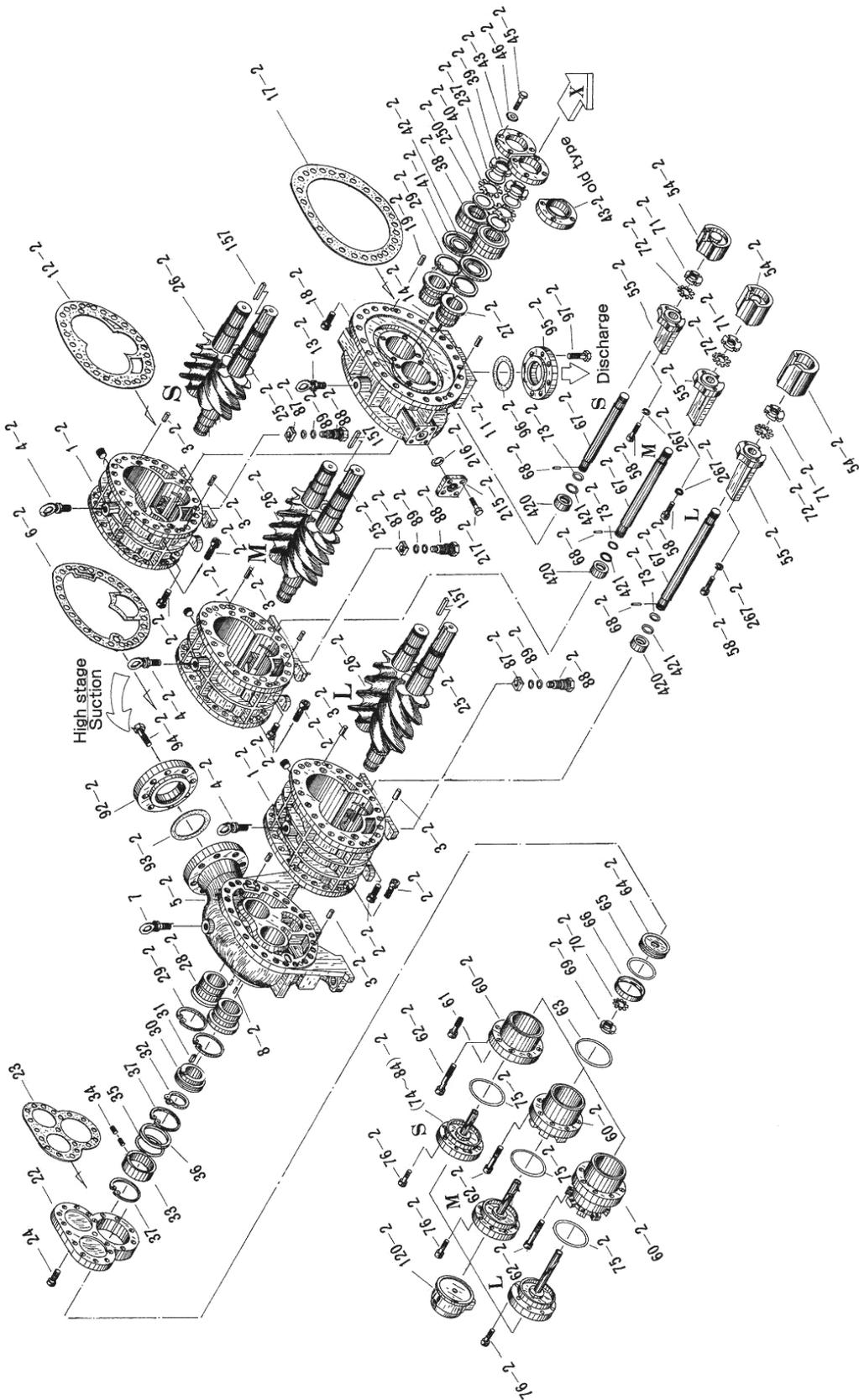


Figure 7-2 2016C Development View (High-stage Side)

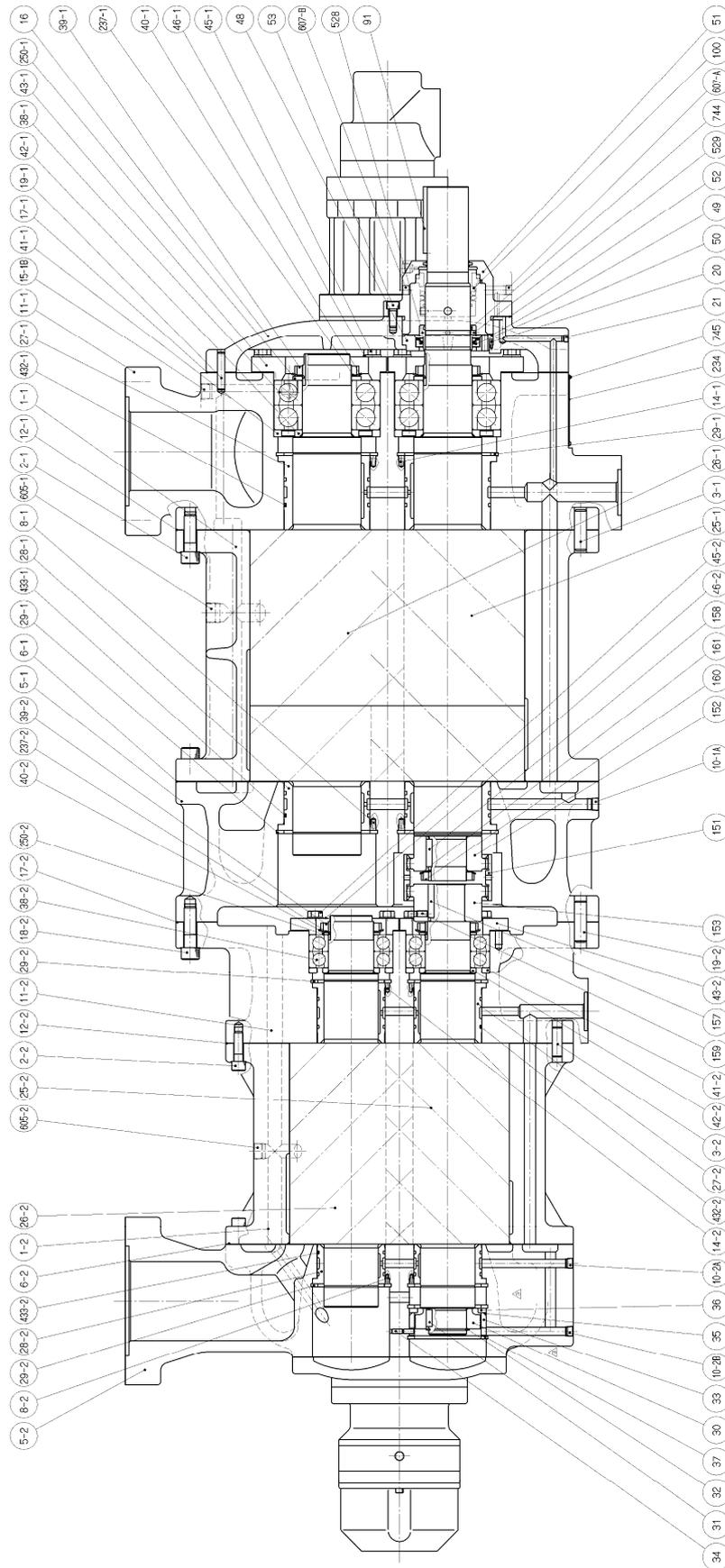


Figure 7-4 2016LLC Assembly Sectional View (Horizontal)

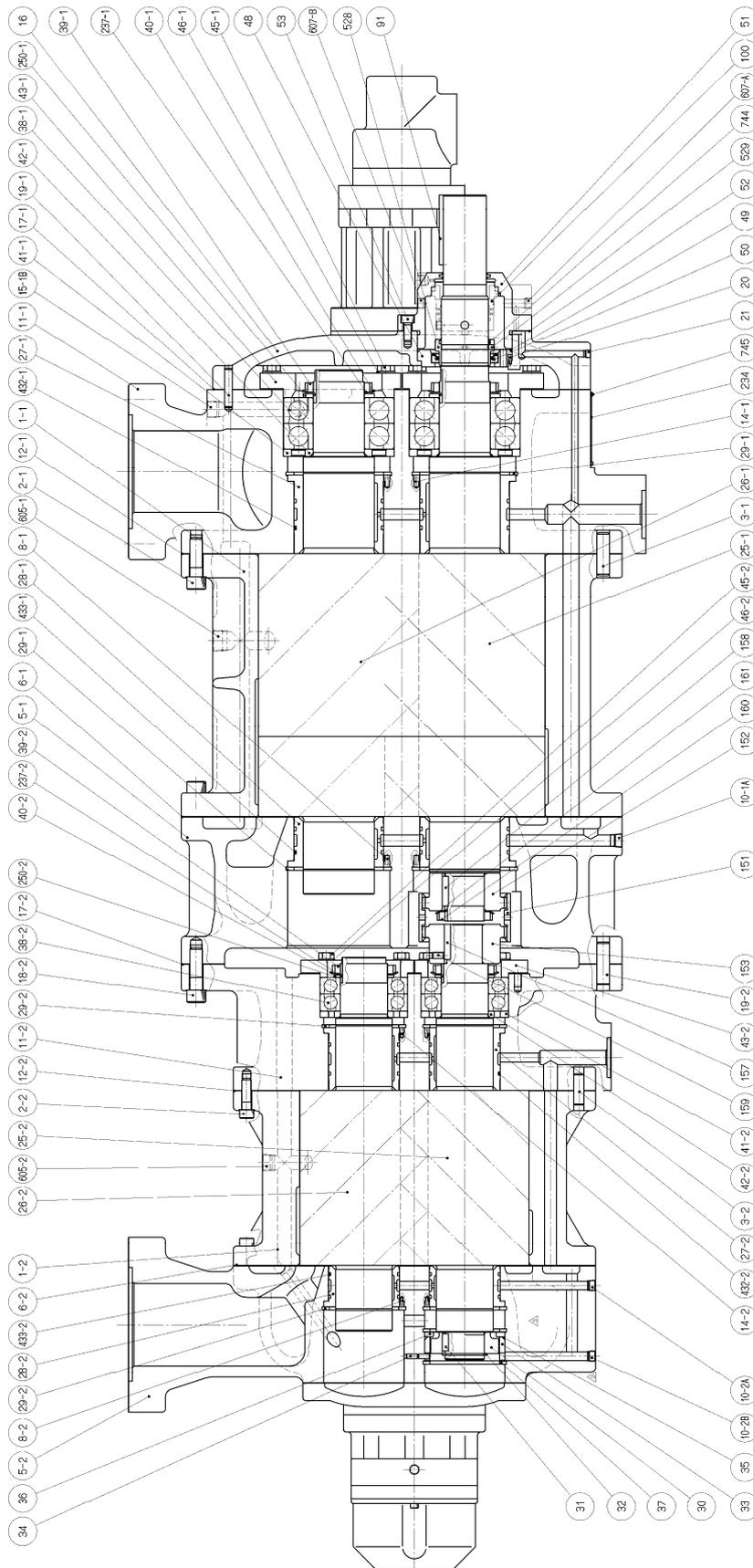


Figure 7-6 2016LMC Assembly Sectional View (Horizontal)

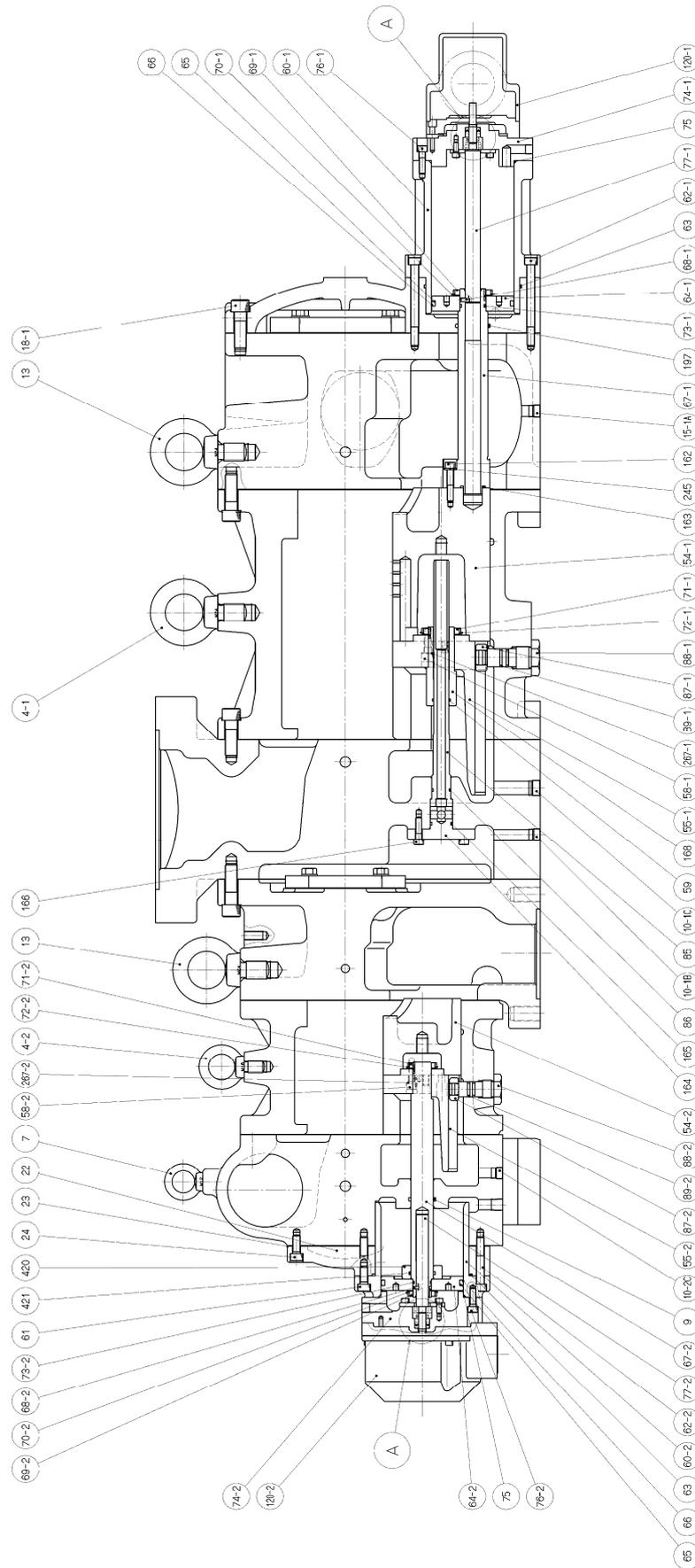


Figure 7-7 2016LSC Assembly Sectional View (Vertical)

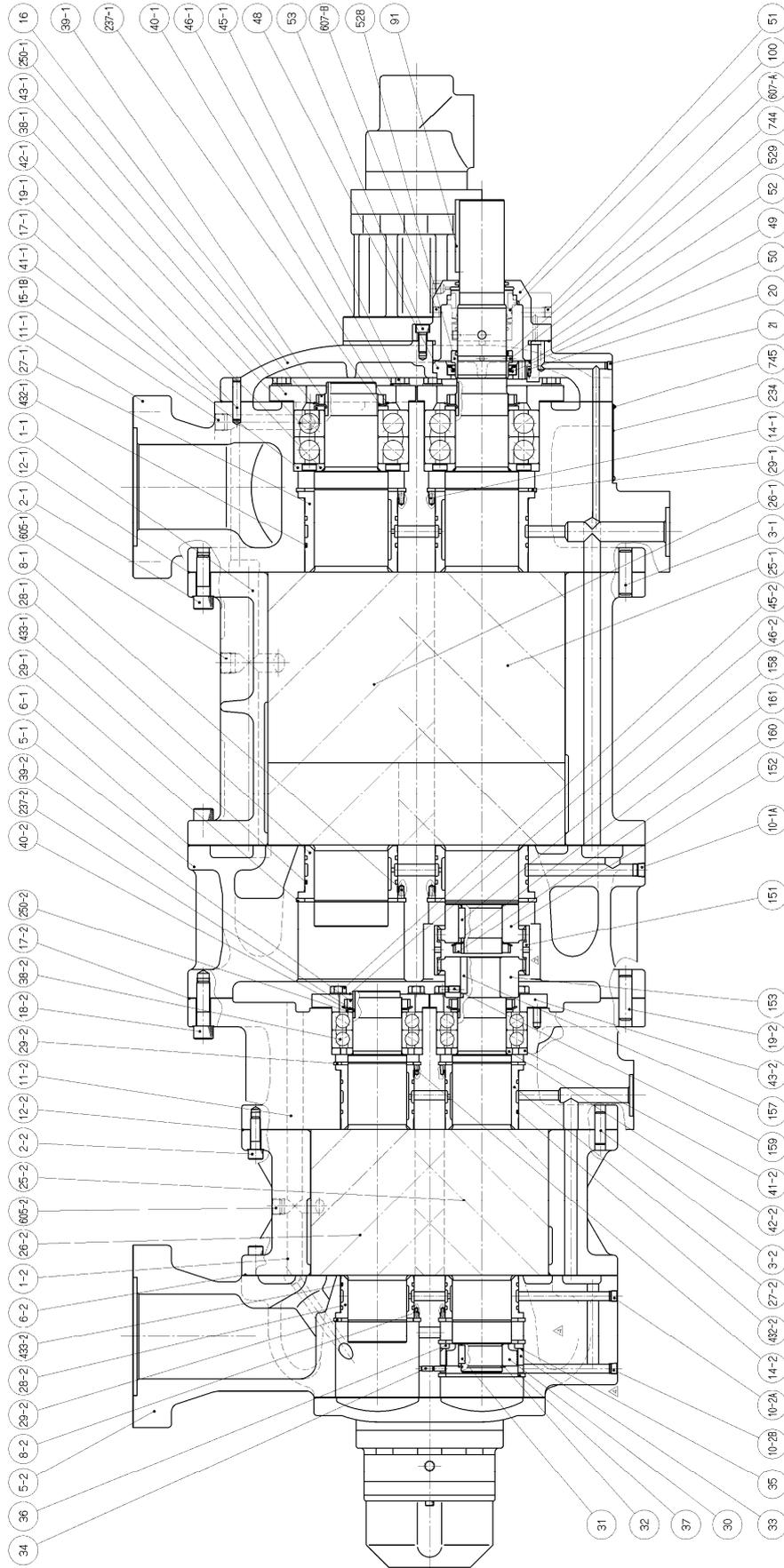


Figure 7-8 2016LSC Assembly Sectional View (Horizontal)

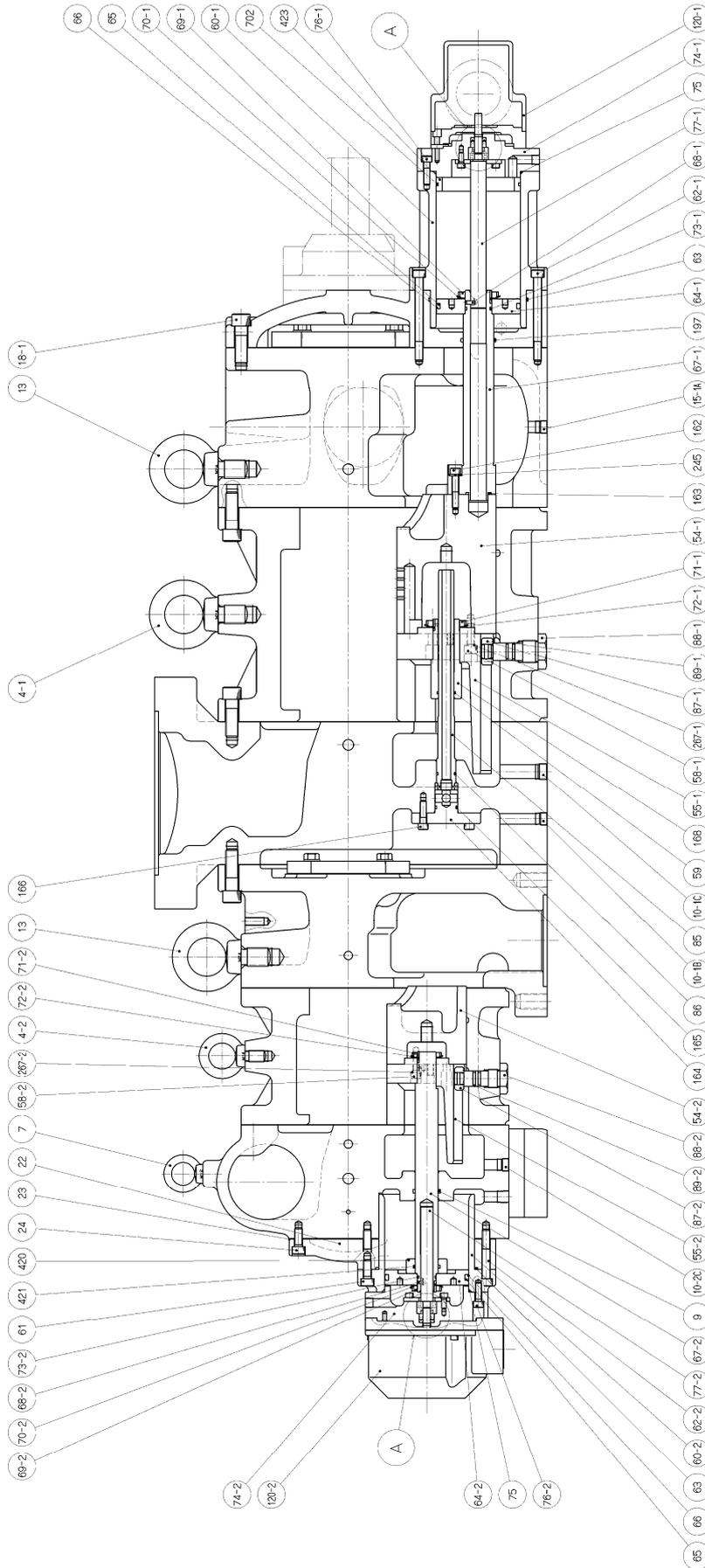


Figure 7-9 2016MSC Assembly Sectional View (Vertical)

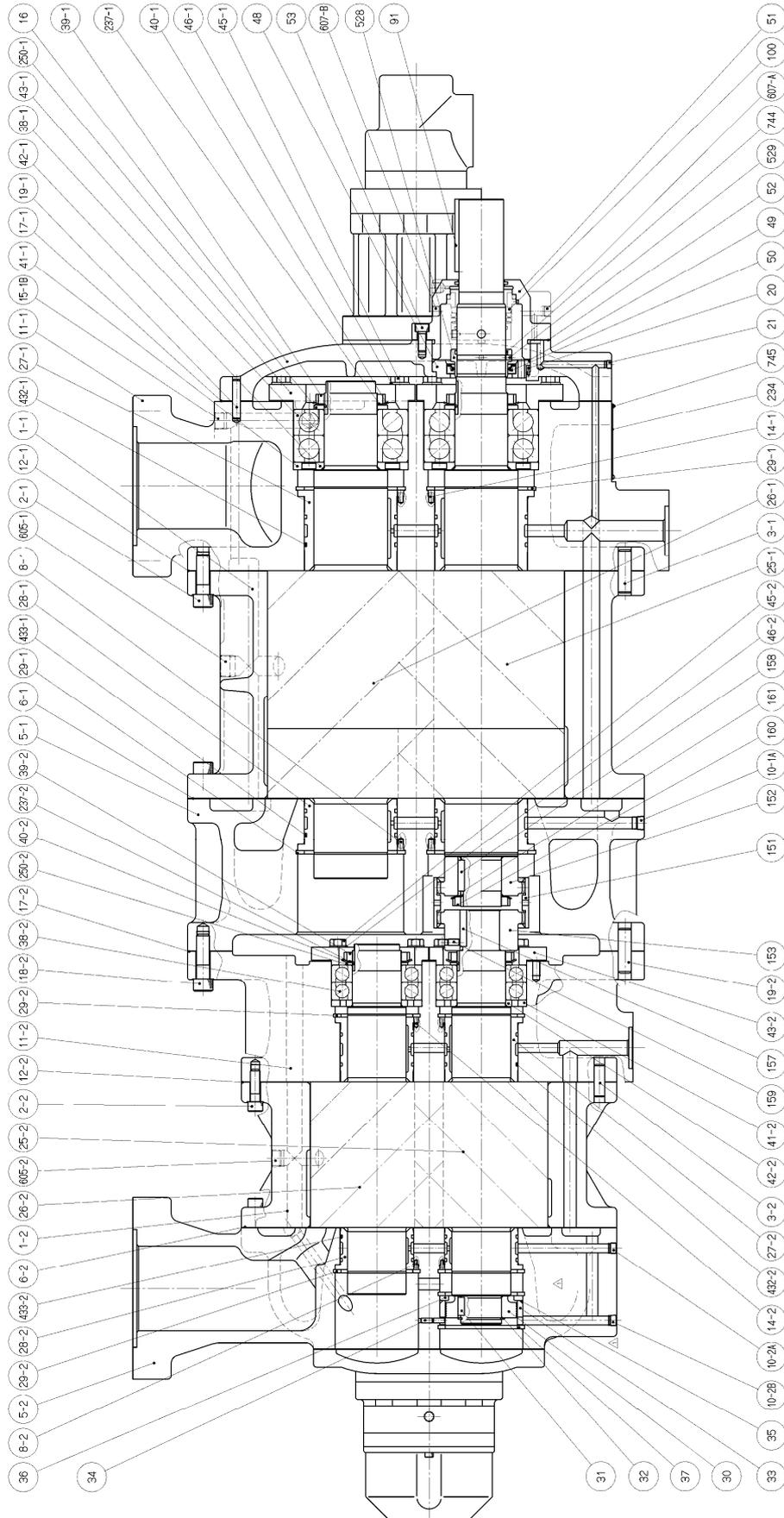


Figure 7-10 2016MSC Assembly Sectional View (Horizontal)

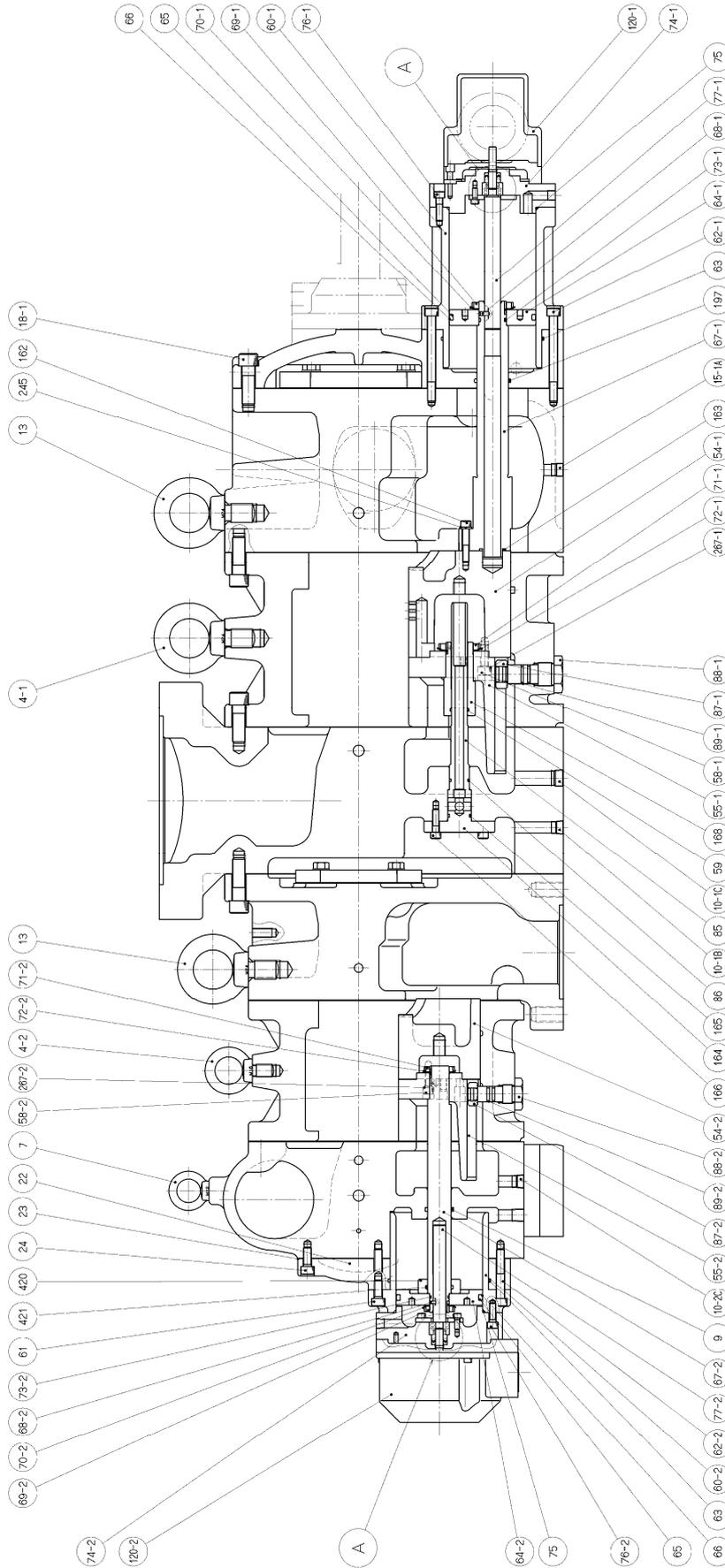


Figure 7-11 2016SSC Assembly Sectional View (Vertical)

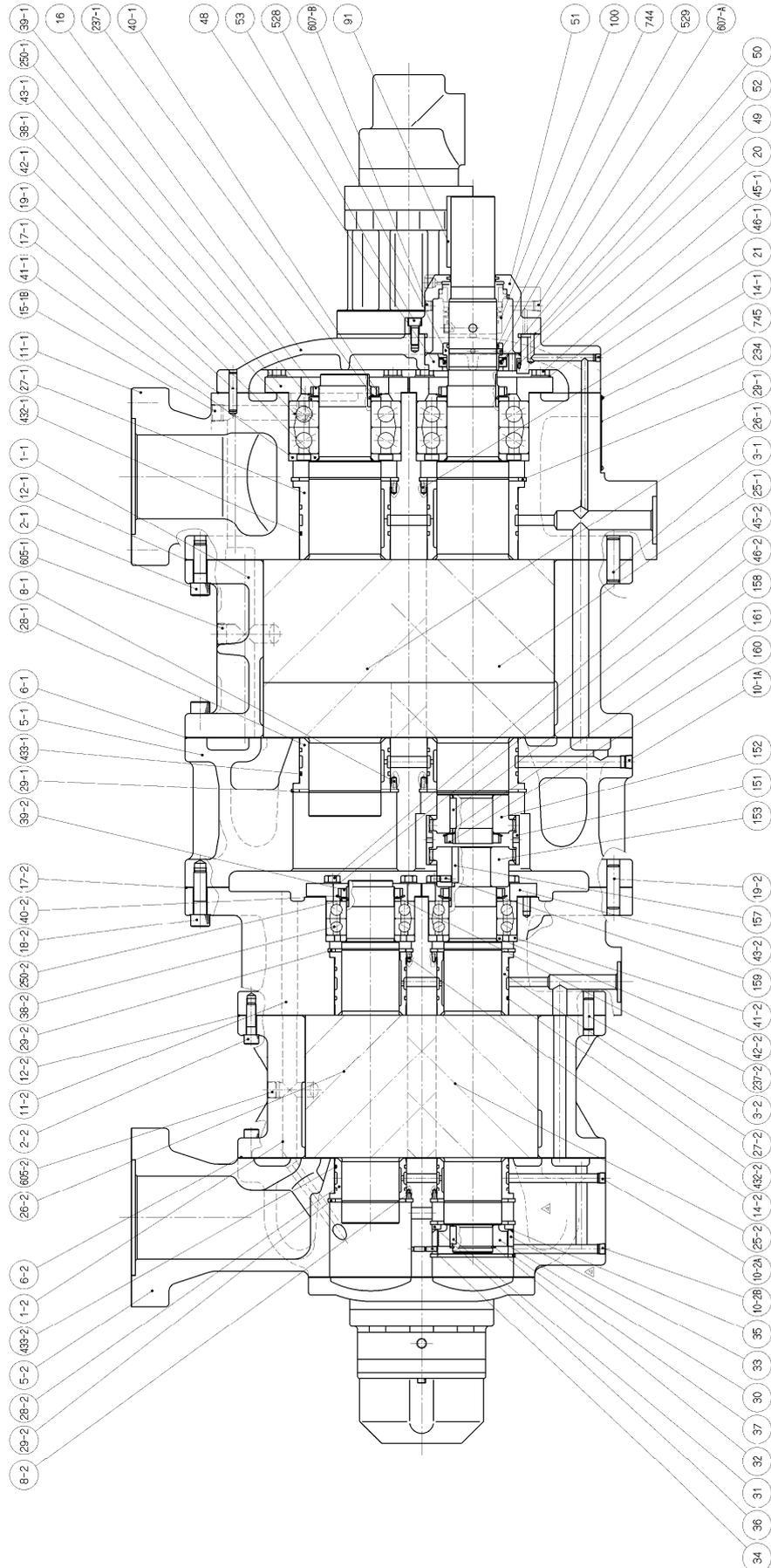


Figure 7-12 2016SSC Assembly Sectional View (Horizontal)

7.2 Parts Configuration Table

Table 7-1 Parts Configuration Table

No.	Part name	Code No.	Remarks	Q'ty.				
				LLC	LMC	LSC	MSC	SSC
1-1	Main Rotor Casing (1)	CS00100-200L	200L**	1	1	1	-	-
1-1	Main Rotor Casing (1)	CS00100-200M	200M**	-	-	-	1	-
1-1	Main Rotor Casing (1)	CS00100-200S	200S**	-	-	-	-	1
1-2	Main Rotor Casing (2)	CS00100-160L	160L**	1	-	-	-	-
1-2	Main Rotor Casing (2)	CS00100-160M	160M**	-	1	-	-	-
1-2	Main Rotor Casing (2)	CS00100-160S	160S**	-	-	1	1	1
2-1	Hexagon Socket Head Cap Screw	NB35416-050	M16×50	50	50	50	50	50
2-2	Hexagon Socket Head Cap Screw	NB35412-040	M12×40	52	52	52	52	52
3-1	Alignment Pin	NE2016-055	Φ16×55	4	4	4	4	4
3-2	Alignment Pin	NE2013-040	Φ13×40	4	4	4	4	4
4-1	Eye Bolt	NB600-020	M20	1	1	1	1	1
4-2	Eye Bolt	NB600-016	M16	1	1	1	1	1
5-1	Suction Cover (1)	CS00500-2016C1	2016**C	1	1	1	1	1
5-2	Suction Cover (2)	CS00500-2016C2	2016**C	1	1	1	1	1
6-1	Gasket, Suction Cover (1)	CS00600-200N	200***	1	1	1	1	1
6-2	Gasket, Suction Cover (2)	CS00600-160N	160***	1	1	1	1	1
7	Eye Bolt	NB600-012	M12	2	2	2	2	2
8-1	Spring Pin (1)	NE3206-012	Φ6×12	2	2	2	2	2
8-2	Spring Pin (2)	NE3204-010	Φ4×10	2	2	2	2	2
9	O-ring	PA11-030	JISB24011AP30	1	1	1	1	1
10-1A	Plug	NF06-010	R3/8	1	1	1	1	1
10-1B	Plug	NF06-015	R1/2	1	1	1	1	1
10-2A	Plug	NF06-008	R1/4	1	1	1	1	1
10-2B	Plug	NF06-008	R1/4	1	1	1	1	1
10-2C	Plug	NF06-010	R3/8	1	1	1	1	1
11-1	Bearing Head (1)	CS01100-2016C1	2016**C	1	1	1	1	1
11-2	Bearing Head (2)	CS01100-2016C2	2016**C	1	1	1	1	1
12-1	Gasket, Bearing Head (1)	CS01200-200N	200***	1	1	1	1	1
12-2	Gasket, Bearing Head (2)	CS01200-160N	160***	1	1	1	1	1
13	Eye Bolt	NB600-024	M24	2	2	2	2	2
14-1	Spring Pin	NE320G-012	Φ6×12	2	2	2	2	2
14-2	Spring Pin	NE3204-010	Φ4×10	2	2	2	2	2
15-1A	Plug	NF06-015	R1/2	1	1	1	1	1
15-1B	Plug	NF06-010	R3/8	1	1	1	1	1
16	Bearing Cover	CS01600-2016C	2016**C	1	1	1	1	1
17-1	Gasket, Bearing Cover (1)	CS01700-2016C1N	2016**C	1	1	1	1	1
17-2	Gasket, Bearing Cover (2)	CS01700-2016C2N	2016**C	1	1	1	1	1
18-1	Hexagon Socket Head Cap Screw	NB35416-050	M16×50	18	18	18	18	18
18-2	Hexagon Socket Head Cap Screw	NB35416-055	M16×55	25	25	25	25	25

No.	Part name	Code No.	Remarks	Q'ty.				
				LLC	LMC	LSC	MSC	SSC
19-1	Alignment Pin	NE2010-050	Φ10×50	2	2	2	2	2
19-2	Alignment Pin	NE2016-055	Φ16×55	2	2	2	2	2
20	Spring Pin	NE3203-010	Φ3×10	1	1	1	1	1
21	Plug	NF06-004	R1/8	1	1	1	1	1
22	Balance Piston Cover	CS02202-160VD	160***	1	1	1	1	1
23	Gasket, Balance Piston Cover	CS02300-160N	160***	1	1	1	1	1
24	Hexagon Socket Head Cap Screw	NB35410-025	M10×25	11	11	11	11	11
25-1	Male Rotor (1)	CS02500-2016****	2016L*C	1	1	1	-	-
25-1	Male Rotor (1)		2016M*C	-	-	-	1	-
25-1	Male Rotor (1)		2016S*C	-	-	-	-	1
25-2	Male Rotor (2)		2016*LC	1	-	-	-	-
25-2	Male Rotor (2)		2016*MC	-	1	-	-	-
25-2	Male Rotor (2)		2016*SC	-	-	1	1	1
26-1	Female Rotor (1)		2016L*C	1	1	1	-	-
26-1	Female Rotor (1)		2016M*C	-	-	-	1	-
26-1	Female Rotor (1)		2016S*C	-	-	-	-	1
26-2	Female Rotor (2)		2016*LC	1	-	-	-	-
26-2	Female Rotor (2)		2016*MC	-	1	-	-	-
26-2	Female Rotor (2)		2016*SC	-	-	1	1	1
27-1	Main bearing (1)	CS0270-ERT	200***	2	2	2	2	2
27-2	Main bearing (2)	CS0270-DRT	160***	2	2	2	2	2
28-1	Side bearing (1)	CS0280-ERT	200***	2	2	2	2	2
28-2	Side bearing (2)	CS0280-DRT	160***	2	2	2	2	2
29-1	Stop Ring (1)	NG11-130	H130	4	4	4	4	4
29-2	Stop Ring (2)	NG11-102	H102	4	4	4	4	4
30	Balance Piston	CS03000-160	160***	1	1	1	1	1
31	Key, Balance Piston	CS03100-160	160***	1	1	1	1	1
32	Stop Ring	NG12-050	S50	1	1	1	1	1
33	Sleeve, Balance Piston	CS03300-160	160***	1	1	1	1	1
34	Set Screw	NA83606-015	M6×15	2	2	2	2	2
35	O-ring	PA12-095	JISB24011AG95	1	1	1	1	1
36	Spacer, O-ring	CS03600-160	160***	1	1	1	1	1
37	Stop Ring	NG11-102	H102	2	2	2	2	2
38-1	Thrust Bearing (1)	CS03800-200P	7313B	2	2	2	2	2
38-2	Thrust Bearing (2)	CS03800-160P	7212B	2	2	2	2	2
39-1	Lock Nut (1)	NG31-013	AN13	2	2	2	2	2
39-2	Lock Nut (2)	NG31-012	AN12	2	2	2	2	2
40-1	Lock Washer (1)	NG32-013	AW13	2	2	2	2	2
40-2	Lock Washer (2)	NG32-012	AW12	2	2	2	2	2
41-1	Spacer, Thrust Bearing (1)	CS04100-200	200***	2	2	2	2	2
41-2	Spacer, Thrust Bearing (2)	CS04100-160	160***	2	2	2	2	2
42-1	Spacer, Thrust Alignment (1)	CS04200B200	200***	2	2	2	2	2
42-2	Spacer, Thrust Alignment (2)	CS04200-160	160***	2	2	2	2	2

No.	Part name	Code No.	Remarks	Q'ty.				
				LLC	LMC	LSC	MSC	SSC
43-1	Thrust Bearing Gland (1)	CS04300-200S	200***	2	2	2	2	2
43-2	Thrust Bearing Gland (2)	CS043002016C2B	2016**C	2	2	2	2	2
45-1	Hexagon Head Bolt	NB111012-035	M12×35	8	8	8	8	8
45-2	Hexagon Head Bolt	NB111010-030	M10×30	8	8	8	8	8
46-1	Lock Washer (1)	ND150-012	200***	8	8	8	8	8
46-2	Lock Washer (2)	ND150-010	160***	8	8	8	8	8
48	Retainer, Oil Seal	CS04800-200VDS	200***	1	1	1	1	1
49	O-ring	PA12-115	JISB24011AG115	1	1	1	1	1
50	Oil Seal	CS05010-200VD	SA1J 65×85×12	1	1	1	1	1
51	Seal Cover	CS05100-200	200***	1	1	1	1	1
51	Seal Cover	CS05100-200HE	200*** (for HE)	1	1	1	1	1
52	Gasket, Seal Cover	CS05200-200N	200***	1	1	1	1	1
53	Hexagon Socket Head Cap Screw	NB35410-025	M10×25	8	8	8	8	8
54-1	Unloader Slide Valve (1-1) (L port)	CS05400-2016****	2016LSC	1	1	1	-	-
54-1	Unloader Slide Valve (1-1) (M port)		2016LSC	1	1	1	-	-
54-1	Unloader Slide Valve (1-1) (L port)		2016MSC	-	-	-	1	-
54-1	Unloader Slide Valve (1-1) (M port)		2016MSC	-	-	-	1	-
54-1	Unloader Slide Valve (1-1) (L port)		2016SSC	-	-	-	-	1
54-1	Unloader Slide Valve (1-1) (M port)		2016SSC	-	-	-	-	1
54-2	Unloader Slide Valve (1-2) (L port)		2016*SC	-	-	1	1	1
54-2	Unloader Slide Valve (1-2) (M port)		2016*SC	-	-	1	1	1
54-2	Unloader Slide Valve (1-2) (H port)		2016MSC	-	-	-	1	-
54-2	Unloader Slide Valve (1-2) (L port)		2016LLC	1	-	-	-	-
54-2	Unloader Slide Valve (1-2) (M port)		2016*LC	1	-	-	-	-
54-2	Unloader Slide Valve (1-2) (L port)		2016LMC	-	1	-	-	-
54-2	Unloader Slide Valve (1-2) (M port)		2016*MC	-	1	-	-	-
55-1	Unloader Slide Valve (2-1)		200L**	1	1	1	-	-
55-1	Unloader Slide Valve (2-1)		200M**	-	-	-	1	-
55-1	Unloader Slide Valve (2-1)		200S**	-	-	-	-	1
55-2	Unloader Slide Valve (2-2)		160L**	1	-	-	-	-
55-2	Unloader Slide Valve (2-2)		160M**	-	1	-	-	-
55-2	Unloader Slide Valve (2-2)		160S**	-	-	1	1	1
58-1	Hexagon Socket Head Cap Screw	NB35410-030	M10×30	4	4	4	4	4
58-2	Hexagon Socket Head Cap Screw	NB35408-025	M8×25	4	4	4	4	4
59	O-ring	PA11-020	JISB2401 1A P20	1	1	1	1	1

No.	Part name	Code No.	Remarks	Q'ty.				
				LLC	LMC	LSC	MSC	SSC
60-1	Unloader Cylinder	CS06000-2016C	2016LSC	1	1	1	1	1
60-2	Unloader Cylinder	CS06000-160L	160L**	1	-	-	-	-
60-2	Unloader Cylinder	CS06000-160M	160M**	-	1	-	-	-
60-2	Unloader Cylinder	CS06000-160S	160S**	-	-	1	1	1
61	Hexagon Socket Head Cap Screw	NB35410-025	M10×25	2	2	2	2	2
62-1	Hexagon Socket Head Cap Screw	NB35410-110	M10×110	8	8	8	8	8
62-2	Hexagon Socket Head Cap Screw	NB35410-065	M10×65	6	6	6	6	6
63	O-ring	PA12-125	JISB2401 1A G125	2	2	2	2	2
64-1	Unloader Piston (1)	CS06400-2016T	2016LSC	1	1	1	1	1
64-2	Unloader Piston (2)	CS06400-160T	160***	1	1	1	1	1
65	O-ring	PA11-100	JISB2401 1A P100	2	2	2	2	2
66	Cap Seal	CS06600-160	CAP-1BE100	2	2	2	2	2
67-1	Push Rod, Unloader Slide Valve (1)	CS06700-2016C1	2016LSC	1	1	1	1	-
67-1	Push Rod, Unloader Slide Valve (1)	CS06700-2016SSC	2016SSC	-	-	-	-	1
67-2	Push Rod, Unloader Slide Valve (2)	CS06700-2016C2	2016LSC	-	-	1	1	1
67-2	Push Rod, Unloader Slide Valve (2)	CS06700-2016LLC	2016LLC	1	-	-	-	-
67-2	Push Rod, Unloader Slide Valve (2)	CS06700-2016LMC	2016LMC	-	1	-	-	-
68-1	Guide Pin	NE2505-012	Φ5×12	1	1	1	1	1
68-2	Guide Pin	NE2503-008	Φ3×8	1	1	1	1	1
69-1	Lock Nut (1)	NG31-007	AN07	1	1	1	1	1
69-2	Lock Nut (2)	NG31-005	AN05	1	1	1	1	1
70-1	Lock Washer (1)	NG32-007	AW07	1	1	1	1	1
70-2	Lock Washer (2)	NG32-005	AW05	1	1	1	1	1
71-1	Lock Nut (1)	NG31-007	AN07	1	1	1	1	1
71-2	Lock Nut (2)	NG31-005	AN05	1	1	1	1	1
72-1	Lock Washer (1)	NG32-007	AW07	1	1	1	1	1
72-2	Lock Washer (2)	NG32-005	AW05	1	1	1	1	1
73-1	O-ring	PA12-030	JISB2401 1A G30	1	1	1	1	1
73-2	O-ring	PA11-021	JISB2401 1A P21	1	1	1	1	1
74-1	Unloader Cylinder Cover (1)	CS07400-2016S	2016LSC	1	1	1	-	1
74-1	Unloader Cylinder Cover (1)	CS07400-2016MSC	2016MSC	-	-	-	1	-
74-2	Unloader Cylinder Cover (2)	CS07400-160S	160***	1	1	1	1	1
74-2	Unloader Cylinder Cover (2) (Explosion-Proof Type)	CS07460-160	160***	1	1	1	1	1
75	O-ring	PA12-110	JISB2401 1A G110	2	2	2	2	2
76-1	Hexagon Socket Head Cap Screw	NB35408-030	M8×30	8	8	8	8	8
76-2	Hexagon Socket Head Cap Screw	NB35408-025	M8×25	8	8	8	8	8
77-1	Indicator CAM (1)	CS07700-2016C	2016LSC	1	1	1	-	-
77-1	Indicator CAM (1)	CS07700-2016MSC	2016MSC	-	-	-	1	-

No.	Part name	Code No.	Remarks	Q'ty.				
				LLC	LMC	LSC	MSC	SSC
77-1	Indicator CAM (1)	CS07700-2016SSC	2016SSC	-	-	-	-	1
77-2	Indicator CAM (2)	CS07700-160L	160L**	1	-	-	-	-
77-2	Indicator CAM (2)	CS07700-160M	160M**	-	1	-	-	-
77-2	Indicator CAM (2)	CS07700-160S	160S**	-	-	1	1	1
78	Ball Bearing	CS07800-200	#6000	2	2	2	2	2
79	Stop Ring	NG12-010	S10	2	2	2	2	2
80	Bearing Gland	CS08000-200	200***	2	2	2	2	2
81	Hexagon Socket Head Cap Screw	NB35406-015	M6×15	6	6	6	6	6
82	V-ring	CS08200-200B	20×10×12	2	2	2	2	2
83	Spring	CS08300-200	200***	2	2	2	2	2
84	Retainer, Indicator Cam Spring	CS08400-200	200***	2	2	2	2	2
85	Oil Injection Pipe	CS08500-200LUK	200LU*	1	1	1	-	-
85	Oil Injection Pipe	CS08500-2016MSC	2016MSC	-	-	-	1	-
85	Oil Injection Pipe	CS08500-2016SSK	2016SSC	-	-	-	-	1
86	O-ring	PA11-021	JISB2401 1A P21	1	1	1	1	1
87-1	Guide Block (1)	CS08700-200	200***	1	1	1	1	1
87-2	Guide Block (2)	CS08700-160	160***	1	1	1	1	1
88-1	Stem, Guide Block (1)		200&250***	1	1	1	1	1
88-2	Stem, Guide Block (2)		160***	1	1	1	1	1
89-1	O-ring	PA11-020	JISB2401 1A P20	2	2	2	2	2
89-2	O-ring	PA11-016	JISB2401 1A P16	2	2	2	2	2
91	Shaft key (1)	CS09100-200	200***	1	1	1	1	1
92-1	Suction Flange (1)	CS71300-150	JIS20K 150A(6")	1	1	1	1	1
92-2	Suction Flange (2)	CS71300-100	JIS20K 100A(4")	1	1	1	1	1
93-1	Gasket, Suction Flange (1)	CS71200-150N	JIS20K 150A(6")	1	1	1	1	1
93-2	Gasket, Suction Flange (2)	CS71200-100N	JIS20K 100A(4")	1	1	1	1	1
94-1	Hexagon Head Bolt	NB12022-055	M22×55	12	12	12	12	12
94-2	Hexagon Head Bolt	NB12020-055	M20×55	8	8	8	8	8
95-1	Discharge Flange (1)	CS71300-100	JIS20K 100A(4")	1	1	1	1	1
95-2	Discharge Flange (2)	CS71300-080	JIS20K 80A(3")	1	1	1	1	1
96-1	Gasket, Discharge Flange (1)	CS71200-100N	JIS20K 100A(4")	1	1	1	1	1
96-2	Gasket, Discharge Flange (2)	CS71200-080N	JIS20K 80A(3")	1	1	1	1	1
97-1	Hexagon Head Bolt	NB12020-055	M20×55	8	8	8	8	8
97-2	Hexagon Head Bolt	NB12020-055	M20×55	8	8	8	8	8
100	Mechanical Seal Assembly (BBSE)	CS10002-200EBS	BBS-E	1	1	1	1	1
120-1	Unloader Indicator Assembly (1)	CS12000-1612F	1612LSC	1	1	1	1	1
120-2	Unloader Indicator Assembly (2)	CS12000-200F	200*** 20-100%	1	1	1	1	1
151	Driven Sleeve	CS15100-2016		1	1	1	1	1
152	Drive Hub			1	1	1	1	1
153	Driven Hub			1	1	1	1	1
154	Stopper, Driven Sleeve	CS15400-2016C		2	2	2	2	2
155	Stop Ring		FRS-90	4	4	4	4	4

No.	Part name	Code No.	Remarks	Q'ty.				
				LLC	LMC	LSC	MSC	SSC
157	Key, Driven Hub	CS15700-2016C		1	1	1	1	1
158	Key, Drive Hub	CS15800-2016C		1	1	1	1	1
159	Set Screw	NA83608-015	M8x15 knurled, anti-loosening	1	1	1	1	1
160	Lock Nut	NG31-010	AN10	1	1	1	1	1
161	Lock Washer	NG32-010	AW10	1	1	1	1	1
162	Hexagon Socket Head Cap Screw	NB35406-045	M8x45	5	5	5	5	5
163	O-ring	PA12-025	JISB2401 1A G25	1	1	1	1	1
164	Retainer, Oil Injection Pipe	CS16400-2016C		1	1	1	1	1
165	O-ring	PA12-025	JISB2401 1A G25	1	1	1	1	1
166	Hexagon Socket Head Cap Screw	NB35408-030	M8x30	4	4	4	4	4
168	Pipe Guide, Oil Injection	CS16800-2016		1	1	1	1	1
197	O-ring	PA11-040	JISB2401 1A P40	1	1	1	1	1
215-1	Flange, Lubrication Oil Supply (1)	CS71300-025	JIS20K 25A(1")	1	1	1	1	1
215-2	Flange, Lubrication Oil Supply (2)	CS71300-020	JIS20K 20A(3/4")	1	1	1	1	1
216-1	Gasket, Lubrication Oil Supply Flange (1)	CS71200-025N	JIS20K 25A	1	1	1	1	1
216-2	Gasket, Lubrication Oil Supply Flange (2)	CS71200-020N	JIS20K 20A	1	1	1	1	1
217-1	Hexagon Head Bolt	NB111016-045	M16x45	4	4	4	4	4
217-2	Hexagon Head Bolt	NB111012-035	M12x35	4	4	4	4	4
218	Flange, Injection Oil Supply	CS71300-015	JIS20K 15A(1/2")	1	1	1	1	1
219	Gasket, Injection Oil Supply Flange	CS71200-015N	JIS20K 15A	1	1	1	1	1
220	Hexagon Head Bolt	NB111012-035	M12x35	4	4	4	4	4
237-1	Torsional Slip Washer (1)	CS23700-200	200***	2	2	2	2	2
237-2	Torsional Slip Washer (2)	CS23700-160	160***	2	2	2	2	2
245	Special Spring Washer for Hexagon Socket Head Cap Screw	ND330-08	M8	5	5	5	5	5
250-1	Thrust Washer (1)	CS25000-200	200***	2	2	2	2	2
250-2	Thrust Washer (2)	CS25000-160	160***	2	2	2	2	2
267-1	Special Spring Washer for Hexagon Socket Head Cap Screw	ND330-10	M10	4	4	4	4	4
267-2	Special Spring Washer for Hexagon Socket Head Cap Screw	ND330-08	M8	4	4	4	4	4
420	Unload Spacer	CS42000-2016	For 2016*LC(2) 20% load	1	-	-	-	-
420	Unload Spacer		For 2016*MC(2) 20% load	-	1	-	-	-
420	Unload Spacer		For 2016*SC(2) 20% load	-	-	1	1	1
421	O-ring	PA12-030	JISB2401 1A G30	-	-	1	1	1
421	O-ring	PA11-030	JISB2401 1A P30	2	2	-	-	-
423	Unload spacer		Used for MSC low-stage only.	-	-	-	1	-

No.	Part name	Code No.	Remarks	Q'ty.				
				LLC	LMC	LSC	MSC	SSC
424	Hexagon Socket Head Cap Screw	NB35406-020	M6×20 Note 1	-	-	-	3	-
432-1	O-ring	PA62-022	JIS W1516 1A G22	4	4	4	4	4
432-2	O-ring	PA12085	JISB2401 1A G85	4	4	4	4	4
433-1	O-ring	PA62022	JIS W1516 1A G22	4	4	4	4	4
433-2	O-ring	PA12-085	JISB2401 1A G85	4	4	4	4	4
528	Sleeve, Oil Seal	CS52809-200VD	200V** with O-ring	1	1	1	1	1
529	Set Screw	NA83606-008	M6×8	2	2	2	2	2
605-1	Plug	NF06-008	R3/4	1	1	1	1	1
605-2	Plug	NF06-015	R1/2	1	1	1	1	1
607	Plug	NF06-004	R1/8	1	1	1	1	1
702	O-ring	PA12-100	JISB2401 1A G100 *1	-	-	-	1	-
744	O-ring	PA12-060	JISB2401 1A G60	1	1	1	1	1
-	O-ring Set	CS7109-0K	2016C NBR					
-	O-ring Set	CS7109-5K	2016C FPM					
-	Gasket Set	CS7118-0K	2016C					
-	Lock Nut and Washer Set	CS8009-K	2016C					

CAUTION

- **The part code of the O-ring is the one assigned to NBR which is standard material. When the material of the O-ring is other than NBR, a different part code is used for each material.
If you are using O-rings made from other than the standard material, please contact Mayekawa when placing an order.**

Note 1: The hexagon socket head cap screw (No. 424) is used to fasten the unload spacer (No. 423), which is for the exclusive use of the MSC low-stage, to the unloader cylinder cover (No. 74-1). In April 2007, this spacer and the explosion proof type unloader piston spacer were standardized according to the design change notification. As a result, the use of this part is discontinued. One piece of O-ring (No.702) (JIS B 2401 G100) is used instead of this part. According to this design change notification, the use of the MSC unloader cylinder cover (1) with bolt hole for spacer is also discontinued. The MSC unloader cylinder cover and the LSC unloader cylinder cover are shared/standardized.

7.3 Tightening Torques for Bolts and Nuts

Table 7-2 List of Tightening Torques

■ Hexagon socket head cap screw

No.	What is tightened	Tightening torque		Q'ty.	Size
		N·m	kgf·cm		
2-1	Main Rotor Casing (1) to Suction Cover (1) and Bearing Head (1)	240	2400	50	M16×50
2-2	Main Rotor Casing (2) to Suction Cover (2) and Bearing Head (2)	90	900	52	M12×40
18-1	Bearing Cover to Bearing Head (1)	240	2400	18	M16×50
18-2	Bearing Head (2) to Suction Cover (1)	240	2400	25	M16×55
24	Balance Piston Cover to Suction Cover (2)	50	500	11	M10×25
53	Seal Cover to Bearing Cover	50	500	8	M10×25
58-1	For Securing Unloader Slide Valve	50	500	4	M10×30
58-2	For Securing Unloader Slide Valve	25	250	4	M8×25
61	Unloader Cylinder (2) to Balance Piston Cover	50	500	2	M10×25
62-1	Unloader Cylinder (1) to Bearing Cover and Bearing Head (1)	50	500	8	M10×110
62-2	Unloader Cylinder (2) to Balance Piston Cover and Suction Cover	50	500	6	M10×65
76-1	Unloader Cylinder Cover (1) to Unloader Cylinder (1)	25	250	8	M8×30
76-2	Unloader Cylinder Cover (2) to Unloader Cylinder (2)	25	250	8	M8×25
81	Bearing Gland	10	100	6	M6×15
162	Push Rod, Unloader Slide Valve (1)	25	250	5	M8×45
166	Gland, Oil Injection Pipe	25	250	4	M8×30

■ Hexagon Head Bolt

No.	What is tightened	Tightening torque		Q'ty.	Size
		N·m	kgf·cm		
45-1	Thrust Bearing Gland (1) * Specified torque	50	500	8	M12×35
45-2	Thrust Bearing Gland (2) * Specified torque	40	400	8	M10×30
94-1	Suction Flange (1) JIS20K 150A	240	2400	12	M22×55
94-2	Suction Flange (intermediate pipe) (2) JIS20K 100A	180	1800	8	M20×55
97-1	Discharge Flange (intermediate pipe) (1) JIS20K 100A	180	1800	8	M20×55
97-2	Discharge Flange (2) JIS20K 80A	120	1200	8	M16×55

■ Lock Nut

No.	What is tightened	Tightening torque (N·m)		Q'ty.	Size
		Standard	Maximum		
39-1	Thrust Bearing (1) Note 1	522	653	2	AN13
39-2	Thrust Bearing (2) Note 1	408	510	2	AN12
69-1	Unloader Piston (1) * Specified torque	120	-	1	AN07
69-2	Unloader Piston (2) * Specified torque	80	-	1	AN05
71-1	Unloader Slide Valve (1-1)	79	99	1	AN07
71-2	Unloader Slide Valve (1-2)	28	35	1	AN05
160	Gear Coupling Drive Hub Note 1	238	297	1	AN10

Note 1: On June 14, 2010, the "Lock Nut Tightening Angle Range Control Standard" has been introduced to our compressor manufacturing division, to control the specified tightening torque for rotor shaft lock nuts ([39-1][39-2][160] in tables above) as follows. Accordingly, the tightening angle range is now added to the rotor shaft lock nut tightening procedure in this manual.

■ Tightening Angle Range of Lock Nuts for Rotors

- After tightening the lock nut by hand, further tighten the lock nut by using a lock nut wrench until the rotor starts to turn. Take care not to over-tighten.
- Put a mark on the lock nut at the right side edge of the rotor groove where the stopper tongue of the lock washer fits in, as shown in Figure 7-9.
- From this marking position, tighten the lock nut in such a way that rotation can be stopped within the tightening angle range shown in Table 7-3 (2016**C [39-1] , [39-2] and [160] : 30° to 40°(first time tightening), 20° to 30°(second time tightening). When measuring the angle, use an angle gauge which is set to the diameter of rotor shaft.

Table 7-3 Tightening Angles Specified for Lock Nuts of Rotor

	Model	Angle range
First time tightening	125 to 250	30° to 40°
	320/400	25° to 35°
Second time tightening	125 to 250	20° to 30°
	320/400	15° to 25°

Rotor groove (slot) where stopper tongue of the lock washer fits

Marking

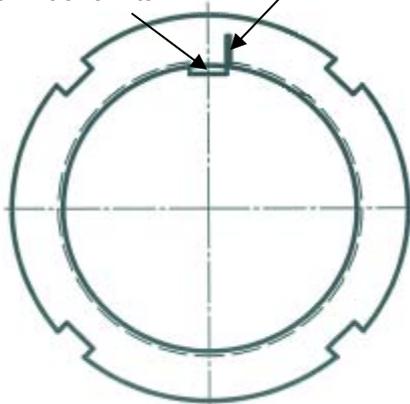


Figure 7-9 Position where mark is put

* When tightening lock nut, tightening start position differs between the first time tightening and the tightening for the second time or after. Therefore, angle ranges are specified also for the second time tightening.

7.4 About the O-rings Used

7.4.1 List of O-rings Used

Table 7-3 List of O-rings Used

No.	Location		nominal symbols
	attached place	description in functional aspect	
9	Suction Cover (2)	Push Rod	P30
35	Sleeve, Balance Piston	same as left	G95
49	Oil Seal Retainer	same as left	G115
59	Pipe Guide, Oil Injection	Oil Injection Pipe	P20
63	Bearing Cover, Balance Piston Cover	Unloader Cylinder (1), (2)	G125
65	Unloader Piston (1), (2)	same as left	P100
73-1	Unloader Push Rod (1)	Unloader Piston (1)	G30
73-2	Unloader Push Rod (2)	Unloader Piston (2)	P21
75	Unloader Cylinder Cover (1), (2)	same as left	G110
86	Oil Injection Pipe	same as left	P21
89-1	Stem, Guide block (1)	same as left	P20
89-2	Stem, Guide block (2)	same as left	P16
163	Unloader Slide Valve (1)	same as left	G25
165	Gland, Oil Injection Pipe	same as left	G25
197	Bearing Cover	Push Rod, Unloader Slide Valve (1)	P40
421	Unload Spacer 2016*SC (2)	same as left	G30
421	Unload Spacer 2016*LC (2), *MC (2)	same as left	P30
432-1	Main Bearing (1)	same as left	* WG22
432-2	Main Bearing (2)	same as left	G85
433-1	Side Bearing (1)	same as left	* WG22
433-2	Side Bearing (2)	same as left	G85
702	Unloader Spacer (used for MSC low-stage only)	same as left	G100
744	Sleeve, Oil Seal	same as left	G60

- Nominal symbols with * are as per JIS W1516:1965 and other symbols are as per JIS B2401:2005.
- Attached place means parts which they have grooves or with taper cutting for attaching O-ring.

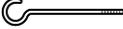
7.4.2 O-ring Materials Used for Screw Compressor

Table 7-4 List of O-ring Materials Used for Screw Compressor
(excluding mechanical seal)

Working fluid	O-ring material
Ammonia	NBR
HFC	
CO ₂	FKM
	HNBR
R23	FKM
Propane	
Propylene	
Natural gas	
City gas	
Helium	

7.5 Tools for Disassembly

Table 7-5 List of Tools for Disassembly

Tool name		size, etc.;
Ratchet wrench		1/4"
Adjustable wrench		250mm
Screwdriver		Phillips
Screwdriver		Flat blade
Stop ring pliers		for shaft
Stop ring pliers		for groove
Eye bolt		M8 two-piece-set
Allen wrench key		Across flats 2mm 3mm 4mm 5mm 6mm 8mm 10mm 12mm 14mm
Lock nut wrench		AN-07
		AN-08
		AN-10(L)
		AN-12
		AN-13
Torque wrench for assembly		5-25N·m
		20-100N·m
		40-280N·m

Chapter 8 Contact Information

8.1 How to Order **MYCOM** Genuine Parts

Confirm the target parts by referring to 7.1 "Development Views, Assembly Sectional Views" and 7.2 "Parts Configuration Tables" in Chapter 7 "Related Documents" of this manual.

Please inform the Model Name and Serial Number, Part Name, Cord No., and required quantity to our local sales offices or service centers.

When you need more information about the compressor or have questions, apart from the ordering of parts, please contact our sales offices or service centers.

8.2 Sales Offices/Service Centers

■ Sales Offices in Japan (as of December 10, 2013)

Description	Location	Phone/Fax
Head Office	3-14-15 BOTAN KOTO-KU, TOKYO 135-8482	TEL: 03-3642-8181 FAX: 03-3643-7094
Hokkaido Branch	2-5-1, 3-JYO NIJYUUYONKEN NISHI-KU, SAPPORO-CITY, HOKKAIDO 063-0803	TEL: 011-631-2052 FAX: 011-631-2053
Tohoku Branch	8-72, ROKUTYONO-MEMINAMI-MACHI, WAKABAYASHI-KU, SENDAI-CITY, MIYAGI 984-0013	TEL: 022-288-5001 FAX: 022-288-5155
Kanto Branch	3-14-15 BOTAN, KOTO-KU, TOKYO 135-8482	TEL: 03-3642-8968 FAX: 03-3641-8468
Chubu Branch	2-9-6, MARUNOUCHI, NAKA-KU, NAGOYA CITY, AICHI 460-0002	TEL: 052-218-3307 FAX: 052-218-3308
Kansai Branch	1-4-27, EBIE, FUKUSHIMA-KU, OSAKA CITY, OSAKA 553-0001	TEL: 06-4795-6000 FAX: 06-4795-6033
Chushikoku Branch	2-3-40, TAKAYADAI, HIGASHIHIROSHIMA CITY, HIROSHIMA 739-2117	TEL: 082-491-1830 FAX: 082-491-1838
Kyushu Branch	FUKUOKA-FUJILAND-BUILD. 10F, 2-3, NAKAJIMA-CHO, NAKASU, HAKATA-KU, FUKUOKA CITY, FUKUOKA 810-0802	TEL: 092-262-0016 FAX: 092-262-0115

■ Manufacturing Bases in Japan (as of December 10, 2013)

Description	Location	Phone/Fax
Moriya Plant	2000, TATSUZAWA MORIYA-CITY, IBARAKI 302-0118	TEL: 0297-48-1361 FAX: 0297-48-5269
Higashi-Hiroshima Plant	2-3-40, TAKAYADAI, HIGASHIHIROSHIMA CITY, HIROSHIMA 739-2117	TEL: 082-491-1828 FAX: 082-491-1838

■ **Global Network (as of December 10, 2013)**

Description	Location	Telephone and facsimile No.
NORTH AMERICA		
MAYEKAWA CANADA INC. (VANCOUVER OFFICE)	12180 RIVERSIDE WAY, RICHMOND, B.C., V6W 1K5, CANADA	TEL: (1) 604-270-1544 FAX: (1) 604-270-9870
MAYEKAWA CANADA INC. (TORONTO OFFICE)	1745 BONHILL ROAD, UNIT #6&7 MISSISSAUGA, ONTARIO, L5T 1C1, CANADA	TEL: (1) 905-564-0664 FAX: (1) 905-564-7614
MAYEKAWA CANADA INC. (CALGARY OFFICE)	4525 6A STREET N.E., CALGARY, ALBERTA, T2E 4B2, CANADA	TEL: (1) 403-250-1554 FAX: (1) 403-250-1504
MAYEKAWA U.S.A. INC. (CHICAGO OFFICE)	1850 JARVICE AVENUE, ELK GROVE VILLAGE, IL 60007, U.S.A.	TEL: (1) 773-516-5070 FAX: (1) 773-516-5071
MAYEKAWA U.S.A. INC. (NEW YORK OFFICE)	250 WEST NYACK ROAD,SUITE 230,WEST NYACK, NY 10994, U.S.A.	TEL: (1) 914-301-9770 FAX: (1) 914-332-0400
MAYEKAWA U.S.A. INC. (HEAD QUARTERS) (NASHVILLE PLANT)	130 SMART PARK DRIVE, LEBANON, TN 37090, U.S.A.	TEL: (1) 615-773-2859 FAX: (1) 615-444-1995
MAYEKAWA U.S.A. INC. (LA OFFICE)	19475 GRAMERCY PLACE, TORRANCE, CA 90501, U.S.A.	TEL: (1) 310-328-1362 FAX: (1) 310-782-6759
MAYEKAWA U.S.A. INC. (SEATTLE OFFICE)	2615 W CASINO ROAD, UNIT-3D, EVERETT, WA 98204, U.S.A.	TEL: (1) 425-645-9400 FAX: (1) 425-353-3344
MAYEKAWA U.S.A. INC. (PORTLAND OFFICE)	4700 SW MACADAM AVENUE, SUITE 201 PORTLAND, OREGON 97239, U.S.A.	TEL: (1) 971-230-1795 FAX: (1) 503-224-9259
MAYEKAWA U.S.A. INC. (COVINA OFFICE)	1272 CENTER COURT DR, SUITE 106, COVINA, CA 91724, U.S.A.	TEL: (1) 626-598-5030 FAX: (1) -
MAYEKAWA U.S.A. INC. (SAN ANTONIO OFFICE)	1219 SAFARI, SAN ANTONIO, TX 78216, U.S.A.	TEL: (1) 210-599-4536 FAX: (1) 210-599-4538
MAYEKAWA U.S.A. INC. (YORK OFFICE)	3395 FARMTRAIL ROAD YORK, PA 17406, U.S.A.	TEL: (1) 717-779-0138 FAX: (1) 717-779-0109
MAYEKAWA U.S.A. INC. CHEMICAL PROCESS DIVISION (LA OFFICE & MANUFACTURING)	19475 GRAMERCY PLACE, TORRANCE, CA 90501, U.S.A.	TEL: (1) 310-328-6279 FAX: (1) 310-328-8487
MAYEKAWA U.S.A. INC. CHEMICAL PROCESS DIVISION (HUSTON SERVICE OFFICE)	3222 PASADENA FREEWAY PASADENA, TX 77503, U.S.A.	TEL: (1) 281-447-2599 FAX: (1) 281-447-6623
EUROPE		
N.V.MAYEKAWA EUROPE S.A. (HEAD OFFICE, FACTORY)	LEUVENSESTEENWEG 605, 1930 ZAVENTEM, BELGIUM	TEL: (32) 2-757-9075 FAX: (32) 2-757-9023
MAYEKAWA DEUTSCHLAND GMBH	UNTER-BOHNHOF-STRASSE 38A, D-82110 GERMERING, DEUTSCHLAND	TEL:(49) 89-5527-989-0 FAX:(49)89-5527-989-19
MAYEKAWA DEUTSCHLAND GMBH (HUMBURG OFFICE)	WEIDESTRASSE 122A, 22083 HAMBURG DEUTSCHLAND	TEL:(49)40-2788-9149-0 FAX:(49)40-2788-9149-9

Description	Location	Telephone and facsimile No.
N.V.MAYEKAWA EUROPE S.A.(UK)	16 OAKHURST GARDENS, BEXLEYHEATH, KENT DA7 5JP, UNITED KINGDOM	TEL: (44) 1322-433558 FAX: (44) 1322-433164
MAYEKAWA. S.L.	CALLE MONTEVIDEO 5, NAVE 13 POL. INDUSTRIAL CAMPORROSO 28806 ALCALA DE HENARES, MADRID, SPAIN	TEL: (34) 91-830-0392 FAX: (34) 91-830-0397
MAYEKAWA FRANCAISE SARL	9, RUE MICHAEL FARADAY, 78180 MONTIGNY-LE-BRETONNEUX, FARNCE	TEL: (33) 1-30-58-26-00 FAX: (33) 1-30-58-19-37
MAYEKAWA MFG. CO., LTD. MOSCOW LIAISON OFFICE	KOROVY VAL ST., 7, OFFICE 228, 119049, MOSCOW, RUSSIA	TEL: (7) 499-230-01-76 FAX: (7) 499-230-21-12
MAYEKAWA INTERTEC AG	ROSENBERGSTRASSE 31, CH-6300 ZUG, SWITZERLAND	TEL: (41) 41-726-8626 FAX: (41) 41-726-8620
MAYEKAWA MIDDLE EAST FZCO	P.O.BOX 61349, PBU: RA08-UC05, JEBEL ALI FREE ZONE, DUBAI, U.A.E.	TEL: (971) 4-888-6363 FAX: (971) 4-888-6373
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MAYEKAWA (TAIWAN) CO., LTD. (TAICHUNG BRANCH)	NO. 19, SEC.3, HUANJUNG RD., TAICHUNG, TAIWAN, REP. OF CHINA	TEL: (886) 4-2251-4128 FAX: (886) 4-2251-4129
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