2202L5JE-DA-C5-N_2015.05.

MYCOM

Compound 2-stage Screw Compressor

1612LSC Speed Increaser Type Instruction Manual

1612LSC-52 ／ 1612LSC-62
1612LSC-53 ／ 1612LSC-63
1612LSC-54

CAUTION

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 and contents of this manual are subject to change without prior notice due to technical improvements, and the like.

MYCOM MAYEKAWA MFG. CO., LTD.

Preface

Thank you for purchasing this MYCOM compound two-stage screw compressor 1612LSC speed increaser type (hereinafter indicated as “this product”).

This instruction manual (hereinafter indicated as “this manual”) describes safety information, operational and maintenance procedures in detail for safe and effective use of this product, and applies to the following types.

1612LSC-*B*-52/62、1612LSC-*B*-53/63、1612LSC-*B*-54

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

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

Revision History

Title		Document No.	First Edition Issue Date
1612LSC Speed Increaser Type Instruction manual		**2202L5JE-DA-C5-N_2015.05.**	**2013.05.30**
Revision No.	**Issue Date**	**Major Contents of Revisions**	**Created / Approved by:**
—	1974.06.30	Issuance of 1612C first edition	Yamamoto
—	1983.10.01	New issuance as 1612C/2016C edition	Yamamoto
—	1993.06.30	Revision of 1612C/2016C (correcting editing errors, etc.)	Yamamoto
—	2006.06.30	2004.07 Re-examination by constitution of Product Liability Act	Ikehara / Shozu
00	2013.05.30	Overall re-examination by reissuance as an electronic edition, its document No. change	Ikehara / Hirao
01	2014.01.15	1.1.1「MSDS」change to「SDS」, etc.	Ikehara / Hirao
02	**2015.05.12**	**Modified the constitution of Chapter 4 and Chapter 5. Correction of describing, etc.**	**Ikehara / Muta**

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.

MAYEKAWA is not liable for production or man-made disaster compensation due to malfunction or damage of this product.

Disclaimer of Warranty

Although MAYEKAWA warrants the clauses mentioned above, the following clauses are exempted.

- Malfunction or damage of this product caused by natural disaster, or other accidental forces (such as fire, thunderbolt, windstorm, intense rainfall, flood, tidal wave, earthquake, land subsidence, etc.).
- Malfunction or damage caused by misusage described below.
  - Malfunctions, damage, or deterioration of this product due to abnormal or improper use (including improperly storing this product outdoors or under too hot/humid conditions, unexpected inspections, tests, operations, too frequent liquid flow-back operation*, and too frequent start-stop cycles, 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 refrigerants, gases, or refrigerant oils, and operating conditions (design conditions) not approved for this product.
  - Malfunction or damage caused by maintenance or inspection not recommended by MAYEKAWA.
  - Malfunction or damage caused by parts that are not MYCOM genuine.
  - Malfunction or damage caused by remodeling the product without approval of MAYEKAWA.
  - Malfunction or damage caused by unexpected misusage

"Liquid flow-back operation" is ・・・

Normally, while the compressor sucks in the refrigerant liquid only after vaporizing it in the evaporator, it may directly sucks it in because of the faulty adjustment or failure of the expansion valve. We call this state of compressor operation "liquid flow-back operation".

No compressor can compress a liquid. The compressor may be damaged should the liquid be sucked in.

Important Information

Intended Use of this Product

This product is a general-purpose screw compressor intended for refrigeration and cold storage.

Do not use the product for any purposes for which it was not intended or which depart from the specifications. For specifications of this product, refer to “2.3 Compressor Specifications”.

The maintenance items described in this manual should be performed safely and closely following procedures.

Important Information for Safe Use of this Product

Although MAYEKAWA has thoroughly considered the safety measures for this product, all hazards, including potential hazards caused by human error or environmental conditions, cannot be anticipated.

There are many guidelines that must be observed for operating this product. However, the warnings in this manual and the safety labels on the product are not all inclusive. When operating this product, always pay extreme attention to general safety precautions as well as on items described in this manual.

Important rules for safe operation that apply to all workers including managers and supervisors are listed below.

Before using this product, carefully read and fully understand the contents written in this manual and pay attention to safety.

- Operation, maintenance, and inspection of this product should be performed by qualified personnel educated about the fundamentals of the product and trained about the hazards involved and measures to avoid danger.
- Do not allow anyone other than those educated about the fundamental expertise of the product and trained about hazards involved and measures to avoid dangers to approach the 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, or use the product for any unapproved purpose.
- Replace parts with MYCOM genuine parts.
- Not only workers but also managers should actively participate in safety and health activities in the workplace to prevent accidents.
- When closing or opening valves during work, apply lockout/tagout without failure, to prevent the valves from closing or opening accidentally 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 by 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, the product may be turned on if power is supplied from outside the package unit in which this product is used. Make sure the power supply on the power source side is shut off, and perform lockout/tagout to prevent this 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. For each sight of MAYEKAWA, refer to "Contact Information" in this manual or following URL. http://www.mayekawa.com/about/network/
- This manual is in English. If any other language is required it is the customer's 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 in 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 the actual product.
- If this manual is lost or damaged, immediately place a purchase order to our local sales offices or service centers for a new manual. Using the product without the manual may result in safety issues.
- If you resell the product, never fail to include this manual with the product.

Construction of This Manual

Title of section and chapter	Description details
Preface	Describes the outline of this manual and how to use it.
Warranties 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 workers' safety information, safety measures taken for this product, and administrative control on industrial safety which is required when handling this product.
2..Compressor Specifications and Structure	Describes main components of this product and their functions, specifications and operating limits.
3. Installation	Describes procedures for installing this product.
4. Compressor and Package Unit Operation	Describes precautions for using this product.
5. Maintenance and Inspection	Describes inspection locations & frequency and assembly & disassembly of this product.
6. Troubleshooting	Regarding major troubles that may occur during use of this product, describes how this product will act as well as what actions should be taken when a trouble may occur.
7. Related Documents	Shows materials such as exploded drawings and parts list.
Contact Information	Provides contact information for our sales offices and service centers which is to be used for purposes such as MYCOM genuine parts ordering.

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6 Troubleshooting

7 Related Documents

Contact Information

1. Safety

1.1 Strict Requirements and Prohibitions

1.1.1 Strict Requirements (Do's)

1.1.1.1 Do's on Operation

- Make sure to install safety and protective devices on the package 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 this product.
- 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 lubricating oil (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 Do's 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, maintenance, or 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, maintenance, or inspection of this product, confirm that the pressure inside this product and the package 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 lubricating oil (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 package unit.

1.1.1.3 Do's 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 Do’s 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 package unit.

1.1.1.5 Do’s 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 Do’s about Handling Emergency Situations

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

1.1.1.7 Do’s 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 Do’s

- Clean the floor around the entire refrigerating/cold storage/gas compression package 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 Prohibitions (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 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 Warning Symbols and their Meanings

Symbol	Meaning
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/gas compression package units.

Note that all hazardous sources cannot be predicted for the applications mentioned.

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 Refer to Figure 1-1	• Caught in due to contact	• Install coupling cover and prohibit opening. • Keep away.	• Turn off motor main power and control power, and conduct lockout/tagout.
B	Motor terminals	• Electric shock caused by contact with live wires or electrical leakage	• Keep away. • Do not open terminal boxes. • Do not touch terminal boxes.	• Turn off motor main power and control power, and conduct lockout/tagout.
C	Compressor low-stage side suction casing Refer to Figure 1-1	• Frostbite due to contact • Contact with or inhalation of hazardous substances generated by leakage of refrigerant or the like	• Keep away and do not touch. • Wear protective gear. • Detect gas leakage.	• Wear protective gear. • Work under room temperature.
D	Compressor intermediate piping (low-stage discharge port to high stage suction port) Refer to Figure 1-1	• Burn injury due to contact • Contact with or inhalation of hazardous substances generated by leakage or spout of refrigerant or the like	• Keep away and do not touch • Wear protective gear • Gas leakage detection	• Wear protective gear • Work in temperatures below 40 °C
E	Compressor high-stage side discharge casing and discharge piping Refer to Figure 1-1	• Burn injury due to contact • Contact with or inhalation of hazardous substances generated by leakage or spout of refrigerant or the like	• Keep away and do not touch. • Wear protective gear. • Detect gas leakage.	• Wear protective gear. • Work at a temperature of not higher than 40°C.
F	Check valves/service valves and joints on each section of the package unit	• Contact with or inhalation of hazardous substances generated by mishandling or leakage • Frostbite or burn due to contact	• Sufficient ventilation • Indicate valve open/close state. • Keep away and do not touch. • Wear protective gear.	• Sufficient ventilation • Wear protective gear. • Tagout for controlled valve
G	Solenoid valves/motor operated valves on each section of the package unit	• Electric shock caused by contact with live wires or electrical leakage • Pinched due to contact with driving part	• Install protective cover on terminals, and prohibit opening. • Keep away and do not touch. • Wear protective gear.	• Turn off each breaker and the control power, and conduct lockout/tagout. • Wear protective gear.
H	Electric components in each section of the package unit (oil heater, protective switch, etc.)	• Electric shock caused by contact with live wires or electrical leakage • Pinched due to contact with driving part	• Install protective cover on terminals, and prohibit opening. • Keep away and do not touch. • Wear protective gear.	• Turn off each breaker and the control power, and conduct lockout/tagout. • Wear protective gear.
I	Package unit oil drains	• Contact with hazardous substances generated by leakage or spout • Burn caused by contact with high-temperature fluid	• Sufficient ventilation • Keep away and do not touch. • Wear protective gear.	• Sufficient ventilation • Wear protective gear. • Work at a temperature of not higher than 40°C.
J	Noises	• Damage caused by noise	• Wear protective gear.	—

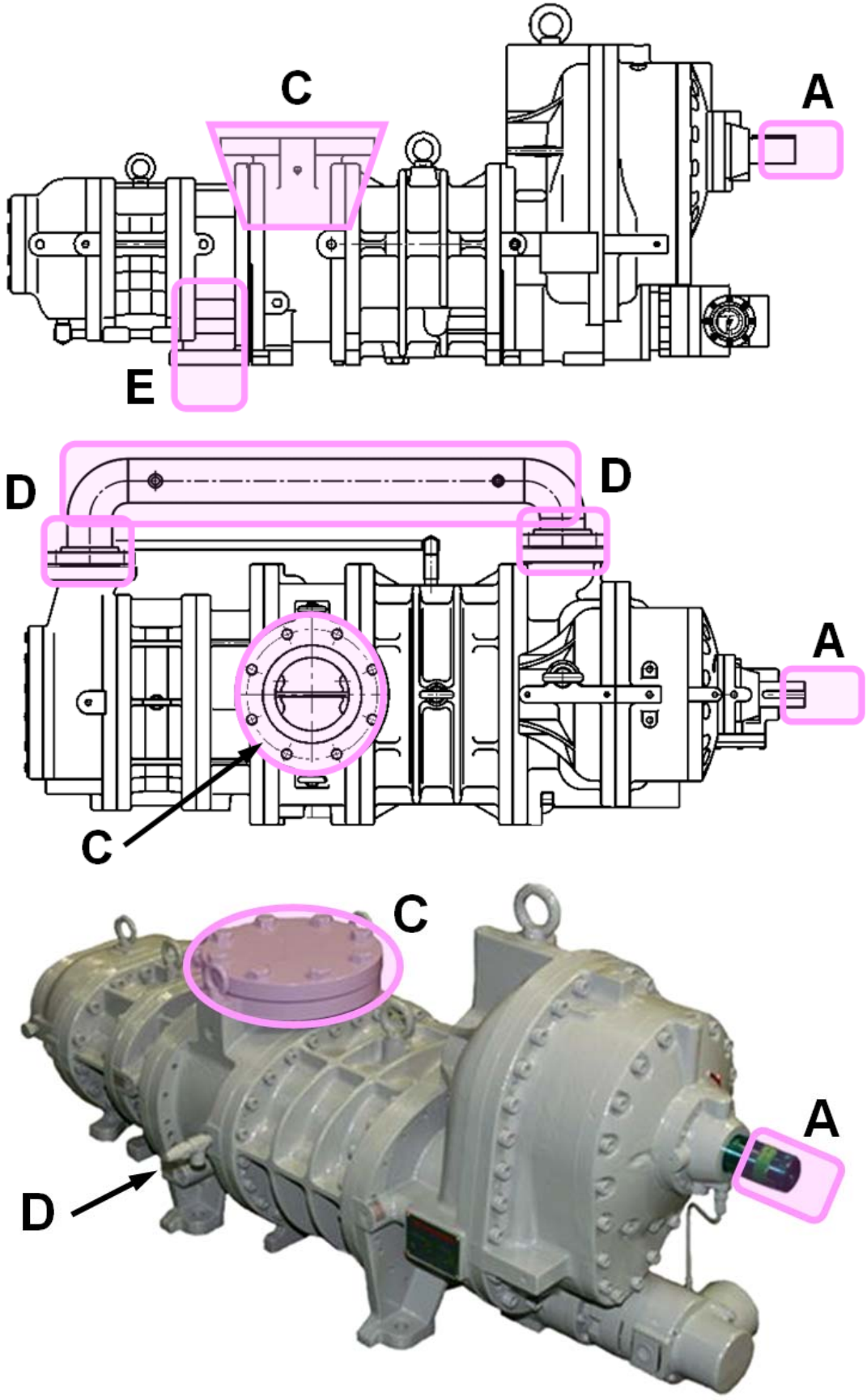


Figure 1-1 Locations of Hazardous Sources (compressor)

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.

WARNING

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

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

The operating procedures for the emergency stop button, i.e., how to stop the operation and restore the normal operating condition, must be clearly defined and the information provided to the user of this product.

■ Inspection Method/Cycle

The emergency stop buttons must be tested before commissioning and must also be periodically re-tested after that. The inspection procedures and the inspection interval for the emergency stop button must be clearly defined and the information provided to the user of this product.

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

The inspection procedures and the inspection interval for the lockout/tagout devices must be clearly defined and the information provided to the user of this product.

1.4.3 Compressor Protective Devices

WARNING

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

■ 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 package 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 mishandling of the compressor 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 package 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 lubricating oil supply is not sufficient, the oil filter is clogged, the refrigerant is mixed into the lubricating oil, 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 package unit's oil supply pipe (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

Specify the connection position and setting for each compressor protective device, and make sure to provide users of this product with them.

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.

Specify the inspection methods/intervals of the compressor protection devices, and make sure to provide users of this product with such information.

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.**

2 Compressor Specifications and Structure

2.1 Overview of the MYCOM Compound 2-stage Screw Compressor 1612LSC Speed Increaser Type

The MYCOM 1612LSC is a compound screw compressor integrating two stages of compressor into a single body. The 1612LSC has been developed based on the LSC model of the 1612C Series compressors —our most popular and long-selling products boasting the delivery of over 1000 units worldwide since they were first put on the market— by adding the speed increaser gear system to provide it with optimum performance for applications to ultra-cold and rapid freezing storage systems in bonito and tuna fisheries.

Generally, screw compressors use oil injection to keep discharge temperature low during operation without loss of volumetric efficiency even at high compression ratios, with singles-stage usage possible even at evaporative temperatures near −40 °C.

However, for low-temperature regular usage, to improve KW/RT (the ratio of power consumption versus cooling ability), a 2-stage compression method is used. To use standard-type screw compressors in a 2-stage compression method, at least two screw compressors must be combined so that there is a high-stage and a low-stage, which requires multiple sets of machinery, power, and utilities, etc. to be installed.

This 2-stage screw compressor combines these two units into one compound machine.

2.2 Model Designation of the Compressor

This manual describes the 1612LSC-*B*-52, -62, -53, -63, and -54 speed increaser type models.
The meaning of the type designation stamped on the nameplate of the compressor MODEL column is as follows.

＊1612LSC-＊B＊-52（62, 53, 63, 54）

- **2, 3 or 4**：Speed increaser gear ratio specification
  (refer to the specifications table on the next page.)
- **5**：Power frequency 50Hz（**6**：60Hz）
- Vi of the high-stage discharge port specification (volume ratio), as standard **L** port or **M** port
- Means the machine (low-stage) booster
- Vi of the low-stage discharge port specification (volume ratio), as standard **L** port or **M** port
- Means two-stage machine single unit
- Shows the specifications of the high-stage rotor length, only **S** for ~~accelerator~~ speed increaser type
- Shows the specifications of the low-stage rotor length, only **L** for speed increaser type
- High-stage rotor diameter of **125**
- Low-stage rotor diameter of **160**
- Means the working fluid
  (Example: N = ammonia, F = Freon, P = Propane , HE = helium)

2.3 Compressor Specifications

2.3.1 Standard Specifications

Table 2-1 1612LSC Speed Increaser Type Screw Compressor Specifications

Item			1612LSC Speed Increaser type				
			52	62	53	63	54
Product mass		kg	560				
Applied frequency		Hz	50	60	50	60	50
Motor Poles		-	4P	4P	2P	2P	2P
Speed increaser gear ratio		-	1.809	1.809	1.220	1.220	1.472
Male rotor rotational speed		min^{-1}	2610	3150	3610	4350	4350
Female rotor rotational speed		min^{-1}	1740	2100	2407	2900	2900
Low-stage swept volume		m^3/h	551	665	762	918	918
High-stage swept volume		m^3/h	174	210	241	290	290
Applied refrigerant		-	Ammonia, Hydrofluorocarbon, other				
Design pressure		MPa	2.6				
Capacity control range (Actual load)		%	10 to 100				
Rotation direction		-	Crockwise viewed from motor				
Connection pipe size	Suction flange low-stage	-	MYCOM 125A (5″)				
	Discharge flange low-stage	-	MYCOM 80A (3″)				
	Suction flange high-stage	-	MYCOM 80A (3″)				
	Discharge flange high-stage	-	MYCOM 65A (2½″)				
	Journal lubricating oil supply (low-stage)	-	Rc1/2				
	Journal lubricating oil supply (high-stage)	-	Rc3/8				
	Oil injection lubricating oil supply	-	Rc3/8				
	Mechanical seal and speed increaser gear lubricating oil supply	-	Rc1/4				
	Capacity control	-	Load: Rc1/4, Unload: Rc3/8				

- In this manual unless otherwise noted, pressure units MPa represents the gauge pressure.
- For usage temperature ranges and pressure ranges, refer to Section2.3.2 “Operation Limits”.

2.3.2 Operation Limits

Table 2-2 Operation Limits of 1612LSC Speed Increaser type

Items		Operation Limits
Maximum discharge pressure	MPa	1.96
Minimum suction pressure	MPa	−0.080
Maximum intermediate pressure	MPa	0.588
Minimum intermediate pressure	-	> Suction pressure
Oil supply pressure		
・ Maximum journal lubrication pressure	MPa	Discharge pressure + 0.39
・ Minimum journal lubrication pressure	MPa	Discharge pressure +0.049 and Suction pressure +0.49
・ Minimum oil injection pressure	MPa	Suction pressure +0.49
Maximum Suction temperature	°C	85
Minimum suction temperature	°C	−60
Maximum low-stage discharge temperature	°C	90
Maximum high-stage discharge temperature	°C	100
Maximum oil supply temperature	°C	60
Minimum oil supply temperature	°C	30
Maximum M (mail) rotor rotation speed	min^{-1}	4500
Minimum M (male) rotor rotation speed	min^{-1}	1450

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

CAUTION

- **If operation at a indicated load of less than 30 % of capacity control is continued for a long time except when starting up the machine, abnormal noises or vibration may occur, so avoid doing so.**
- **Repeating startup or shutdown operations in a short period of time is detrimental for the starter and the motor as well as for the compressor itself. Refer to the documentation of each device for the starting and stopping limitations of the starter and the motor. After stopping the compressor, wait 15 minutes or more before performing the next startup procedure.**

2.3.3 Outer Dimensions

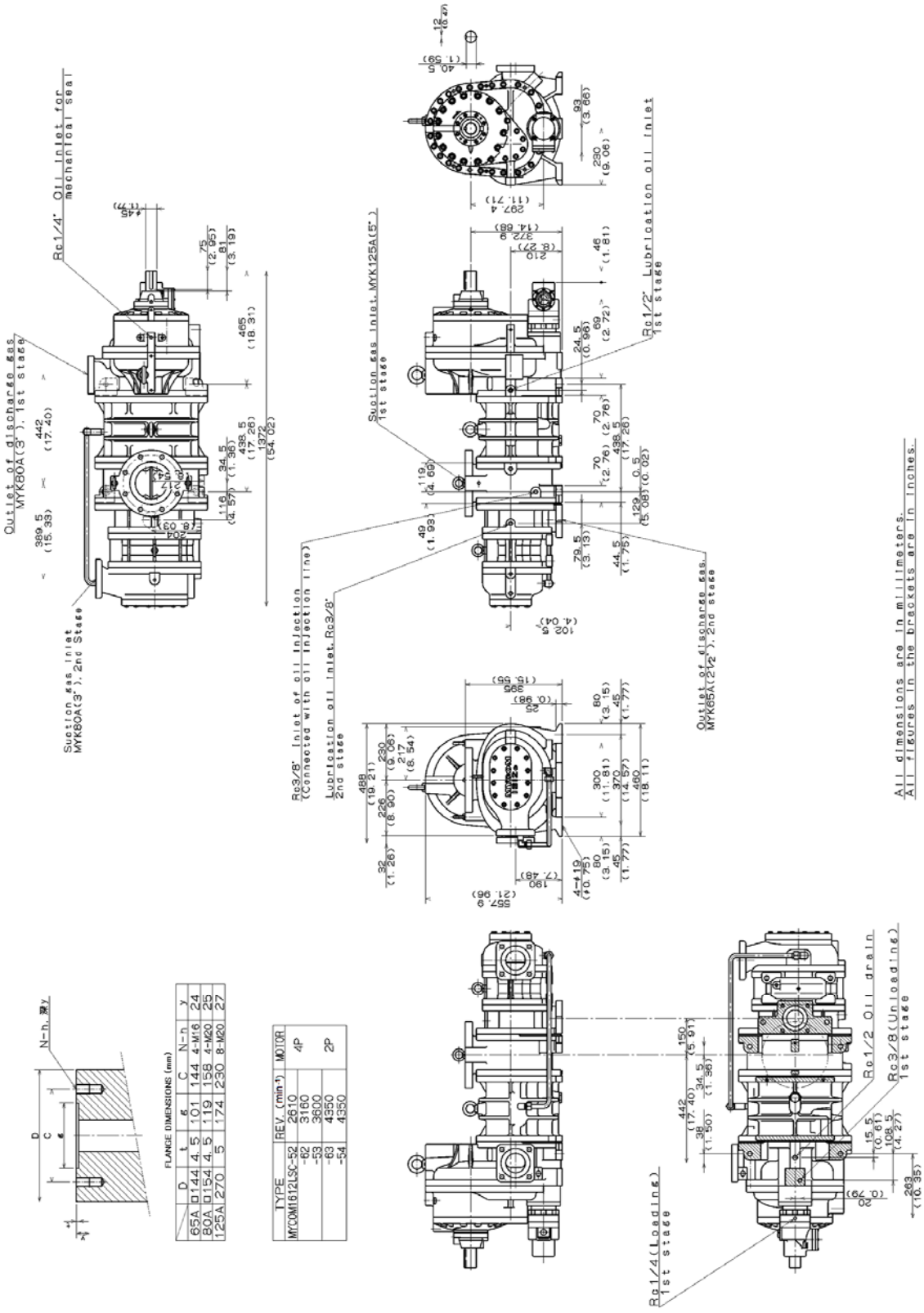


Figure 2-1 1612LSC Speed Increaser Type Outer Dimensions

2.4 Structure of Compressor

【POINT】

- For the names and locations of the compressor components, refer to Section 7.1 “Development Views, Assembly Sectional Views” and Section 7.2 “Parts Configuration Table” in this manual.

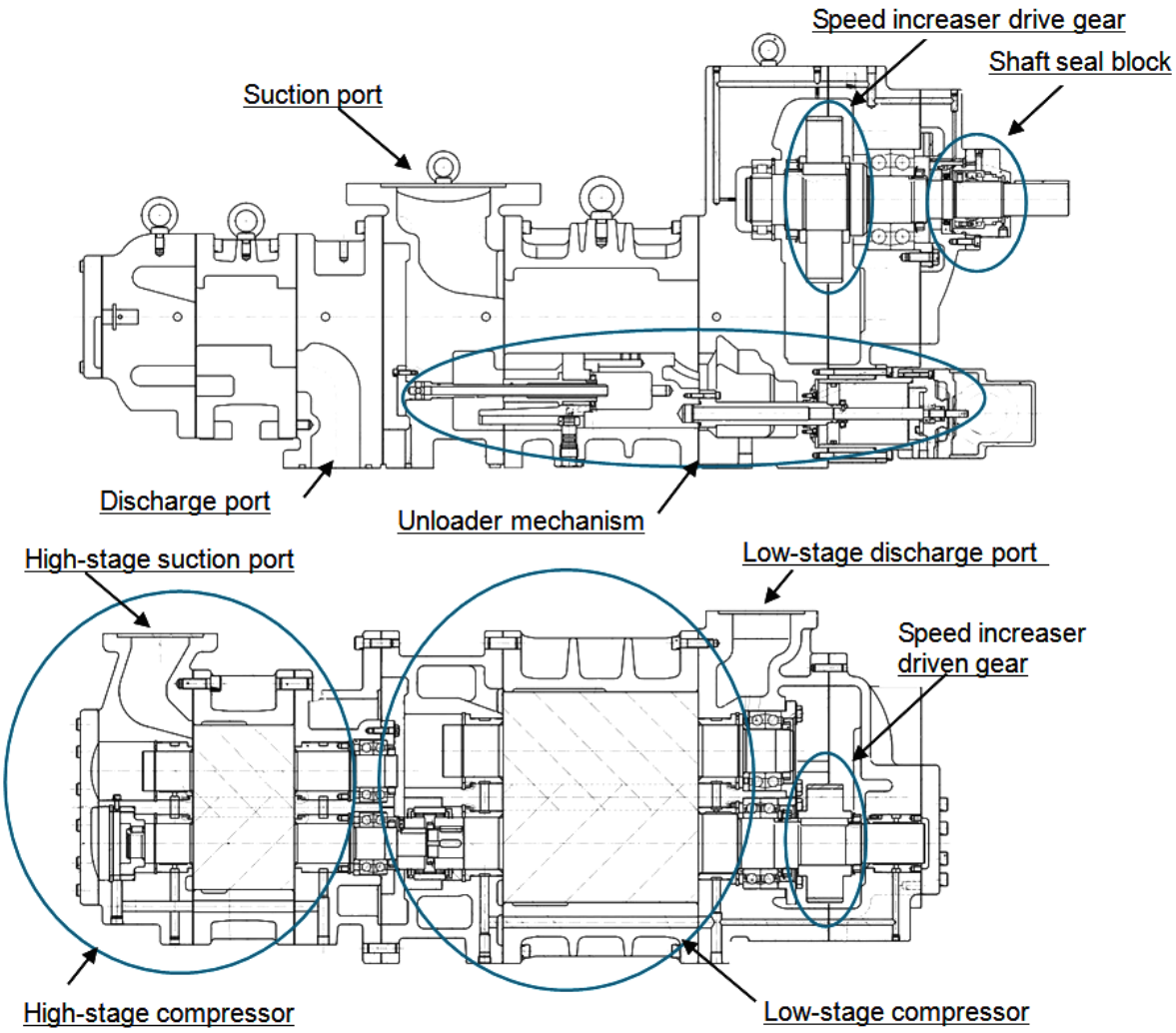


Figure 2-2 1612LSC Speed Increaser Type Sectional View

The 162LSC screw compressor consists of the following four main blocks: the shaft seal block which prevents leakage of the refrigerant gas and lubricating oil from the compressor’s axis; the speed increaser gear casing assembly which houses the drive and driven gears for increasing the rotating speed of the electric motor’s output shaft; the low-stage compressor block which pressurizes (pre-compresses) the gaseous working fluid coming from the freezing storage system; and the high-stage compressor block which further compresses the working fluid gas pressurized by the low-stage compressor before discharging it into the freezing storage system.

Like with the 1612**C Series direct drive type screw compressors, the 1612LSC speed increaser type screw compressors has the capacity control (unloading) mechanism which works for reducing the machine load at the time of the start of operation and keeping constant the load which would otherwise vary during operation of the freezing storage system.

Inside each of the low-stage and high-stage compressor casings, there is a pair of screw rotors meshing each other and supported by bearings at both ends. One of each pair is the male rotor having four convex-shaped screw lobes and the other is the female rotor having six concave-shaped screw lobes. In combination, they perform the work of compressing the refrigerant gas through the process described in the next section.

2.5 Mechanisms

2.5.1 Basics of the Screw Compressor

The screw compressor is a positive displacement rotary compressor.

As shown in Figure 2-3 Compressor Mechanism, the refrigerant (gas) is continuously compressed by changing the volume between the casing and the male and female meshed screw rotors, which have different profiles.

The rotor with 4 protruding lobe sections is called the M rotor (male rotor), and the rotor with 6 lobe depressions is called the F rotor (female rotor). Throughout this manual they are referred to as the M rotor and F rotor.

The compressor M rotor shaft is driven by the two-pole or four-pole motor via the speed increaser gear.

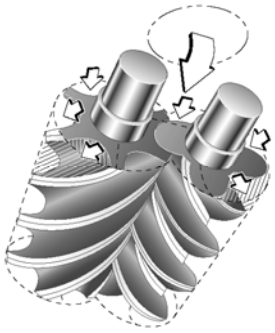


Figure 2-3 Compressor Mechanism

2.5.2 Suction Process

As shown in Figure 2-4 Suction Process, the rotors' different profiles mesh together. Also the volume enclosed between the M and F rotor lobes and compressor casing increases from the suction side as the rotors turn.

As rotations continue, at a certain point the volume reaches its maximum, the rotors start to trap the gas between the lobes and compressor casing thereby isolating the gas from the suction port.

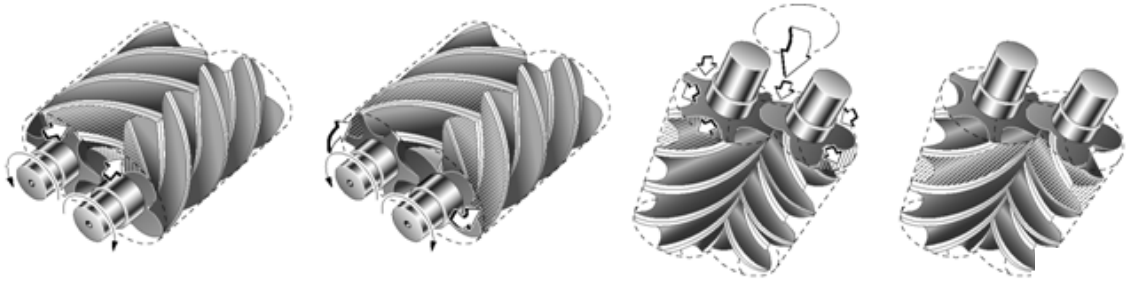


Figure 2-4 Suction Process

2.5.3 Compression Process

As the rotors further rotate, the sealing line between them moves toward the discharge side and the volume between the rotor lobes decreases and compresses the trapped gas.

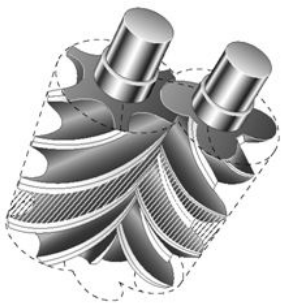


Figure 2-5 Compression Process

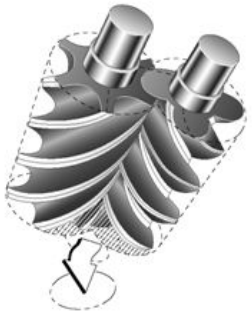


Figure 2-6 Discharge Process

2.5.4 Discharge Process

Through the compression process, the volume between rotor lobes decreases to a predetermined value at the discharge port.

Following rotor rotation, the compressed refrigerant gas is pushed out of the discharge port.

2.5.5 About Volume Ratio (Vi)

Volume ratios (Vi) of MYCOM C-series screw compressors are indicated in performance tables or catalogs by using port symbols L and M.

The volume ratio represented by each symbol is as follows:

L=2.63, M=3.65.

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

Which volume ratio (L or M) 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:

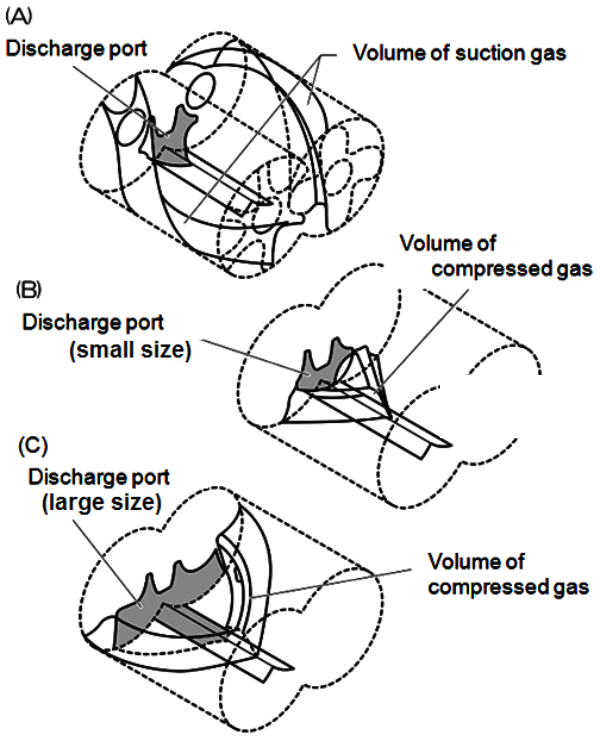


Figure 2-7 Volume Ratio Explanation

$$Vi = \left(\frac{Pd}{Ps}\right)^{\frac{1}{\kappa}} \quad \text{or} \quad Vi^{\kappa} = \frac{Pd}{Ps}$$

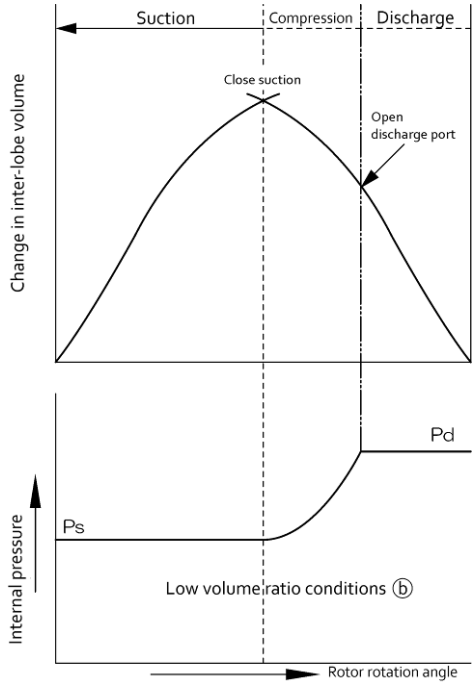
$(Vi)^{\kappa} = \pi i = Pd/Ps$ κ = Cp/Cv of refrigerant gas

Vi = designed volume ratio πi = designed compression ratio

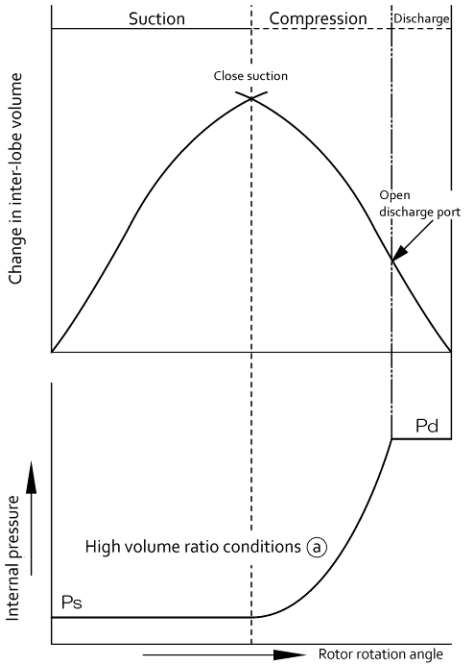
The constant of the refrigerant gas also a factor, and the Vi value for the compression ratio will change according to the refrigerant gas used.

(A) When Vi matches operation conditions

The required compression ratio and Vi are both low

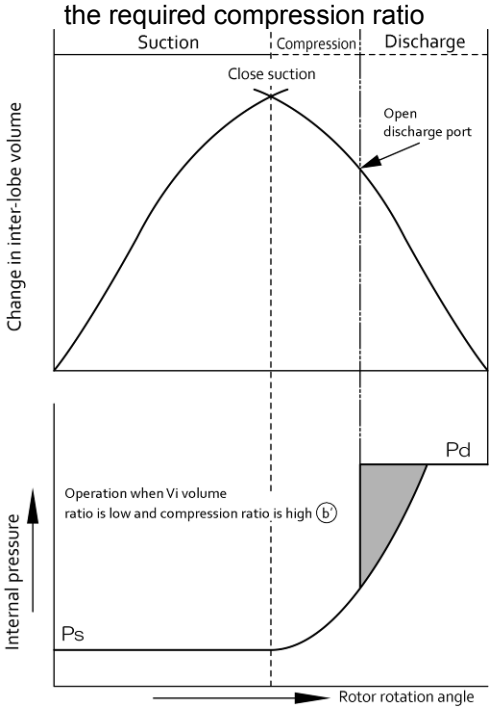


The required compression ratio and Vi are both high



(B) When Vi does not match operation conditions

Vi is too low compared to
the required compression ratio



Vi is too high compared to
the required compression ratio

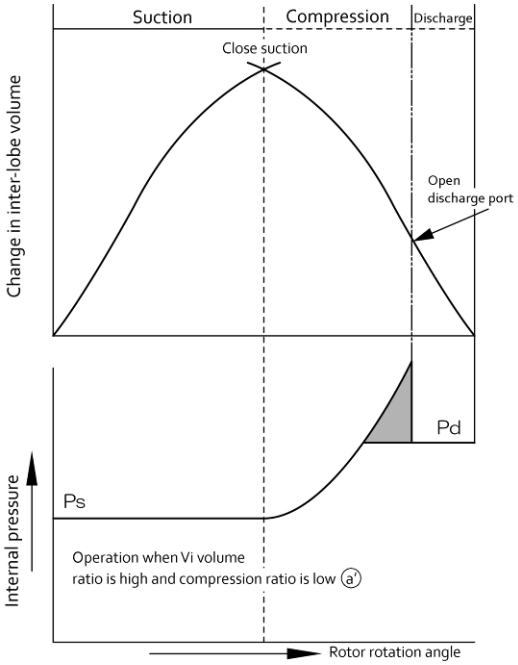


Figure 2-8 Relationship between volume ratio (Vi) and operation conditions

2.5.6 Capacity Control Mechanism

The capacity control structure involves the moving of a slide valve, bypassing suction gas just before compression on the suction side, which shortens the portion of the rotor used for compression. The slide valve is at the bottom of the casing where the rotors mesh together, and is constructed to move parallel to the rotor's axis. This movement is changed by a cam mechanism into rotation movement, and as the position (capacity control ratio) is indicated externally, the electrical resistance value changes to provide feedback to the automatic control circuit.

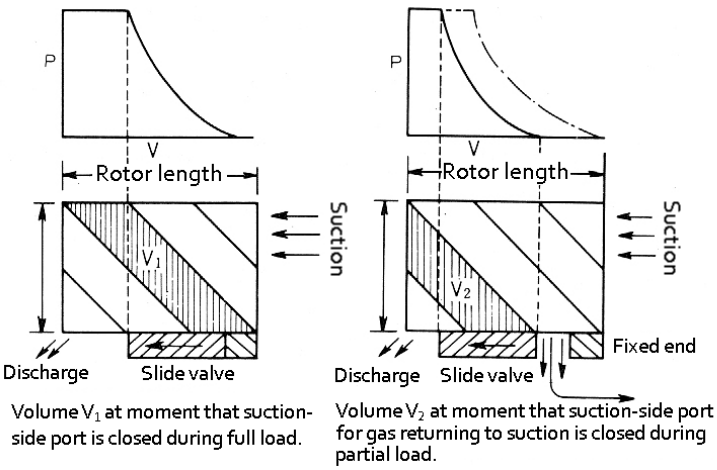


Figure 2-9 Capacity Control Mechanism

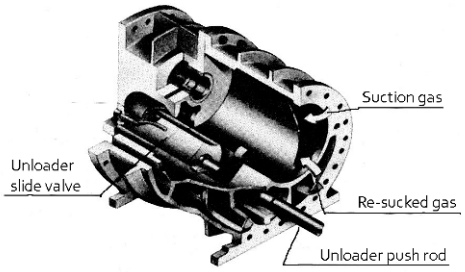


Figure 2-10 Slide Valve in the Rotor Casing

The 1612LSC speed increaser type has capacity control on the low-stage block only.

2.5.7 Bearings and Balance Piston

For the load created on the rotor perpendicular to the axle, a white metal-lined sleeve-type bearing is used. The bearing uses surface fitted ball bearings with angular contact for loads along the axis direction.

In particular, axial load for the M rotor, which has one type of helical gear, is comparatively larger than that of the F rotor because of the thrust load from discharge pressure. This load for the M rotor is reduced by the use of a thrust bearing, along with a balance piston providing opposing hydraulic pressure.

2.5.8 Shaft Seal

To prevent refrigerant gas and oil leakage, a reliable mechanical seal assembly is used for the shaft seal of the speed increaser gear spindle.

Mechanical seal assembly is mainly composed of "rotating ring" installed on the rotor shaft and "stationary ring" installed in the seal cover. Rotating ring rotates with the shaft, and slides each other with the stationary ring while maintaining a micron class gap. The sliding each other place is called as the sliding surface.

As an example, for the BBSE (Balanced Bellows Single Seal)-type, which is a standard seal currently in use, the fixed ring (mating ring) is cast iron, and the rotating ring is carbon, with an O-ring for the packing.

2.6 Gas and Oil Flow

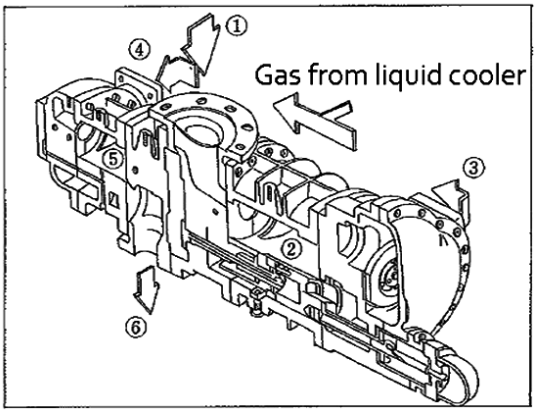


Figure 2-11 Gas Flow

The screw compressor's compression process is described earlier in this manual.

Gas for the compound speed increaser type 1612LSC compressor passes from the evaporator and through the suction strainer and check valve, and is sucked into the center part of the compressor ①, and it is compressed at the low-stage ② .Then the compressed gas is discharged at ③. ③ and ④ are connected by piping through which gas used for super cooling is mixed in from the liquid cooler.

Lubricating oil injected at the low-stage is, while kept mixed with gas, suctioned from ④ into the high-stage. After being compressed at ⑤, the gas mixed with lubricating oil is discharged from ⑥ to the oil separator, and then sent to the condenser.

The oil is cooled even without intermediate gas cooling, so the high-stage discharge temperature can be maintained at below 90 °C.

■ Oil Supply Route

Lubricating oil is split into 4 flows as shown in Figure 2-12, and after providing lubrication, it is mixed with discharge gas and leaves the compressor. In standard configurations, oil injection is not performed at the high-stage.

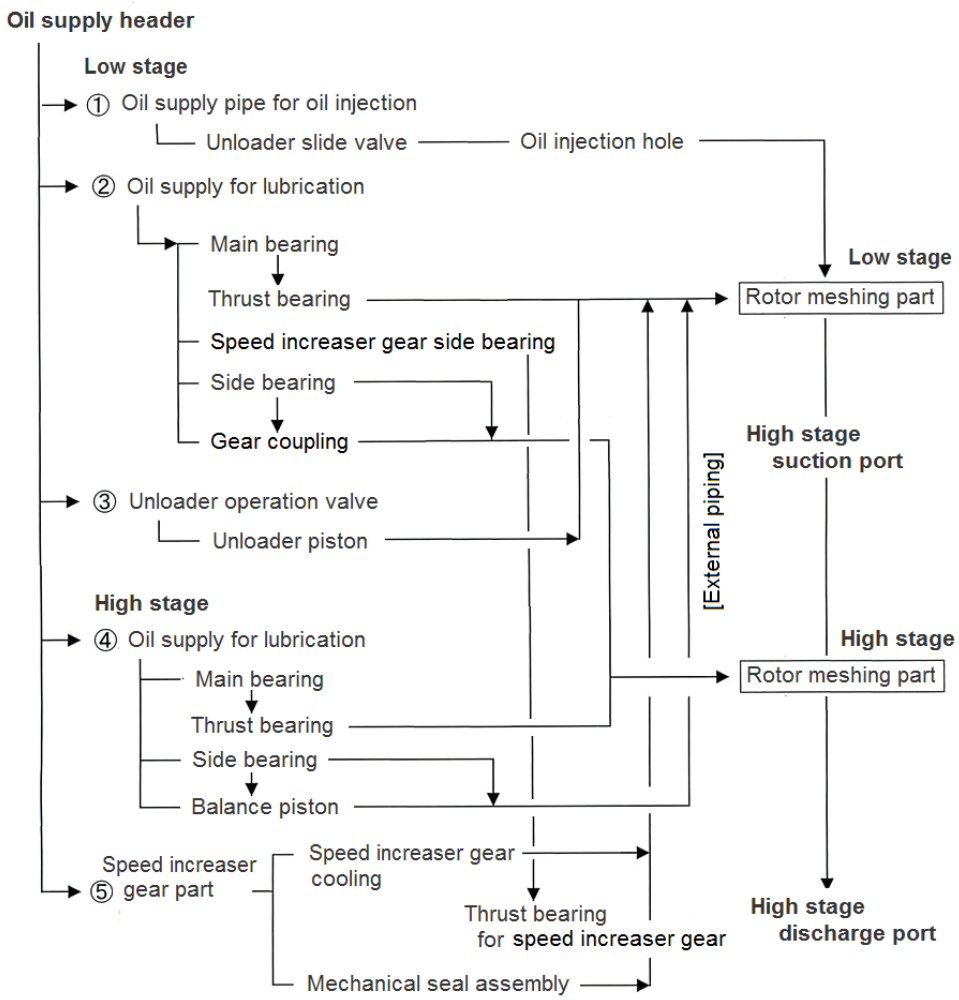


Figure 2-12 1612LSC Speed Increaser Type Oil Supply Route

3 Installation

3.1 General Precautions for Installation

【POINT】

- This chapter is based on the assumption that the compressor is installed to a standard refrigeration/cold storage package unit.
  If the package unit is not a standard refrigeration/cold storage package unit, prepare an installation procedure manual referring to this chapter and considering safety precautions, 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 and ordinances.
- Read this chapter and related documents, and fully understand their contents before performing installation.
- Electrical work must 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 local sales offices or service centers.
- Unnecessary packaging materials should be discarded according to the laws and ordinances, or your company's rules.

3.2.2 Storage

If you need to store the compressor before installation, perform the followings:

- Store it indoors.
- Seal nitrogen gas in the compressor. (Pressure: approximately 0.15 MPa)

3.2.3 Transportation

⚠ DANGER

- **Dropping of the lifted compressor may cause death or serious injury to the worker. Do not allow anyone to be under the lifted compressor.**

1. To lift the compressor, use lifting equipment with sufficient load capacity for the mass of the compressor and appropriate lifting slings having proof load of more than the mass of compressor.
2. Secure sufficient space for safe lifting.

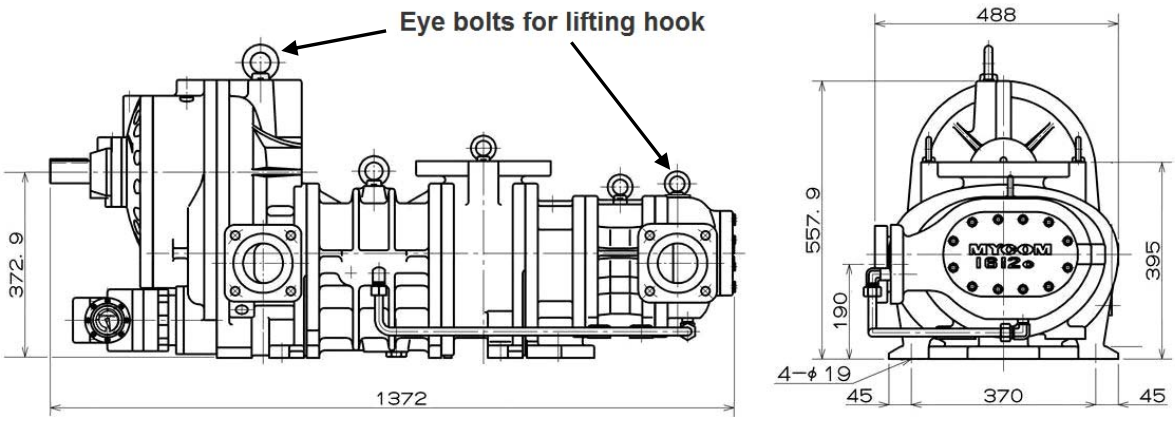
3. Check the wire ropes before use. Thoroughly check the wire ropes for problems such as kinks, knots, and broken strands. Do not start lifting unless the wire ropes have been verified and have no problems. If you cannot make a correct evaluation or judgment, entrust an expert to inspect.
4. To lift the compressor, attach the wire ropes to the attached eyebolts using appropriate shackles and hooks. The eyebolts are only used for lifting the compressor. Do not use the eyebolts to lift the compressor with any attached apparatus.

CAUTION

- **The compressor eyebolts must not be used to lift the package unit. To lift the package unit, use the lifting chains on the compressor unit base periphery or other lifting devices provided on the compressor unit base.**

5. Check the transportation route for any obstacles in consideration of the compressor size.
6. Before lifting, check that the hook is located above the gravity center of the compressor.
7. Instruct all workers to move from near the work site before lifting.
8. Before lifting the compressor, alert all workers on the site of possible dangers of the 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 are completely understood by all personnel working together.
9. Slowly windup the wire ropes until shortly before the compressor leaves the ground.
10. Then, wind up the wire ropes a little further until the compressor is slightly away from the ground and check that the compressor is balanced. If the compressor is inclined, return the compressor to the ground and correct the inclination by adjusting the wire ropes. Then, restart the lifting operation.
11. Make sure to wind up the compressor slowly. Lifting it too quickly may damage the lifting equipment including the wire ropes or part of the compressor.
12. When lifting the compressor, check the state of the wire ropes and lifting equipment. Check that the compressor is not inclined.
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 any safety aisles unless absolutely necessary.
16. Do not put the compressor in a safety aisle. Always keep the safety aisle free of obstacles.
17. Remove any obstacles before putting down the compressor on the ground. The compressor should not be inclined or unstable.
18. Before putting down the compressor on the ground, announce to the workers around the working area.
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. Lower the compressor slowly so that it does not get damaged due to impact.

■ Outer Dimensions, Mass and Lifting Position



1612LSC speed increaser type common	
Mass (kg)	560
Length (mm)	1372

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

Lifted View

3.2.4 Preparation for Installation

■ Installation Space

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

■ Illumination

Prepare lighting for easy operation, cleaning, maintenance, and inspection.

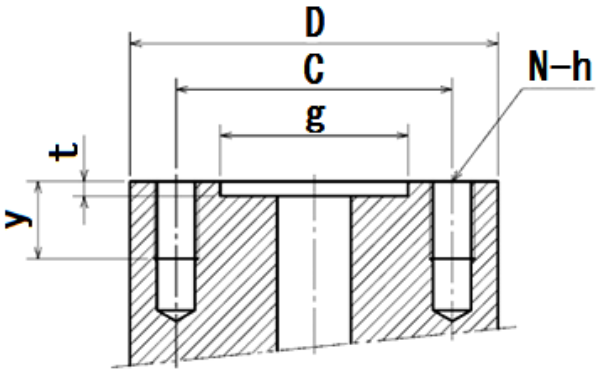
■ Ventilation

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

■ Piping

Table 3-1 Connected Piping List (Compressor)

Item	Dimensions	Remarks
Suction gas inlet	MYCOM 125A (5″)	See figure 3-2.
Low-stage gas outlet	MYCOM 80A (3″)	See figure 3-2.
High-stage gas inlet	MYCOM 80A (3″)	See figure 3-2.
High-stage discharge gas outlet	MYCOM 65A (2½″)	See figure 3-2.
Low-stage bearing (journal) oil inlet	Rc1/2	
Low-stage capacity control oil inlet (increase side)	Rc1/4	
Low-stage capacity control oil inlet (decrease side)	Rc3/8	
Oil injection inlet	Rc3/8	
Mechanical seal and speed increaser gear oil inlet	Rc1/4	
High-stage bearing (journal) oil inlet	Rc3/8	



	D	t	g	C	N-h	y
65A	□144	4.5	101	144	4-M16 × P2	24
80A	□154	4.5	119	158	4-M20 × P2.5	25
125A	270	5	174	230	8-M20 × P2.5	27

Figure 3-2 MYCOM Flange Dimensions

* In external dimensions figures 2-1 in “2.2.2 Outer Dimensions” in chapter 2 of this manual, these MYCOM flange dimensions are noted as MYK**A.

3.2.5 Installation

3.2.5.1 Installation

Check that the surface of the package unit for compressor installation is even and horizontal. If it is not flat and horizontal, tightening the bolts may lead to compressor deformation, and operation may be affected.

3.2.5.2 Shaft Alignment between Compressor and Driving Machine

DANGER

- **Turn off the main power and control power of the driving machine before shaft alignment work between the compressor and the driving machine. Be careful so that the power of instruments does not turn on during shaft alignment work. If the power turns on during shaft alignment work, the driving machine starts moving and there is a risk of being entangled with the rotating shaft.**
- **At the time of turning ON/OFF each electric power breaker, make sure to prevent electric shock.**

CAUTION

- **For shaft alignment work between the compressor and driving machine, use designated tools in normal condition. If a worn or damaged tool or a tool unsuitable for the work is used, there is a risk of being injured.**

In the case shaft alignment between the compressor and the driving machine, be sure that the deviations within the range shown in the Table 3–2. However, if alignment tolerance of the driving machine side is more stringent than Table 3-2, please adjust to the request within the allowable value of the driving machine side.

Table 3–2 Tolerance of Misalignment

	Tolerance
Offset	6/100 mm
Angularity	3/100 mm (reference: Φ100 mm)

The Figure 3–3 and 3–4 show how to measure offset and angularity when performing the centering of the shafts of the driving machine and this product using a dedicated hub, a dial gauge and a magnet stand.

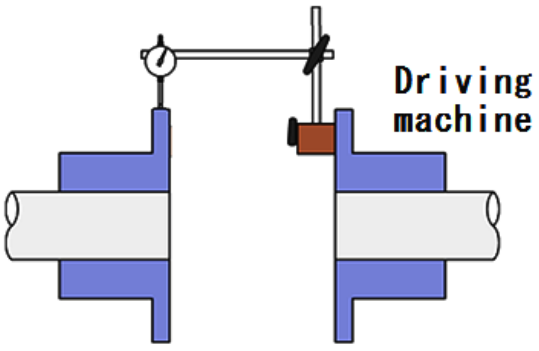


Figure 3-3 Measurement of Offset

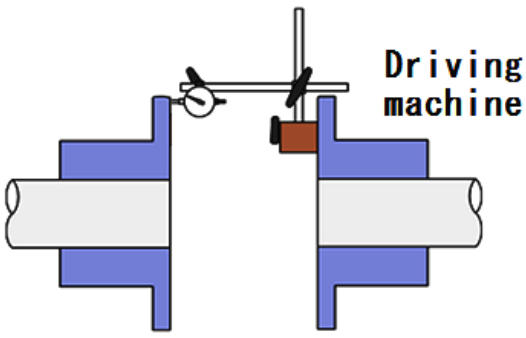


Figure 3-4 Measurement of Angularity

3.2.5.3 Piping Connection

■ Refrigerant Piping

When connecting the refrigerant piping to the compressor, follow the instructions below.

- The compressor is one of the few devices with moving components in the package unit. The moving components are adversely affected by foreign substances within the system (scale, dust, spatter, etc.). Therefore when connecting the piping, make sure that no such foreign substances enter the piping.
- In some compressors, in particular those shipped overseas, nitrogen gas is enclosed to prevent rust. Release the pressure before starting piping work.
- Do not allow moisture to enter the piping because it can cause trouble after starting operation. Assemble piping when it is dry.
- Cover flanges are attached to the low-stage gas outlet and the high-stage gas inlet of the compressor, but after installation attach piping (intermediate piping) to both connection ports.
- Inappropriate piping may cause operating problems such as oil not returning to the compressor or liquid flowing back to the compressor.
- When connecting piping to the compressor, as a general rule, use piping that is the same size as the compressor connection port. If the size of the piping is smaller than the compressor connection port, the flow of lubricating oil or refrigerant will be obstructed leading to problems.
- Do not block flange or fittings with the mass of the piping connected to the compressor. Prepare the appropriate support for piping.

3.2.5.4 Equipment and Devices for Protection of the Compressor

■ Oil Filter

According to the requirements of the use of the package unit or the standard to apply, install an oil filter of appropriate filtration precision in the lubrication system of the compressor.

In the case of general applications such as closed-cycle refrigeration systems, we recommend to use an oil filter with beta ratio in the range of $\beta_{20} \geq 150$ that conforms to requirements of NAS 1638 class 8 or ISO 4406 17/15/13.

When the package unit requires API 619 4th/5th edition conformity, use an oil filter with beta ratio in the range of $\beta_{10} \geq 200$.

The oil filter may be clogged just after commissioning. 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 lubricating oil 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 compatible (inter-soluble) oil is used, the mesh size of suction strainer should be not less than 200 meshes. When incompatible (non- inter-soluble) oil is used, it should be not less than 100 meshes.

For details about compatible and incompatible oils, refer to Section 4.1 "Lubricating Oil (Refrigerant Oil)" in this manual Chapter 4.

During commissioning, 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 Section 1.4.3 "Compressor Protective Devices" in this manual Chapter 1.

3.2.6 Airtightness Test

Perform an airtightness test on the package unit before starting commissioning. To prevent water entry in the package unit, use nitrogen gas or dry air for the airtightness test.

3.2.7 Lubricating Oil Charge

CAUTION

- **TO select the lubricating oil to be used, refer to Section 4.1 "Lubricating Oil (Refrigerant Oil)" in this manual.**
- **When refilling lubricating oil, 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 lubricating oil does not absorb air moisture, keep it indoors in an airtight container until use.**

3.2.7.1 Initial Charge of Lubricating Oil

Depending on the package unit configuration and operating condition, specify the procedure, method and amount of the initial charge of lubricating oil, and make sure to provide users of this product with such information.

In determining the procedure and work procedure of the initial charge of lubricating oil, please care oil is to be filled in the oil filter and oil cooler always.

3.2.7.2 Additional Charge of Lubricating Oil

Specify the procedure of the additional filling of lubricating oil based on the configuration of the package unit, and make sure to provide users of this product with the information.

3.2.8 Charge of Refrigerant

Depending on the use working fluid and equipment configuration of your package unit, specify the work procedure that considered safety enough, and conduct the refrigerant initial filling work accordingly.

In addition, specify the procedure of the additional filling of refrigerant, make sure to provide users of this product with the information.

3.2.9 Check after Installation

Depending on the package unit to which this product is installed, formulate the necessary confirmation items and methods for package unit after installation and conduct them accordingly before the commissioning. In addition, make sure to record and keep the results of your confirmation.

4. Compressor and Package Unit Operation

4.1 Lubricating Oil (Refrigerant Oil)

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

4.1.1 Precautions for Selecting the Lubricating Oil

- Selection of the lubricating oil 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 lubricating oil are the properties of the oil that include not only the viscosity but also such characteristics as compatibility in refrigerant, separability from refrigerant, low temperature fluidity, high temperature thermal stability, etc.

  We therefore recommend contacting our sales offices or service centers for choice of a specified brand for your system.
- Lubricating oil 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 lubricating oil significantly changes depending on the type of the refrigerant used in combination with the lubricating oil. If the refrigerant dissolves in the lubricating oil (or the lubricating oil and refrigerant are compatible), the viscosity of the lubricating 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 lubricating oil (or the lubricating oil and refrigerant are incompatible), the viscosity may become too high when the supply oil temperature is low. For this reason, the lubricating oil must be selected such that it is supplied to the compressor with an appropriate viscosity (kinematic viscosity of 13 to 40 mm^2/s) in the operating state.
- The circulation of the lubricating oil for the entire system must be considered. After lubricating and cooling each part of the compressor, the lubricating oil 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 lubricating oil is required to have sufficient fluidity and stability inside each part in the refrigerating cycle where temperatures differ.
- Note that some lubricating oils cannot be used depending on the combination with the refrigerant. The following caution is an example case that is required especially attention.

CAUTION
● **Be careful since polyolester synthetic oil (POE) must not be used with ammonia refrigerant.**

4.1.2 Recommended Lubricating Oils

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

4.1.2.1 Recommended Lubricating Oils for Ammonia Refrigerant

■ **Polyalkylene Glycols (PAG) Based Synthetic Oil (compatible oil)**

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

■ **Mineral oils (incompatible 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 (incompatible 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 Hydrofluorocarbon (HFC) refrigerants

■ **Polyolester synthetic oil (POE) for R404A, R507A and R410A (compatible 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 (Incompatible 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 lubricating oil of a brand not described in this section, or when using lubricating oil along with refrigerants or gases not described in this section, please contact us.**

4.1.3 Change of Lubricating Oil Brand

When changing the lubricating oil brand in currently use for some reason, attention must be paid to the following points.

CAUTION

- **The change of lubricating oil brand may cause problems in operating conditions and the compressor. When changing the lubricating oil brand in use, make sure to contact us because appropriate steps must be surely followed.**
- **Package unit composition differs depending on the characteristics of lubricating oil (compatible/incompatible with refrigerant). As a general rule, changing compatible oil to incompatible oil or vice versa is not allowed.**

- Lubricating oil 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 lubricating oil. If mixed brands of lubricating oil are used, the different additives in the lubricating oil may react with each other and produce foreign substances like slurry.
- If it is necessary to change the brand of lubricating oil, 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 lubricating oil. After 100 to 200 hours of operation, replace the oil again.
- If lubricating oil 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).

4.1.4 Precautions for Handling lubricating Oil

- When refilling lubricating oil, 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 lubricating oil does not absorb air moisture, keep it indoors in an airtight container until use.

4.1.4.1 Precautions for Handling Polyalkylene Glycol (PAG)

PAG oil is much more hygroscopic than mineral oils and any moisture mixed in the oil may lead to rust, corrosion and wear within the package. When handling PAG oil, pay special attention to the following points.

- Do not perform oil charging in rainy weather or at a place with high humidity to prevent absorbing moisture.
- Before charging, remove as much moisture as possible from the system by exhausting it with a vacuum pump for a sufficient length of time and leaving the system in vacuum condition overnight.
- Do not open the lid of pail (oil container) until just before charging. Once the can is opened, finish the oil charge as quickly as possible. (Finish the charge of a single can of oil within 15 minutes.)
- Cover any gaps between the pail opening and the charge hose so that foreign substances or moisture cannot enter. A more effective way is to substitute any space inside the pail with nitrogen gas.
- Always charge all oil from the pail. Even if some oil remains, do not use it subsequently.
- If any oil drops on a painted surface, wipe it away as soon as possible. Otherwise the paint may come off.

4.1.4.2 Precautions for Handling Polyolester (POE) Oil

This type of oil has high hygroscopicity as polyalkylene glycol, and also exhibits hydrolyzability under high temperature environments. Moisture entry must be avoided. Therefore, special attention must be paid as with PAG when handling POE.

- Finish the charging in as short a time as possible after opening the pail to minimize exposure to air.
- Make sure that all oil in a pail is used in a single charging. Any remaining oil must be stored indoors with the can lid closed tightly. Do not attempt to store it for a long time.
- Because POE can hydrolyze, make sure to perform an oil analysis regularly in the package to see if any abnormal conditions are present.

4.1.5 Lubricating Oil Management Criteria

Lubricating oils that are managed by the criteria are classified into the following categories:

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

- **Oil sampling and analysis is recommended every six months.**
- **If the following control criteria are not satisfied, replace the oil.**
  - ◆ Note that the water content of PAG shall be excluded from the above oil replacement criteria. Refer to the **Note** in the following table.

The analysis items and the criteria are shown in the following tables. Please note that these management criteria may be changed without notice.

●Table 4-1 Synthetic Oil (PAG)

Item	Criteria
(a) Color phase	ASTM color scale: 4.0 or less
(b) Total acid number (TAN)	0.1 mg KOH/g or less
(c) Kinematic viscosity	Within ±10 % from that of fresh oil
(d) Water content	2000 mass ppm or less **Note**
(e) Degree of contamination	Degree of contamination measured by mass method (Millipore value) shall be 15 mg/100 mL or less

●Table 4-2 Mineral Oil and Synthetic Oil (AB, PAO)

Item	Criteria
(a) Color phase	ASTM color scale: 6.0 or less
(b) Total acid number (TAN)	0.3 mg KOH/g or less
(c) Kinematic viscosity	Within ±15 % from that of fresh oil
(d) Water content	100 mass ppm or less
(e) Degree of contamination	Degree of contamination measured by mass method (Millipore value) shall be 15 mg/100 mL or less

●Table 4-3 Synthetic Oil (POE)

Item	Criteria
(a) Color phase	ASTM color scale: 4.0 or less
(b) Total acid number (TAN)	0.2 mg KOH/g or less
(c) Kinematic viscosity	Within ±10 % from that of fresh oil
(d) Water content	200 mass ppm or less
(e) Degree of contamination	Degree of contamination measured by mass method (Millipore value) shall be 15 mg/100 mL or less

Note: Synthetic oils (compatible 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. Thus, use the criterion value only as a reference.

4.1.6 Lubricating Oil Replacement Timing

4.1.6.1 After Starting the Initial Operation

As the oil can easily be contaminated and degraded relatively quickly during the initial operation due to scales and deposits remaining in piping and vessels, be sure to sample and analyze the oil after 500 hours of operation.

If it is found as a result of the analysis that the criteria given in Tables 4-1 to 4-3 are not satisfied, the oil must be replaced.

4.1.6.2 During Normal Operation

Lubricating oils will degrade gradually as the system is operated over time.

The rate of degradation depends on the operating condition, type of oil and amount of foreign matters and moisture contained in the oil.

The lubricating oil must be sampled and analyzed every six months. If it is found as a result of the analysis that the control criteria given in Tables 4-1 to 4-3 are not satisfied, the oil must be replaced.

If the oil filters are frequently clogged or the oil color quickly becomes darker and unclear, replace the oil after removing the cause of the problem.

4.2 Precautions for Operation

If the package unit is used in the refrigeration cycle, please keep in mind the contents of this section in particular.

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 lubricating oil (too much oil loss). To prevent liquid flow-back, properly adjust the expansion valve of each liquid cooler. For details, refer to Chapter 6 "Troubleshooting" in this manual.

4.2.2 Purging of Non-Condensable Gases

WARNING

- **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 refrigeration cycle, air may enter the package 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 4-4 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.

4.3 When Stopping the Compressor for a Long Time

When stopping the compressor for a long period of time, make sure to perform the following steps.

- Turn off the motor main power.
- Turn off the heater power and control panel power.
- Close the suction and discharge side shut-off valves.

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

- Operate the oil pump for 10 seconds per week.
  After that, rotate the compressor shaft (10 rotations or more).
- Measure the package unit pressure once per month.
- Check for refrigerant leakage once per month.

When restarting the compressor after an operation stop period of 1 year or longer, check the system for refrigerant leak and analyze the lubricating oil.

If it is found as a result of the analysis that the control criteria given in this Chapter, Section 4.1.5 Tables 4-1 to 4-3 are not satisfied, the oil must be replaced.

Also check the motor insulation resistance.

Supply power to the oil heater at least 1 day before operation start.

Before starting the operation, confirm that the refrigerant is not condensed in the package unit by checking the package temperature and pressure.

5 Maintenance and Inspection

5.1 Precautions for Maintenance and Inspection

When reading this Section, also refer to Section 1.1 in this manual Chapter 1.

DANGER

- **When entering the machine room for maintenance services, ensure that sufficient ventilation has been started and measure the oxygen concentration so that there is no risk of oxygen deficiency. The ventilation must be continued steadily until the work is completed.**
- **For performing the inspection work, be sure to prepare safety shoes, protective glasses, gas mask and other proper protective equipment and do not fail to use them whenever they are required.**
- **After stopping the machine and before working on a regular inspection or overhaul, be sure to shut off the main motor power, control power, and other power to each equipment and valve. After they are shut off, be sure to make the switches inoperable by others. Also, be sure to attach notification tags to prohibit operation (lock-out/tag-out).**
- **When any manual stop valve has been closed, be sure to make the valve inoperable by others and put a notification tag to prohibit the operation (tag-out).**
- **When the compressor is to be overhauled, check that the internal pressure of this product is at the atmospheric pressure before starting the work.**
- **When using lifting devices, e.g. a crane, etc. and/or lifting tools, ensure that they can sufficiently withstand the load.**
- **When lifting a heavy load object, do not allow anyone's body to put under it.**
- **The work to turn each power supply ON/OFF or operate a lifting unit must be exclusively performed by qualified personnel.**
- **When using electric tools, ensure that they are properly managed in accordance with each instruction manual. Especially before using and while using, be sure to follow the care instructions on the safety of each instruction manual.**

WARNING

- **Be sure to use only MYCOM genuine parts for replacement. Using parts that are not genuine can cause damage to this product or other devices during operation.**
- **Do not convert or modify this product or its components without prior permission from MAYEKAWA. Otherwise, it can lead to an unexpected accident.**
- **Exercise sufficient care for handling a heavy load, and use such a lifting device as a crane or work with an adequate number of personnel commensurate with the magnitude of the weight. Also, be sure to use stud bolts (safety retention bolts) and other support tools for the work. Neglecting the above warning can lead to low back pain of the worker or injury due to dropping of the parts.**
- **If two or more people are to work together, be sure to clearly define the work procedures to share a common understanding among all workers before performing the work.**
- **Not only the work to turn each power supply ON/OFF or operate a lifting device, but also any type of work requiring qualification must be exclusively performed by qualified personnel.**

⚠ CAUTION

- **When checking the operation data of units and executing other daily maintenance services, pay particular attention to avoid touching the area heated to a high temperature causing skin burns or inadvertently moving the handle of a valve leading to an erroneous operation.**
- **In the disassembly/inspection workplace, secure a sufficient space for temporary storage of the removed parts and tools, replacement parts, and for the disassembling work as well as safety passages, and then put up necessary off-limit signs.**
- **In the workplace, secure a sufficient space and refrain from putting tools directly on the floor or from haphazardly laying wires.**
- **Keep the floor clean all the time. Leaving the floor smeared with oil and the like causes it to be slippery and may result in the fall and injury of personnel. Thus, do not leave it but wipe it off right away.**
- **Make sure that the temperature of the high temperature sections such as head covers and discharge lines has been cooled down to normal ambient temperature, before working on them.**
- **When disassembling and reassembling the compressor, use the specified tools properly. Before starting to use those tools, gain the full understanding of their characteristics and the method for use.**
- **During the maintenance service, keep the tools clean all the time. Using those tools smeared with oil increases the risk of slip and fall, leading to an injury. Also during the service, there is a risk of foreign matters intruding inside the compressor to cause its damage.**
- **Parts are slippery with oil. Fully watch out for the risk of any object falling down. Pay attention to any parts falling down, which could lead to personal injury.**

CAUTION

- **Before disassembly, inspections, and handling of the compressor, sufficiently understand the disassembly and assembly procedures.**
  This manual is not intended to provide complete disassembly and assembly procedures for the compressor. Instead, it describes only the important points in relation to the maintenance service of the compressor.
- **If complete disassembly and assembly of the compressor are required, please contact your nearest sales office or service center of MAYEKAWA.**
- **When removing a part, be careful not to damage it.**
- **Place the removed parts on a clean workbench in an orderly manner.**
- **For cleaning parts, use kerosene and/or machine parts cleaner.**
- **Washed parts shall be dried by compressed air or wiped up using clean cloth. Do not use synthetic textiles or woolen textiles to prevent fibers from attaching the parts.**
- **When separating the assembled compressor casings, sometimes it is difficult to separate them due to the gasket stuck. In such a case, never hammer in a screw driver or flat chisel into the gap. Screw jack bolts using the screw holes to separate the casing each other. When some gap is observed between them, use a scraper to remove one side of the gasket from the surface.**
- **Removed bolts from each part should be classified into each used section to prevent confusion.**

5.2 Maintenance and Inspection 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.

Table 5-1 Daily Inspection Items

Inspection Items			Inspection Contents	Check Points and Actions
Compressor	Operating hours	hr	Total operating hours	• Judgment of periodic maintenance timing
	Suction pressure	MPa Note 1	Difference from the set value of evaporation temperature equivalent pressure	• 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)	• If it is too high, check high-stage. If it is too low check low-stage.
	Discharge pressure	Mpa	Difference from cooling water temperature equivalent condensing pressure	• 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	• 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	• Contamination of lubricating oil • Clogging of oil filter element
	Suction temperature	°C	Whether within upper and lower limits	• Temperature, flow rate, etc. of the object to be cooled
	Degree of superheat for suction	°C	Whether degree of superheat is proper	• Adjust expansion valve • Insufficient refrigerant flow
	Intermediate temperature	°C	Whether within upper and lower limits	• Adjust intermediate expansion valve
	Discharge temperature	°C	Whether within upper limit	• Non-condensable gases mixed into the system • Oil supply temperature, insufficient oil supply • Compressor failure

Inspection Items			Inspection Contents	Check Points and 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/Motor failure
	Oil level of oil separator	-	Oil level	• Oil loss • Replenish oil
	Fluid level in the receiver	-	Fluid level	• Replenish refrigerant
	Check for refrigerant leak	-	leak or not	• Inside the machine room and in the facility on the load side

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 lubricating oil by referring to the instruction manual of the unit.

2. Replacing oil filter element
When the differential pressure between the inlet and out let ports of the oil filter exceeds 0.1 MPa, replace the oil filter element.
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. Lubricating oil 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

	1612LSC
Allowable leak rate	≤ 3 ml/hr
Rate at which inspection must be done	≥ 9 ml/hr

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 Periodic Inspection

Conduct inspection for the following items according to the specified intervals.

In addition, observe relevant laws and regulations on the inspections and recording of the results that are provided for other related items such as any safety devices (e.g. gas leak detectors), or other utility (gas/electricity) protection devices that constitute the cooling package unit together with the compressor.

Table 5-3 Periodic Inspection Items

Item	Inspection interval and Content	Remarks
Pressure gauges/ pressure sensors	Yearly inspection	
Thermometers/ temperature sensors	Yearly inspection	
Protection devices and safety valves	Yearly inspection	
Suction strainer	Inspect 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.
	Yearly inspection and cleaning	
Lubricating oil	Analyze lubricating oil after 500 hours from the start of operation.	Replace the oil if the analysis result does not satisfy the control criteria given in Section 4.1.5.
	Analyze oil every 6 months.	
Oil filter element	Yearly replacement	Replace the filter element if the differential pressure between the inlet and outlet ports of the oil filter exceeds 0.1 MPa.
Cooling water side of oil cooler	Yearly inspection	Clean if excessively contaminated.
Cooling water side of condenser	Yearly inspection	Clean if excessively contaminated.
Mechanical seal	Inspection every year or every 8000 hours of operation **Note***	To be replaced if any abnormality is found If it is difficult to stop equipment except for scheduled inspections, replace the part at each inspection.
Coupling	Inspection every year or every 8000 hours of operation **Note***	

Note*: Inspect the machine per period or operating hours, whichever comes first.

5.2.3 Guidelines for the Timing of Compressor Overhaul

The compressor overhaul interval 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 shows the recommended interval of overhaul, as a guideline.

Table 5-4 Guidelines for the Timing of Overhaul Based on the Conditions of Use (standard package)

Category of operating condition	Application example	Guideline for the overhaul timing
Relatively stable operating condition	Cold storage and refrigeration	Every 5 years or 40,000 operating hours
Relatively variable operating condition	Ice maker/chiller	Every 4 years or 30,000 operating hours
Frequently started/stopped, and relatively variable 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.
(Refer to Section 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.
(Refer to Section 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 Compressor Disassembly Preparation

Although screw compressors are very reliable machines, it is still necessary to perform overhaul to inspect internal parts after a certain period of operation.
This chapter 5 explains the essential points of disassembly methods, where to inspect on parts, and reassembly procedure of the compound 2-stage screw compressor 1612LSC speed increaser type.

In principle, overhauling of the screw compressor that requires complete disassembly should be performed in the maintenance factory. If you must do the overhaul work at the installation site due to unavoidable reasons, use the methods described in the following paragraphs.

However, please note that regular overhaul work requires removal of the compressor from the base frame. And then, the compressor should be placed on a work bench which has properly size area to disassembling the compressor.

When moving the compressor from the unit base to the workbench, be sure to follow the instructions given in Chapter 3, Section 3.1 "General Installation Precautions" and Section 3.2.3 "Transportation" of this manual.

Note that some parts name given in the text of this manual is followed by a number enclosed in square brackets [ ], which indicates the part identification number given in assembly sectional views or development views.

5.3.1 Disassembly Tools and Workplace

Prepare necessary disassembly tools for the compressor by referring to Section 7.5 "Disassembly Tools" in this manual Chapter 7.

In addition, prepare other necessary tools and materials including general hand tools, GC (green carbonite) grinding stones, sandpapers of #80 to #100, about #400 to #800 sandpapers, parts cleaner, lubricating oil, oilcan, empty can to receive drain oil, waste, etc.

If the overhaul work is to be done with the compressor removed from the installation base, prepare the work bench whose size is at least around 1.5 times the length and the width of the compressor.

In addition, a special stand for the compressor is required in order to safely perform the removal/fastening of bolts and plugs on the bottom side of the compressor. Refer to Section 5.3.5 of this chapter.

To the extent possible, choose a dry and clean workplace free from sand or dust. Note that a sufficient space is required around the compressor. In addition, it is necessary a temporary storage place for disassembled parts.

5.3.2 Replacement Parts

Prepare the MYCOM genuine parts for replacement.

Parts listed in Table 5-5, we recommend to be replaced on the occasion of each compressor overhaul.

When ordering parts, be sure to inform the (a) model name, (b) serial number, (c) part name, (d) code No. and (e) quantity required, to our sales offices or service centers.

In particular, if the serial number (b) is unknown, the details of the applicable design and manufacturing specifications cannot be identified, and thus it becomes difficult to choose correct parts. So, make sure to inform the (b) serial number to us.

Table 5-5 Replacement Parts of 1612LSC Speed Increaser Type Overhauling**

P/N	Part Name	Code No.	Remarks	Q'ty.
6-1	Gasket, Suction Cover (1)	CS00600-160N		1
6-2	Gasket, Suction Cover (2)	CS00600-1612CN		1

P/N	Part Name	Code No.	Remarks	Q'ty.
12-1	Gasket, Bearing Head (1)	CS01200-160N		1
12-2	Gasket, Bearing Head (2)	CS01200-1612CN		1
17-2	Gasket, Bearing Cover (2)	CS01700-1612CN		1
23	Gasket, Balance Piston Cover	CS02300-1612CN		1
27-1A	Main/Side Bearing (1) A	CS02700-1612C3		1
27-1B	Main/Side Bearing (2) B	CS02800-1610C1		1
27-2	Main Bearing (2)	CS02700-125		2
28-1	Main/Side Bearing (1)	CS02800-1610C1		2
28-2	Side Bearing (2)	CS02800-125		2
29-1A	Snap Ring (1) A C Type Internal H112	NG11-112	To be replaced if any abnormality is found.	1
29-1B	Snap Ring (1) B C Type Internal H102	NG11-102		3
29-2	Snap Ring (2) C Type Internal H80	NG11-080		4
30	Balance Piston	CS03000-1612C	To be replaced if any abnormality is found.	1
32	Snap Ring S40 external	NG12-040	To be replaced if any abnormality is found.	1
33	Balance Piston Sleeve	CS03300-160	To be replaced if any abnormality is found.	1
35	O-ring JIS B 2401 G95	PA12-095		1
37	Snap Ring C Type Internal H102	NG11-102	To be replaced if any abnormality is found.	1
38-1A	Thrust Bearing (1) A	CS03800-1612CP		1
38-1B	Thrust Bearing (1) B	CS03800-160P		1
38-2	Thrust Bearing (2)	CS03800-125P		2
39-1A	Lock Nut (1) A AN14	NG31-014	To be replaced if any abnormality is found.	1
39-1B	Lock Nut (1) B AN12	NG31-012		2
39-2	Lock Nut (2) AN09	NG31-009		2
40-1A	Lock Washer (1) A AW14	NG32-014		1
40-1B	Lock Washer (1) B AW12	NG32-012		2
40-2	Lock Washer (2) AW09	NG32-009		2
49	O-ring JIS B 2401 G90	PA12-090		1
50	Oil Seal	CS05000-160VD		1
52	Gasket, Seal Cover	CS05200-160N		1
59	O-ring JIS B 2401 P16	PA11-016		1
63	O-ring JIS B 2401 G95	PA12-095		2
65	O-ring JIS B 2401 P75	PA11-075		1
66	Cap Seal BE75	CS06600-125		1
68	Guide Pin Φ3×8	NE2503-008	To be replaced if any abnormality is found.	1
69	Lock Nut (1) AN05	NG31-005	To be replaced if any abnormality is found.	1
70	Lock Washer AW05	NG32-005		1
71	Lock Nut AN06	NG31-006	To be replaced if any abnormality is found.	1
72	Lock Washer AW06	NG32-006		1
73	O-ring JIS B 2401 P21	PA11-021		1
75	O-ring JIS B 2401 G85	PA12-085		1
77	Indicator Cam	CS07700-1610C	To be replaced if any abnormality is found	1
78	Ball Bearing, Indicator Cam #6000	CS07800-200		1

P/N	Part Name	Code No.	Remarks	Q'ty.
79	Snap ring C type External S10	NG12-010		1
82	V-ring, Indicator Cam VH10 NBR	CS08200-200B		1
83	Spring	CS08300-200		1
86	O-ring JIS B 2401 P16	PA11-016		1
89	O-ring JIS B 2401 P16	PA11-016		2
93-1	Gasket, Suction Flange (1)	CR72000-125N	MYK 125A(5")	1
93-2	Gasket, Suction Flange (2)	CR72000-080N	MYK 80A(3")	1
96-1	Gasket, Discharge Flange (1)	CR72000-080N	MYK 80A(3")	1
96-2	Gasket, Discharge Flange (2)	CR72000-065N	MYK 65A(2"1/2)	1
100	Mechanical Seal Assembly BBS-E	CS10002-160EBS	To be replaced if any abnormality is found	1
125	Set of Micro-switch 125L	CS1259-C	To be replaced if any abnormality is found	1
129	Potentiometer 1612 1k with Wire	CS1299-J	To be replaced if any abnormality is found.	1
202	Bevel Gear ID 6 mm	CS20100-1612C6	To be replaced if any abnormality is found	2
-	Gear Coupling Assembly (Current Type)	CS1519-J	To be replaced if any abnormality is found.	1
159	Knurled Cup Point Socket Set Screw with anti-loosening	NA83606-015	To be replaced if any abnormality is found.	1
160	Lock Nut AN8	NG31-008	To be replaced if any abnormality is found.	1
161	Lock Washer AW8	NG32-008		1
163	O-ring JIS B 2401 G25	PA12-025		1
165	O-ring JIS B 2401 P21	PA11-021		1
170	Gasket, Speed Increaser Gear Casing	CS17000-1612CN		1
172	Gasket, Speed Increaser Gear Casing Cover	CS17200-1610CN		1
183	Side Bearing Speed Increaser Driven Gear	CS02700-125		1
185	Roller Bearing	CS18500-1612C		1
186	Snap Ring C Type Internal H110	NG11-110	To be replaced if any abnormality is found	1
187	Snap Ring C Type External S60	NG12-060		1
189	Thrust Bearing	CS03800-200P		1
193	Lock Nut AN13	NG31-013	To be replaced if any abnormality is found	1
194	Lock Washer AW13	NG32-013		1
197	O-ring JIS B 2401 P32	PA11-032		1
237-1A	Tortional Slip Washer (1) A	CS23700-1612CB		1
237-1B	Tortional Slip Washer (1) B	CS23700-160		2
237-1C	Tortional Slip Washer (1) C	CS23700-200		1
237-1D	Tortional Slip Washer (1) D	CS23700-250		1
237-2	Tortional Slip Washer (2)	CS23700-125		2
269	Lock Nut AN17	NG31-017	To be replaced if any abnormality is found	1
270	Lock Washer AW17	NG32-017		1

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 us when placing an order.

5.3.3 Refrigerant Gas Recovery

At the time the compressor operation is stopped, the pressure inside the compressor is still high. As such, it is necessary to lower the pressure down to the atmospheric pressure before starting the disassembly process. To do this, there are the following methods for example. Perform your recovery work in an appropriate manner considering site conditions, requirements of regulatory laws and regulations.

- By using the bypass valve, release the high pressure gas in the package unit to the low pressure side.
- If there is another compressor unit to which a permanent bypass line is connected, operate the other compressor and lower the pressure through the bypass line.
- Operate the refrigerating system, and close the fluid supply master valve to turn the gas into liquid, and recover the liquid at the receiver.
- By using a refrigerant recovery machine, recover the liquefied refrigerant in the receiver.

In using either method, prepare a working flow sheet of the system beforehand. Check the valves to be controlled during the recovery work, according to the method to be used, by comparing them with the ones in the flow sheet, and clearly note the valves to be operated, other connected devices, and tubes on the flow sheet.

Two flow sheets must be prepared: one at the foreman and the other for posting in the workplace.

In addition, prepare a work procedure document for the refrigerant recovery work to reflect the actual conditions of the workplace, and sufficiently share the work details among all the coworkers through checking and confirmation before actually starting the work.

The gas mask and other protective gears required at each stage of refrigerant recovery work must be prepared before starting the work.

WARNING

- **Before the work, be sure to check and communicate the work details and procedure among all coworkers, and carry out hazard prediction activities based on the information shared. Neglecting to do this will increase the risk of on-the-job accidents and injuries to a considerable level.**
- **After closing (opening) a valve for work, conduct lockout/tagout to prevent it from being handled accidentally during work.**

5.3.4 Removing Parts Connected to the Unit

DANGER

- **If there is residual high-pressure refrigerant gas or oil dissolved in the refrigerant, the gas and oil may blow off when closed valves (components) are opened. This may result in injury such as frostbite and loss of vision. Always check and confirm the pressure in the compressor, before opening any pipe connections and valves.**

When removing the compressor from the mounting base frame, the following parts must be disconnected beforehand:

(1) The coupling joining the compressor and driving machine

(2) The compressor's suction piping flange and discharge piping flange (if the suction strainer is connected directly to the compressor, remove the strainer too), and the intermediate piping connecting the low-stage discharge port to the high-stage suction port

(3) Compressor lubrication piping (journal lubrication: 2 places, oil injection: 1 place, capacity control loading/unloading: 1 place each)

(4) Capacity control operation electric wiring
(Depending on the situation of the workplace, unloader indicator assembly may be separated, with the wiring left as it is. Refer to "5.7.15" in this manual.)

(5) Bolts for attaching compressor (leg bolts)

【POINT】

When removing oil lines from the compressor, there is possibility of gas and oil blowing out caused by residual gas pressure. Moreover, any residual oil in the pipe will flow out. To be prepared for this, either check the amount of oil outflow by slightly loosening the pipe joint or drain the oil from the oil temperature gauge at the supply header before removing the pipe.

Work carefully in particular when disassembling the unloader cylinder block since there is residual pressure and oil fills in the unloader cylinder. Moreover, prepare a larger volume container than the unloader cylinder volume to receive oil flowing out.

For easy reconnection, disconnected electric wires should be properly marked for identification. Any wrong reconnection may result in a startup failure or inability to operate the capacity control mechanism.

5.3.5 Compressor Removing and Lifting

DANGER

- **The work to lift up or move the compressor must be performed by a qualified operator.**
- **Make sure that the lifting equipment and wires have sufficient load capacity for the compressor before starting the compressor lifting work.**
- **Never try to perform disassembly or assembly while the compressor is lifted in the air.**

【POINT】

Since the suction piping is located immediately above the compressor, hold it up or partially remove it before lifting the compressor.

For the lifting positions of the compressor, refer to Figure 3-1 in page 3-3 of Chapter 3 in this manual.

If the planned overhaul work includes separation between low-stage and high-stage blocks of the compressor, place the compressor on a special stand as shown in Photo 004 and then remove eight or more hexagon head cap screws around the bottom flange part. **Never try to remove these bolts while the compressor is lifted in the air.** Note that these bolts cannot be removed once the compressor is placed on the work bench.

Lifting the Compressor

Lower Bolts for Tightening Rotor Casing

5.3.6 Removing Oil from Inside the Compressor

Since there is a large quantity of oil inside the compressor, remove it beforehand.
There is a plug [10] under the suction cover [5-1] and a plug [15] under the bearing head [11-1].
Most of the oil will flow from these plug holes. The remaining oil will flow onto the work bench during disassembly.
Main locations remaining oil are a) inside the unloader cylinder, b) inside the balance piston cover, c) inside the seal cover [51], and d) inside the suction cover [5-1]. Prepare a tray and cloth for oil that spills during disassembly.

5.4 Disassembly and Inspection

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 ⑲, 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 that have no problem should be left as they are. Do not disassemble such parts unless during periodic inspection.
Since it is difficult to completely eliminate the risks of performing inaccurate work at the field, disassemble the minimum required parts only.

Table 5-6 Disassembly Order of Compressor (examples)

	Part for Disassembly	Disassembly Order (Refer to Figure 5-1)
(1)	Shaft seal block	① - ②
(2)	Unloader indicator	③
(3)	Unloader cylinder cover	③ - ④
(4)	Unloader piston and unloader cylinder	④
(5)	Speed increaser gear casing cover	③
(6)	Speed increaser gear casing	⑥
(7)	Separating high-stage and low-stage	⑦
High-stage		
(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 casing and main bearing	⑩ - ⑪ - ⑫
(13)	Rotor and main rotor casing	⑬ - ⑭
(14)	Bearing head and main bearing	⑭
Low-stage		
(15)	Thrust bearing	⑮
(16)	Gear coupling	⑯
(17)	Suction cover casing and side bearing	⑰
(18)	Rotor and main rotor casing	⑱ - ⑲
(19)	Bearing head and main bearing	⑲
(20)	Unloader slide valve and guide block	⑲

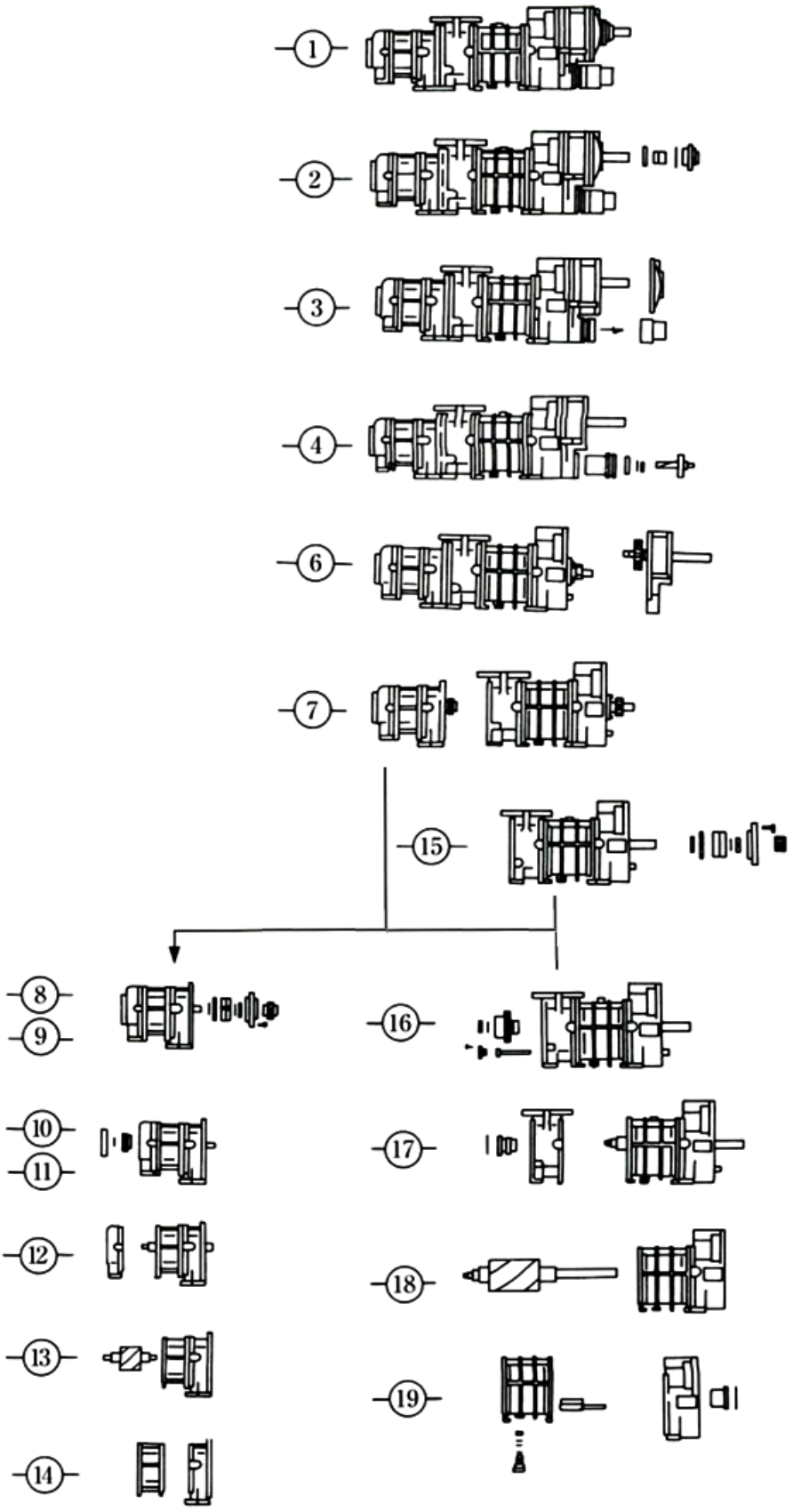
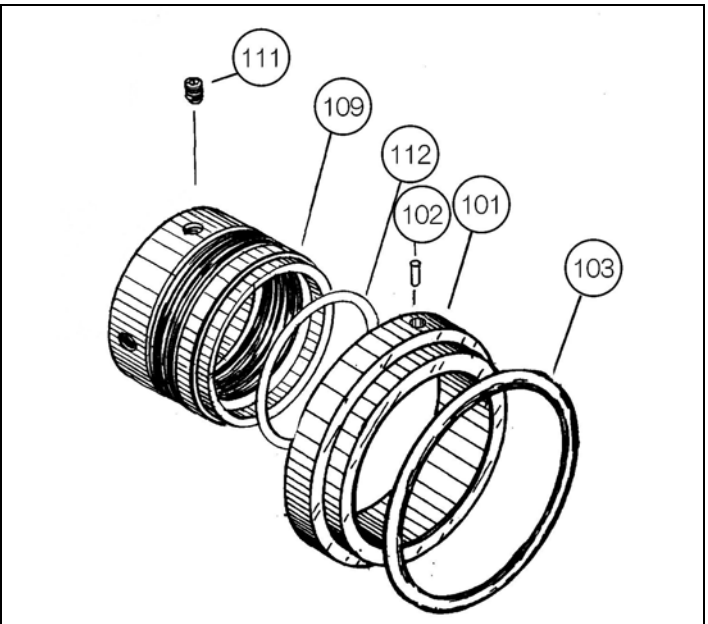


Figure 5-1 Disassembly Order Description

5.4.1 Shaft Seal Block



P/N	Part name	
101	Mating ring	Mating ring
102	Insert lock pin	
103	O-ring	
109	Seal collar	Rotating ring
111	Seal collar set screw	
112	O-ring	

Figure 5-2 Details of BBSE Type Mechanical Seal Assembly

5.4.1.1 Disassembly

a) Of the eight hexagon socket head cap screws [53] on the seal cover [51], remove six screws leaving two diagonally opposite screws.

b) Slowly loosen the remaining two screws by turns so that they stay even. After a certain amount of loosening, the seal cover of the mechanical seal will be pushed by the spring and a gap will appear. A gap will not appear if the gasket is stuck. In that case, push the seal cover by screwing the M8 eyebolts into the seal cover's service holes.

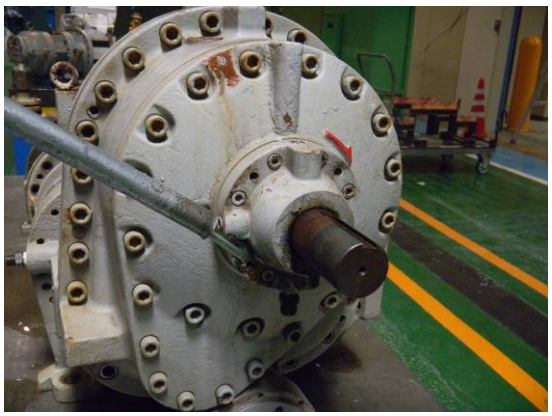
c) Use a container to catch the oil that will flow out through the gap.

d) Pull out the seal cover keeping it parallel with the shaft (rotor axis). The mating ring inside the seal cover is attached with an O-ring [103]. Ensure that the mating ring and shaft do not come into contact causing damage.

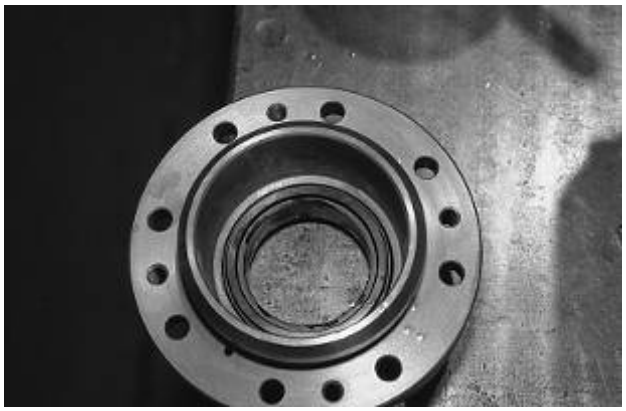
e) Remove the O-ring [49] between the seal cover and the seal retainer [48].

f) After removing the seal cover, wipe clean and inspect the axis 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 three times.
For 1612LSC type compressors, remove the plug on the speed increaser gear casing cover and loosen the set screws through the plug hole with a hexagonal wrench. At this time, do not remove the set screws, but leave them so that the tips are below the surface of the seal collar. There are two set screws separated by 90°.

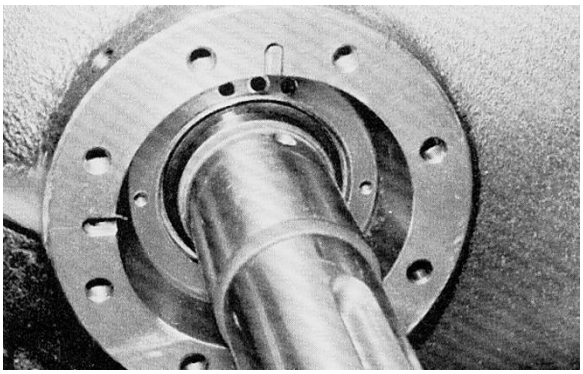


Loosening Screws Fastened Seal Cover



Seal Cover and Mating Ring

Loosening the Seal Collar Set Screw



Seal Retainer

h) Pull out the seal collar part with your fingers. When pulling out, ensure that the tips of the set screws do not hit the shaft. Axial direction damage to the shaft can cause leaks.

i) Screw two M8 eye bolts into the threaded holes in the oil seal retainer and pull out the oil seal retainer while keeping it at a right angle against the shaft.

j) Remove the oil seal [50] that is attached into the oil seal retainer.

5.4.1.2 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. In addition, if it is difficult to stop the compressor operation except for scheduled inspections, we recommend to replace the mechanical seal assembly with a new one at every inspection of this block.

b) Since swelling or deformation can occur easily on O-rings, replace them each time the mechanical seals are inspected.
There are three seal O-rings: the O-ring [49] between the seal cover and seal retainer, the O-ring [103] between the mating ring and seal cover, and the O-ring [112] between the seal collar and shaft. For BOS models, there is another O-ring [106-2] on the main body of the mechanical seal, bringing the total to four O-rings.

c) Oil seal is also unconditional replace. Use genuine replacement parts. Since the oil seal is made of a special material, only a genuine oil seal must be used for replacement.

d) Replace the seal cover gasket with a new one.

5.4.2 Unloader Indicator

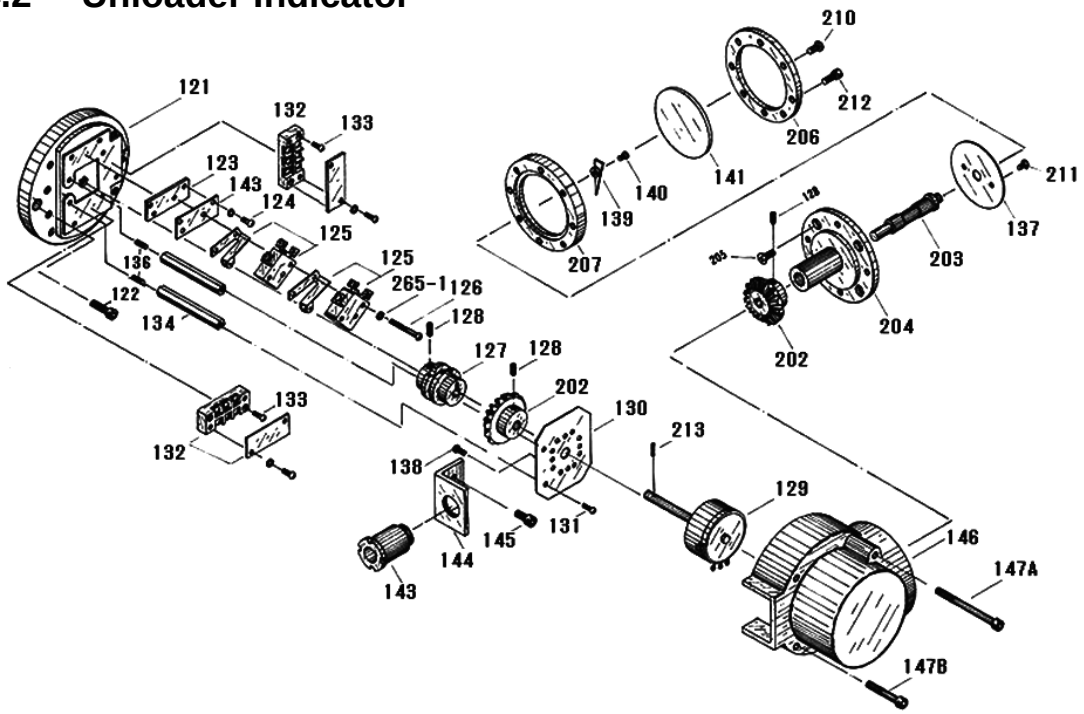


Figure 5-3 1612C Unloader Indicator Block**

Table 5-7 Unloader Indicator Components

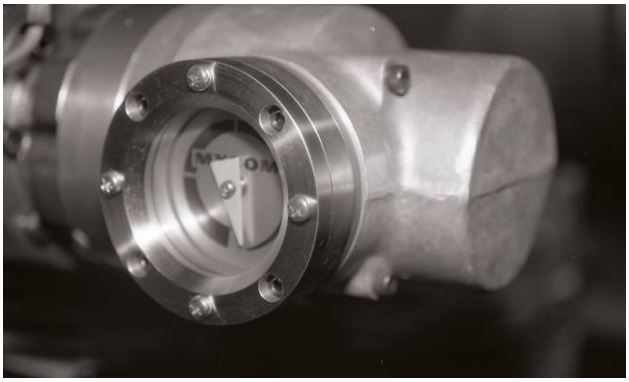
P/N	Part Name	Qty	Remarks	P/N	Part Name	Qty	Remarks
120	Indicator assembly	1		141	Indicator glass	1	141
121	Micro-switch base plate	1	125L**	143	Electric wiring connector	1	
122	Hexagon socket head cap screw	2	M6 x 25	144	Connector support	1	125L**
123	Micro-switch set-plate	1	125L**	145	Hexagon socket head cap screw	2	M6x15
124	Philips screw	2	M3 x 10	146	Indicator cover (2)	1	1612LSC
125	Micro-switch	2		147A	Hexagon socket head cap screw	2	M6x95
126	Philips screw	2	M2.5 x 25	147B		2	M6x60
127	Micro-switch cam	1	125L**	149	Micro-switch Insulation plate	1	125L**
128	Set screw	2	M4 x 8	202	Bevel gear (2)	2	Φ6
129	Potentiometer	1		203	Indicator shaft	1	
130	Potentiometer set-plate	1	200L**	204	Indicator shaft bearing	1	
131	Philips screw	3	M3x5	205	Flat head screw	4	M5x14
132	Terminal block	2	LK-3P	206	Indicator glass gland	1	
133	Philips screw	4	M3 x 20	207	Indicator glass support	1	
134	Potentiometer support arm	2		210	Philips screw	4	M5x15
136	Potentiometer mounting screw	4	M3 x 14	211	Flat head screw	2	M3x5
137	Indicator dial	1		212	Hexagon socket head cap screw	4	M5x30
138	Indicator dial screw	2	M3x5	213	Spring pin	1	Φ2x8
139	Indicator needle	1	200L**	265-1	Spring washer	2	M2.5
140	Indicator needle screw	1	M3x10	265-2	Spring washer	2	M3

5.4.2.1 Disassembly

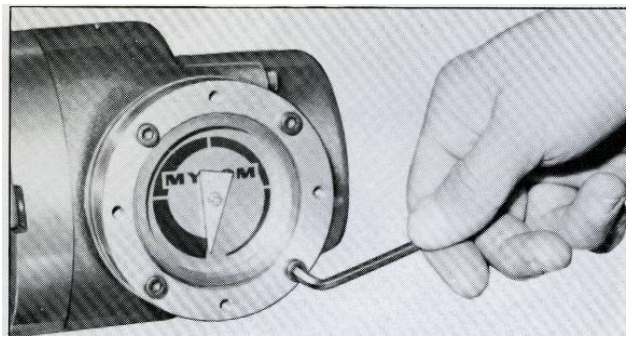
■ **When removing wiring only**

Remove the indicator cover before pulling out the unloader indicator wiring because the indicator has a terminal board for wiring. Perform the work as described below and after removing the wiring reattach the cover for protection.

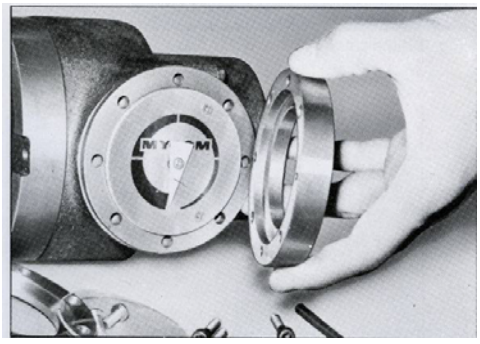
a) Loosen the hexagon socket head cap screws [212] holding the indicator glass. Do not mistakenly loosen the phillips screws [210] on the same surface. Remove the indicator shaft assembly parts [141], [202 – 207], [210], and [211].
b) Remove hexagon socket head cap screws [147A] [147B] (two each) that fasten the indicator cover [146]. Then the cover gets removable.
c) Since there is a terminal block [132], remove wiring after removing the surface plastic sheet and loosening the screws.



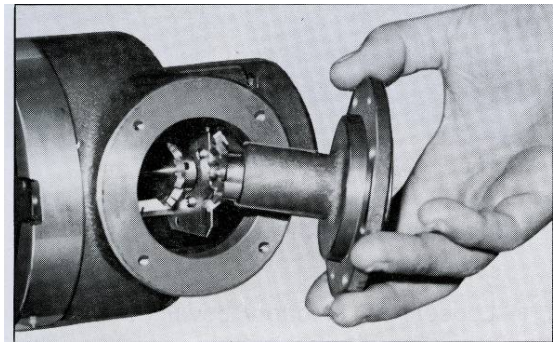
Unloader Indicator Assembly Part



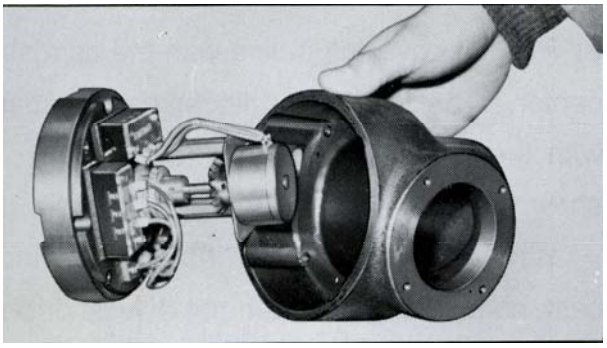
Removing Indicator Glass and Gland



Removing Indicator Glass and Gland



Removing Indicator Shaft Assembly

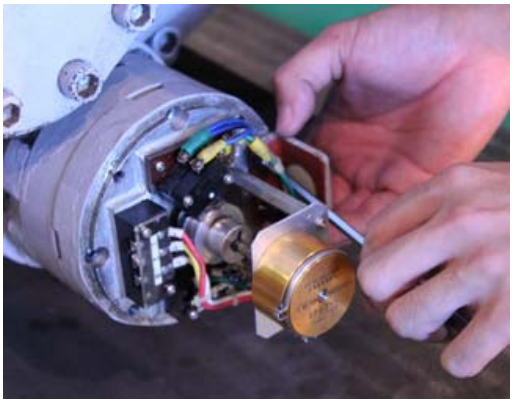


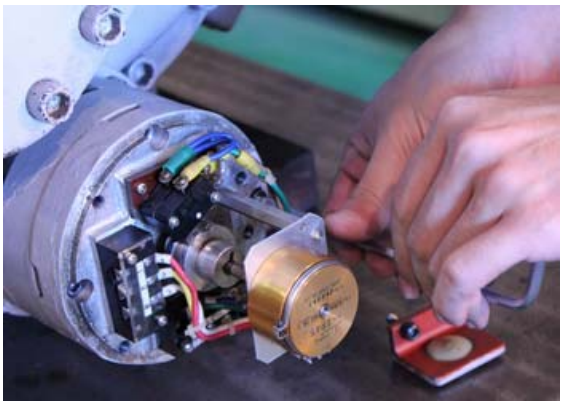
Removing Indicator Cover

■ **When removing entire unloader indicator assembly, with the wiring left as it is**

a) After the disassembly in the previous section, the internal potentiometer [129], micro-switches [125], and micro-switch base plate [121] with micro-switch cam [127] attached can be removed.

b) Micro-switch base plate is fastened to the unloader cover with two hexagon socket head cap screws [122]. Since the one screw of them is hidden under the connector support [144], remove two hexagon socket head cap screws [145] and the connector support (following picture to the left).



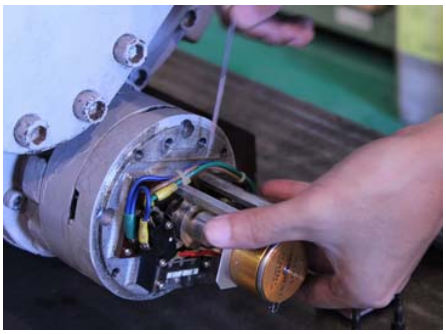


c) Then remove two hexagon socket head cap screws fastening the micro-switch base plate (above picture to the right).

d) Micro-switch cam [127] is secured to the indicator cam [77] by a set screw [128]. Turn the micro-switch base plate to easy direction for the work, and then loosen this set screw to free the micro-switch cam (following picture to the left).

CAUTION

- **When you remove the set screw [128] from the micro-switch cam, it is easy to lose the screw. Leave it only to loosen.**



e) Now, it is possible to remove the indicator assembly as is by pulling in the axial direction.

5.4.2.2 Inspection

Since the unloader indicator block is removed as assembly and its inspection and adjustment is often performed after reassembling and recovering the compressor, the inspection procedure is described in Section 5.7 "Reassembly" in this chapter. Refer to Section 5.5.15 "Unloader Indicator".

5.4.3 Unloader Cover

The unloader cover [74] contains the indicator cam [77], which converts the linear motion of the unloader slide valve to a rotational motion, and its attachment parts.

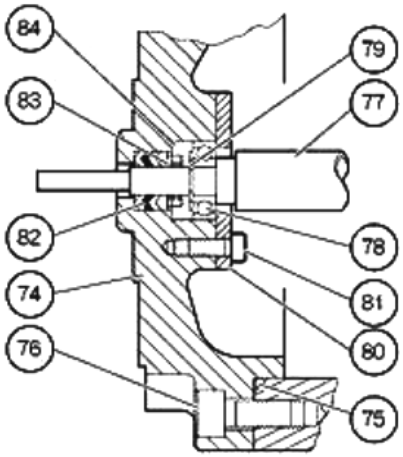


Figure 5-4 Unloader Cover Block

5.4.3.1 Disassembly

a) Remove the hexagon socket head cap screws [76] for attaching the unloader cylinder cover.

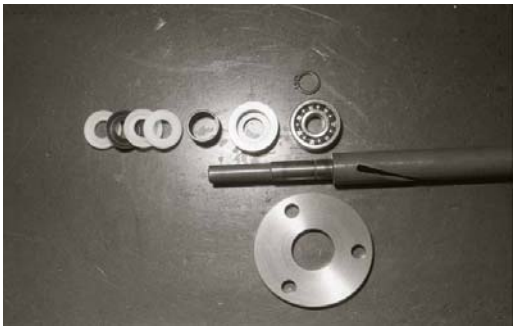
b) The unloader cylinder cover can be pulled straight out as is because the indicator cam [77] attached to the unloader cylinder cover is stuck to the inner side of the unloader push rod [67] in the unloader cylinder, and the grooved pin (guide pin) [68] is in the groove of the indicator cam.
Ensure that the unloader cylinder cover is not bent because the axis part of the indicator cam will also become bent.

c) If the indicator cam does not move properly, check the spiral groove of the indicator cam, bearing 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 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 external snap ring [79] securing the bearing.

c-3) The spring retainer [84], spring [83] and V-ring [82] are attached, in this order, to the inside of the unloader cover.
The outer diameter of the Teflon V-rings is attached tightly to the holes of the unloader cover. These V-rings, once removed, cannot be reused because their tongue portion gets damaged. So be careful.



Indicator Cam Mounting Parts

5.4.3.2 Inspection

a) Check the packing portion of the indicator cam shaft for any flaw. If the refrigerant leaks without any flaw observed in this part, it should be due to a defect of the V-ring or installing the V-ring without sufficient oil. In this case, replace the V-ring.

b) Check the spiral groove of the indicator cam. If defect such as damage or wear is found, replace it with a new one.

V-ring

5.4.4 Unloader Piston and Unloader Cylinder

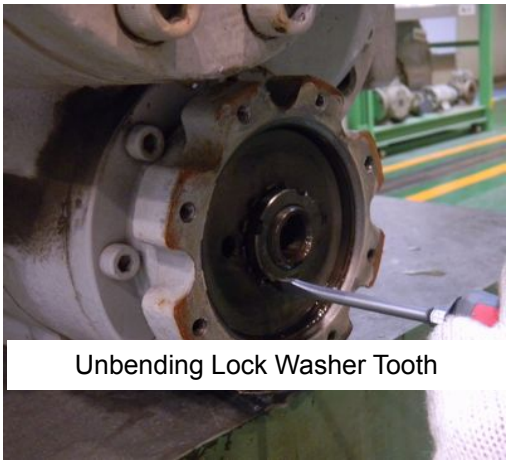
5.4.4.1 Disassembly

a) Screw two M8 eyebolts into the unloader piston [64], and pull out it to the no-load position (utmost front position).

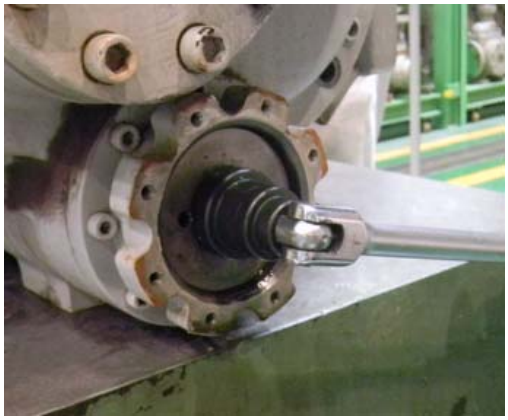
b) Unbend the rotation stopper tooth of the lock washer [70], loosen and remove the lock nut [69].

c) Now, you can remove the unloader piston.

d) The unloader cylinder [60] is attached to the low-stage bearing head [11-1] along with the speed increaser gear casing [169] by eight long bolts [61]. Remove [61] and then pull out the unloader cylinder.



Unbending Lock Washer Tooth



Loosening Lock Nut

Removing Unloader Cylinder

5.4.4.2 Inspection

a) Remove and inspect the O-ring [65] attached to outside the unloader piston and the cap seal [66], testing the O-ring for elasticity and deformation. Replacing the O-ring is recommended after more than two years of use.

b) Since the unloader cylinder often has damage or oil refuse stuck to the inner surface, clean thoroughly and use fine sandpaper to smoothen it.

Removing the Cap Seal

5.4.5 Speed Increaser Gear Casing Cover

The 1612LSC model is speed increaser type compressor, so remove the speed increaser gear casing cover [171] as drive shaft cover.

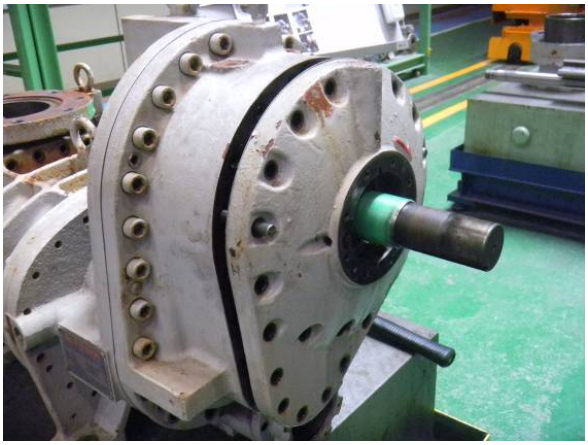
5.4.5.1 Disassembly

Loosen the hexagon socket head cap screws [195]. Before removing these bolts, screw two stud bolts into the threaded holes at the top of the cover.

【POINT】

Although no alignment pins, the speed increaser gear casing cover does not drop by itself even when the bolts are removed because it is fitted on the thrust bearing gland located inside.
However, when you go on the disassembly work of this block without screwing the stud bolts, there is a risk to damage of the speed increaser gear spindle by dropping the cover.
Make sure to screw in the stud bolts beforehand.

Tap the cover gently with a hammer to loosen the gasket which is sticking to both mating surfaces. Pull out the speed increaser gear casing cover in a direction parallel with the shaft.



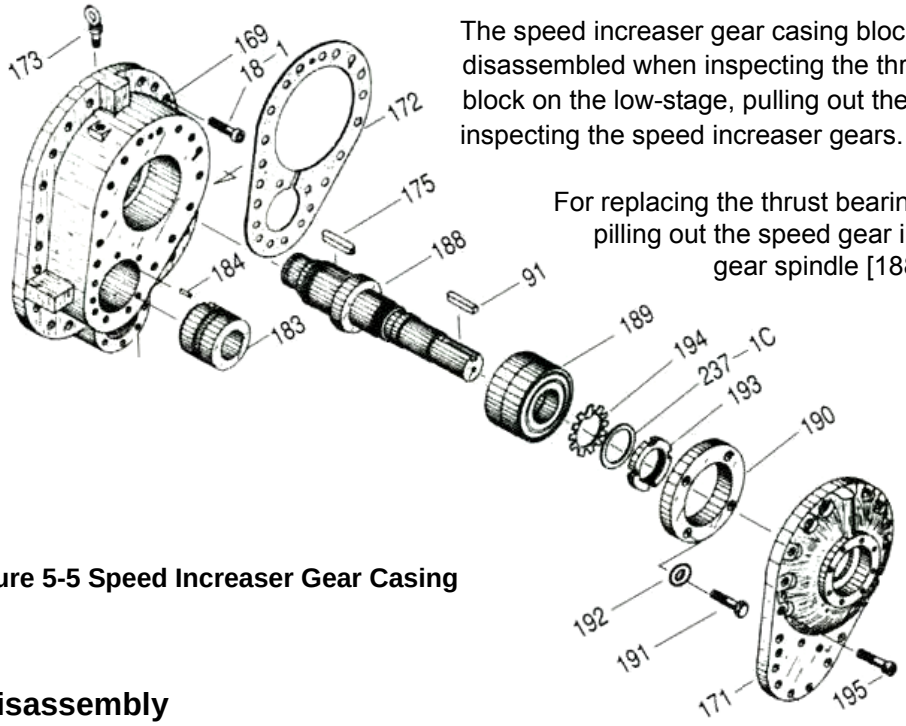
Removing Speed Increaser Gear casing Cover

After Cover Removal

CAUTION

- **At this time, ensure that the speed increaser gear casing cover is supported to avoid it toppling or dropping onto the shaft (spindle axis). Protect the shaft with a cloth beforehand.**

5.4.6 Speed Increaser Gear Casing Block



The speed increaser gear casing block needs be disassembled when inspecting the thrust bearing block on the low-stage, pulling out the rotors, or inspecting the speed increaser gears.

For replacing the thrust bearing [189], pilling out the speed gear increaser gear spindle [188] is required.

Figure 5-5 Speed Increaser Gear Casing

5.4.6.1 Disassembly

It is possible to separate the speed increaser gear block as an entire assembly.
However, remove the side bearing for the speed increaser gear spindle before separating the speed increaser gear casing assembly.

a) Remove the speed increaser drive gear side bearing [183]. The side bearing is positioned by the spring pin [184] inside the speed increaser gear casing and held by the speed increaser gear casing cover [171].
Screw two M8 eyebolts into threaded holes on the side bearing, hang a pipe on the eyes of the eyebolts and pull out by tapping the pipe lightly toward you (following picture to the left).

b) Screw M12 eyebolts into two threaded holes on the upper surface of the speed increaser gear casing, and hook lifting tools onto the eyebolts (above picture to the right).

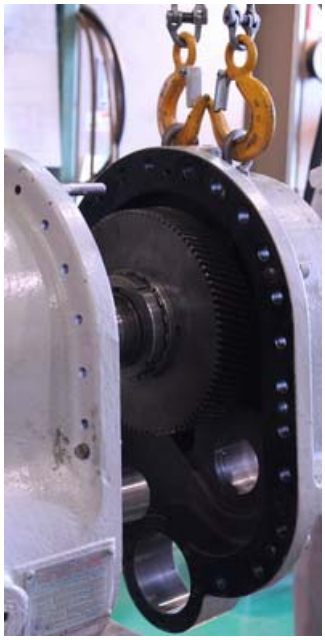
c) Remove all the hexagon socket head cap screws [18-1]. The casing is held in position by the alignment pins [19-1], so it remains attached to the bearing head [11-1].

d) Tap the alignment pins [19-1] toward the bearing head [11-1].

e) Screw the previously removed three bolts [18-1] into the jacking threaded holes in the flange of the speed increaser gear casing, and screw them alternately and evenly to separate the flange from the speed increaser gear casing (picture below).



f) After disengaging alignment pins, pull out the casing with parallel direction to the speed increaser gear spindle shaft (following picture to the left).

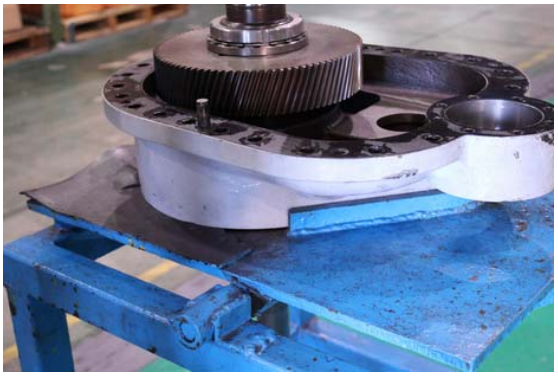


When there is no need to replace the speed increaser drive gear [174] and/or speed increaser gear spindle [188] because no abnormalities are observed in them, it is not necessary to remove the speed increaser drive gear from the speed increaser gear spindle.

In such a case, start next disassembly work from removing the inner race of roller bearing [185] described in step k) on next page.

Following steps g) to j) are the procedures for replacing the speed increaser drive gear and/or spindle [188].

g) Place the speed increaser gear assembly on the work stand while facing the drive gear up, i.e. the thrust bearing toward floor. It is acceptable to use to the work stand as shown in the above picture to the right. However, if you can prepare the special work stand with the angle changeable surface as shown in the following picture, you can do more safely work.

h) Unbend the rotation stopper tooth of the lock washer [270] for the lock nut [269] as shown in the picture below, then loosen the lock nut and remove it with the torsional slip washer [237-D] and the lock washer.

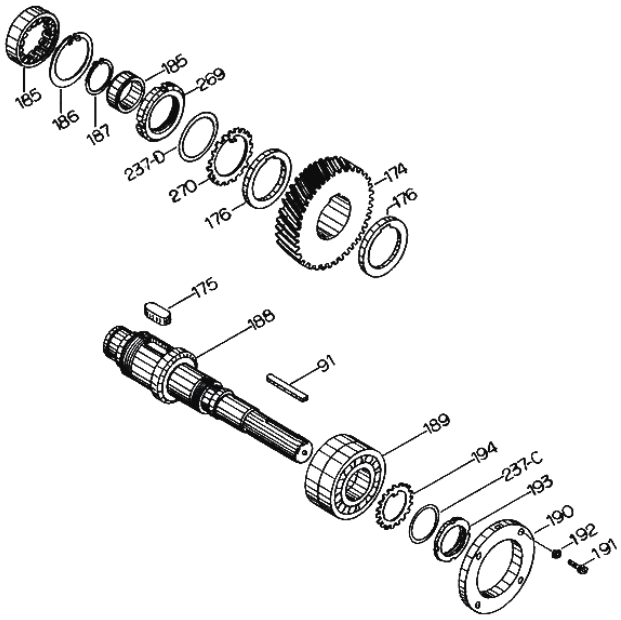


Figure 5-6 Speed Increaser Drive Gear and gear spindle

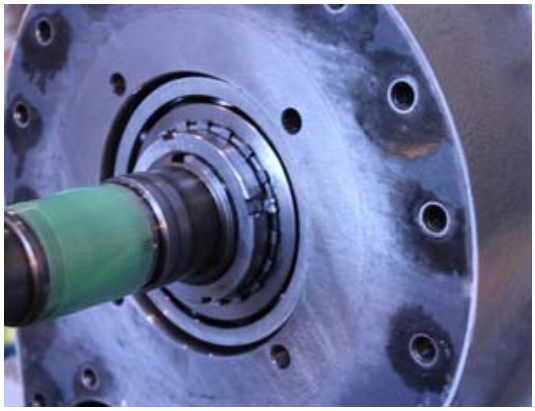
i) Then remove the speed increaser gear spacer [176] (following picture to the left).

j) Screw two eyebolts into threaded holes on the drive gear [174] as sown in the above picture to the right to remove the drive gear with lifting it.

k) The inner race of roller bearing [185] which supports the spindle shaft end is attached on the shaft end with shrink-fitting. Pull out the inner race of the roller bearing while heat up it by using a blowtorch or the like.

m) Turn upside down the speed increaser gear casing together with the spindle, place it on the work stand while facing the thrust bearing side to up.
Since the thrust bearing [189] is firmly shrink-fitted on the spindle to support the radial load as well as the thrust load, there is no risk of dropping down with the spindle during the work.

n) Remove the hexagon head bolts [191] together with the spring washers [192] and the thrust bearing gland [190]. The right picture is overviewed after removing them.



o) Unbend the rotation stopper tooth of the lock washer [194], loosen and pull out the lock nut [193] with the torsional slip washer [237-C] and the lock washer.

p) As shown in the below left picture, when you tap the speed increaser gear spindle shaft end face lightly with fitting a plastic block or the like, the spindle will fall off. Prepare a cushion to prevent the spindle shaft from directly dropping on the floor (following picture to the right).

5.4.6.2 Inspection

a) The speed increaser gears are given extra allowance in durability to withstand hard operations and least likely to show abnormalities under ordinary operating conditions.

   The gears are normal when their teeth have mirror gloss surfaces. If abnormally worn should be found, replace them after investigating the cause and taking necessary measures.

   Lubrication-related components and lines should be primarily checked in this case.

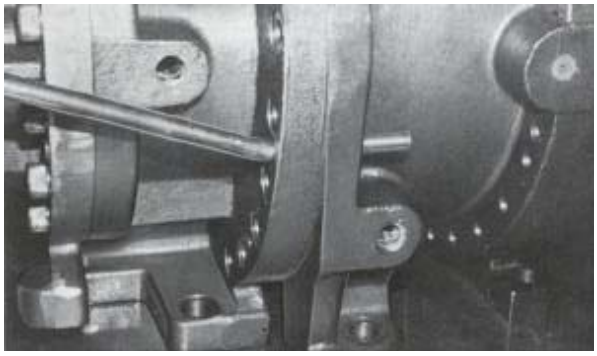
b) Check the shaft seal area of the spindle shaft surface on which a mechanical seal assembly is installed. If any flaw is observed, resurface and finish with sandpaper.

c) When you disassemble following each part, replace them with new ones, i.e. a speed increaser drive gear side bearing [183], a roller bearing [185] including inner race and outer race, and a thrust bearing [189].

5.4.7 Separating High-stage and Low-stage

Separate the high-stage and low-stage when inspect the high-stage thrust bearing block or pull out each stage's rotor is required.

Structurally, it does not matter even if separated at the first step of disassembly.



Separating High-stage and Low-stage

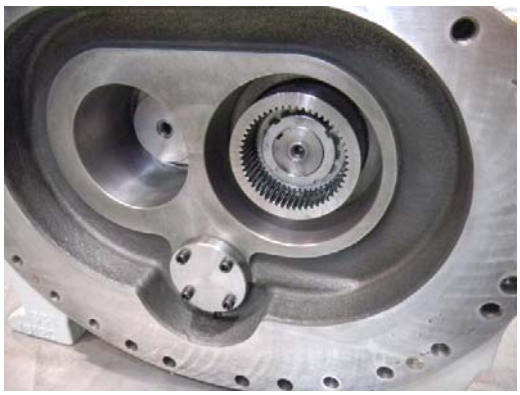
5.4.7.1 Disassembly

a) As explained in Section 5.3.5 of this chapter, 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 high-stage of the compressor is spaced apart the work bench. Brace the high-stage with a rectangular piece of wood or the like to prevent it from falling when disassembled.

b) Drive alignment pins [19-2] into suction cover [5-1].

c) Since the bearing head [11-2] and suction cover are stuck together with the gasket [17], screw the previously removed bolts [18-2] into two jacking threaded holes on the bearing head to push out the suction cover evenly.
   Do not insert a screwdriver or chisel into the gap.

d) On the M rotor axis there are power transmission gear couplings [151 to 161].
   Move the casing in parallel with the axis to separate the driving side and the driven side in the axial direction.



Low-stage After Separation

Removing Driven Hub

* Above pictures are gear coupling before the design modification of February, 2011.

5.4.8 Gear Coupling

The gear coupling, which is used as a power transmission means, is divided into the high-stage and the low-stage blocks, with each block attached to the corresponding M rotor shaft, and these two blocks are directly connected by a drive sleeve.

Gear coupling mechanism of 1612C models**

In January 1979, the coupling method was changed from the initial type (coupling hub is directly connected using hexagon head screws) to the method using coupling hub and sleeve. This method was used for a long time.

However, the anti-falling method of the drive sleeve was modified in February 2011 as the design modification. While the old couplings have stoppers on both outer ends of the drive sleeve, the stoppers are placed on the inside of the drive sleeve after the design modification (compatible with the old type).

After this design modification, the drive sleeve stopper [154] and snap ring [155] are no more used.

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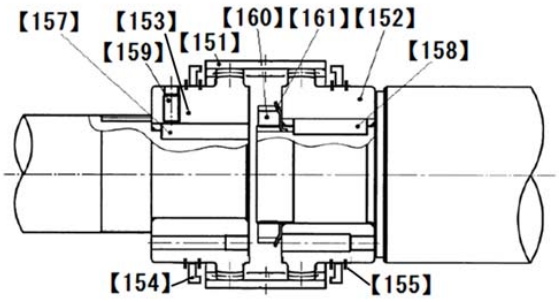
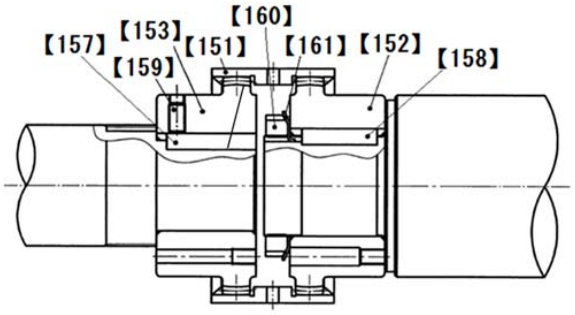


Gear coupling assembly comprising
151, 152, 153, 154*2, 155*2 and 159.

**Figure 5-7 Former Method
(Used Until Design Change in Feb. 2011)**



Gear coupling assembly comprising
151, 152, 153 and 159.

**Figure 5-8 New Method
(Used After Design Change in Feb. 20101**

5.4.8.1 Disassembly

a) Drive sleeve [151] can be removed with hands when the high-stage and low-stage are separated.
b) On the high-stage (driven) side, loosen the set screw [159] of the key [157] attached on the driven hub [153], and then remove the driven hub. As it is clearance-fitted, it can be removed easily.
c) On the low-stage side, unbend the lock washer tooth [161] and loosen the lock nut [160] to remove the drive hub [152].
d) Two screw holes are provided on the drive hub. Screw in M8 eye bolts, and pull out the drive hub. As it is clearance-fitted, it can be removed easily.

【POINT】

For the set screw [159], MAYEKAWA recommends a knurled cup point locking screw with an anti-loosening coating on the screw.

5.4.8.2 Inspection

Check the hub and sleeve for possible deformation of the gear teeth and wear on each tooth flank.

If any defect is found, replace the whole gear coupling assembly. Also, investigate cause(s) of the defect.

5.4.9 Balance Piston Cover

Disassemble the balance piston cover when pulling out the rotors or inspecting the side bearing [28-2] or balance piston [30].

a) Loosen all hexagon socket head cap screws [24] 3 or 4 rotations, lightly tap the side of the balance piston cover [22] with a soft hammer, and peel off the sticking balance piston cover gasket [23].

b) In this state, drain the oil from the balance piston and the side bearing block inside the suction cover. When the oil has been drained, remove all screws apart from the one on the upper side. While holding down the balance piston cover, remove the remaining screw and remove the balance piston cover.

5.4.10 Balance Piston

When the screw compressor is operated, the thrust load on the M rotor is large and the rotation compared to the F rotor is fast. Therefore, the life of a thrust bearing on the M rotor would normally be much shorter than the life of a thrust bearing on the F rotor. To reduce the thrust bearing load on the M rotor, a hydraulic piston is installed at the end of the high-stage M rotor shaft in order to cancel the thrust load.

* A balance piston is not required on the low-stage because, due to low-pressure conditions, the difference in life is not as big as the high-stage.

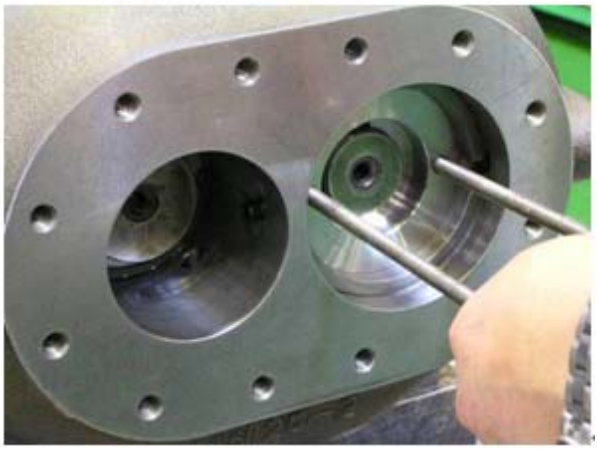
Balance Piston and Balance Piston Sleeve

5.4.10.1 Disassembly

Change in Shape of the 1612C Suction Cover [5-2]** * It might be a too old episode.

Due to the modification in shape design of the high-stage suction cover [5-2] in February 1975, the attachment of a balance piston sleeve [33] became necessary. Accordingly, the balance piston [30] and the balance piston cover [22] were newly created.

a) Using external snap (retaining) ring pliers, remove the snap ring [32] that secures the balance piston [30] to the rotor shaft (following picture to the left). Screw in two M8 eyebolts to remove the balance piston (following picture to the right). It is not necessary to remove the balance piston key [31] embedded in the rotor shaft.



b) Since the 1612C model has a balance piston sleeve attached to the high-stage, remove the hexagon socket head cap screws [34] for stopping the balance piston sleeve [33] from rotating. Make sure not to lose the attached special spring washer [335] for the hexagon socket head cap screw.

Rotation Stopping Part
for Balance Piston Sleeve

Loosen Hexagon Socket Head Cap Screw
for Rotation Stop

c) By using internal snap ring pliers, remove the snap ring [37] for securing the balance piston sleeve. Since the snap ring is pushed out by the inner O-ring, it can be removed easily by pushing gently.

d) Pull out the balance piston sleeve. The sleeve can be removed easily because the gap between its outer diameter and the suction cover is loose.

5.4.10.2 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.

However, you should still carefully check the condition because when the side bearing is significantly worn, the balance piston may also be worn.

5.4.11 High-stage Suction Cover and Side Bearings

If the work sequence is such that the thrust bearing block is disassembled first and then the suction cover is removed, there is a risk that, when the suction cover is separated from the main rotor casing, the rotor may also be pull out and dropped. As such, in the procedure described in this manual, the suction cover is removed first, and then the thrust bearing is disassembled.

CAUTION

- **In this procedure to remove the suction cover before disassembling the thrust bearing block, it is necessary to sufficiently loosen the lock nut that are securing the thrust bearing while the rotor is supported by both the main and side bearings, in order not to damage the rotor during the disassembly process.**

5.4.11.1 Disassembly

a) Remove the hexagon head bolts [45-2] and the conical spring washers [46-2] that are used to fasten 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 bent plate of the rotation stopper and remove it from the hexagon head blot [46-2], and then remove the hexagon head bolt and the thrust bearing gland.

b) Unbend the rotation stopper tooth of the lock washer [40-2] holding the lock nut [39-2] which retains the inner race of thrust bearing [38-2] on the rotor shaft and loosen the lock nut using a lock nut wrench.

c) As the height of the high-stage main rotor casing is low, the casing is installed like a bridge to connect between the suction cover and the bearing head. As such, the main rotor casing will be supported only by one side (i.e., overhang) when the suction cover is removed. To avoid this, either place squared timbers or use a lifting device to properly support the main rotor casing.

d) Loosen and remove the hexagon socket head cap screws [2-2] that hold the high-stage suction cover [5-2] and the high-stage main rotor casing [1-2]. e) Since the suction cover gasket [6-2] is stuck to the flange surface, evenly push the suction cover by screwing two of the removed hexagon socket head cap screws [2-2] into the jacking threaded holes in the flange part of the main rotor casing. When a gap has opened, use a scraper to peel up to one direction.

f) At the position where the alignment pins can be disengaged, remove the suction cover parallel to the axis with a single pulling motion (picture to the right).

d) The side bearing 【28-2】 is press-fit from the balance piston cover side of the suction cover.
   By using internal snap ring pliers, remove the snap ring [29-2] and push it out from the rotor side.

5.4.11.2 Inspection

a) Check the oil inlet path to the balance piston part of the suction cover by spraying air or the like.

b) We recommend unconditional exchange of the side bearings on the occasion of the compressor overhaul, but for confirmation of the compressor condition and system operating condition, carefully check the sliding part metal surface of the side bearings.

   If the metal surface is turned gray or any foreign matter is embedded, also carefully check the wear of the rotor shaft.

c) The inside surface of the main rotor casing should have no problems because sufficient clearance is provided. However, if any trace of scraping by the end of the rotor is found, it should be determined that the thrust bearing is defective. It is also necessary to check the operational condition, such as whether the system is operated for a long time with a high intermediate pressure.

5.4.12 Low-stage Suction Cover and Side Bearings

Similarly to the case of the high-stage, remove the low-stage suction cover before disassembling the low-stage thrust bearing block in order to prevent the rotor dropping at the time of removing the suction cover.
Also in the same way of the high-stage, the lock nut fastening the thrust bearing should be loosened beforehand.

In the case of 1612LSC speed increaser type, the thrust bearing inner race on the low-stage M rotor is fastened together with the speed increaser driven gear [179] by the lock nut [39-1A]. First, pull out this driven gear to loosening the lock nut.

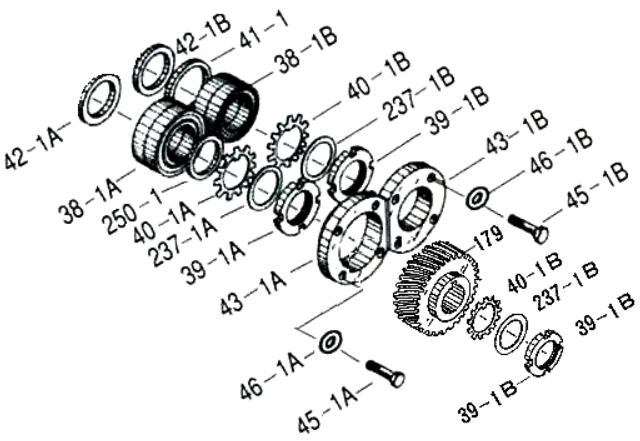


Figure 5-9 Low-stage Thrust Bearing Block

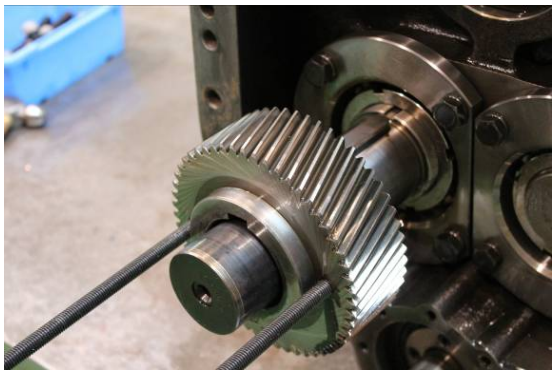
5.4.12.1 Disassembly

a) As shown in the following picture to the left, unbend the rotation stopper tooth of the lock washer [40-1B], loosen the lock nut [39-1B] (following picture to the right) which is fastening the speed increaser driven gear [179]. Then, remove the lock nut, torsional slip washer [237-1B] and lock washer [40-1B].

b) As shown in the following picture to the left, pull out the speed increaser driven gear, and remove the shaft key [180] for rotation stopper of the driven gear.

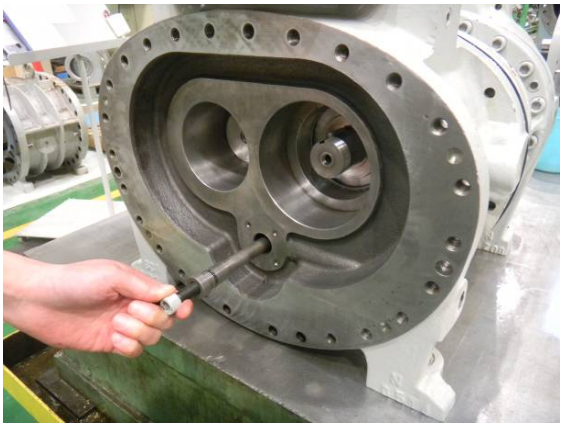
c) Remove the hexagon head bolts [45-1] that is fastening the thrust bearing gland [43-1] together with the spring washer [46-1] (following picture to the right).

d) Remove the thrust bearing gland.



e) And then, unbend the rotation stopper tooth of the lock washer [40-1] (following picture to the left), loosen the lock nut [39-1] (following picture to the right).

f) Unscrew and remove four hexagon head cap screws which secured the oil injection pipe gland [164] located in the lower area of the low-stage suction cover (following picture to the left)..



g) Screw a hexagon socket head cap screw [2-1] into the threaded hole of the oil injection pipe, and pull out it (above picture to the right)..

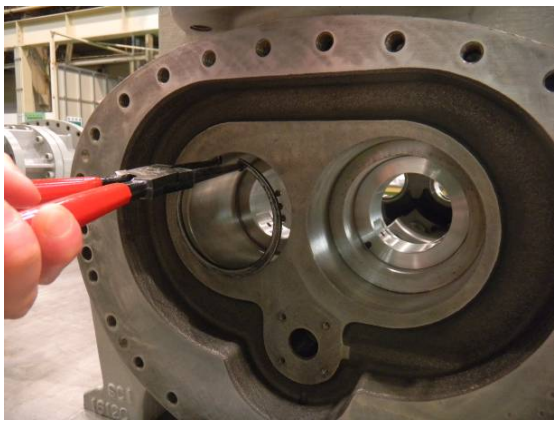
h) Remove all of the hexagon socket head cap screws [2-1] tightening the main rotor casing [1-1] to the suction cover [5-1]. Next, drive alignment pins [3-1] into the main rotor casing.

i) Screw in screws [2-1] into the two threaded holes in the rotor casing flange, and then push the suction cover flange evenly.

j) When a gap has opened, use a scraper to peel it up.

k) When a gap has opened to the length of the screw, pull out the rotor axis and side bearing combination by sliding the suction cover on the work bench parallel with the axis.

m) It is possible to remove the side bearing [28-1] by removing the internal snap ring [29-1] (picture to the right) and gently pushing the rotor side.



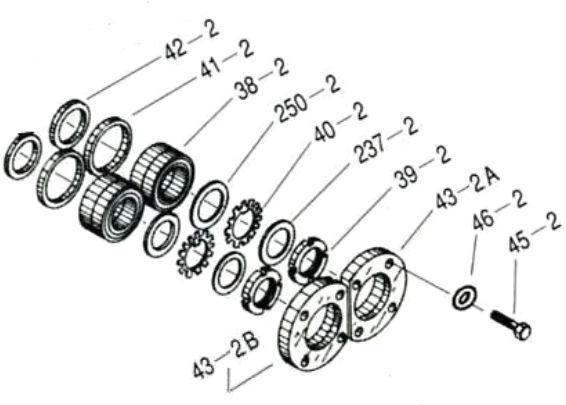
5.4.12.2 Inspection

Inspect the suction cover and side bearings in the same way as for the high-stage.

5.4.13 Thrust Bearing Block

Thrust bearing (picture to the right) 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.

5.4.13.1 Disassembly of High-stage Thrust Bearing Block



P/N	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
43-2A	Thrust bearing gland (2) A for F rotor	1
43-2B	Thrust bearing gland (2) B for M rotor	1
45-2	Hexagon head screw (M8 x 30)	8
46-2	Spring washer (for M8)	8
237-2	Torsional slip washer (for 125***)	2
250-2	Thrust washer (for 125***)	2

Figure 5-10 High-stage Thrust Bearing Block

a) Remove the lock nut [39-2] that has been loosened. Then, remove the torsional slip washer [237-2], lock washer [40-2], and thrust washer [250-2].

b) The clearance fit is applied to two gaps between the outer race of the thrust bearing and the bearing head, between the inner race of the thrust bearing and the rotor shaft

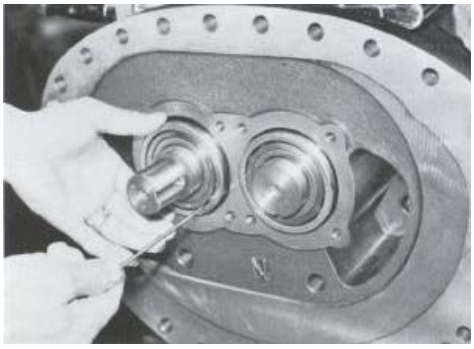
   Prepare a 1 or 2 mm diameter aluminum wire, make the tip of the wire flat by hammering, and slightly bend the tip to make a hook. Then, insert the tip of the wire between the outer race and the ball retainer of the thrust bearing [38-2] to hook and pull out the bearing. In this way, the bearing can be easily removed.

c) The whole thrust bearing will be removed helped by the surface tension of the oil on the side face. If you have failed to remove the whole bearing at once, put the components in the order of the removal.

d) 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 race. 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 washers, thrust bearings, 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).

   You must be very careful because if an assembly error is made to result in a wrong combination of parts after failing to neatly arranging and separating the parts, it can lead to performance degradation and/or dragging accident due to overheating caused by being too narrow end clearance, for example.



Pulling Out Thrust Bearing

Outer race Spacer and Alignment Spacer

5.4.13.2 Disassembly of Low-stage Thrust Bearing Block

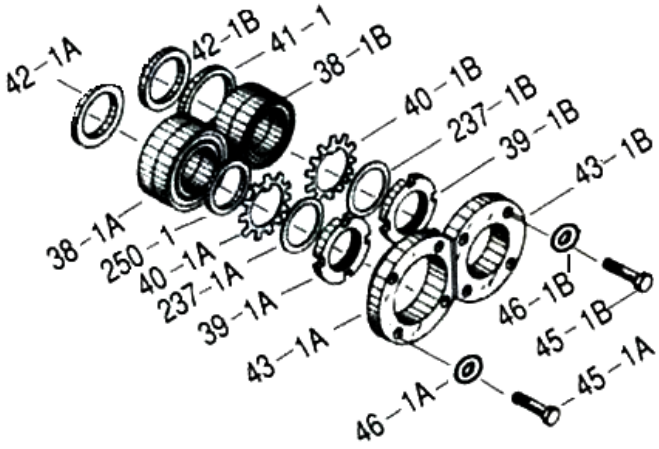
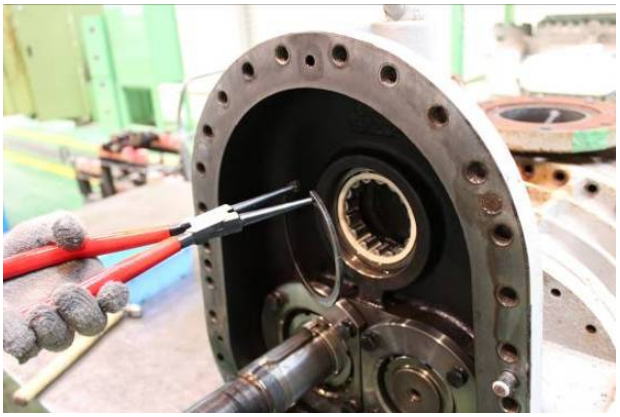


Figure 5-11 Low-stage Thrust Bearing Block

a) The roller bearing [185] outer race supporting the speed increaser dear spindle shaft end is installed in the upper part of the low-stage bearing head (above picture). To remove this roller bearing outer race, remove the internal snap ring [186] retaining the outer race, first (following picture to the left).

b) Next remove the plugs from the two holes on the back of the bearing head. Through the holes, insert steel rods or similar tools. Strike the rods on their ends alternately and little by little to force out the roller bearing (following picture to the right).

* The roller bearing outer race may be removed prior to the removal of the thrust bearing gland as shown in the picture to the left.

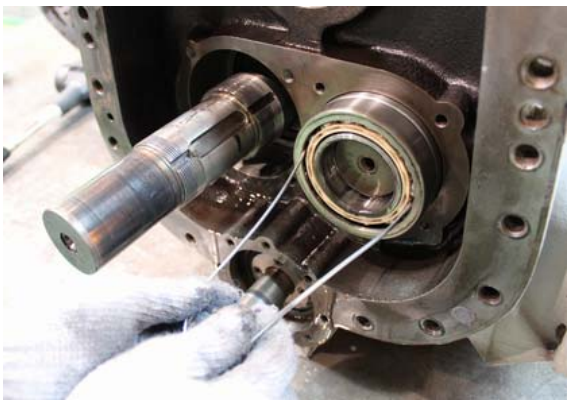


c) Remove the lock nut [39-1] that has been loosened. Then, remove the torsional slip washer [237-1], and lock washer [40-2], and thrust washer [250-2].

b) At the M rotor side, remove the thrust washer [250-], thrust bearing [38-1A] and thrust bearing alignment spacer [42-1A] in the order.

c) At the F rotor side, remove the thrust bearing [38-1B], thrust bearing outer race spacer [41-1] and thrust bearing alignment spacer [42-1B] in the order.

Removing the Thrust Bearing (M rotor)



Removing the Thrust Bearing (F rotor)

5.4.13.3 Inspection (High-stage/Low-stage)

a) The thrust bearing is normal if the bearing balls are found fully glossy after the thrust bearing has been fully washed and cleaned. It is abnormal if the ball surface has tarnish streaky pattern.

b) Support the inner race with your hand and rotate the outer race. If you feel abnormal vibration on the hand, the rolling contact surface of the inner or outer race or some balls may be in an abnormal condition. So, carefully check the conditions. You could feel some irregular click even with a small foreign matter that has entered during the removal process. In such a case, it should return to the normal condition when high pressure air is used to blow out the foreign matters after washing and cleaning the unit. If the bearing is determined to be defective, it must be replaced with new ones.

c) If the inner race and outer race can be easily separated, the wear is considered excessive. If so, you cannot reuse the bearing.

d) After washing the bearing, you should be able to hear a clattering sound when the bearing is rotated by hand. Such a sound is due to the motion of the ball within the backlash or play, or the gap between the retainer and the ball. Such a sound will not be heard if the bearing is held horizontal and turned. If some lubricating oil is applied after washing the bearing, the sound should not be heard when the bearing is turned. If you can still hear the sound, the bearing is abnormal.

e) If any abnormality is seen in the thrust bearing in the above inspection, replace with new ones.
In addition, carefully check the reason whether due to mere aging or any problem with the operating condition and/or lubricating mechanism.

If the compressor has been operated for more than 20,000 hours without replacing the thrust bearing, it is recommended to replace the bearing with a new one for safely continuing the operation until the next overhaul, even if no abnormality is found in the above described inspection.

CAUTION

- **Since 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.**

5.4.14 High-stage Rotors and Main Rotor Casing

5.4.14.1 Disassembly

a) 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. When pulling out the M rotor (or F rotor) first, pull out about 2/3 of the full length of the rotor by holding the shaft upward and turning it in the CW (or CCW) direction.

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

- **You should carefully note that the rotor must be rotated in the specified direction while pulling it out. If the M (F) rotor is not turned during the pulling out process, the F (M) rotor can also be pulled out together.**

b) Do not place the removed rotor directly on the floor. Use a cushion made of wood, etc., an I-block or a V-block to suspend the bearing part of the rotor (right picture).

c) Pull out the F rotor in the same way. Take care not to damage the main bearing with the end of the rotor axis when removing.

5.4.14.2 Inspection

a) No abnormality should be observed on the surface of the rotor lobes under normal operations. Regarding the contact surface of the teeth, black luster should be seen on the root area of the M rotor lobes and on the tip area of the F rotor lobes.

In other cases, when the suction gas or oil is contaminated by fine dust, there may be fine linear scratches on the shaft surface, in the direction perpendicular to the shaft axis. If any such flaw is found, use a fine sand paper or grindstone to smooth the surface.

b) In case of ammonia refrigerant or gas compressor, the non-contact surface of the rotor may be discolored by rust or deposits (above picture) . Use sand papers or others to finish the surface according to the degree of the problem.

c) Then, check the bearing areas of the rotor shaft. Two types of finishing are used: one is the induction hardening (polish finishing) for the standard specification, and the other is the hard chrome plating (polish finishing), as a special specification. The most suitable finish is selected according to the type of refrigerant and operation conditions.

Very little wear will be present unless the compressor is operated for a long time using dirty oil or any hard matter is buried in the metal of the inner circumference of the bearing.

d) Check the portion of the shaft on which the thrust bearing is mounted for any trace to show that the inner race of the bearing has rotated.
If the lock nut that fastens the inner race of the thrust bearing is loosened, or if the bearing is abnormally worn, the inner race will become rotate. If any trace of rotation is seen, correct the problem. Depending on the degree of the rotation trace, it might be necessary to replace the rotors with new ones.

e) Check the inner surface of the main rotor casing.
There is a narrow clearance between the periphery of the rotor and the main rotor casing. Any slight flaw present on the tip of the rotor teeth or on the inner surface of the main rotor casing, due to small foreign matters, will not be a problem.
If there is any trace to show that the tips of the rotor teeth have hit the inner surface of the main rotor casing, it is an abnormal condition. In such a case, the possible cause is that the main bearing and/or side bearing is worn out. Take proper actions by finding the cause of the problem, such as contamination of the lubricating oil or entrance of foreign matters.

5.4.15 Low-stage Rotors and Main Rotor Casing

Care must be taken because the low-stage rotors are heavy.

In addition, since the low-stage M rotor is installed with a mechanical seal; do the work very carefully not to damage the shaft. It is recommended to apply a protective tape on the shaft surface.

Inspect the ends of the rotor lobes and main rotor casing in the same way as the high-stage, but be aware that there is an unloader slide valve on the low-stage which may hit against the ends of the rotor lobes. If the contact is particularly hard, scrape off the contacting parts with a scraper or file. Finally, make the surface smooth with sandpaper. After making the surface smooth, wash thoroughly with wash oil and make sure that no iron powder is left inside.

5.4.16 High-stage Bearing Head and Main Bearings

There is a gas discharge port, based on the compressor's operating conditions, on the surface that has the rotor of the bearing head [11-2] assembled on it.

This discharge port affects the performance of the compressor.

On the bearing head there is also the main bearing which supports one end of the rotor.

5.4.16.1 Disassembly

a) Remove all hexagon socket head cap screws [2-2] that hold the casing and bearing head and hit alignment pins into the rotor casing side.

b) Screw two hexagon head cap screws [2-2] into the jacking threaded holes of the main rotor casing flange to push the bearing head evenly.

c) When some gap is observed, use a scraper to remove one side of the gasket [12-2] from the body.

d) By using internal snap ring pliers, remove the snap ring [29-2] that is retaining the main bearing.

e) The main bearing [27-2] is lightly press fit to the bearing head.
As shown in the right picture, screw two M8 eyebolts into threaded holes on the main bearing, and pull out it.

5.4.16.2 Inspection

a) We recommend as well as the side bearings, unconditional exchange of the main bearings on the occasion of the compressor overhaul, but for confirmation of the compressor condition and system operating condition, carefully check the sliding part metal surface of the main bearings.

If the metal surface is gray or any foreign matter is buried, also carefully check the wear of the rotor shaft.

b) Check the condition of the surface of the bearing head on the rotor side, where the discharge port is. Properly mend the surface if any flaw is observed. If the entire surface has significant flaws, either the thrust bearing is defective or the end clearance adjustment is poor.

If oil compression has been caused during the operation, carefully and thoroughly check the area of the discharge port in particular. If the continued use is in doubt at all, perform the penetrant testing (color check) to determine if it can be used or not.

5.4.17 Low-stage Bearing Head and Main Bearings

Apart from when disassembling and inspecting the unloader slide valve, it is not necessary to separate the low-stage bearing head [11-1] and the main rotor casing [1-1].

However, according to the design modification in July 1986, of the low-stage bearing head the part where the unloader push rod is set has been changed.

Compressors manufactured before this modification need to be separated into low-stage bearing head and main rotor casing to replace O-ring [197] attached to this part.

After this modification, since the O-ring gland [326] has been added, the O-ring [197] replacement work is able to easily by removing the O-ring gland.

5.4.17.1 Disassembly

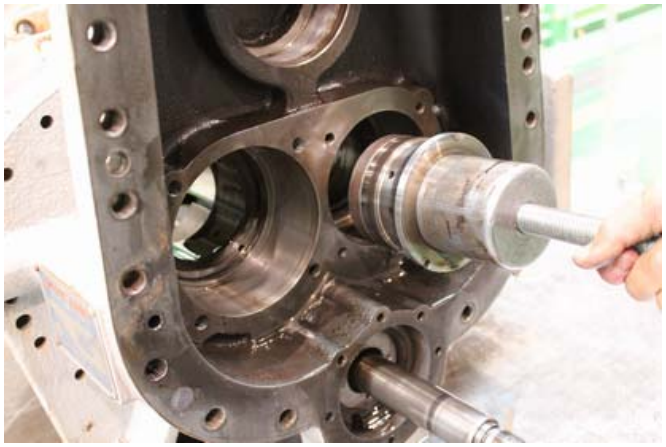
a) Remove all of the hexagon socket head cap screws [2-1].

b) Drive alignment pins [3-1] into the main rotor casing flange side.

c) Separate the bearing head and main rotor casing using two jacking threaded holes in the bearing head flange part.

d) Separate the embedded unloader push rod [67] parallel to the axis.

e) Remove the internal snap ring [29-1] and then remove the main bearing and then pushing it from the main rotor casing side via a pad. Otherwise, use a special tool to pull it out as shown in the right picture.



5.4.17.2 Inspection

a) Low-stage bearing head has two lubrication holes for the speed increaser gear and the speed increaser gear spindle. These lubrication holes are screwed in the oil flow control throttles [196-2], check that there are not clogged in the lubrication holes and throttles.

b) Other parts check in the same way as the high-stage.

5.4.18 Low-stage Unloader Slide Valve and Guide Block

When the low-stage bearing head and the main rotor casing are separated, the slide valve is attached to the bottom of the main rotor casing and moves in parallel with the axis whose position is controlled by the inside guide block [87] and the outside perimeter (of the rotor casing).

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

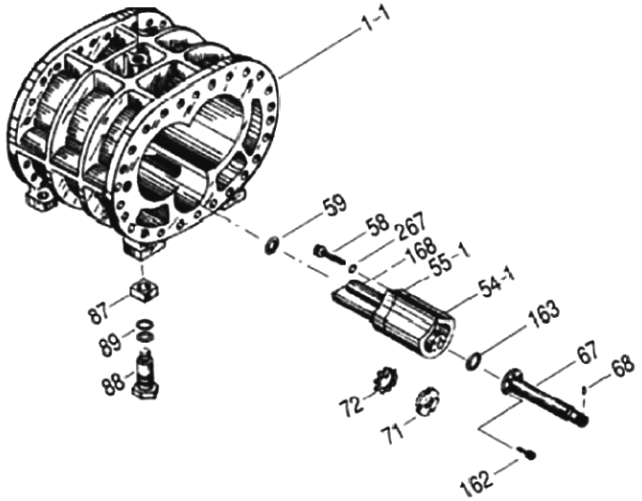


Figure 5-12 Unloader Slide Valve Assembly and Guide Block

5.4.18.1 Disassembly

a) The unloader slide valve assembly can be pulled out toward the bearing head side.
   If any abnormalities are not observed, it is not necessary to disassemble the unloader slide valve assembly.
b) The guide block stem [88] is screwed from bottom of the main rotor casing, and the guide block [87] is engaged from the top. To replace two O-rings [89], remove the guide block stem.

5.4.18.2 Inspection

a) Inspect for abnormalities (e.g., flaw and/or wear) in the sliding surface between the unloader slide valve and guide block. If any abnormalities observed, finish up with whetstone or the like.
   Also it is necessary to investigate the cause.
b) Check for defect in the guide pin [68] which mates with the indicator cam [77] of the unloader push rod.
c) Check for looseness in the assembled state.
d) With the unloader slide valve mounted in position, check a step difference from the main rotor casing. Normally, the slide valve is positioned lower than the surface of the main rotor casing.
   If the top surface of the slide valve has a trace of hitting the rotor, the probable cause is that the slide valve is worn or the rotor shaft/bearing is worn. Please contact our local sales offices or service centers.

5.5 Reassembly

CAUTION

- **When reassembling, ensure that the replaced O-rings are of the correct standard (size, material, for secure/moving parts 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, a major defect could be caused by the oil route inside the casing being blocked.**

After completing the disassembly and inspection procedures, start the assembly process.

First, read again Section 5.1 "Precautions for Maintenance and Inspection" in this Chapter 5.

Before starting the assembly, check the replacement parts once again.

Like gaskets, all O-rings that have been removed during the compressor disassembly must be replaced with new ones.

The reassembly sequence is mostly the reverse of the disassembly sequence. First of all, clean the work bench and the tools to be used.

Immediately prior to the assembly, use washing agent (e.g., kerosene, parts cleaner) to clean the parts to be assembled, dry them with compressed air, and sufficiently apply lubricating oil, etc. For this, prepare a sufficient amount of clean lubricating oil for the reassembly. Also, apply oil on both sides of the gasket.

Because the assembly procedure is mostly similar between the high-stage and low-stage sides, the following sections provide explanations that are commonly used for both stages. For this purpose, the part number given in the common explanations will omit the distinction between high-stage and low-stage by means of a hyphenated suffix (the suffix of [**-1] for low-stage and [**-2] for high-stage part number will be omitted).

Please fully understand the details in this Section 5.5 for correct assembly work.

Table 5-8 Standard Tightening Torque for Hexagon Socket Head Cap Screws

Torque Unit	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 hexagon socket head cap screw referring to the torque shown in the table above.

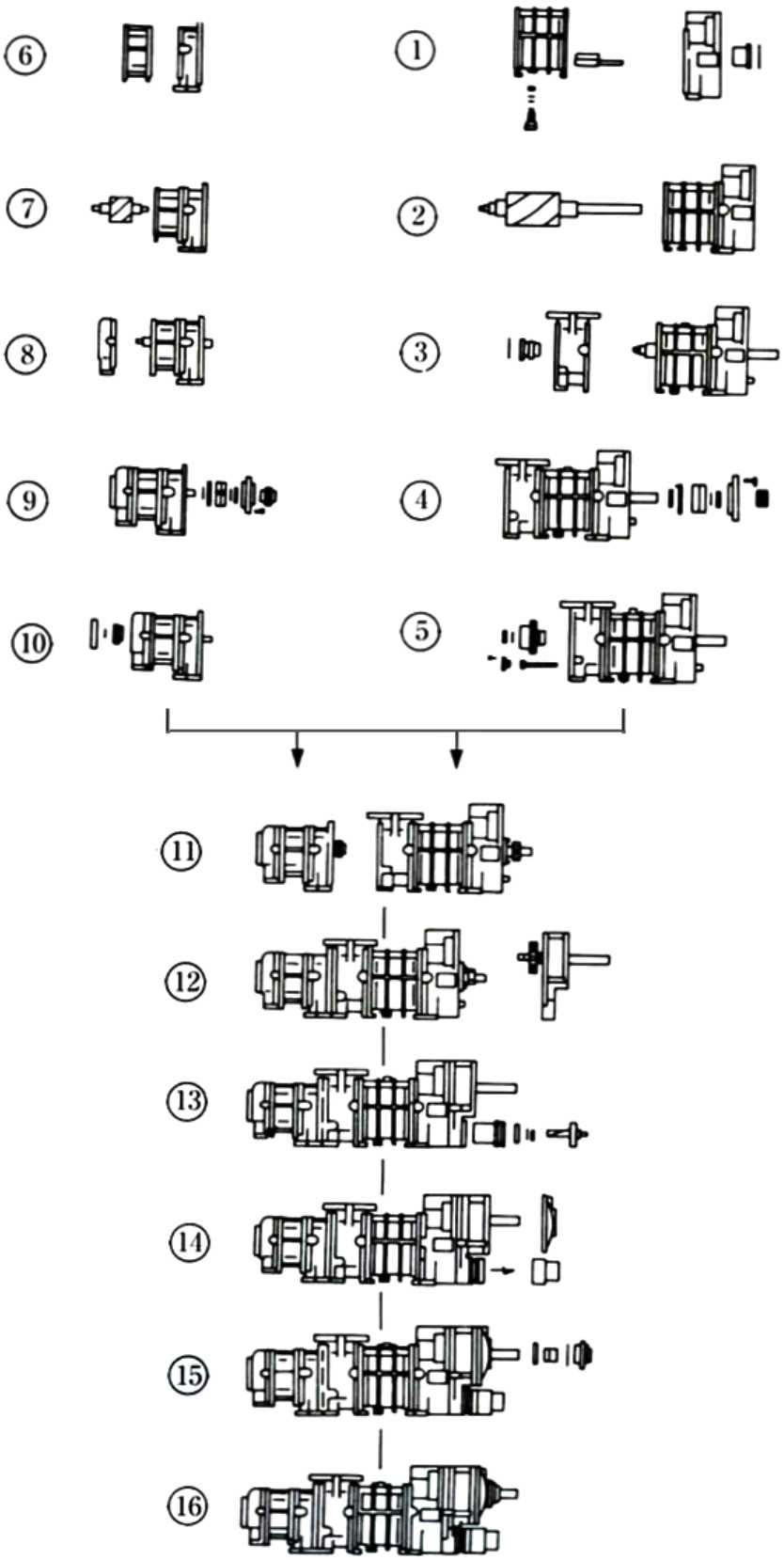


Figure 5-13 Assembly Order Explanation (example)

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

5.5.1 Low-stage Unloader Slide Valve and Guide Block

a) First, tightly screw the guide block stem [88] into the bottom of the main rotor casing, and then mount the guide block [87] inside the main rotor casing.

b) If the slide valve assembly has been disassembled, first make sure that the alignment position between the slide valves [54] and [55] is accurately reproduced and then tighten the hexagon socket head cap screws [58] with spring washers [267] at the specified torque. The outer diameter of the spring washers used here is less than normal spring washers for hexagon socket head cap screws. So, be careful not to mix up with other washers.

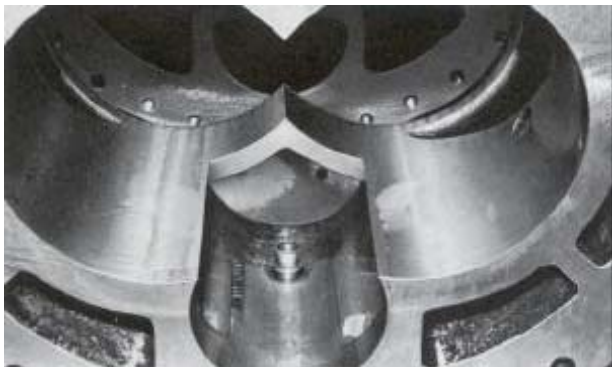
c) Make sure to attach the O-ring [59] in the Oil injection pipe guide [168].

d) Gently smooth the outer surface of each part with a grindstone or sandpaper before attaching it to the main rotor casing. Next, match the slide valve groove with the guide block and push gently.

d) After assembly, hold and move the unloader push rod, and inspect its movement. Also, inspect the seam between the part and the casing to ensure that it is even.
If it is not even, the part has not been assembled correctly and reassembly is necessary. Using it in that state can lead to an unforeseen accident due to the outer surface of the rotor hitting the slide valve.
* : It is not a problem if the unloader slide valve is slightly lower than the casing.

CAUTION

- **There is a problem with assembly if the unloader slide valve is higher than the rotor casing. In that case, reassembly is essential. Using it in that state can lead to heavy damage or an accident due to the outer surface of the rotor coming into contact with the slide valve.**



Guide Block Stem Inside Main Rotor Casing

5.5.2 Bearing Head and Main Rotor Casing

CAUTION

- **Since the bearing head gasket [12] is not formed symmetric laterally, pay attention to the installation direction.**
- **If you place the bearing head gasket by just hanging it on the stud bolts, the gasket will protrude into the inside of the rotor casing when the casing is assembled. Apply sufficient amount of oil, etc. to the gasket to make it fully attached to the surface to prevent protruding upon the assembly.**

a) In case of assembling the low-stage, fit the unloader push rod [67] in the hole of bearing head [11-1]. Then, slide the bearing head or main rotor casing to let them mate together.

b) Loosely tighten the two screws, secure the alignment pin [3-1] in position, and then tighten the screws in turn evenly.

c) After tightening the screws, check that the bearing head gasket is not protruding inside the casing.

d) Also, move the slide valve back and forth to check that it works normally.

CAUTION

- **Make sure to check for protrusion of the bearing head gasket after assembling the bearing head and rotor casing. If this work is not performed, measurements may be incorrect due to the gasket becoming stuck between the end of the rotor and the surface of the bearing head when adjusting end clearance. Also, performance may deteriorate by operating the compressor after confirming the incorrect end clearance.**

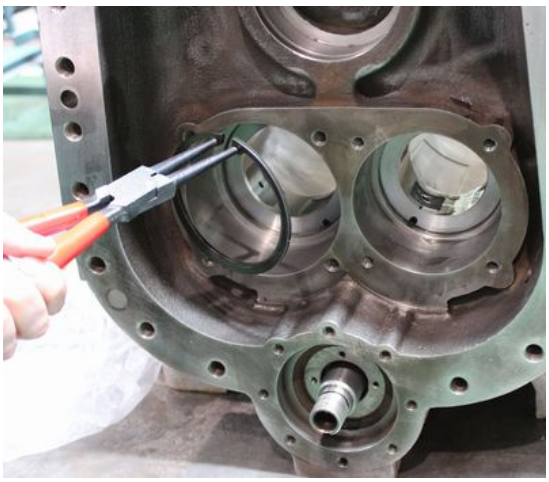
e) Since the full height of the high-stage main rotor casing is lower than that of the bearing head, both centers will not be aligned when they are placed on the work bench. Therefore, either use a pedestal as used in the disassembly process or lift the rotor casing using a crane or other device to align the centers.

The assembly procedure after mating the both casing flanges is same as the high-stage.

f) As shown in the right picture, make sure to attach the O-ring [197] and O-ring gland [326] to the part where the unloader push rod goes through low-stage bearing head.

However, this O-ring gland [326] is applied after the design modification in July 1986. For the compressors manufactured before this change O-ring [197] should be attached in the groove on bearing head.

5.5.3 Bearing Head and Main Bearings



a) The main bearing [27] is dimensioned in such a way that it is lightly press fit to the bearing head [11].
Position the notch of the main bearing so that it is aligned with the spring pin [14] in the bearing head (in the case of low-stage work, using a fixture such as a guide rod is helpful as shown in the above picture to the left), then, using a pad, lightly tap in the notch.

High-stage main bearings are pushed into bearing head using M8 eyebolts as shown in the right picture.

If the position is not aligned, pull out the main bearing and install it in again.

b) After attaching main bearings, secure them by attaching internal snap rings (above picture to the right).

c) Low-stage bearing head [11-1] has two lubrication holes for the speed increaser gear and the speed increaser gear spindle. These lubrication holes are screwed in the oil flow control throttles [196-2], Make sure to check that there are not clogged in the lubrication holes and throttles.

d) Install the outer race of the roller bearing [185] for the speed increaser gear spindle [188] into the low-stage bearing head (following picture to the left) by securing with the internal snap ring [186] (following picture to the right).

*: This assembly work may be performed as part of the reassembling procedure of the speed increaser gear casing.

5.5.4 Rotor Assembly

Note on the rotor profile of 1612C**

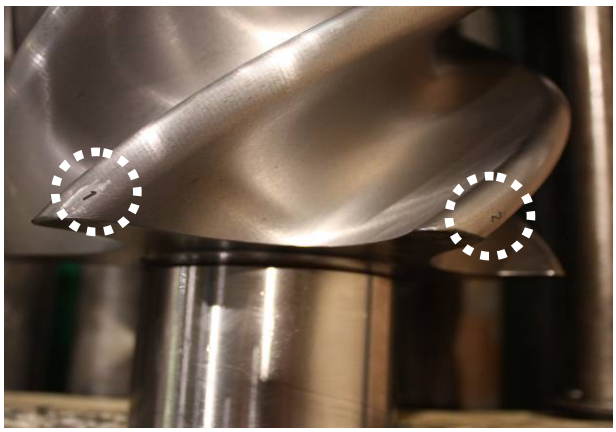
The rotor profile design was changed from A Profile to O Profile in July 1994.
The biggest difference is the lobe tip edges. Profile A has the lobe tip edges while profile O does not have them

Make sufficient adjustments to the rotor. Smooth over all damage on the shaft surface of the bearing and seal using fine sandpaper.

Both the M and F rotors have unique messing positions which are indicated by engravings.

When attaching to the main rotor casing, it is possible to align their positions easily by checking the engraved numbers for the M rotor on the peak of the lobe on the discharge side and the F rotor on the peak of the lobe on the suction side.

M Rotor Assembly Mark



F Rotor Assembly Mark

a) Lubricate the main bearings in the bearing head and the rotor shaft bearings sufficiently.
b) While it is easier to mate the markings if the F rotor is first installed into the casing, it is not a mistake to install the M rotor first.
c) Regardless of which rotor is installed first, engage the M rotor lobe, which has engraved mark 1, between the F rotor lobes having engraved marks 1 and 2. As factors, such as mating of lobes, balance, etc., should be considered, be sure to mate the lobe profiles as instructed.

CAUTION

- **Since the outer side of the rotor touches the rotor casing in this state, do not rotate too much. Rotating may cause the rotor teeth to wear.**

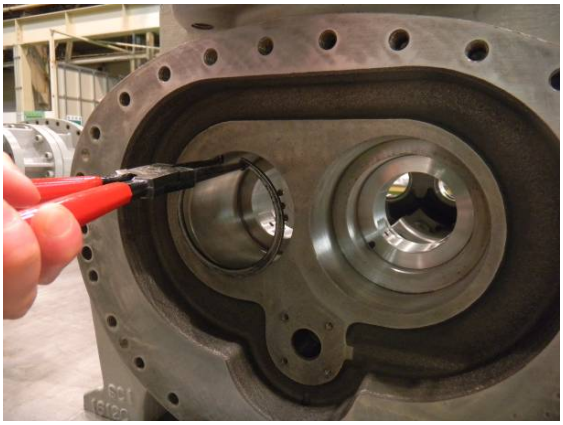
5.5.5 Suction Cover and Side Bearings

a) The side bearing [28] is dimensioned in such a way that it is gentle press-fit to the suction cover [5].
   Press it onto the bearing positioning pin (spring pin) [8] in the suction cover aligning it with the bearing notch. Check the alignment of the pin and notch while pressing. If they become misaligned, remove the bearing and try again. After assembly is complete, secure with an internal snap ring [29].
b) The suction cover gasket is asymmetrical. Check the position of the oil supply hole.
   Lubricate the side bearing thoroughly.

【POINT】

In case of the installing work of bearings, it is helpful to use a guide rod as shown in the above picture to the left. It is able to insert the tip of the guide rod into the spring pin [8].

Since there is no flange part in the high-stage side bearing (main bearing) to fitting a guide rod, align and write a straight line on the suction cover (bearing head), also put a alignment mark to the bearing , and then push in the bearing to keep the correct position.



【POINT】

When press fitting, using a weight jig and a plastic spacer indicated in the Figure 5-14 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.

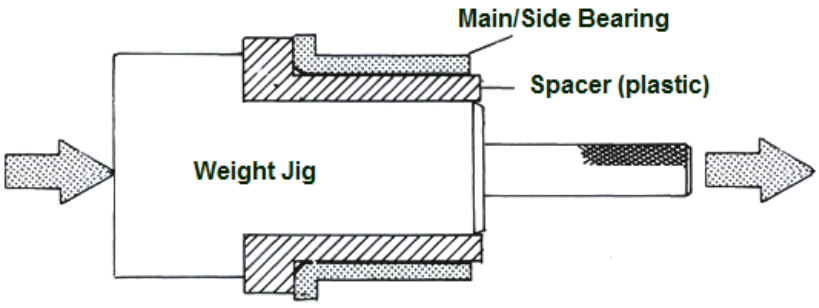


Figure 5-14 Spacer and Weight Jig (example) for press fitting a Bearing

c) When assembling the low-stage side, slide the suction cover on the work bench to move it to the assembly location (above picture to the left). When assembling the high-stage side, use a lifting tool shown in above picture to the right or put a stand witch adjusted height.

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.

d) When the rotor shaft has entered the side bearing, push the suction cover parallel with the axis to assemble.

e) First, screw two hexagon socket head cap screws [2] and fasten them temporarily. Then drive alignment pins [3] into the suction cover for positioning, and tighten the fastening screws [2] evenly.

The six screws on the lower side should be tightened during ***final assembly on the special stand*** used at disassembling.

f) Rotate the M rotor shaft with your hand and check that there is no abnormality is in meshing of the rotors.

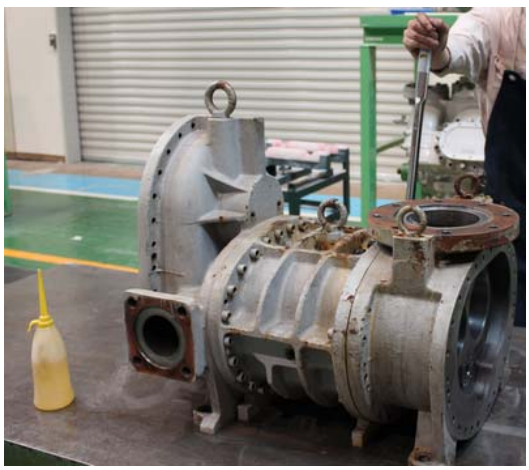
g) For the low-stage, attach the O-ring on the oil injection pipe [85].Then, in the same way of the disassembly; screw a hexagon socket head cap screw [2-1] into the threaded hole on the oil injection pipe, and push the oil injection pipe into the low-stage suction cover.

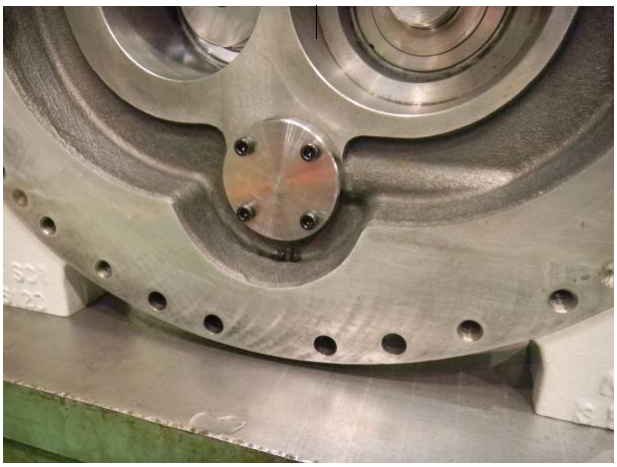
h) Next, install the oil injection pipe gland [164] with attaching the O-ring [165] and fasten it with four hexagon socket head cap screws [166].

h) Move the unloader push rod with your hand and check the smoothly movement of the unloader slide valve.

i) While holding the M rotor shaft move it in the axis direction and check that there is allowance.

j) For the high-stage, assemble the balance piston and secure with an external snap ring. Check that it is in the groove.





5.5.6 Thrust Bearing Block

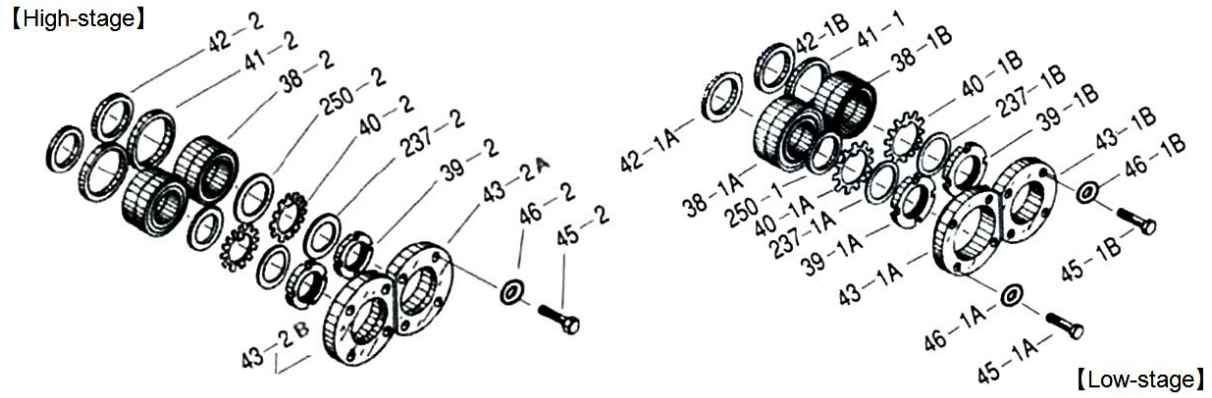


Figure 5-15 Thrust Bearing Block

Table 5-9 Configuration Parts of Thrust Bearing Block

P/N	Part Name (High-stage)	Q'ty
42-2	Thrust bearing alignment spacer (2)	2
41-2	Thrust bearing outer race spacer (2)	2
38-2	Thrust bearing (2)	2 sets
250-2	Thrust washer (for 125***)　*High-stage only	2
40-2	Lock washer (2)	2
237-2	Torsional slip washer (2)	2
39-2	Lock nut (2)	2
43-2A	Thrust bearing gland (2)A for high-stage F rotor	1
43-2B	Thrust bearing gland (2)B for high-stage M rotor	1
46-2	Spring washer (2)	8
45-2	Hexagon head bolt	8
P/N	**Part Name (Low-stage)**	**Q'ty**
42-1A	Thrust bearing alignment spacer (1)A for low-stage M rotor	1
42-1B	Thrust bearing alignment spacer (1)B for low-stage F rotor	1
41-1	Thrust bearing outer race spacer (1) *Low-stage F rotor only	1
38-1A	Thrust bearing (1)A for low-stage M rotor	1 set
38-1B	Thrust bearing (1)B for low-stage F rotor	1 set
250-1	Thrust washer　*for Low-stage M rotor only	1
40-1A	Lock washer (1)A for low-stage M rotor	1
40-1B	Lock washer (1)B for low-stage F rotor	1
237-1A	Torsional slip washer (1)A for low-stage M rotor	1
237-1B	Torsional slip washer (1)B for low-stage F rotor	1
39-1A	Lock nut (1)A for low-stage M rotor	1
39-1B	Lock nut (1)B for low-stage F rotor	1
43-1A	Thrust bearing gland (1)A for high-stage M rotor	1
43-1B	Thrust bearing gland (1)B for low-stage F rotor	1
46-1A	Spring washer (1)A for low-stage M rotor	4
46-1B	Spring washer (1)B for low-stage F rotor	4
45-1A	Hexagon head bolt for low-stage M rotor	4
45-1B	Hexagon head bolt for low-stage F rotor	4

CAUTION

- **When installing the disassembled thrust bearing as is, check the M/F engravings on the thrust bearing outer race spacers and thrust bearing alignment spacers, and reassemble them in the same way as before disassembly. This is essential to control the end clearance of the rotor discharge side.**
- **Even if the same bearing is reassembled, small pieces of paint or dirt between the spacers and washers can cause dimensions to become incorrect.**
- **Regarding the direction of thrust bearing assembly, there may or may not be a V-shaped mark for assembly on the outer side of the bearing. Follow the instructions below accordingly.**

a) The procedure for assembling this block is described in Figure 5-15. The important points are explained below.

If there is a V-shaped mark for assembly on the outer side of the thrust bearing (right picture), install with the pointed end of the mark on the inner side of the machine due to 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, after assembling with the bearing number engravings on the outer side, make a V-shaped mark using blue whetstone on the machine's inner side of the bearing.

b) After the thrust bearing has been installed, attach the thrust washer, lock washer, and torsional slip washer. Then, tighten the lock nut at the specified torque or within the specified range of the tightening angle (refer to Chapter 7, Section 7.3 "Tightening Torques for Bolts and Nuts" in this manual) to secure the inner race of the thrust bearing on the rotor shaft.

c) After assembling the thrust bearing, rotate the M rotor shaft with your hand and check that it rotes smoothly.

【POINT】

Tightening the lock nut while keeping the setting position between the lock nut wrench hooks and the lock nut grooves may cause to make the rotor run-out to enlarge due to uneven tightening forces.
Change the setting position between the lock nut wrench hooks and lock nut grooves about four times when fastening the lock nut.

CAUTION

- **Since the inner race of the thrust bearing is lodged 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 race and outer race surfaces is different even if within standard values. Therefore, fully tightening the nut from the start may lead to a noticeable reduction in the life of the bearing due to a lack of end clearance between the rotor and bearing head discharge side edge, and indentations on the contact surface from ball pressure. To avoid this, check for end clearance while tightening.**

5.5.6.1 End Clearance Measurement

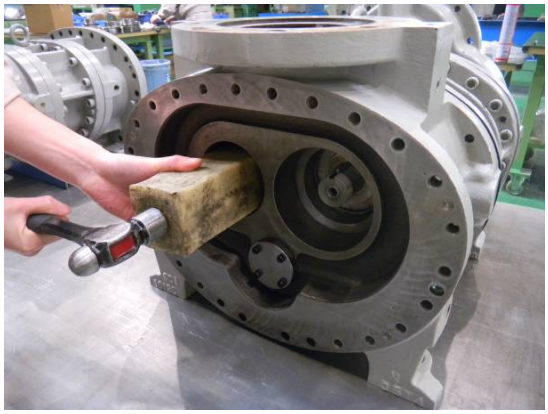
At this point (i.e., after the thrust bearing block has been fully assembled), measure the clearance between the bearing head end face and the rotor end face on the discharge side. This clearance is called as the end clearance.
In particular, this measurement must be made when the thrust bearing has been replaced. Even if the same bearing is used, the measurement should be made for verification.
If the measured clearance does not satisfy the range specified in Table 5-10, proper adjustment must be made.

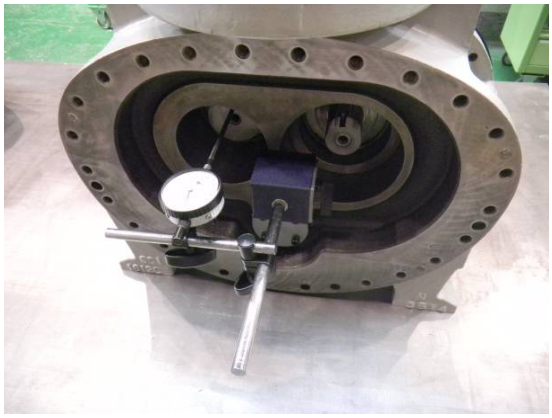
Table 5-10 End Clearance (Unit: mm)

Compressor Model	Rotor Profile	High-stage	Low-stage
1612LSC speed increaser type	A	0.04 to 0.06	0.24 to 0.26
	C	0.03 to 0.05	

a) Push the rotor to the discharge side while the thrust bearing inner race is secured to the rotor shaft. As shown in the following picture to the left, push the rotor from the suction side using a fixture (Teflon or the like).
Alternatively, as shown in Figure 5-16, using the chamfered part of the lock nut, pull out the rotor with the edge of a flat screwdriver.

b) When the rotor has been pushed to the discharge side, prepare to attach the thrust bearing gland, then attach a dial gauge on the suction side axial end of the rotor and match the indicating needle to 0 (following picture to the right).





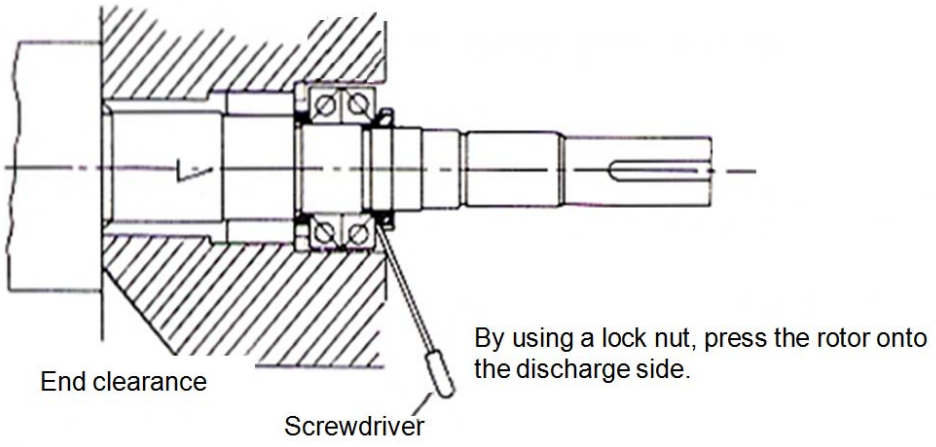


Figure 5-16 Preparation for End Clearance Measurement

c) Secure the bearing gland by tightening the four screws evenly to the specified tightening torque gradually. Tightening each screw to the specified torque at once will lead to uneven tightening so tighten each screw little by little.

c) Then, read the dial gauge measurement. This value is the actual end clearance.

If the end clearance is outside the specified value, perform the adjustment work described in the next section. If the end clearance is within the specified value, turn the M rotor shaft by hand and confirm the smooth turning without uneven tightening. And then perform the measurement of the run-out of the rotor shaft described in next section (3).

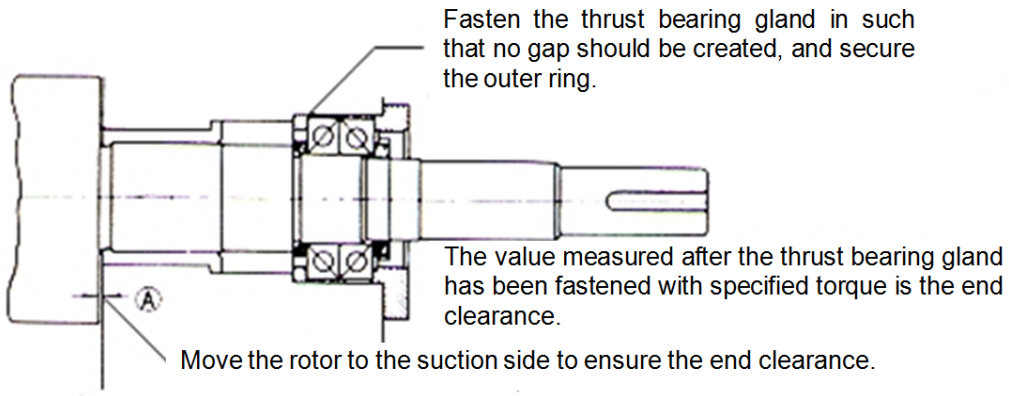


Figure 5-17 End Clearance Measurement

Table 5-11 Thrust Bearing Gland Tightening Torque

Compressor Model			Tightening Torque	
			N·m	kgf·cm
1612LSC speed increaser type	High-stage		30	300
	Low-stage	M	50	500
		F	40	400

Tightening by Bearing Gland

【POINT】

1. There are two types of high-stage thrust bearing gland. The one on the male rotor has structure which flows lubrication oil into the gear coupling.
2. The low-stage thrust bearing gland, structure is the same in M rotor side and F rotor side, size is incorrect. Hexagon head bolt to tighten also different.

5.5.6.2 End Clearance Adjustment Method

(1) When the 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 race.

* The thrust adjustment liner is not shown in the sectional view and 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 spacer [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 the 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 service 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 runout measurement

When the end clearance has been adjusted to within the specified range, place a dial gauge probe on the low-stage M rotor shaft on which a side bearing for the speed increaser gear is to be installed. Measure the runout by turning the rotor shaft. The tolerance for 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. And it occurs if fastening the lock nut performed without changing the position of the lock nut wrench (i.e., the uneven fastening of the lock nut).
Moreover small particles of dirt trapped between parts may cause excessive runout.
If the rotor 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.

5.5.6.3 Tightening after End Clearance Adjustment

a) Bend the lock washer tooth to the notch of the lock nut which is tightening the thrust bearing inner race, to prevent rotation.

b) Remove the hexagon head bolts that are tightening thrust bearing gland [43] one by one. Insert spring washers [46] as rotation stoppers, and tighten to the specified torque again.


After Thrust Bearing Gland Tightening


Securing the Speed increaser Driven Gear

c) When reassembling the low-stage compressor section of the -53, -54 and -63 models with a speed increaser gear system, install the speed increaser driven gear [179] on the M rotor shaft by locking the gear with the key [180]. Secure the gear by fastening the lock nut with the lock washer and spacer placed in-between. Lock the lock nut by bending a tooth of the lock washer.

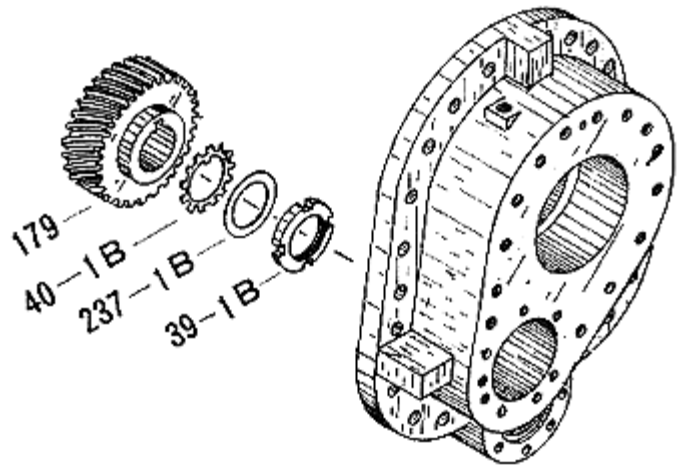
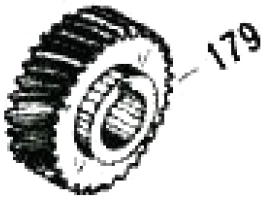


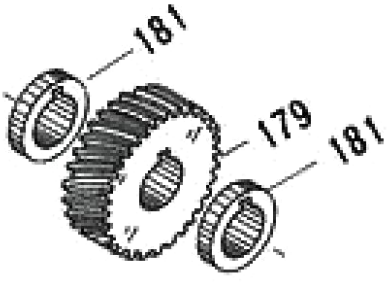
Figure 5-18 Speed Increaser Driven Gear

【POINT】

In the -52 and -62 models which are equipped with a speed increaser gear system and driven by a 4-phase electric motor, the speed increaser driven gear has spacers [181] on both the front and rear sides (refer to Figure 5-19).

*

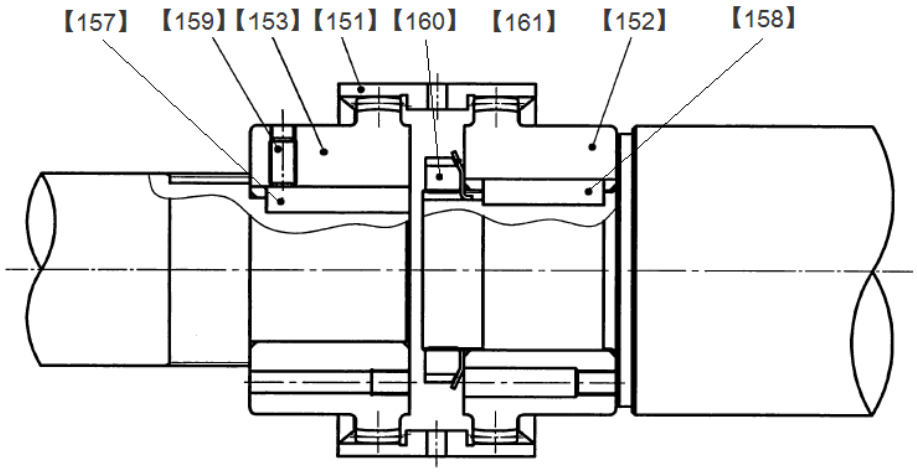




For -53, -54 and-63 models For -52 and -63 models

Figure 5-19 Difference in Type of Speed Increaser Driven Gear

5.5.7 Combining High-stage and Low-stage Blocks



【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 5-20 Gear Coupling Assembly

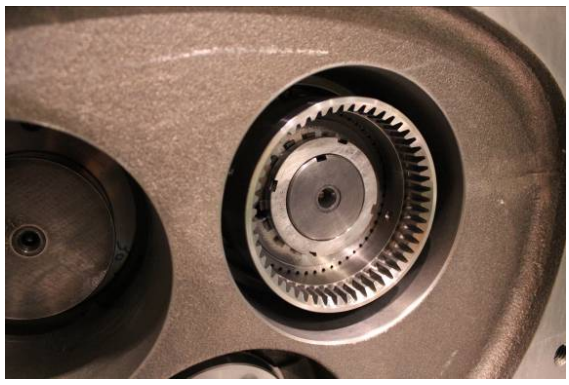
a) On the high-stage, attach the driven hub [153] of the gear coupling, and fasten the M8 set screw 【159] for securing the driven hub key [157]. This set screw is knurled and provided with anti-loosening.

b) 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.

c) Set the driven sleeve onto the low-stage drive hub.

The Present Gear Coupling Parts

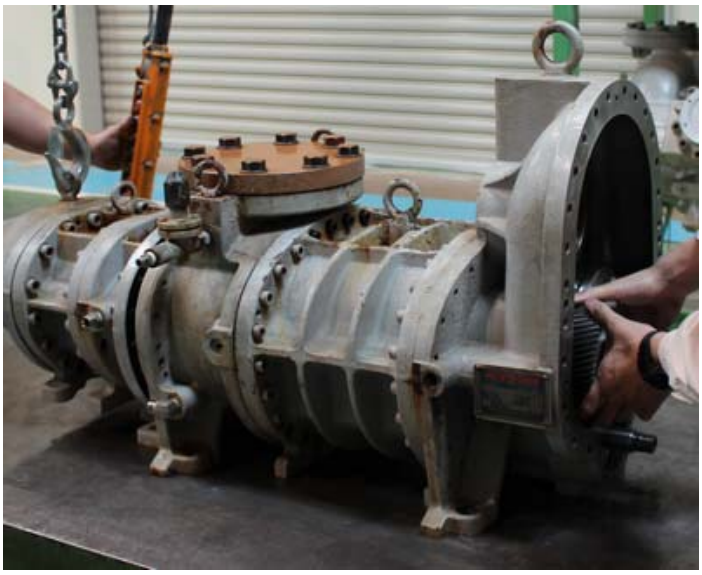


Low-stage Gear Coupling Part

d) Screw stud bolts into two of the upper holes provided in the low-stage suction cover flange surface which is to be attached to the high-stage.

e) Apply sufficient 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 work bench, 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 (picture below).



g) After the gear coupling is engaged, press the high-stage block 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 or two holes apart from the left or right alignment pin, until the high-stage and low-stage flange surfaces come into contact.

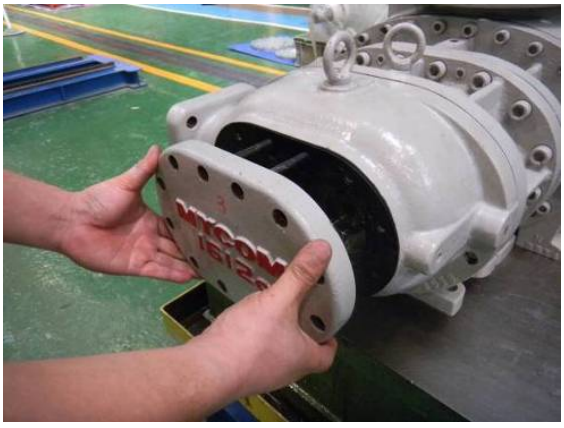
h) After the flange surfaces come into contact, slightly loosen the four hexagon socket head cap screws, which have been temporarily tightened, and then drive in the left and right alignment pins.

i) Tighten the hexagon socket head cap screws to the specified torque (90 N·m). The lower bolts should be tightened on the special-stand, 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.

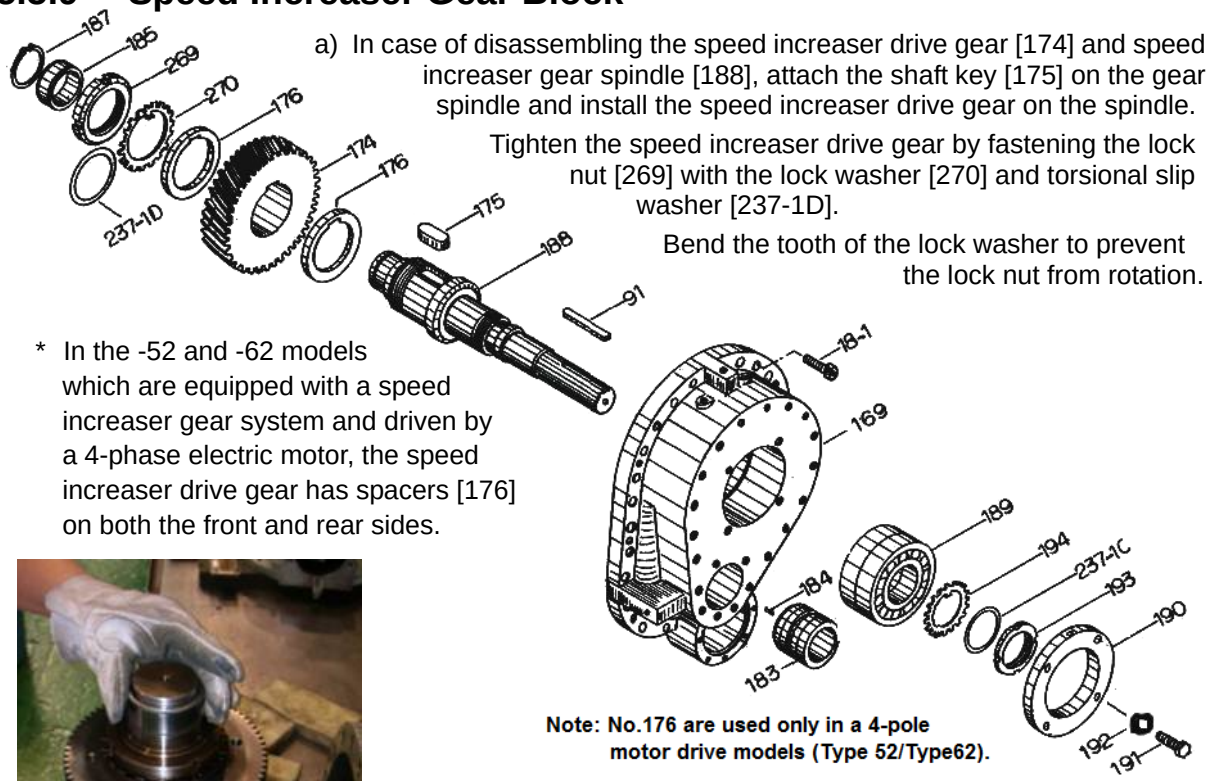
5.5.8 Balance Piston Cover

Attach the balance piston cover gasket [23] on the high-stage suction cover flange while paying attention to the oil hole of the gasket.
It is no problem which assembly work is fast, attaching balance piston cover to main rotor casing or combining low-stage and high stage blocks.



Attaching Balance Piston Cover

5.5.9 Speed Increaser Gear Block



a) In case of disassembling the speed increaser drive gear [174] and speed increaser gear spindle [188], attach the shaft key [175] on the gear spindle and install the speed increaser drive gear on the spindle.

Tighten the speed increaser drive gear by fastening the lock nut [269] with the lock washer [270] and torsional slip washer [237-1D].

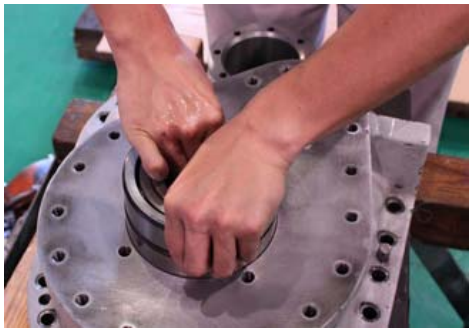
Bend the tooth of the lock washer to prevent the lock nut from rotation.

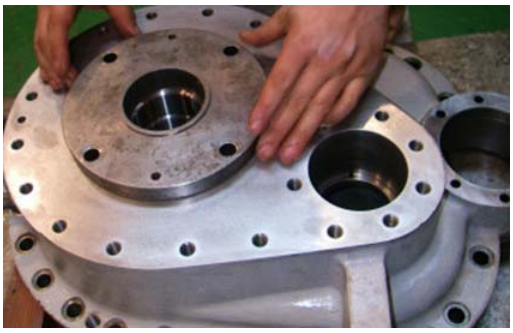
* In the -52 and -62 models which are equipped with a speed increaser gear system and driven by a 4-phase electric motor, the speed increaser drive gear has spacers [176] on both the front and rear sides.

Figure 5-21 Speed Increaser Gear Casing Block

b) Heat the inner race of the roller bearing [185] using a bearing heater (set at 90°C), as shown in the left picture, fit it on the speed increaser gear spindle and install the external snap ring [187] to secure the inner race.

c) Install the thrust bearing [189] for the speed increaser gear spindle into the speed increaser gear casing [169] (following picture to the left). This bearing is a face-to-face angular contact ball bearing as same as the thrust bearings for M rotors and F rotors.





d) Temporarily hold the thrust bearing by installing a jig in the place where the thrust bearing gland [190] is to be installed (above picture to the right).

The jig serves for holding the thrust bearing inner race to prevent it from being forced out toward the speed increaser gear casing cover [171] when the speed increaser gear spindle is installed.

The reason of using the jig in this step instead of the thrust bearing gland is as follows.

* The thrust bearing gland cannot be used for the above purpose as the gland has no part to hold the inner race (because if the gland had a part for holding the inner race, the part would block the motion of the speed increaser).

Install the jig by finger-tightening the four hexagon head bolts. Do not use any tool to tighten them.

e) After installing the jig, turn the speed increaser gear casing upside down to be able to install the speed increaser gear spindle, and place the casing on the work stand used at disassembling.

f) Insert the speed increaser gear spindle into the spindle thrust bearing by lightly tapping the end of the spindle with a soft hammer or the like.

Alternatively, preheat the speed increaser gear casing using a light projector (following picture to the left) before insertion of the spindle. Then the spindle can be inserted smoothly without using a soft hammer (following picture to the center/right).

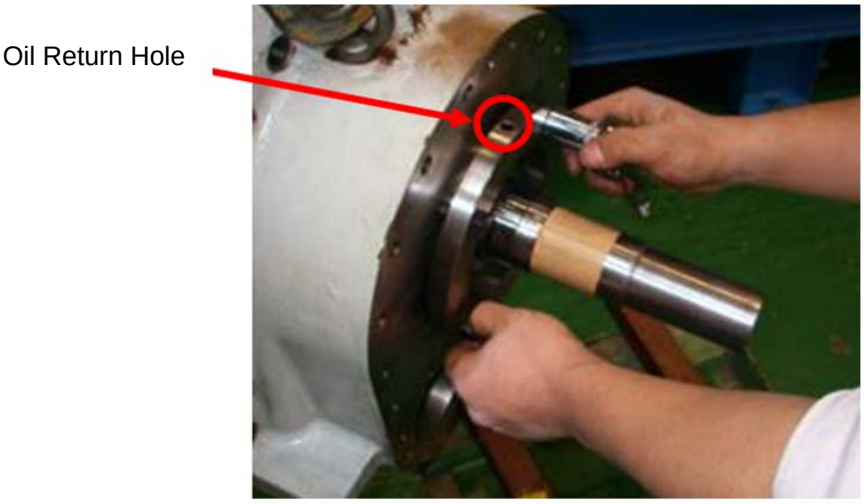
Insert Spindle with Drive Gear

Insert Spindle without Drive Gear

Note: In case of installing the speed increaser drive gear in this step, refer to following pictures.

f) Install the thrust bearing gland [190] by finger-tightening the hexagon head bolts [191] evenly with the gland's oil return hole (for speed increaser gear side bearing lubrication) facing up as shown in the picture below).

Finally tighten these bolts after installing the speed increaser gear casing assembly to the bearing head of the low-stage compressor section, that is, after the roller bearing's inner race on the speed increaser gear spindle has properly engaged with the roller bearing's outer race on the bearing head (namely the spindle is finally positioned).



5.5.10 Installation of Speed Increaser Gear Casing to Low-stage Bearing Head

a) Start this operation after checking the bearing head assembly for the following point:
The bearing head has two oil holes, one for lubricating the speed increaser gear and the other for lubricating the roller bearing of the speed increaser gear spindle. As each of the oil holes has the oil flow control throttle [196-2] screwed inside, check that the throttle is not clogged.

b) Apply oil to both sides of the speed increaser gear casing gasket [170] and attach it.

CAUTION

- **Carefully install the speed increaser gear casing gasket [170] with its sides directed correctly. The gasket has an oil hole for the side bearing in the speed increaser gear casing on one side, although the gasket is symmetrically shaped and the bolt holes in it are also symmetrically arranged.**

c) Install the speed increaser gear casing assembly to the low stage bearing head. For the sake of safety, it is strongly recommended to perform this operation by suspending the speed increaser gear casing assembly with a proper means like a chain block.

By holding the end of the spindle protruding from the speed increaser gear casing assembly, move the assembly until the roller bearing outer race on the bearing head engages with the roller bearing inner race on the spindle and then press on the assembly in the axial direction (right picture).

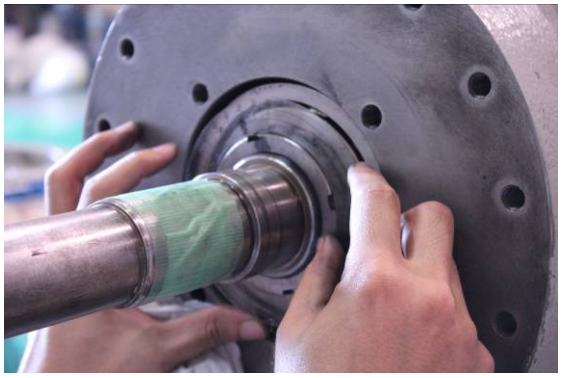
Do this operation while turning the spindle in both directions by holding its end a little to make the speed increaser drive and driven gears engage with each other.

d) When the flanges of both blocks come into contact, align them and temporarily tighten two hexagon socket head cap screws [18-1] in a left-right symmetry way. Then, drive alignment pins [19-1] into the low-stage bearing head.

e) Fasten the hexagon socket head cap screws [18-1] in turn and evenly to the specified torque.

f) Remove the temporary thrust bearing holding jig to fix the thrust bearing inner race onto the speed increaser gear spindle, insert the lock washer [194], torsional slip washer [237-1C] and the lock nut [193]. Then, tighten the lock nut to the specified torque or within the specified range of the tightening angle (following picture to the right) by using the lock nut wrench.

Also tightening the lock nut in this step should change the position of applying the lock nut wrench to avoid uneven tightening (refer to Section 5.5.6 b) [POINT]).

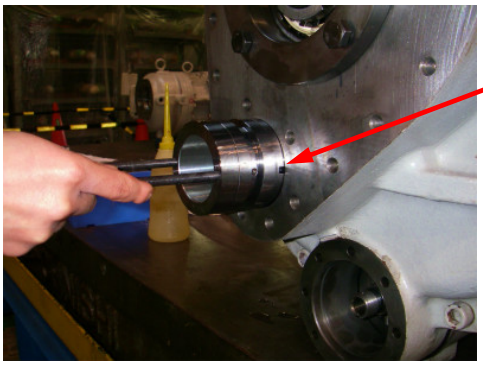


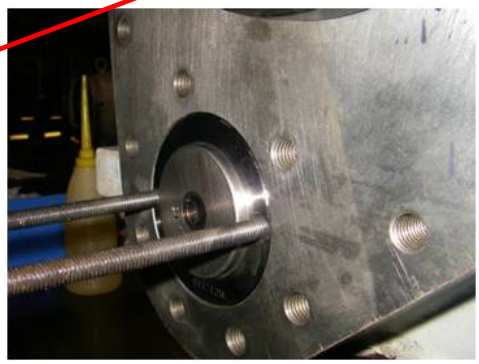
g) Bend the lock washer tooth into the notch of the lock nut to prevent loosening (following picture to the left).

h) Tighten the thrust bearing gland [190] with the hexagon head bolts [191] inserting spring washers [192] in turn and evenly to the specified torque (above picture to the right).

The thrust bearing for the speed increaser gear spindle receives both lateral and axial loads.

i) Install the speed increaser gear side bearing [183] to the speed increaser gear casing by using two eye bolts. In this case, force the side bearing into position while aligning the notch in it with the bearing anti-rotation pin [184] located in the casing.



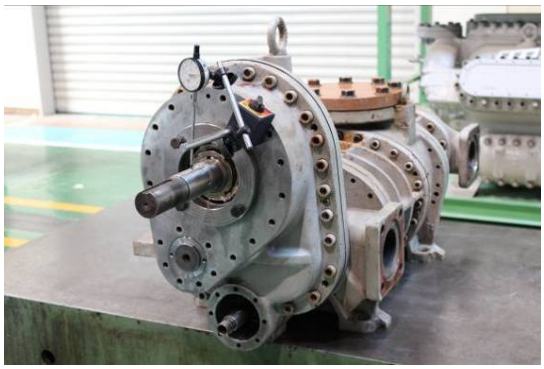


j) Turn the speed increaser gear spindle [188] by utilizing the coupling key [91] to check that there are no abnormalities.

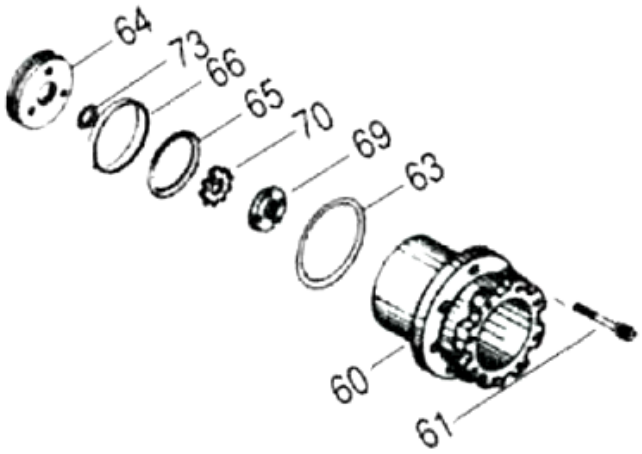
With the dial gauge probe applied against the mechanical seal fitting portion of the speed increaser gear spindle, turn the spindle to check for axial runout (picture below). The amount of axial runout must not exceed 0.03 mm with all models.

Excessive runout occurs when the thrust bearing mark is not at the correct side, and it occurs if fastening the lock nut performed without changing the position of the lock nut wrench (i.e., the uneven fastening of the lock nut).

Moreover small particles of dirt trapped between parts may cause excessive runout.
Precise control of runout is important since the performance and the life of the mechanical seal are significantly affected if its amount exceeds the limit.



5.5.11 Unloader Cylinder and Unloader Piston



P/N	Part Name	Q'ty
60	Unloader Cylinder	1
61	Hexagon Socket Head Cap Screw M8X95	8
63	O-ring JISB2401 G95	1
64	Unloader Piston	1
65	O-ring JISB2401 P75	1
66	Cap Seal BE75	1
69	Lock Nut AN05	1
70	Lock Washer AW05	1
73	O-ring JISB2401 P21	1

Figure 5-16 Unloader Cylinder Block

a) Attach the O-ring [73] to the O-ring groove at the end of the unloader push rod [67] where the unloader piston is to be attached.

b) Attach the O-ring [65] to the unloader piston [64] without using lubricating oil, and then attach the cap seal [66] on that. Inserting an outer side fold in the circumferential direction of the cap seal makes attachment smooth.
Also, using a small smooth spatula-shaped object makes attachment easier.

c) From the side of the unloader cylinder [60] where the inner surface is chamfered for ease of assembly (inner machine side), push the unloader piston into the unloader cylinder, which lubricating oil is applied, while taking care of the unloader piston direction so that the screw holes for eyebolts face the unloader cover. After assembly, check that the cap seal is not broken or pinched.

d) Attach the O-ring [63] to the O-ring groove at the speed increaser gear casing [169] where the unloader cylinder is to be installed.
* According to a design modification in October 1996, the place where O-ring [63] is attached has been changed from the opening with chamfered to the current position.
In case of 1612**C models, this modification has been applied from the compressor manufactured on December 13, 1996 (serial number 1622548).

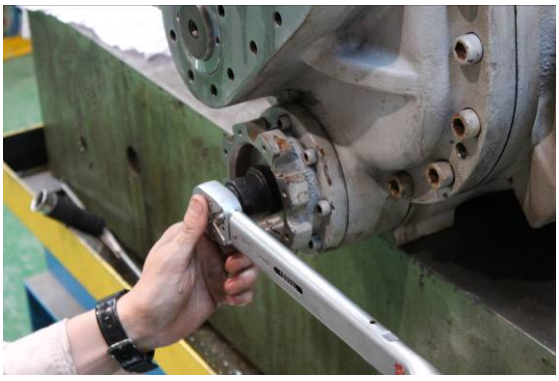
e) Install the unloader cylinder to the speed increaser gear casing, and fasten the eight hexagon socket head cap screws [61] to the specified torque (25 N·m).

O-ring [73] and [63]

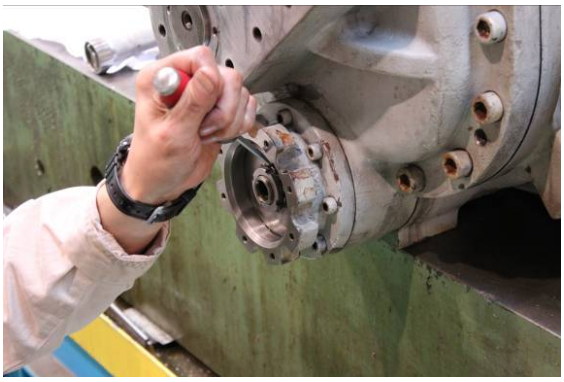
Installing the Unloader Cylinder

f) Insert a new lock washer [70] and the lock nut [69] into the unloader push rod, tighten the lock nut and bend the lock washer tooth into the notch of the lock nut to prevent loosening. The tightening torque for this lock nut is 80 N·m.

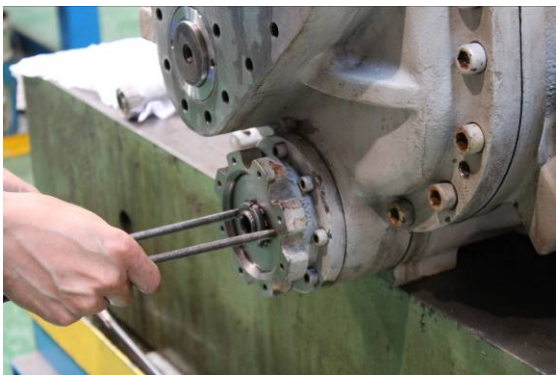
g) After securing the unloader piston, screw eyebolts into the unloader piston, and move the piston 2 to 3 times to check it's motion.



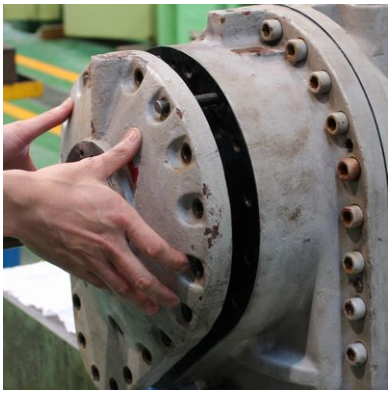
Tightening Lock Nut to secure Unloader Piston



Bending the Lock Washer Tooth



Lastly, Pulling Piston to Front



Attaching Speed Increaser Gear Casing Cover

h) The speed increaser gear casing cover [171] has a lubrication hole for the thrust bearing and mechanical seal for the speed increaser gear spindle and the hole has the oil flow control throttle [196-1] screwed inside. Install the speed increaser gear casing cover after checking that this hole is not clogged.

When attaching the cover, fit its convex portion into the concave portion of the thrust bearing gland in the speed increaser gear casing and then fasten the cover with the hexagon socket head cap screws [195] to the specified torque.
Do not fail to install the speed increaser gear casing cover gasket [172].

CAUTION
● **Speed increaser gear casing cover gasket [172] is not symmetrical because it has an oil hole on one side. Take care not to attach the gasket incorrectly.**

5.5.12 Unloader Cover

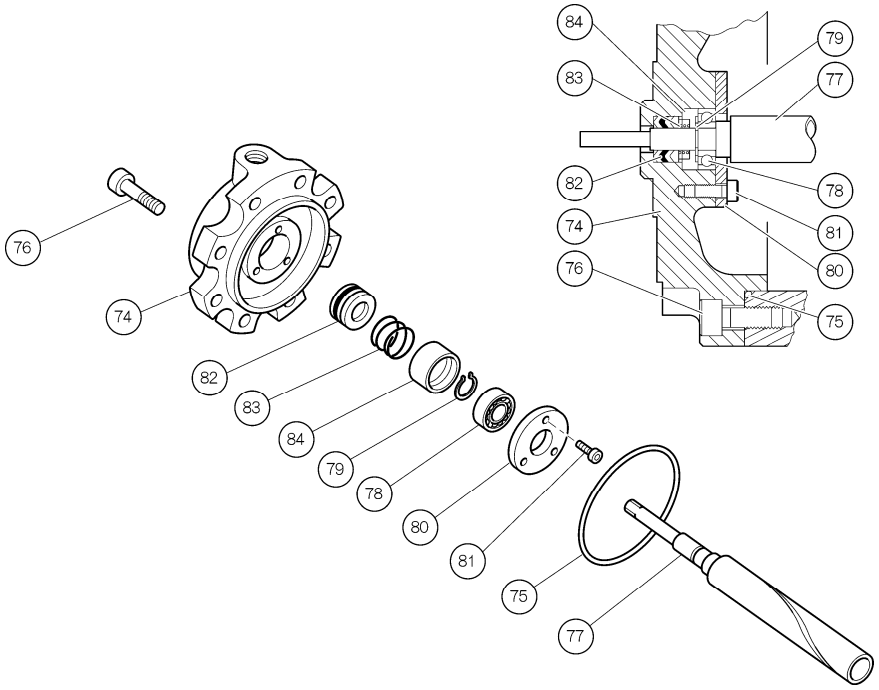


Figure 5-17 Unloader Cover Development View

a) Before proceeding to the next procedure, make sure to pull the unloader piston to the no-load position (toward you).

b) Attach the ball bearing [78] to the axial part of the indicator cam [77]. When pushing in, push the inner race of the bearing. Pushing the outer race may cause damage to the bearing.
Push up to the indicator cam step and use a stop ring to hold.

c) Attach the V-ring set [82] applying sufficient oil to the unloader cover [74].
One of the rings in the V-ring set is made of rubber to improve sealing capacity.
Make sure that the V protrusion of the V-ring faces the outer side and the lip faces the inner side of the machine.

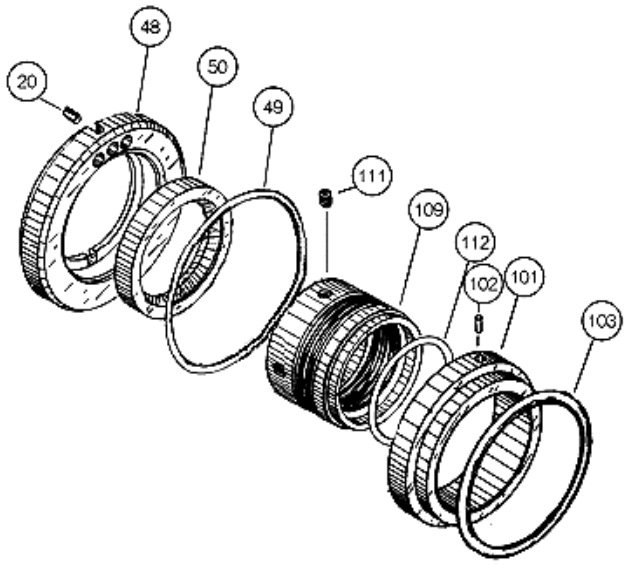
d) Attach the indicator cam spring [83] and spring retainer, insert the shaft of the indicator cam assembled in b) into the V-ring, and tighten the bearing to the unloader cover using the bearing gland [80].

e) Check that the indicator cam rotates smoothly, and then attach the O-ring [75] to the unloader cover.

f) Attach the unloader cover to the unloader cylinder [60]. Push from a position where the spiral groove of the indicator cam is aligned with the guide pin [68] of the push rod. Make sure that the unloader work oil supply hole of the unloader cover is facing up and tighten the hexagon socket head cap screws [76] to secure it at the specified torque 10N･m.

5.5.13 Shaft Seal Block

The BBSE (balance bellows single) type of the mechanical seal assemblies used in current standard MYCOM screw compressors as standard specification.
In addition, the BOS (balance O-rings single) type may be used by the specification of the customer.



P/N		Part Name	
100	101	Mating ring	Stationary ring
	102	Insert lock pin	
	103	O-ring	
	109	Seal collar	Rotating ring
	111	Seal collar set screw	
	112	O-ring	
20		Spring pin	
48		Oil seal retainer	
49		O-ring	
50		Oil seal	

Figure 5-18 BBSE Type Mechanical Seal Assembly and Related Parts

a) Before assembly, clean the part of the rotor shaft where the seal will be installed.

b) In particular, immediately before assembly, recheck the step part for mounting the shaft seal for damage.

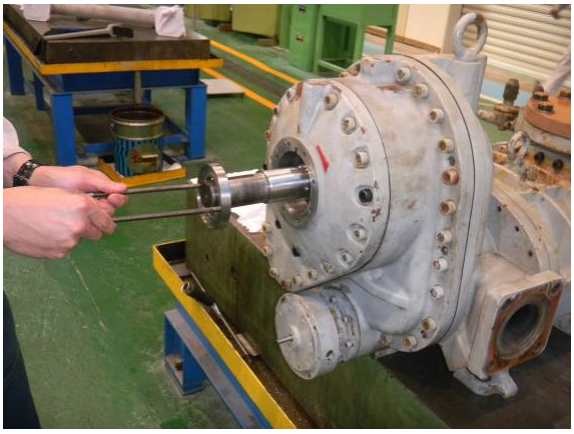
c) Attach the oil seal [50] to the oil seal retainer [48].
Since the design modification in November 2002, the oil seal attachment direction has changed from the oil seal lip facing the atmosphere side to it facing the opposite side. This was in order to improve oil flow from inside the seal box and ensure that pressure is not excessive. Using a resinous material such as Teflon as a pad, gently hit the oil seal while pushing it evenly and fully to assemble. When it has been pushed in fully, the sound and feedback will change.
After assembly, check that the seal is aligned with the retainer and that they are even from the other side.

d) Install the oil seal retainer with the oil seal attached along the rotor shaft using two M8 eyebolts. At this time, ensure that the retainer's oil hole is on the upper side of the rotor shaft, and accurately align the spring pin [20] for stopping rotation on the speed increaser gear casing cover with the retainer notch part.
After assembly, rotate the retainer's eyebolts to check that they are secure. If they are secure, the retainer will not rotate.

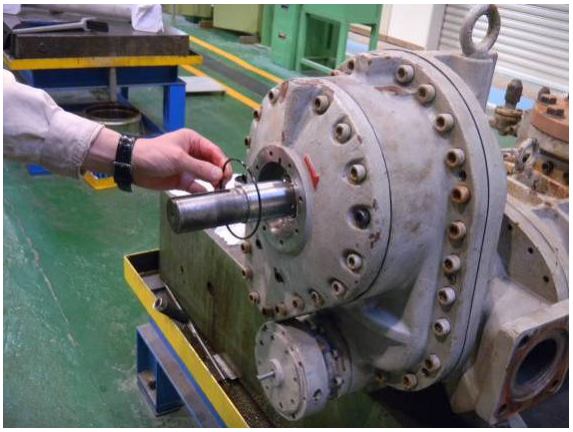
e) Next, attach the O-ring [49] for the seal retainer (following picture to the right).

CAUTION

- **Take special care because users frequently omit to attach the O-ring【49】for oil seal retainer.**



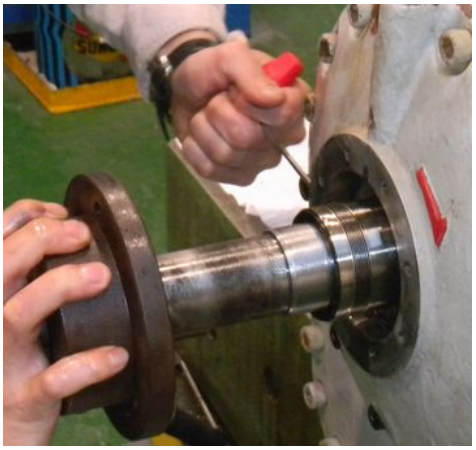
Installing Oil seal Retainer



Attaching O-ring [49]

f) Install the seal collar [109] to the rotor shaft. Before assembly, apply sufficient lubricating oil to the rotor shaft and seal in order to wash away any dirt.
After assembly, check movement by pushing the seal collar with your hand in the axial direction. Take care not to damage the O-ring [112] on the rotor shaft steps while doing so.

g) Fasten the seal collar on the rotor shaft by screwing two set screws [111] into the securing countersinking holes on the rotor shaft. Perform this fastening work with an Allen key via the machining hole in the speed increaser gear cover. Failing to fasten the set screws at the countersink holes will damage the rotor shaft, and it can cause a leakage.



Securing Seal Collar by fastening Set Screw via Machining Hole in Cover

h) Attach the mating ring O-ring [103] and the mating ring [101] to the seal cover [51].

i) Apply oil to the seal cover gasket [52], align the gasket oil hole with the speed increaser gear casing cover oil hole, and affix the gasket to the attachment (flange) side.

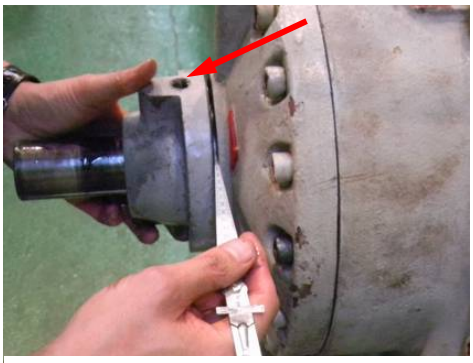
【POINT】

With the standard internal oil supply type compressors, the speed increaser gear casing 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.

j) Install the seal cover with the gasket, so that the oil drop 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, to ensure that the mating ring inside the seal cover does not hit the rotor shaft.

k) 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 speed increaser gear casing cover flange surface by using a taper gauge (picture below). This value is called fastening margin 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 1612**C, make sure that this value is in the range of two to three mm.
With the 1612**C compressor, the thickness of the seal cover gasket is 0.5 mm.



Measuring Fastening Margin for Seal

m) When the seal fastening margin is proper, push the seal cover firmly into the speed increaser gear casing 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 (25 N·m).

n) The hole for fastening the seal collar set screw on 1612LSC speed increaser models is on the speed increaser gear casing cover, so do not forget to plug it after attaching the seal cover.

o) After fastening the seal cover, remove the plug on the top of the seal cover (above picture red arrow). Then supply oil approx 160 mL or more into the seal cover while rotating the rotor shaft.

This oil refilling work is very important to maintain the airtightness in the shaft seal block when vacuuming after the compressor overhauling.

After oil refilling work, make sure to attach the removed plug on the seal cover.

5.5.14 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.

⚠ WARNING

- **When testing/adjusting or replacing parts on the indicator, make sure to turn off and lockout/tagout the control power. Failure to do so could cause an electric shock.**

The 1612**C models have, on its low-stage, 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.

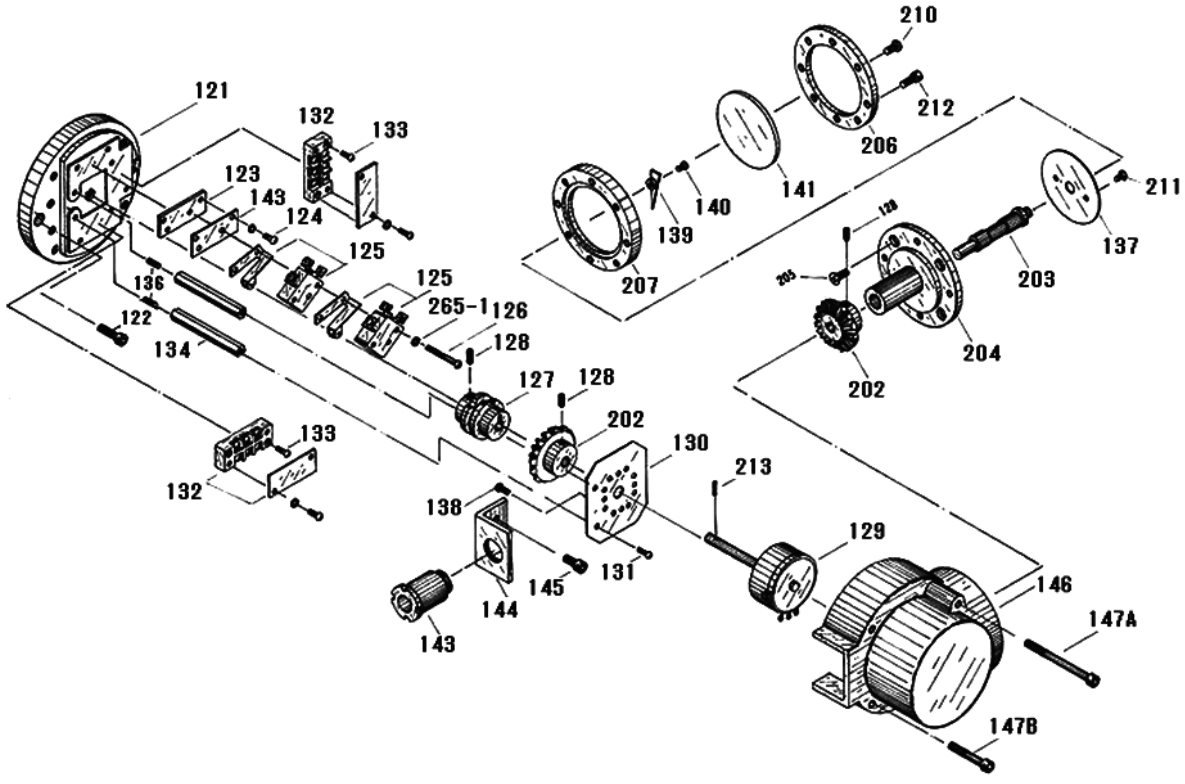


Figure 5-19 Development View of the 1612C Unloader Indicator**

5.5.14.1 Potentiometer

The potentiometer of the 1612**C 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) Remove the hexagon head cap screws securing indicator glass【141】, indicator glass gland【206】 and indicator glass support【205】. At this time, do not mistakenly loosen the phillips screws【210】 on the same surface.
   It become possible to remove the indicator shaft assembly with【141】,【202～207】,【210】, and 【211】.

b) When remove two hexagon head cap screws【147A】【147B】for each which are securing the indicator cover【146】, it becomes possible to remove the indicator cover.

c) 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.

d) Remove the phillips screws【131】of the potentiometer set-plate【130】. This allows the potentiometer set-plate with the potentiometer [129] attached to be removed.
   The potentiometer shaft is removed with the micro-switch cam [127] and bevel gear [202] attached.

e) The micro-switch cam moves freely in the direction of the shaft can be easily removed because only the rotation direction is secured by a spring pin [213] in the potentiometer shaft and a notch.

f) The bevel gear [202] is secured to the potentiometer shaft by the set screw [128].
   Loosen the set screw, and then pull out the potentiometer spring pin using pliers to remove.

g) Loosening two phillips screws [138] allows the potentiometer and potentiometer set-plate to be separated.

■ 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 shaft of the potentiometer with hand, and check with a tester whether the resistance value changes smoothly.

5.5.14.2 Micro-switch

The 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) Same work as disassembly procedure of the potentiometer a) to d).

b) 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.

c) The micro-switch【125】is secured with two long phillips 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.

■ Inspection

a) 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 circuit tester.

b) 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 % and 100 % position of the micro-switch cam.

c) 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.

5.5.14.3 Assembly and Adjustment

a) Attach the micro switches. In theory, the switches will work on the cam irrelevant of the position of the attachment holes. However, attach switches as close as possible to the cam.

b) Secure the potentiometer to the attaching board, attach the bevel gear, and secure with locking screws.

c) Press a spring pin into the potentiometer shaft hole.

d) Align the micro switch cam notch with the pin and attach to the potentiometer shaft.

e) Secure the potentiometer part to the support post [134].

f) Attach the assembled part to the unloader cover using hexagon socket head cap screws [122].
Match the indicator cam shaft of the unloader cover with the micro switch cam.
Rotate the micro switch cam with your hand to check micro switch operation. (Make sure to use a circuit tester etc.)

g) Align the countersinking holes of the shaft with the set screw of the micro switch cam and secure it. This fixes the positions of the unloader slide valve, micro switch cam, and potentiometer.

h) Attach the indicator cover. Electric wiring should be placed considering ease of operation.

i) Attach the indicator. If the dial needle is not set to 0 due to the alignment of the gears, remove the indicator glass part, loosen the dial needle locking screw, and set the dial needle to 0. Assembly is now complete.

■ When the position of the unloader piston is unknown

When the position of the unloader piston is unknown, 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 dial 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 dial 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 dial needle.

6 Troubleshooting

Table 6-1 describes typical trouble symptoms of compressors, their causes and actions to be taken.

The explanations of this Chapter are assumed that the compressor is used in the general refrigeration cycle.

Table 6-1 Troubleshooting

01: Compressor does not start up

Direct cause	Root cause	Action
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

Direct cause	Root cause	Action
Low pressure protection circuit activates.	Insufficient refrigerant flow • Insufficient refrigerant	To correct insufficient refrigerant, check leak, stop leak and then add refrigerant. * Also pay attention to moisture entering into the system.

02: Compressor stops immediately after startup (continued)

Direct cause	Root cause	Action
Low pressure protection circuit activates.	Insufficient refrigerant flow • Insufficient liquid supply	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.
	Heat exchange failure in heat exchanger	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 control 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)

Direct cause	Root cause	Action
Refer to direct cause, "Low pressure protection circuit activates", in Item 02 above.	Same as left	Same as left

04: Low oil pressure (low lubricating oil supply pressure)

Direct cause	Root cause	Action
Oil filter element is clogged. * Pressure difference between the outlet port and inlet port is large.	Contamination of lubricating oil	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 lubricating oil temporarily.
	Troubles such as clogging in oil return passage	Remove causes of the trouble, and restore the system.

04: Low oil pressure (continued)

Direct cause	Root cause	Action
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.	Remove clogging, and check oil for contamination/replace oil.

05: Intermediate pressure is unusually high.

Direct cause	Root cause	Action
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 control 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 control 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 lubricating oil.

06: Unusually high pressure (abnormal discharge pressure)

Direct cause	Root cause	Action
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.
	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.

06: Unusually high pressure (continued)

Direct cause	Root cause	Action
Discharge 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).
	Clogging of 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.

Direct cause	Root cause	Action
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

Direct cause	Root cause	Action
Initial leak after replacement until sliding surfaces 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.
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.
	Excessive refrigerant solved into the lubricating oil, resulting in decreased viscosity of oil.	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	If machine is sometimes stopped longer than a week, take either of the following measures: (i) Manually operate oil pump alone and turn the rotor shaft of the compressor. (ii) Attach an oil pot for supply oil to the seal cover.
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 lubricating oil 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 lubricating oil and operating conditions (such as working temperature range or refrigerant)	Unsuitable lubricating oil was selected, or operating conditions have changed after installation of the equipment.	If possible, review the operating conditions. If not, see "4-1 Lubricating Oil (Refrigerant Oil)" to select suitable lubricating oil and replace the whole quantity.

08: Leak from mechanical seal (continued)

Direct cause	Root cause	Action
Poor contact of sliding surfaces	Foreign matter attached to sliding surfaces, due to contaminated lubricating oil.	Replace the whole quantity of lubricating oil. Install bypass filter to oil supply line.
	Faulty assembly of parts Human error	Disassemble, replace parts and reassemble. Use assembly check sheet to ensure confirmation.

09: Squeaking of mechanical seal

Direct cause	Root cause	Action
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

Direct cause	Root cause	Action
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 gears are 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 bevel gears.
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 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 potentiometer.
	Improper zero span adjustment of E/E positioner	Readjust.

10: Capacity control position is indicated incorrectly (continued)

Direct cause	Root cause	Action
Inaccurate reading of capacity control indicator on the control panel.	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

Direct cause	Root cause	Action
↑ See the causes for "Inaccurate reading of capacity control indicator on the control panel".	Same as left	Same as left
"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 solenoid valve or related relays	Mostly caused by coil burnout.	If deteriorated over time, replace. If the symptom is caused by wet with water, 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 solenoid valve	Oil compression 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.

Direct cause	Root cause	Action
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).
M rotor shaft runout excessively.	Lock nuts and/or 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 tooth 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 compression	Continuous low-load operation with capacity control not greater than 30%	During low-load operation, lubricating oil 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, NH3, 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.

12: Compressor generates abnormal vibration and/or sound (continued)

Direct cause	Root cause	Action
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 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 with proper size one(s).
		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 with proper size one(s).
	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.

12: Compressor generates abnormal vibration and/or sound (continued)

Direct cause	Root cause	Action
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, Section 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 tooth 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 in the machine room, oil level change, etc.) →If occurrence of resonance vibration is a suspected, contact our service centers.

7 Related Documents

7.1 Development Views, Assembly Sectional Views

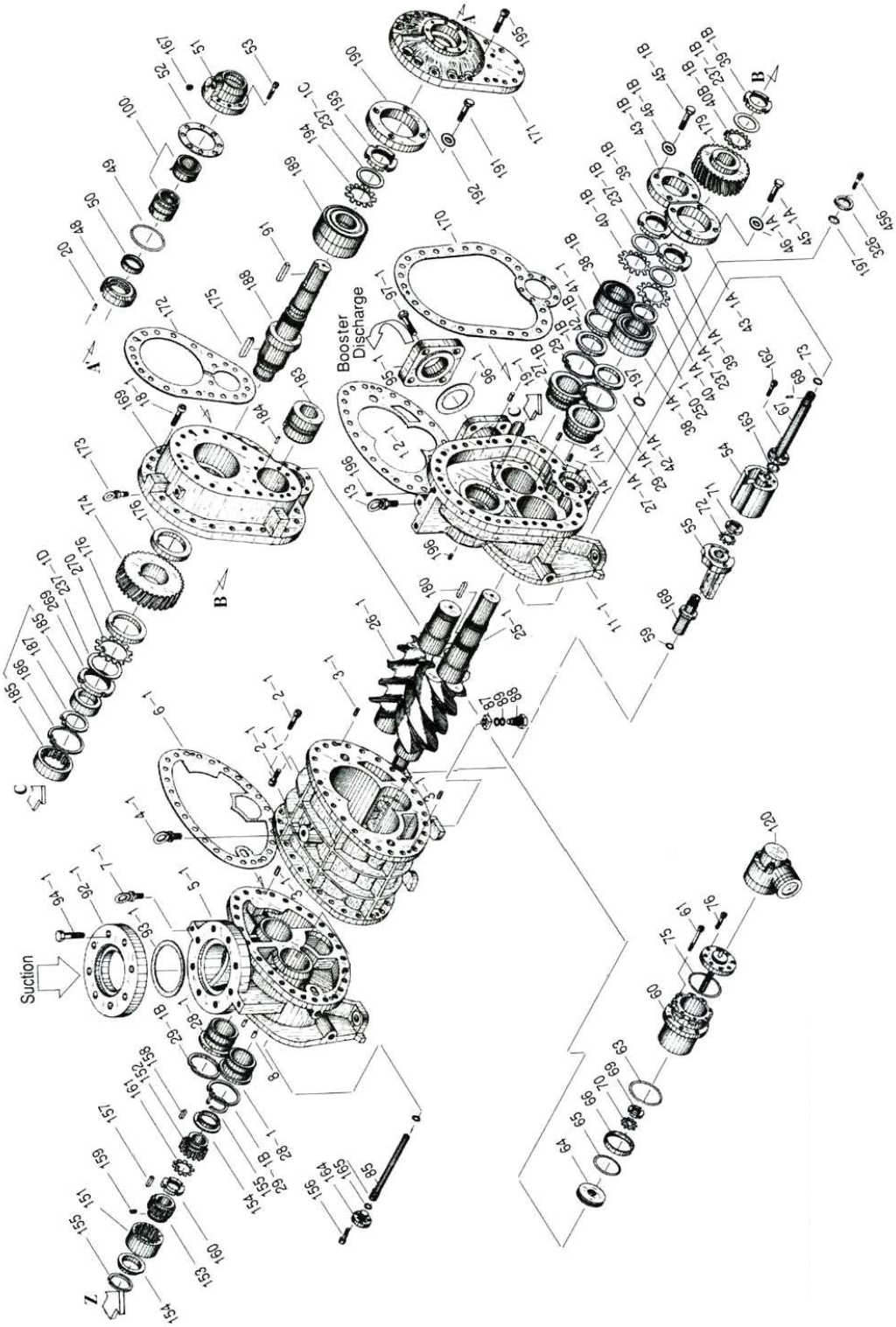


Figure 7-1 Development View (Low-stage)

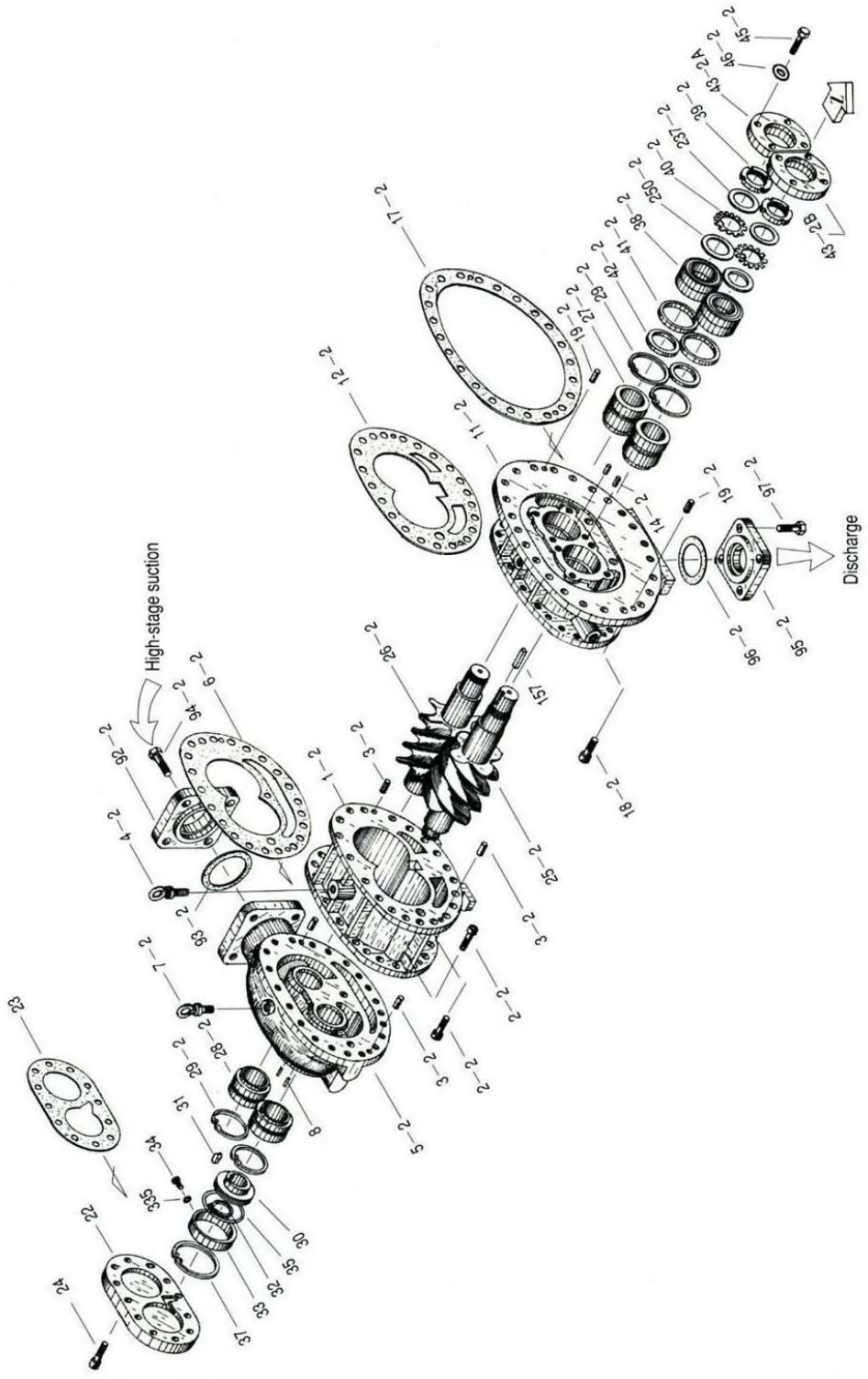


Figure 7-2 Development View (High-stage)

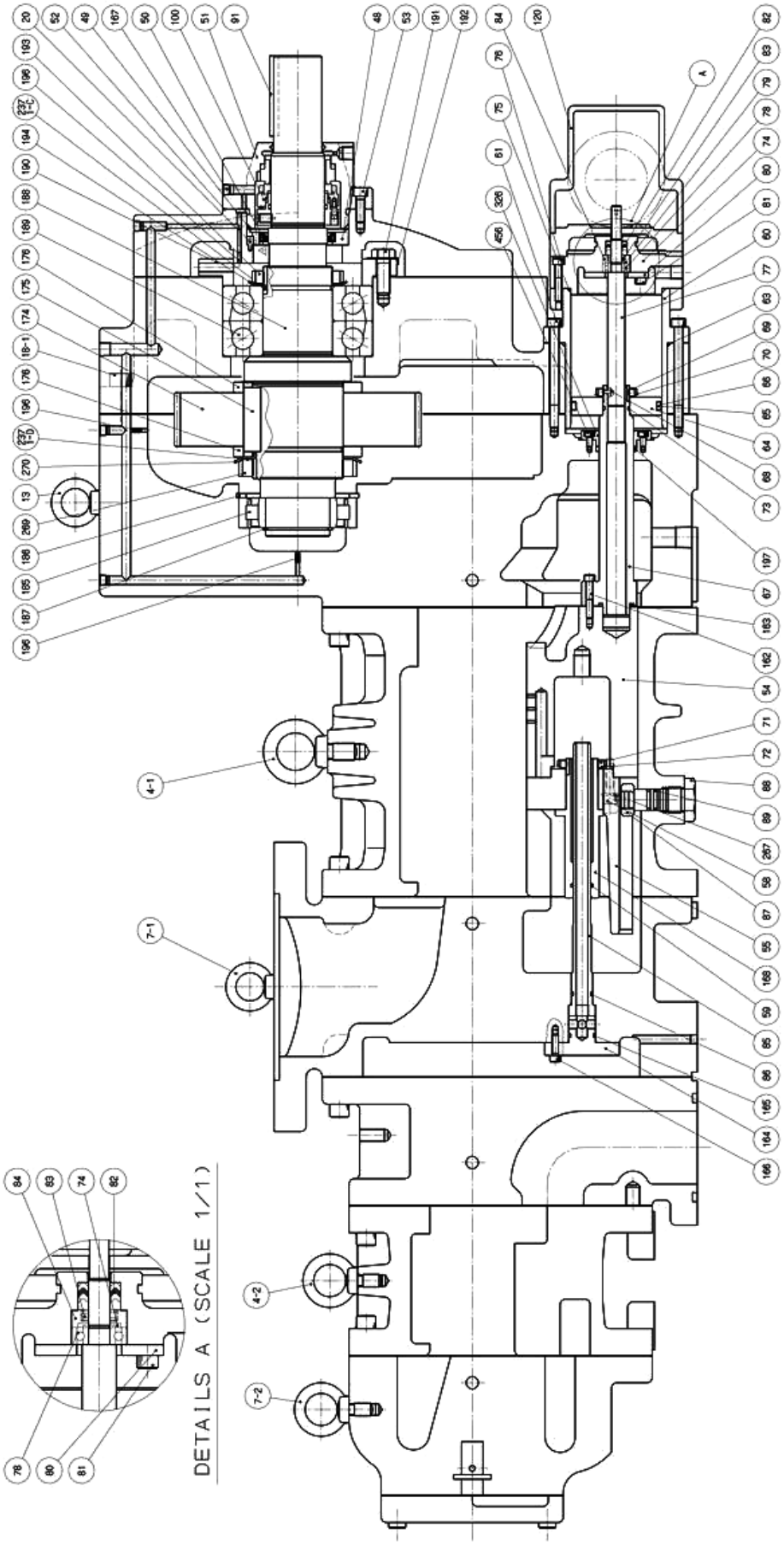


Figure 7-3 Assembly Sectional View (Vertical)

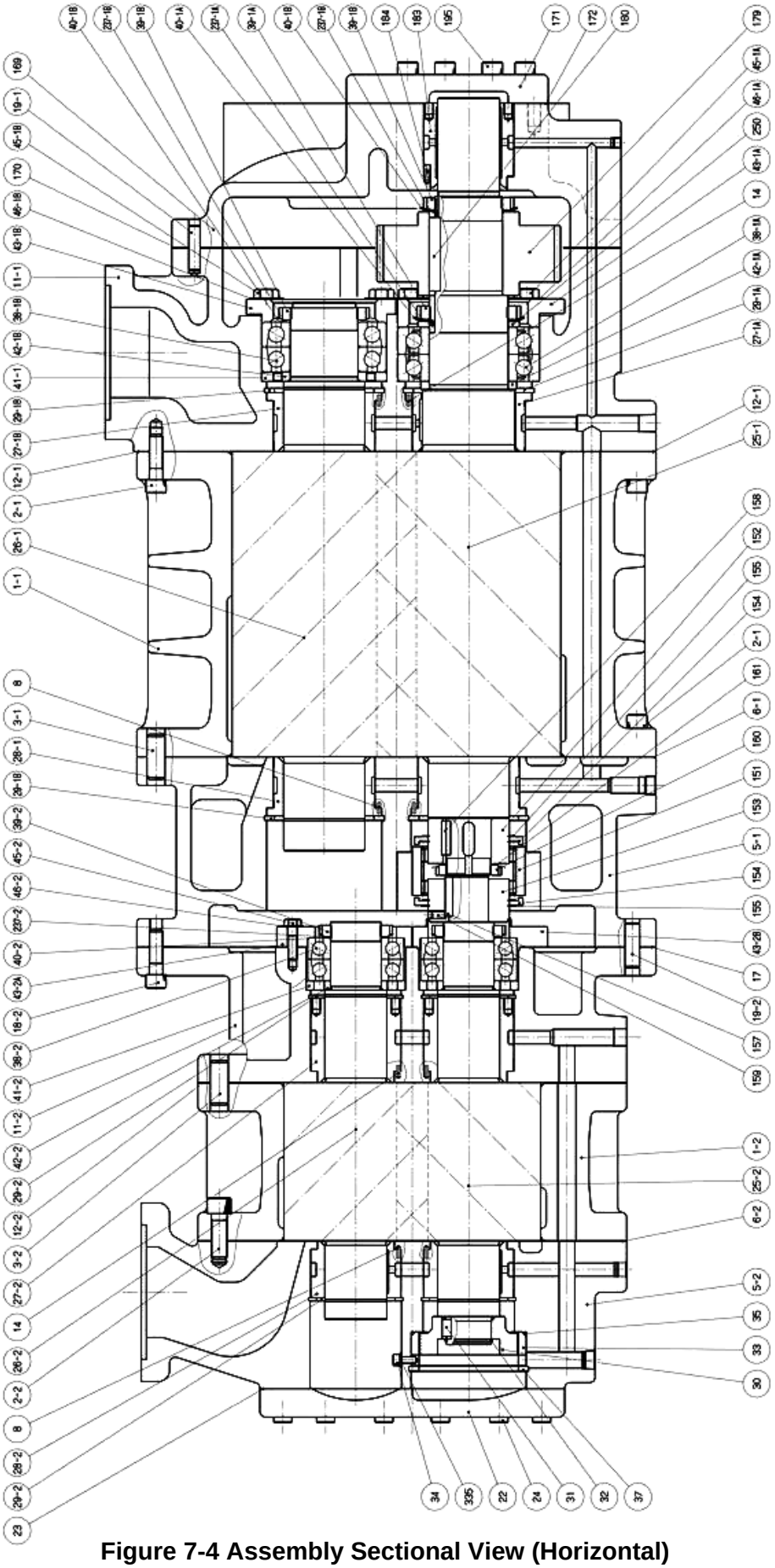


Figure 7-4 Assembly Sectional View (Horizontal)

7.2 Parts Configuration Table

Table 7-1 Configuration table of the parts

P/N	Part name	Part code No.	Remarks	Quantity		
				52/62	53/63	54
1-1	Main Rotor Casing (1)	CS00100-160L	160L**	1	1	-
1-2	Main Rotor Casing (2)	CS00100-1612C	1612*SC	1	1	1
2-1	Hexagon Socket Head Cap Screw	NB35412-040	M12×40	52	52	52
2-2	Hexagon Socket Head Cap Screw	NB35414-040	M14×40	36	36	36
3-1	Alignment Pin	NE2013-040	Φ13×40	4	4	4
3-2	Alignment Pin	NE2016-040	Φ16×40	4	4	4
4-1	Hanger Bolt	NB600-16	M16	1	1	1
4-2	Hanger Bolt	NB600-12	M12	1	1	1
5-1	Suction Cover (1)	CS00500-1612C1	1612**C	1	1	1
5-2	Suction Cover (2)	CS00500-1612C2	1612**C	1	1	1
6-1	Gasket, Suction Cover (1)	CS00600-160N	160***	1	1	1
6-2	Gasket, Suction Cover (2)	CS00600-1612CN	1612**C	1	1	1
8	Spring Pin	NE3204-010	Φ4×10	4	4	4
10-1A	Plug	NF06-010	R3/8	1	1	1
10-2A	Plug	NF06-008	R1/4	1	1	1
10-2B	Plug	NF06-010	R3/8	1	1	1
11-1	Bearing Head (3)	CS01100-1612C3	1612**C	1	1	1
11-2	Bearing Head (2)	CS01100-1612C2	1612**C	1	1	1
12-1	Gasket, Bearing Head (1)	CS01200-160N	160***	1	1	1
12-2	Gasket, Bearing Head (2)	CS01200-1612CN	1612**C	1	1	1
13	Hanger Bolt	NB600-12	M12	1	1	1
14	Spring Pin	NE3204-010	Φ4×10	4	4	4
15-1A	Plug	NF06-004	R1/8	1	1	1
15-1B	Plug	NF06-004	R1/8	1	1	1
15-1C	Plug	NF06-015	R1/2	1	1	1
15-1D	Plug	NF06-020	R3/4	1	1	1
17-2	Gasket, Bearing Cover (2)	CS01700-1612CN	1612**C	1	1	1
18-1	Hexagon Socket Head Cap Screw	NB35414-040	M14×40	24	24	24
18-2	Hexagon Socket Head Cap Screw	NB35412-040	M12×40	26	26	26
19-1	Alignment Pin	NE2013-040	Φ13×40	2	2	2
19-2	Alignment Pin	NE2013-040	Φ13×40	2	2	2
20	Spring Pin	NE3203-010	Φ3×10	1	1	1
21	Plug	NF06-004	R1/8	1	1	1
22	Balance Piston Cover	CS02200-1612C	1612**C	1	1	1
23	Gasket, Balance Piston Cover	CS02300-1612CN	1612**C	1	1	1
24	Hexagon Socket Head Cap Screw	NB35410-035	M10×35	12	12	12
25-1	Male Rotor (1)	CS02500-1612C1N	1612LSC speed increaser type	1	1	1
26-1	Female Rotor (1)					
25-2	Male Rotor (2)	CS02500-1612C2N	1612LSC	1	1	1
26-2	Feale Rotor (2)					
27-1A	Main Bearing /Side Bearing (1) A	CS02700-1612C3	1612LSC speed increaser type	1	1	1
27-1B	Main Bearing /Side Bearing (1) B	CS02800-1610C1	1610SLC/1612**C	1	1	1
27-2	Main Bearing (2)	CS02700-125	125***	2	2	2
28-1	Main Bearing /Side Bearing (1)	CS02800-1610C1	1610SLC/1612**C	2	2	2
28-2	Side Bearing (2)	CS02800-125	125***	2	2	2
29-1A	Snap Ring (1) C type Internal	NG11-112	H112	1	1	1
29-1B	Snap Ring (1) C type Internal	NG11-102	H102	3	3	3
29-2	Snap Ring (2) C type Internal	NG11-080	H80	4	4	4
30	Balance Piston	CS03000-1612C	1612**C	1	1	1

P/N	Part name	Part code No.	Remarks	Quantity		
				52/62	53/63	54
31	Key, Balance Piston	CS03100-125	125***	1	1	1
32	Snap Ring C type External	NG12-040	S40	1	1	1
33	Sleeve, Balance Piston	CS03300-160	160***	1	1	1
34	Hexagon Socket Head Cap Screw	NB35406-015	M6×15	1	1	1
35	O-ring	PA12-095	JIS B 2401 G95	1	1	1
37	Snap Ring C type Internal	NG11-102	H102	1	1	1
38-1	Thrust Bearing (1) A	CS03800-1612CP	7214B	1set	1set	1set
38-1	Thrust Bearing (1) B	CS03800-160P	7212B	1set	1set	1set
38-2	Thrust Bearing (2)	CS03800-125P	7209B	2set	2set	2set
39-1	Lock Nut (1) A	NG31-014	AN14	1	1	1
39-1	Lock Nut (1) B	NG31-012	AN12	2	2	2
39-2	Lock Nut (2)	NG31-009	AN09	2	2	2
40-1A	Lock Washer (1) A	NG32-014	AW14	1	1	1
40-1B	Lock Washer (1) B	NG32-012	AW12	2	2	2
40-2	Lock Washer (2)	NG32-009	AW09	2	2	2
41-1	Spacer, Thrust Bearing Outer Race (1)	CS04100-160	160***	1	1	1
41-2	Spacer, Thrust Bearing Outer Race (2)	CS04100-125	125***	2	2	2
42-1A	Spacer, Thrust Bearing Alignment (1)	CS04200-1612C	1612LSC speed increaser type	1	1	1
42-1B	Spacer, Thrust Bearing Alignment (1)	CS04200-B160	160*** Booster	1	1	1
42-2	Spacer, Thrust Bearing Alignment (2)	CS04200-125	125***	2	2	2
43-1A	Thrust Bearing Gland (1) A	CS04300-1612C3M	16LSC speed increaser type	1	1	1
43-1B	Thrust Bearing Gland (1) B	CS04300-1612C3F		1	1	1
43-2A	Thrust Bearing Gland (2) A	CS04300-1612C2F	1612**C	1	1	1
43-2B	Thrust Bearing Gland (2) B	CS04300-1612C2M	1612**C	1	1	1
45-1A	Hexagon Head Bolt	NB15512-035	M12×35	4	4	4
45-1B	Hexagon Head Bolt	NB15510-030	M10×30	4	4	4
45-2	Hexagon Head Bolt	NB111008-030	M8×30	8	8	8
46-1A	Spring Washer	ND320-012	M12	4	4	4
46-1B	Spring Washer	ND320-010	M10	4	4	4
46-2	Spring Washer	ND320-008	M8	8	8	8
48	Retainer, Oil Seal	CS04800-160	160***	1	1	1
49	O-ring	PA12-090	JIS B 2401 G90	1	1	1
50	Oil Seal	CS05000-160VD	SA1J55 × 70 × 9	1	1	1
51	Seal Cover	CS05100-160	160***	1	1	1
52	Gasket, Seal Cover	CS05200-160N	160***	1	1	1
53	Hexagon Socket Head Cap Screw	NB35408-025	M8×25	8	8	8
54	Unloader Slide Valve (L Port)	CS05400-1612C	1612LSC	1	1	1
54	Unloader Slide Valve (M Port)	-	1612LSC	1	1	1
58	Hexagon Socket Head Cap Screw	NB35408-030	M8×30	4	4	4
59	O-ring	PA11-016	JIS B 2401 P16	1	1	1
60	Unloader Cylinder	CS06000-1612C	1612**C	1	1	1
61	Hexagon Socket Head Cap Screw	NB35408-095	M8×95	8	8	8
63	O-ring	PA12-095	JIS B 2401 G95	1	1	1
64	Unloader Piston	CS06400-1612C	1612**C	1	1	1
65	O-ring	PA11-075	JIS B 2401 P75	1	1	1
66	Cap Seal	CS06600-125	CAP-1BE75	1	1	1
67	Push Rod (3), Unloader Slide Valve	CS06700-1612C3	16LSC speed increaser type	1	1	1
68	Guide Pin	NE2503-008	Φ3×8	1	1	1
69	Lock Nut	NG31-005	AN05	1	1	1
70	Lock Washer	NG32-005	AW05	1	1	1
71	Lock Nut	NG31-006	AN06	1	1	1
72	Lock Washer	NG32-006	AW06	1	1	1
73	O-ring	PA11-021	JIS B 2401 P21	1	1	1
74	Unloader Cover	CS07400-125S	125***	1	1	1

P/N	Part name	Part code No.	Remarks	Quantity		
				52/62	53/63	54
75	O-ring	PA12-085	JIS B 2401 G85	1	1	1
76	Hexagon Socket Head Cap Screw	NB35406-035	M6×35	8	8	8
77	Indicator Cam	CS07700-1610C	1610SLC	1	1	1
78	Ball Bearing	CS07800-200	#6000	1	1	1
79	Snap Ring C type External	NG12-010	S10	1	1	1
80	Bearing Gland	CS08000-200	200***	1	1	1
81	Hexagon Socket Head Cap Screw	NB35406-015	M6×15	3	3	3
82	V-ring	CS08200-200B	20×10×12	1set	1set	1set
83	Spring	CS08300-200	200***	1	1	1
84	Retainer, Indicator Cam Spring	CS08400-200	200***	1	1	1
85	Oil Injection Pipe	CS08500-160SUK	125L**/160S**	1	1	1
86	O-ring	PA11-016	JIS B 2401 P16	1	1	1
87	Guide Block	CS08700-160	160***	1	1	1
88	Stem, Guide Block	"	160***	1	1	1
89	O-ring	PA11-016	JIS B 2401 P16	2	2	2
91	Shaft Key (Coupling Key)	CS09100-160	160***	1	1	1
92-1	Suction Flange (1)	CS71400-125	MYK 125A (5")	1	1	1
92-2	Suction Flange (2)	CS71400-080	MYK 80A (3")	1	1	1
93-1	Gasket, Suction Flange (1)	CR72000-125N	MYK125A (5")	1	1	1
93-2	Gasket, Suction Flange (2)	CR72000-080N	MYK 80A (3")	1	1	1
94-1	Hexagon Head Bolt	NB12020-055	M20×55	8	8	8
94-2	Hexagon Head Bolt	NB12020-055	M20×55	4	4	4
95-1	Discharge Flange (1)	CS71400-080	MYK 80A (3")	1	1	1
95-2	Discharge Flange (2)	CS71400-065	MYK 65A (2"1/2)	1	1	1
96-1	Gasket, Discharge Flange (1)	CR72000-080N	MYK 80A (3")	1	1	1
96-2	Gasket, Discharge Flange (2)	CR72000-065N	MYK 65A (2"1/2)	1	1	1
97-1	Hexagon Head Bolt	NB12020-055	M20×55	4	4	4
97-2	Hexagon Head Bolt	NB12010-055	M16×55	4	4	4
100	Mechanical Seal Assembly	CS10000-160BT	BOS-T1 160V**	1set	1set	1set
100	Mechanical Seal Assembly	CS10002-160EBS	BBS-E 160	1set	1set	1set
120	Unloader Indicator Assembly	CS12000-1612F	1612LSC	1set	1set	1set
151	Driven Sleeve		1610**C	1	1	1
152	Drive Hub		1610**C	1	1	1
153	Driven Hub		1612**C	1	1	1
154	Stopper, Drive Sleeve		1610**C	2	2	2
155	Stop Ring		RR-293(#10 用)	4	4	4
157	Key, Driven Hub			1	1	1
158	Key, Drive Hub			1	1	1
159	Set Screw	NA83606-015	M6×15	1	1	1
160	Lock Nut	NG31-008	AN08	1	1	1
161	Lock Washer	NG32-008	AW08	1	1	1
162	Hexagon Socket Head Cap Screw	NB35406-035	M6×35	5	5	5
163	O-ring	PA12-025	JIS B 2401 G25	1	1	1
164	Retainer, Oil Injection Pipe	CS16400-1612C		1	1	1
165	O-ring	PA11-021	JIS B 2401 P21	1	1	1
166	Hexagon Socket Head Cap Screw	NB35406-025	M6×25	4	4	4
168	Pipe Guide, Oil Injection	CS16800-1612C	1612LSC	1	1	1
169	Speed Increaser Gear Casing	CS16900-1610C	1610SLC	1	1	1
170	Gasket, Speed Increaser Gear Casing	CS17000-1612CN	1612LSC	1	1	1
171	Speed Increaser Gear Casing Cover	CS17100-1610C	1610SLC	1	1	1
172	Gasket, Speed Increaser Gear Casing Cover	CS17200-1610CN	1610SLC	1	1	1
174-1	Speed Increaser Drive Gear (4P)	CS17400-1610C52	52-2610rpm 62-3150rpm	1	-	--

P/N	Part name	Part code No.	Remarks	Quantity		
				52/62	53/63	54
174-2	Speed Increaser Drive Gear (2P)	CS17400-1612153	53-3610rpm 63-4350rpm	-	1	-
174-3	Speed Increaser Drive Gear (2P)	CS17400-1612154	54-4350rpm	-	-	1
175	Key, Speed Increaser Gear Shaft	CS18000-1610CD	1610C	1	1	1
176	Gland, Speed Increaser Gear	CS18100-1610CD	1610C, 4P	2	-	-
179-1	Speed Increaser Driven Gear (4P)	CS17900-1610C52	52-2610rpm 62-3150rpm	1	-	-
179-2	Speed Increaser Driven Gear (2P)	CS17900-1612153	53-3610rpm 63-4350rpm	-	1	-
179-3	Speed Increaser Driven Gear (2P)	CS17900-1612154	54-4350rpm	-	-	1
180	Key, Speed Increaser Driven Gear	CS18000-1610CI	1610C	1	1	1
181	Gland, Speed Increaser Driven Gear	CS18100-1610CIB	1610C, 4P	2	-	-
183	Side Bearing Speed Increaser Driven Gear	CS02700-125	125*** Main bearing	1	1	1
184	Spring Pin	NE3204-010	Φ4×10	1	1	1
185	Roller Bearing, Speed Increaser Driven Gear Spindle	CS18500-1612C	NU2212	1	1	1
186	Snap Ring C type Internal	NG11-110	H110	1	1	1
187	Snap Ring C type External	NG12-060	S60	1	1	1
188	Speed Increaser Gear Spindle	CS18800-1612C		1	1	1
189	Thrust Bearing	CS03800-200	200***	1set	1set	1set
190	Gland, Thrust Bearing	CS19000-1610C		1	1	1
191	Hexagon Head Bolt	NB111012-035	M12×35	4	4	4
192	Conical Spring Washer	CS04600-200	M12	4	4	4
193	Lock Nut	NG31-013	AN13	1	1	1
194	Lock Washer	NG32-013	AW13	1	1	1
195	Hexagon Socket Head Cap Screw	NB35412-040	M12×40	21	21	21
196-1	Oil Flow Control Throttle	CS19600-M408	M4×8×Φ1.5	1	1	1
196-2	Oil Flow Control Throttle		R1/8×Φ1.5	2	2	2
197	O-ring	PA11-032	JIS B 2401 P32	1	1	1
237-1A	Torsional Slip Washer (1) A	CS23700-1612CB	1612**C	1	1	1
237-1B	Torsional Slip Washer (1) B	CS23700-160	160***	2	2	2
237-1C	Torsional Slip Washer (1) C	CS23700-200	200***	1	1	1
237-1D	Torsional Slip Washer (1) D	CS23700-250	250***	1	1	1
237-2	Torsional Slip Washer (2)	CS23700-125	125***	2	2	2
250-1	Thrust Washer	CS25000-1612C3	1612LSC speed increaser type	1	1	1
267	Special Spring Washer	ND330-08	M8	4	4	4
326	Gland, O-ring	CS32600-1612C	1612LSC speed increaser type	1	1	1
335	Special Spring Washer	ND330-06	M6	1	1	1
456	Hexagon Socket Head Cap Screw	NB35405-010	M5×10	4	4	4
605-1	Plug	NF06-015	R1/2	1	1	1
605-2	Plug	NF06-008	R1/4	1	1	1
607	Plug	NF06-004	R1/8	1	1	1

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.

7.3 Tightening Torques for Bolts and Nuts

Table 7-2 List of Tightening Torques

■ **Hexagon socket head cap screw**

P/N	Tightening point	Tightening torque		Qty.	Size
		N·m	kgf·cm		
2-1	Main Rotor Casing (1) to Suction Cover (1) and Bearing Head (1)	90	900	52	M12×40
2-2	Main Rotor Casing (2) to Suction Cover (2) and Bearing Head (3)	140	1400	36	M14×40
18-1	Speed increaser gear casing to Bearing Head (3)	140	1400	24	M14×40
18-2	Bearing Head (2) to Speed Increase Gear Casing	90	900	26	M12×40
24	Balance Piston Cover to Suction Cover (2)	50	500	12	M10×35
34	Balance Piston Sleeve	10	100	1	M6×15
53	Seal Cover to Speed Increaser Gear Casing Cover	25	250	8	M8×25
58	Unloader Slide Valve Unloader Slide Valve (2)	25	250	4	M8×30
61	Unloader Cylinder to Speed Increaser Gear Casing	25	250	8	M8×95
76	Unloader Cylinder Cover to Unloader Cylinder	10	100	8	M6×35
81	Bearing Gland	10	100	3	M6×15
162	Push rod, Unloader Slide Valve	10	100	5	M6×35
166	Oil Injection Pipe Gland	10	100	4	M6×25
195	Speed Increaser Gear Casing Cover to Speed Increaser Gear Casing	90	900	21	M12×40
456	O-ring Gland to Bearing Head (3)	6	60	4	M5×10

■ **Hexagon head screw**

P/N	Tightening point	Tightening torque		Qty.	Size
		N·m	kgf·cm		
45-1A	Thrust bearing gland (1) M	50	500	4	M12×35
45-1B	Thrust bearing gland (1) F	40	400	4	M10×30
45-2	Thrust bearing gland (2)	30	300	8	M8×30
94-1	Suction cover flange (1) MYK125A	140	1400	8	M20×55
94-2	Suction cover (intermediate piping) flange (2) MYK80A	140	1400	4	M20×55
97-1	Discharge cover (intermediate piping) flange (1) MYK80A	140	1400	4	M20×55
97-2	Discharge cover flange (2) MYK65A	110	1100	4	M16×55
191	Thrust bearing gland (speed increaser gear spindle)	50	500	4	M12×35

■ Locknut

P/N	Tightening point	Tightening torque N·m		Qty.	Size
		Regular use	Maxi-mum		
39-1A	Thrust bearing (1) M	656	820	1	AN14
39-1B	Thrust bearing (1) F Speed increaser driven gear	408	510	2	AN12
39-2	Thrust bearing (2)	206	258	2	AN09
69	Unloader piston	80	—	1	AN05
71	Unloader slide valve	49	61	1	AN06
160	Intermediate gear coupling, drive hub	90	113	1	AN08
193	Thrust bearing, speed increaser gear	522	653	1	AN13
269	Speed increaser drive gear	1186	1483	1	AN17

Note: When tightening a lock nut, if it is difficult to use a torque wrench, manage the tightening torque of the lock nut controlling the tightening angle range as explained below.

■ Tightening Angle Range of Lock Nuts for Rotors

a) 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.

b) 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.

c) 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.

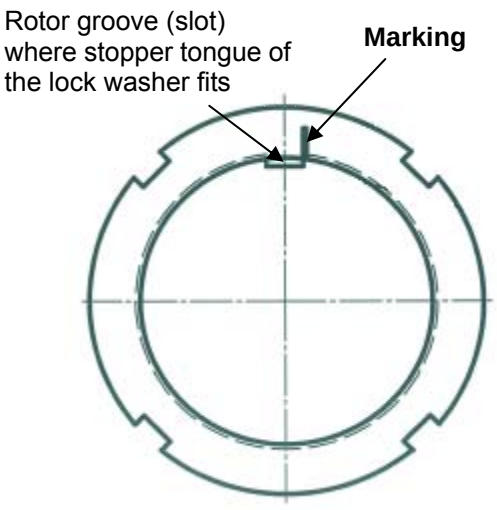
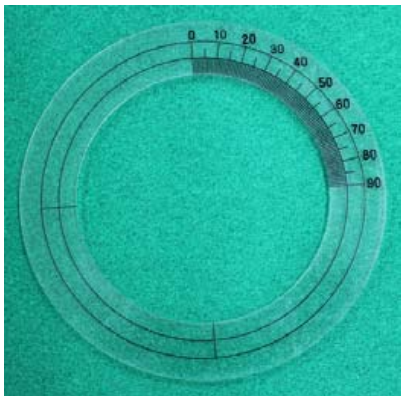


Figure 7-11 Position where mark is put

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

	Model	Angle range
First time tightening	125 to 250	30° to 40°
Second time tightening	125 to 250	20° to 30°

* 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.



Angle Gauge (example)

7.4 O-rings for Use

7.4.1 List of O-rings for Use

Table 7-4 List of O-rings for Use

P/N	Used locations		JIS-B2401 (mm type)
	attached place	description in function aspect	
35	Balance Piston Sleeve	same as left	G95
49	Oil Seal Retainer	same as left	G90
59	Oil Injection Pipe Guide	Oil Injection Pipe	P16
63	Speed Increaser Gear Casing	Unloader Cylinder	G95
65	Unloader Piston	same as left	P75
73	Unloader Push Rod	Unloader Piston	P21
75	Unloader Cover	same as left	G85
86	Oil Injection Pipe	same as left	P16
89	Guide Block Stem	same as left	P16
163	Special specification only for the LLC type, Guide Block Stem	same as left	G25
165	Unloader Slide Valve (1)	same as left	P21
197	Bearing Head (3)	Unloader Push Rod	P32

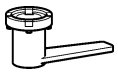
7.4.2 List of O-ring Materials for Screw Compressor

Table 7-5 List of O-ring Materials for Screw Compressor (except for mechanical seal)

Operation fluid	O-ring materials
Ammonia	NBR
Hydrofluorocarbon (HFC)	
Carbon dioxide (CO_2)	FKM
	HNBR
Triflorofluoromethane (R23)	FKM
Propane	
Propylene	
Natural gas	
City gas	
Helium	

7.5 Disassembly Tools

Table 7-6 List of Tools for Standard Disassembly

Tool name		size, etc.;	Code No.
Ratchet wrench		1/4”	SG261-08
Adjustable wrench		250 mm	SG231-250
Screwdriver		Phillips	SG112-075
Screwdriver		Flat blade	SG111-075
Snap ring pliers external		for shaft ST-2N	SG311-02N
Snap ring pliers internal		for groove RT-4	SG312-04
Eye bolt		M8 two-peace-set	UHT0016
Allen wrench key		Across flats 2 mm	SG241-02
		3 mm	SG241-03
		4 mm	SG241-04
		5 mm	SG241-05
		6 mm	SG241-06
		8 mm	SG241-08
		10 mm	SG241-10
		12 mm	SG241-12
Lock nut wrench		AN-05	SAS111-05
		AN-06	SAS111-06
		AN-8	SAS111-08
		AN-9	SAS111-09
		AN-12	SAS111-12
		AN-13	SAS111-13
		AN-14	SAS111-14
		AN-17	SAS111-17
Torque wrench for assembly		5-25 N･m	-
		20-100 N･m	SG132-0900
		40-280 N･m	SG132-2800
		500-1500 N･m	-

Contact Information

Sales Offices/Service Centers

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MAYEKAWA (TAIWAN) CO., LTD. (CHEMICAL DEPARTMENT)	1F., NO.2, SHIN JANN ROAD, CHIEN CHEN DIST., KAOHSIUNG, TAIWAN 80672, ROC	TEL: (886) 7-812-7709 FAX: (886) 7-812-9019
MAYEKAWA (TAIWAN) CO., LTD. (TAIPEI HEAD OFFICE)	8F, NO, 421, SUNG-SHAN ROAD, TAIPEI, TAIWAN 11083, REP. OF CHINA	TEL: (886) 2-2727-9711 FAX: (886) 2-2759-8484
MAYEKAWA (TAIWAN) CO., LTD. (TAICHUNG BRANCH)	NO. 80-2, SEC.3, HUANJUNG RD., TAICHUNG, TAIWAN, 40755, REP. OF CHINA	TEL: (886) 4-2251-4128 FAX: (886) 4-2251-4129
MAYEKAWA CHINA INDUSTRIES CO., LTD. (SHANGHAI BRANCH)	ROOM 3001, NANZHENG BUILDING, NO.580 WEST NANJING RD., 200041 SHANGHAI, P.R. CHINA	TEL: (86) 21-5234-1988 FAX: (86) 21-5234-1788
MAYEKAWA CHINA MFG.CO., LTD.	201700 PLANT 1, NO.39, WEST XIQING ROAD, QINGPU, SHANHAI, P.R. CHINA	TEL: (86) 21-6920-7718 FAX: (86) 21-6920-7719
MAYEKAWA CHINA MFG.CO., LTD. (GUANGZHOU BRANCH)	RM.1205, TIANLHEFULI BUSINESS MANSION, No.4, HUA TING RD, GUANGZHOU, 510610, CHINA	TEL: (86) 20-8527-6161 FAX: (86) 20-8527-6165
MAYEKAWA CHINA MFG. CO., LTD. (QINGDAO BRANCH)	ROOM 601, FULIN BUILDING NO.87 SOUTH FUZHOU ROAD, SOUTH DISTRICT, QINGDAO CITY, 266071, CHINA	TEL: (86) 532-8602-6169 FAX: (86) 532-8602-6269

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MAYEKAWA CHINA MFG. CO., LTD. (DALIAN BRANCH)	RM.A13-5, No.1 BUILDING, AREA A , WUCAI CITY, DALIAN ECO-TECH DEVELOPMENT ZONE, 116100, DALIAN, P. R. CHINA	TEL: (86) 411-8753-9620 FAX: (86)411-8757-9620
MAYEKAWA (THAILAND) CO., LTD. MAYEKAWA HOLDING (THAILAND)CO., LTD.	2/3 MOO 14, 3RD FLOOR BANGNA TOWER BLDG., TOWER A, BANGNA-TRAD RD, K.M.6.5, BANGKAEW BANGPLEE, SAMUTPRAKARN 10540, THAILAND	TEL: (66) 2-751-9610 FAX: (66) 2-751-9565
MAYEKAWA (THAILAND) CO., LTD. (TRANG BRANCH)	1/7 TRANG-PALIAN RD., MUANG, TRANG 92000, THALAND	TEL: (66) 75-224-784 FAX: (66) 75-224-351
MAYEKAWA VIETNAM ONE MEMBER CO., LTD.	ROOM 305, 3FL, TUOI TRE TOWER, 60A HOANG VAN THU, WARD 9, PHU NHUAN DIST., HO CHI MINH CITY, VIETNAM	TEL: (84) 8-3997-5284 FAX: (84) 8-3997-5287
MYCOM KOREA CO., LTD. (HEAD OFFICE)	2F, 345, CHEONGRA-RO , YONGSAN-KU, SEOUL, 140-710, REP.OF KOREA	TEL: (82) 2-796-1766 FAX: (82) 2-798-7715
MYCOM KOREA CO., LTD. CHANGWON FACTORY	19, BANGYE-RO, UICHANG-KU, CHANGWON-SI, GYEONGSANGNAM-DO 641-847, REP.OF KOREA	TEL: (82) 55-294-8678 FAX: (82) 55-299-7678
MYCOM KOREA CO., LTD. (BUSAN BRANCH)	5F, 26, JUNGANG-DAERO, JUNG-GU, BUSAN 600-714, REP.OF KOREA	TEL: (82) 51-242-3737 FAX: (82) 51-243-8542
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MAYEKAWA ARGENTINA S.A. (BUENOS AIRES OFFICE)	DR. JOSE VALENTIN GOMEZ 151, LOT42, HAEDO-PARTIDO DE MORON, BUENOS AIRES, CP B1706FMA, ARGENTINA	TEL: (54) 11-4627-6660 FAX: (54) 11-4628-1511
MAYEKAWA ARGENTINA S.A. (PUERTO MADRYN OFFICE)	OFICINA PTO. MADRYN LEOPOLDO LUGONES 45 (U9129KDA)-PUERTO MADRYN PCIA DE CHUBUT REPUBLICA ARGENTINA	TEL: (54) 2965-475414 FAX: (54) 2965-475414
MYCOM PERU S.A.C.	CALLE LUIS PASTEUR 1490, LINCE, LIMA, PERU	TEL: (51) 1-205-5400 FAX: (51) 1-222-1543
MAYEKAWA CHILE S.A.C.el. (SANTIAGO OFFICE)	CORDILLERA No.331, MODULO D14, FLEX CENTER, PUERTO VESPUCIO, QUILICURA, SANTIAGO, CHILE	TEL: (56) 2-739-0202 FAX: (56) 2-739-2700
MAYEKAWA CHILE S.A.C.el. (CONCEPCION OFFICE)	ANIBAL PINTO No.215, OFICINA 403, CONCEPCION, CHILE	TEL: (56) 41-223547 FAX: (56) 41-212443
MAYEKAWA CHILE S.A.C.el. (PUERTO MONTT OFFICE)	BERNARDINO 1057 MODULO 6, PARQUE INDUSTRIAL SAN ANDRES PUERTO MONTT, CHILE	TEL: (56) 65-257570 FAX: (56) 65-288073
MAYEKAWA ECUADOR S.A.	CALLE 15B Y AV. GUILLERMO PAREJA C.C.STEFANY LOCAL #4, CALLA.LA GARZOTA 1 MZ.28 SOLOR 13, GUAYAQUIL, ECUADOR	TEL: (593)4-262-9108 TEL: (593)4-262-6407 FAX: -
MAYEKAWA COLOMBIA S.A.S	TRANSVERSAL 93 NO.53-48 INTERIOR 37, PAQUE INDUSTRIAL EL DORADO, BOGOTA, COLOMBIA	TEL: (57) 1-430-9980 TEL: (57) 1-224-3028 FAX: (57) 1-437-0988

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MAYEKAWA COLOMBIA S.A.S. (MEDELLIN OFFICE)	DIRECCION CR 43B No. 8 SUR 10 OFICINA 404 EDF. OVIEDO MEDELLIN, COLOMBIA	TEL: (57) 4-313-4343 FAX: (57) 4-313-4343
MAYEKAWA DO BRASIL EQIPAMENTOS INDUSTRIAIS LTDA.	RUA LICATEM 250, BLOCO B/C, JARDIM PEROVA-ARUJA-SP CEP:07428-280, BRASIL	TEL: (55) 11-4654-8000 FAX: (55) 11-4654-8002
MAYEKAWA DO BRASIL LTDA. (BAHIA BRANCH)	RUA DR. JOSE PEROBA, 275 - SALA 902 EDIFICIO METROPOLIS - BAIRRO STIEPE, SALVADOR – BA,CEP:41770-235, BRASIL	TEL: (55) 71-3341-0737 FAX: —
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MAYEKAWA DO BRASIL EQIPAMENTOS INDUSTRIAIS LTDA. (CUIABA BRANCH)	AVENIDA ISSAC POVOAS, 586 – SALA 405 EDIFICIO WALL STREET - CENTRO CUIABA-MT, CEP 78055-560, BRASIL	TEL: (55) 65-3023-7559 FAX: —
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MAYEKAWA DO BRASIL EQIPAMENTOS INDUSTRIAIS LTDA. (LINHARES BRANCH)	AV. GOVERNADOR CARLOS LINDENBERG, 873/107 CENTRO CEP:29900-020 LINHARES-ES, BRASIL	TEL: — FAX: —
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MAYEKAWA DO BRASIL EQIPAMENTOS INDUSTRIAIS LTDA. (RIO DE JANEIRO BRANCH)	AV.LUIZ CARLOS PRESTES, 350-SALA 313-EDIFICIO BARRA TRADE II, BARRA DA TIJUCA, RIO DE JANEIRO-RJ CEP:22775-055, BRASIL	TEL: (55) 21-2431-3600 FAX: (55) 21-2430-8882
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MYCOM VENEZUELA SALES & SERVICE, C.A. (MARACAIBO OFFICE)	CALLE 148,CENTRO EMPRESARIAL SAN FRANCISCO NIVEL 1 LOCAL 5 Y 6, ZONA INDUSTRIAL IIETAPA,SAN FRANCISCO EDO.ZUILIA, VENEZUELA	TEL: (58) 261-418-1760 FAX: -
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MYCOM CHEMICAL PROCESS CORP. DE VENEZUELA S.A.	CALLE 148,CENTRO EMPRESARIAL SAN FRANCISCO NIVEL 1 LOCAL 5 Y 6, ZONA INDUSTRIAL IIETAPA,SAN FRANCISCO EDO.ZUILIA, VENEZUELA	TEL: (58) 261-418-1760 FAX: -
MAYEKAWA DE MEXICO, S.A. DE C.V. (CUERNAVACA OFFICE)	AV.DE LOS 50MTS.NO.381, CIVAC. JIUTEPEC MORELOS, C.P.62578, MEXICO	TEL: (52) 77-73-19-0925 FAX: (52) 77-73-20-5762
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