VZ / VZL

REFRIGERATION COMPRESSOR

OPERATION, DATA & MAINTENANCE

MANUAL

Ver. 5

HASEGAWA
REFRIGERATION, LTD.

Surely®
ESTABLISHED 1910

CONTENTS

PREFACE

Hasegawa Refrigeration Ltd. is a specialized manufacturer of refrigerating machines and equipment, having been established in 1910.

Hasegawa Refrigeration Ltd. manufactured the first High-speed, Multiple cylinder Compressor in Japan, establishing a sound reputation through dynamic achievement in the domestic and global markets.

Hasegawa Refrigeration Ltd. manufactures exceedingly efficient compressors to comply with market demands, utilizing Hasegawa's vast experience, advanced manufacturing techniques and materials. Therefore Hasegawa is able to supply worldwide, from its modern manufacturing facility the most advanced series of High-speed, Multiple cylinder compressors.

This manual provides the operator and maintenance technician the necessary information to operate the compressor efficiently and maintain the compressor economically. Hasegawa is confident that our compressors will exceed your requirements and achieve a high degree of product satisfaction.

In the event that technical assistance or information is required on VZ compressors, please have the following information available when contacting Hasegawa Refrigeration Ltd:

1. Compressor serial number
2. Compressor model number
3. Type of system
4. Operating conditions
   - Suction pressure & temperature
   - Intermediate pressure & temperature (if applicable)
   - Discharge pressure & temperature
   - Oil differential pressure
   - Motor current – full and partial load
   - Run hours
5. Compressor rpm
6. Motor HP
7. Refrigerant type
8. Any other relevant information

Hasegawa Refrigeration Ltd. provides the information enclosed as a guide and is subject to periodic revision.

Surely®

SAFETY INSTRUCTIONS & GUIDELINES

INTRODUCTION

Thank you for selecting the HASEGAWA reciprocating compressor unit. The compressor is provided complete with a HASEGAWA SURELY→ trademark and is supplied with the standard HASEGAWA limited warranty.

This leaflet explains the safety instructions and guidelines associated with the operation and maintenance of HASEGAWA reciprocating compressors. Prior to operating or performing equipment inspection and maintenance procedures on HASEGAWA reciprocating compressors, these instructions must be comprehended and complied with unless superceded by local codes or regulations.

Follow the safety instructions and guidelines carefully to prevent personal or fatal injury during the operation and maintenance of HASEGAWA reciprocating compressors.

DISCLAIMER

HASEGAWA does not accept responsibility for personal or fatal injuries caused by unauthorized modification, the use of non-genuine components, or operation and maintenance of HASEGAWA reciprocating compressors not performed in accordance with the following guidelines.

The following flags denote the level of caution to be adhered to:

Warning

Incorrect equipment operation or handling may cause serious injury or possibly death.

Attention

Incorrect equipment operation or handling may cause personal injury or equipment damage.

Warning

- Refrigeration service personnel with the appropriate level of training, qualifications and knowledge may only be authorized to undertake equipment operation, inspection and maintenance.
- Remain at a safe distance from operational equipment. Do not operate the compressor with the fixed belt or coupling guard removed, or attempt to inspect V- belts while the compressor is in operation.
- Stop the compressor prior to inspection. Use the appropriate ‘lock – out’ / ‘tag – out’ method to prevent inadvertent compressor manual or remote automatic start – up.
- Electrical service personnel with the appropriate level of training, qualifications and knowledge may only be authorized to undertake electrical repairs or modifications.

- Use the appropriate ‘lock – out’ / ‘tag – out’ method prior to opening electrical service panels or controls to ensure electrical isolation of the equipment.
- Follow the appropriate local codes of practice and regulations at all times while undertaking mechanical or electrical maintenance procedures.

Attention

General

- Do not utilize or install any components, equipment or materials that are not compatible with the system.

Operation

- In the event of uncharacteristic indications, stop the compressor immediately. Continued operation of the compressor with abnormal indications can result in personal injury or equipment damage.
- Should the compressor be stopped due to uncharacteristic indications, investigate and repair the problem prior to restarting the compressor.
- Do not operate the compressor beyond the design specifications and limits.
- Remain at a safe distance from the compressor driving system when the compressor is operational or set for remote automatic control.
- Do not remove the fixed belt or coupling guard while the compressor is operating or set for remote automatic control as personal injury may occur.
- Do not remove plugs or open service valves while the compressor is operating or set for remote automatic control, as leakage of high-pressure (high temperature) refrigerant gas or lubricating oil will occur. This would result in personal injury or equipment damage.

Daily Inspection & Maintenance

- Qualified, trained and authorized personnel must complete operation, inspection and maintenance tasks.

Note

- Service personnel should keep these safety instructions and guidelines adjacent to the compressor, in a place that is both safe and accessible.
- Adherence to these safety instructions and guidelines is mandatory, unless superceded by local codes and regulations.

1. INTRODUCTION

1.1 Construction

The Hasegawa "SURELY" compressor is designed and manufactured for use with refrigerants R717, R22 and HFCs. The compressor is shipped only after completing leak and performance testing to strict Hasegawa procedures and regulations.
The fundamental principals of design and manufacture of Hasegawa compressors are:

- Large capacity,
- Compactness,
- Lighter weight and
- Ease of handling.

These principals have been attained with many years of compressor design and operational experience, being instigated by means of close collaboration with existing and prospective customers.

Crankcase, Cylinder Covers and Principal Components

Are manufactured from high-grade cast iron and are precisely machine finished to Hasegawa specifications.

Cylinder Liners

Are manufactured from high grade, exceptional wear-resistant cast iron to exact tolerances and polished for extended durability.

Pistons

Are manufactured from precision cast heat-treated aluminum alloy, for a lighter and stronger reciprocating mass. The pistons have passages for oil transfer, which allow for superior wear resistance and seizure protection with cylinder liners.

Piston Rings

Are manufactured from high grade cast iron and are fitted as three rings per piston:

1. Compression ring – chrome plated.
2. Compression ring and oil control ring.
3. Oil scrapper ring.

These rings are specifically designed and manufactured for exceptional oil control efficiency for long periods, resulting in minimal oil consumption.

Piston Pins

Are manufactured from high-grade alloy steel for enhanced hardness, roundness and face accuracy, as the pins are super-finished after the hardening process.

Piston Pin Plain Bearings

Are steel-backed bronze bushes.

Piston Pin Needle Roller Bearings

Are installed in the high side of a two-stage compressor. The piston pins are common to both high and low sides of a compressor.

Connecting Rods

Are manufactured from heat treated forged aluminum alloy designed with high rigidity and minimal weight, thus combined with the piston ensuring minimum vibration and ease of maintenance.

Crankshaft

Is of forged steel with induction-hardened crank pins for greater reliability than conventional cast iron.

Crank Pin Bearings

Are steel-backed white metal split sleeves manufactured to exact tolerances with a mirror-like finish.

Main Bearings

Are manufactured by centrifugal casting metal alloy to a highly rigid steel liner and are machined to exact tolerances. The front bearing is inserted into the crankcase and is held in position by bolts; the rear bearing is set into the rear (oil pump) housing, which is bolted to the crankcase. These bearings can be removed, inspected and refitted without the need to remove the crankshaft or piston assemblies.

Oil Pump

Is of the simple and rugged spur gear type with high efficiency and long life.

Oil Pressure Regulating Valve

The valve is fitted to the rear of the compressor on the rear housing and is used for obtaining the correct oil pressure.

Oil Lubrication System

Oil, filtered through a suction screen located in the lower portion of the crankcase sump is drawn up and pressurized by the oil pump and is fed into the front bearing after being cooled and filtered. From the front bearing oil is fed internally through the crankshaft to lubricate the crank pin bushings and internally through connecting rod to lubricate the piston pin bearings. An external pipe tapped from the front casing to the rear housing distributes oil to the rear bearing and then to the crank pin bushings and piston pin bearings via the internal passages of the crank shaft and connecting rods. This divided supply ensures an instantaneous supply of lubricating oil to all of the reciprocating components on start-up and hence minimal component wear.

Mechanical Shaft Seal

Spring loaded synthetic rubber bellows type for compensation of crankshaft float.

Suction Gas Strainer

A screen located in the suction inlet manifold (single stage compressor), or inlet housing (x 2 compound compressor) filters refrigerant gas.

Suction and Discharge Valve Plates

Are manufactured to high specification by heat-treating and lap finishing the stainless steel utilizing the process of vacuum refining to ensure extensive durability.

Safety Heads

Ensure, in the event of liquid refrigerant or oil carry-over that abnormal pressure is not created within the cylinders by unseating and directing the flow to discharge. The head which combines the discharge valve plate, inner valve seat and valve guide are assembled with the outer seat which is held in place by three springs under the cylinder cover.

Unloader Mechanism

Piston type, acting under pressure or bleed from the lubricating oil supply to load or unload a bank of pistons. The piston plate rotates cam rings, which lower or raise the suction valve plate to load or unload a bank of pistons.

High and Low Pressure Switches

Are to protect the compressor by interrupting electrical power to the motor in the event of abnormal high or low pressure.

Oil Protection Switch

Ensures that, should the oil differential pressure decrease below a set point then electrical power to the motor is interrupted and the compressor will stop. The differential pressure is calculated between the crankcase pressure and oil pressure, the switch having an in-built delay of approximately 45 seconds to prevent nuisance tripping.

Safety Relief Valve

Protects the compressor from excessive internal pressure and relieves to atmosphere, or alternatively to the system 'low' side. Should excessive pressure be designed to be relieved to the 'low' side, then relief piping to a point as remote as possible from the compressor is required to prevent superheating of the gas by repeated compression.

Driving Method

Land based compressors are capable of being driven either by v-belts or direct coupled using a flexible coupling. Marine (RM) type compressors are constructed with a flange that permits the motor to be mounted on the crankshaft and bolted directly to the compressor. The RM package is most suited to lower temperature systems, where space and ease of handling are critical.

RM Compressor Motor

The squirrel cage rotor is specifically designed for the marine application and mating with the Hasegawa compressor ensuring high efficiency at full and partial loads. Maintenance of the compressor mechanical seal is accomplished by removing the rotor but leaving the motor casing mounted to the compressor.

1.2 Models

The VZ compressor range is divided into two distinct categories, namely land and marine, which comprise both single stage and compound compressors.

Single Stage Compressor

Used for comparatively higher evaporating temperature, above -22°F (-30°C) and comprising the following models: VZ6, VZ8, VZL4 and VZL8.

Compound Compressor

The crankcase is internally divided into low and high stages; so as to enable two- stage compression by one compressor and is used for temperatures below -22°F (-30°C). This compressor range is comprised of the following models: VZ42, VZ62, VZL31 and VZL62.

Nomenclature

The model number, refrigerant type and application (marine) identify each compressor, in addition to the serial number. Therefore a typical compressor would be identified as follows:

1. Serial number: VZ_ _ _ _ _ _
2. Model number: VZ42RM
   Where 'R' is the refrigerant type, i.e. R22 (other letters apply to different refrigerants and comply with international standards) and 'M' is the flanged motor application.

These compressors comprise a considerable number of common and interchangeable components, which permit spare parts inventory to be kept to a minimum.

1.3 Operational Limits

VZ compressors should not be operated beyond the following limits:

Compressor RPM	Max. = 1250 rpm	Min. = 600 rpm
Compression ratio*	Max. = 15	Target Max: R717 – 10, R22 - 11
Pressure difference	Max. = 227 psi	(16.47 kg/cm″) [1.6MPa]
Suction pressure	<u>Single stage compressor</u> Max. 76 psig (C.S.T: R717 = 50°F, R22 = 45°F, R134a = 78°F) Max. 0.54 MPaG (C.S.T: R717 = 10°C, R22 = 7°C, R134a = 25°C) Min. 0 psig (C.S.T: R717 = -31°F, R22 = -40°F, R134a = -22°F) Min. 0 MPaG (C.S.T: R717 = -35°C, R22 = -40°C, R134a = -30°C) <u>Two stage compressor</u> Max. 28 psig (C.S.T: R717 = 14°F, R22 = 5°F) Max. 0.2 MPaG (C.S.T: R717 = -10°C, R22 = -15°C) Min. 11 psig (C.S.T: R717 = -76°F, R22 = -94°F) Min. -0.08MPaG (C.S.T: R717 = -60°C, R22 = -70°C) <u>RM type compressor</u> Max. Determined by motor capacity. Min. 11 psig (C.S.T: R22 = -94°F) Min. -0.08MPaG (C.S.T: R22 = -70°C) In the event of low suction pressure, suction gas superheat should be less than 27°F (15°C) so that discharge gas temperature may not be higher.	
Discharge pressure	Below: 213 psig (C.S.T: R717 = 104°F, R22 = 104°F) 1.5 MPaG (C.S.T: R717 = 40°C, R22 = 40°C) When compression ration is high, temperature of discharge gas should be less than 248°F.	
Oil Pressure	Max. = 114 psig Max. = 8kg/cm2G	Min. = 28 psi Differential Min. = 2kg/cm2 Differential
Oil Temperature	Max. = 140°F Max. = 60°C Normal operation = 131°F	Min. = 59°F Min. = 15°C Normal operation = 55°C

*Compression ratio = Absolute discharge pressure / Absolute suction pressure, for each stage.
Do not have parallel operation of single and two stage compressors on the same suction line.

1.4 Specification, Refrigeration Capacity and Required Power

Single Stage Compressor

Model		VZ6	VZ8	VZL4	VZL8
Cylinders		6	8	4	8
RPM (Max)		1200	1200	1200	1200
Bore	In.(mm)	5.20 (132)	5.20 (132)	5.20 (132)	5.20 (132)
Stroke	In. (mm)	4.17 (106)	4.17 (106)	5.20 (132)	5.20 (132)
Unloading Steps		6-4	8-6-4(2)	4	8-6-4(2)
Suction	In. (mm)	4 (100)	4 (100)	3 (80)	4 (100)
Discharge	In. (mm)	2½ (65)	3 (80)	2½ (65)	3 (80)
Net Weight	Lbs. (kg)	2641 (1200)	2861 (1300)	2072 (940)	2880 (1310)
Oil Charge	US gallons (Litres)	7.9 (30)	7.9 (30)	7.9 (30)	7.9 (30)

Compound Compressor

Model		VZ42	VZ62	VZL31	VZL62
Cylinders		4 + 2	6 + 2	3 + 1	6 + 2
RPM (Max)		1200	1200	1200	1200
Bore	In.(mm)	5.20 (132)	5.20 (132)	5.20 (132)	5.20 (132)
Stroke	In. (mm)	4.17 (106)	4.17 (106)	5.20 (132)	5.20 (132)
Unloading Steps		4-2	6-4-2(0)	3-1	6-4-2(0)
Suction	In. (mm)	3 (80)	4 (100)	3 (80)	4 (100)
Discharge Low Stage	In. (mm)	2 (50)	2½ (65)	2 (50)	2½ (65)
Suction High Stage	In. (mm)	2 (50)	2½ (65)	2 (50)	2½ (65)
Discharge	In. (mm)	1½ (40)	2 (50)	1½ (40)	2 (50)
Net Weight	Lbs. (kg)	2660 (1210)	2880 (1310)	2091 (950)	2903 (1320)
Oil Charge	US gallons (Litres)	7.9 (30)	7.9 (30)	7.9 (30)	7.9 (30)

- Capacity control in ( ) is optional, for RM – AM compressors standard for starting.
- Weight of compressor only, not including base, flywheel (coupling) or motor.

RM, AM Type Motor

Rated Output BHP(kW)	Type	Rated speed (rpm)		Pole	Voltage		Insulation
		50 Hz	60Hz		50 Hz	60 Hz	
60 (45)	Drip-proof Squirrel Cage Rotor Flanged	980	1180	6	200/400	220/440	F
75 (60)		980	1180	6	200/400	220/440	
100 (75)		980	1170	6	200/400	220/440	
125 (90)		980	1170	6	200/400	220/440	
140 (100)		980	1170	6	400	440	
145 (110)		980	1170	6	400	440	
150 (115)		980	1170	6	400	440	
160 (120)		980	1170	6	400	440	
170 (125)		980	1170	6	400	440	
175 (130)		980	1170	6	400	440	
190(140)		980	1170	6	400	440	
200 (150)		980	1170	6	400	440	
215 (160)		980	1170	6	400	440	

2. OPERATION

Introduction

To ensure compressor optimum and efficient operation a full understanding of the compressor and refrigeration system are required. A qualified technician, with the appropriate level of training to complete system adjustments therefore guarantee the design operating parameters are achieved must undertake initial system start-up.

The following fundamental guidelines are to be utilized to ensure the start-up procedure is completed trouble free and may be used for manual or automatic operation of the compressor. Prior to a compressor start-up on a new installation an appropriate vacuum test is to be carried out, after which oil charging is to be performed. These guidelines are not exhaustive and are designed for use by a technician with the appropriate training.

The following points cover basic operation and must be closely adhered to:

1. Hand turning	Prior to initial start-up and after a long period of standstill the compressor must be hand turned to ensure a positive supply of lubricating oil.
2. Oil charging	The compressor must be charge with oil to the correct quantity after the final vacuum test. Operation of the compressor without oil is prohibited. Initial charging should be made through the oil charge inlet, located in the side cover.
3. Air compression	Air compression must be avoided, with the exception of post maintenance air purging – undertaken for a few seconds. Air compression for the purpose of leak testing etc is prohibited. Operation of the compressor while structurally / mechanically incomplete is prohibited.
4. V– belt	Sheaves are to be correctly aligned and belts are to be correctly tensioned prior to start-up. Further checks are to be completed as belts stretch after initial use. Do not over-tighten belts as damage to the mechanical seal may result.
5. Dust	Prior to pressure / vacuum testing cotton cloth is to be wrapped around each gas suction strainer and secured in place with steel wire. Due to the characteristics of some refrigerants acting as solvents, scale and other debris is prevented entering the compressor preventing rapid wear or failure. This cloth must be examined and if required, replaced at the first and subsequent oil changes to ensure system cleanliness.
6. Oil return valve	The oil return valve of a compound compressor must be fully closed during operation except for a few seconds periodically to ensure oil drains from the high-side casing.

2.1 Preparation for Operation

1. Perform a thorough check of the system piping and connections for correct routing and integrity.
2. Confirm that an adequate volume of cooling water is circulating the condenser, compressor and oil cooler.
3. Confirm that the initial oil charge has been completed.
4. Turn the compressor by hand for several revolutions and confirm oil level is above half the sight glass. Replenish as required.
5. Confirm the electro-mechanical sequence of operations and correct motor rotation.
6. The following valves must be placed in the fully open position:
   - Compressor discharge stop valve (both high and low on compound compressor).
   - Compressor bypass stop valve (if fitted).
   - Compound compressor suction stop valve.
   - Two-stage system intercooler inlet and outlet valves (only if separated from liquid cooler).
   - Evaporator suction valve (if fitted).
   - Safety relief, stop valve.
   - Pressure gauge stop valves (to be partially open).
   - Condenser inlet and outlet valves.
   - Liquid receiver inlet and outlet valves.
   - Condenser / receiver pressure equalizing valve.
7. The following valves must be placed in the fully closed position:
   - Compressor suction stop valve (low side only for compound compressor).
   - Oil separator, oil return line stop valve.
   - Liquified refrigerant cooler inlet and outlet valves (to be opened when parallel operation with other compressor).
8. For RM type compressor the oil pressure gauge reading shall not exceed 70 psi. (5Kg/cm″ [0.5Mpa]).

2.2 Starting

When the items in **2.1** above have been confirmed as correct, then the compressor may be started. Close attention is required to the following:

1. Switch on the electric motor and start the compressor.
2. Open gradually the suction stop valve and monitor for oil or liquid carry-over (excessive mechanical noise – safety springs or oil foaming).
3. Confirm the oil pressure and adjust as required to obtain the correct differential pressure by adjusting the regulating valve. Should the compressor be shut down by the action of the oil pressure switch, then conduct a thorough investigation as to the nature of the fault and rectify. Repeated starting of the compressor by operation of the reset button is prohibited.
4. Set each valve to the correct position incrementally.
5. Perform the following checks and document the observations at regular intervals:
   - Current and voltage
   - Suction pressure
   - Intermediate pressure (as required)
   - Discharge pressure
   - Oil pressure
   - Oil level (replenish as required)
6. Set control valves to obtain the correct operational condition.
7. Monitor the compressor for abnormal noise or vibration.
8. Open oil separator oil drain valve.

For RM type compressors, when the items in **2.1** above have been confirmed as correct then the compressor may be started. Close attention is required to the following which is a method using a star-delta motor as the preferred type:

1. Compressor shall be fully unloaded prior to start.
2. Switch on the electric motor and start the compressor on 'STAR'.
3. Remain in this mode until the ampere draw falls to half the rated value. This will take approximately 30 seconds when the suction pressure is 70 psig (5Kg/cm″ [0.5Mpa]) and a further 8 seconds to achieve 0 psig. (0Kg/cm″ [0Mpa]).
4. At this point switch from 'STAR' to 'DELTA' and simultaneously open fully the discharge by-pass valve.
5. Gradually open the suction valve and monitor the compressor for abnormal mechanical noises and oil foaming.
6. Gradually load the compressor and monitor the current draw to ensure the motor is not over-loaded.
7. Confirm the oil pressure and adjust as required to obtain the correct differential pressure by adjusting the regulating valve. Should the compressor be shut down by the action of the oil pressure switch, then conduct a thorough investigation as to the nature of the fault and rectify. Repeated starting of the compressor by operation of the reset button is prohibited.
8. Adjust as required the expansion valves to the oil cooler and gas cooler.
9. Open inlet and outlet valves and adjust the expansion valve of the liquid cooler.
10. Perform the following checks and document the observations at regular intervals:
    - Current and voltage
    - Suction pressure
    - Intermediate pressure (as required)
    - Discharge pressure
    - Oil pressure
    - Oil level (replenish as required)
11. Set control valves to obtain the correct operational condition.
12. Monitor the compressor for abnormal noise or vibration.
13. Open oil separator oil drain valve.

2.3 Operational and Inspection Criteria

During operation of the compressor data must be collected either manually or electronically and checked against previous data for abnormalities to establish a preventative maintenance program. The following items should form the basis for data recording:

1. Operation hours.
   Record the duration of operation for each compressor.
2. Suction, discharge and if applicable intermediate pressures.
   Close attention must be paid to the suction and discharge pressures, which are the basis of performance for the compressor and refrigeration system, by which abnormalities can be observed.
3. Oil pressure.
   The following values are the standard operating ranges for oil pressure.

Oil protection switch	Minimum pressure 22 psi (1.5kg/cm″)
Compressor	Oil pressure = Suction pressure + Differential pressure

Differential pressure to be set by the oil pressure regulating valve in the following range: 28 to 35 psi (2 to 2.5 kg/cm″).

4. Oil temperature.
   Maximum oil temperature, +131°F (+55°C).
5. Suction and discharge temperature.

18° to 36°F (10° to 20°C) of superheat is recommended for suction temperature.
Discharge temperature should not be abnormally high.

6. Oil quantity.
   Maximum level – 1/2 sight glass.
   Minimum level – 1/4 sight glass, replenish to normal level.
   Extreme care must be taken to prevent oil over-replenishment, as excessive consumption will result.
   Accurate recording of oil changes and replenishments is required to ascertain the quantity of oil consumption.
   Excessive oil consumption may be a function of liquid carry-over or wear on the piston rings or valve plates.
7. Voltage and current draw.
   Monitor at each loading stage and unload the compressor if either become excessive.
8. Jacket cooling water, plant room and wet bulb temperature.
   Monitor jacket cooling inlet and outlet water temperatures and confirm flow / temperature differential to ensure correct level of heat removal.
9. The occurrence of abnormal sounds and vibration.
   In the event that either of the above occur then stop the compressor, investigate the cause and rectify.
10. Refrigerant gas and oil leaks.
    Stop the compressor, investigate the cause and rectify.

2.4 Compressor Shutdown

1. Evaporators should be kept in a vacuum but not excessively deep, therefore continue operation for a short period after closing isolate valves.
2. Close the compressor suction stop valve.
3. Isolate the supply to the compressor motor.
4. When the compressor ceases to rotate, close the discharge stop valve.
5. Isolate the jacket cooling water supply.

2.5 Extended Period of Shutdown

In the event that the refrigerant system is to be left idle for an extensive period, then the following actions are to be undertaken:

1. Refrigerant should be transferred to the liquid receiver.
   - Close the receiver outlet valve.
   - Circulate cooling water through the condenser and compressor.
   - Operate the compressor and monitor refrigerant level in the receiver, should the level rise excessively then decant refrigerant into the appropriate storage / transportation cylinders.
   - When a 7 psi (0.5 Kg/cm″ [0.5Mpa]) suction pressure is achieved, then stop the compressor and close the suction and discharge stop valves.
   - The system should be kept at a positive pressure to prevent air entering the system.
2. Perform a system refrigerant leak check.
3. Stop the circulation of cooling water and drain the cooling system, this is particularly relevant in cold climates.

2.6 Operation of the Compressor Prior and Post Maintenance

Prior to maintenance tasks being performed the compressor must be purged of refrigerant gas which shall be completed using the following procedure:

1. Open the discharge stop valve (both low and high sides of a compound compressor).
2. Close the suction stop valve (both low and high sides of a compound compressor).
3. Operate the compressor for 10 to 20 seconds.
4. Immediately after stopping the compressor close the discharge stop valve (both low and high sides of a compound compressor).
5. Gradually open the purge valve (both low and high sides of a compound compressor). Standard safety precautions should be used for the venting procedure, in the event that the refrigerant is R717 then the vent line should be placed in a drum of water. Ensure that no water is allowed to flow into the compressor.
6. Final venting shall be completed, by removing the vent plug fitted to the crankcase.

Maintenance tasks may now be undertaken after final confirmation that no gas pressure exists in the compressor and that the appropriate electrical safety precautions have been performed.

Compressor air purging and setting post maintenance tasks shall be completed as follows:

1. Close fully both suction and discharge stop valves (low and high side).
2. Close fully drain and oil charging valves; ensure all plugs are fitted.
3. Ensure the air purge valve is open (both low and high side of a compound compressor).
4. Operate the compressor for 10 to 20 seconds to purge air.
5. Immediately after stopping the compressor close fully the purge valve (both low and high sides of a compound compressor).
6. When the indicated oil pressure is below 2”Hg (60mmHg [-0.08Mpa]) vacuum after approximately 3 minutes, air purging is complete.

Should the indicated oil pressure rise rapidly, then the following should be checked to determine the cause:

1. All plugs are fitted.
2. Drain and oil charging valves are fully closed.
3. After completing the appropriate gas and electrical safety precautions, remove and examine the suction and discharge valves for correct installation / abnormal wear. Replace and / or refit as appropriate.

When the compressor is operated for the purpose of gas or air purging, running time must be kept to a minimum, as oil pressure cannot be maintained. Repeated starting and stopping of the compressor is to be absolutely avoided, as inadequate lubrication will result.

2.7 Action to Prevent Liquid Carry-over

Either by excessive opening of expansion valves or sudden changes in refrigeration load, incomplete evaporation of the refrigerant occurs and liquid is sucked into the compressor. This may well lead to compressor seizure due to inadequate lubrication or possible failure of internal components and therefore the situation must be rectified as a matter of urgency. Circulation of the jacket water cooling supply should continue to prevent damage to the crankcase by freezing water, however if the temperature of the discharge gas is abnormally low then the water supply should be isolated and the jacket immediately drained of water.

The following are indications of liquid carry-over:

1. Suction line thermometer indicates near to the saturated temperature corresponding to the suction pressure.
2. Frost may have formed on the suction part or side lower part of the crankcase.

3. Metallic sound may be heard, caused by the action of the safety head (liquid hammer sounds).
4. Oil foaming, as observed through the sight glass due to the mixing of oil and refrigerant.
5. A decrease in oil pressure due to the mixing of oil and refrigerant.

- Action in the event of light liquid carry-over

From the above indications, should the frosting be light, metallic sounds are intermittent and the oil pressure can be maintained then the liquid carry-over is comparatively less serious and the following actions should ensue:

1. Throttle the suction stop valve to cause the liquid refrigerant to evaporate, which is indicated by the decreasing level of frost on the crankcase.
2. Close the expansion valve. Continue compressor operation while maintaining oil pressure and gradually open the suction stop valve. When the valve is fully opened and the suction line thermometer indicates approximately 18°F (10°C) superheat, gradually open the expansion valve and return to normal operation.

- Action in the event of heavy liquid carry-over

Should the crankcase be heavily frosted, continuous liquid hammer sounds or the oil pressure cannot be maintained then the following actions should be undertaken as continuing compressor operation will result in mechanical failure:

1. Stop the compressor.
2. Close the compressor suction stop valve and expansion valve.
3. Close the compressor discharge stop valve.
4. Gradually open the oil drain valve and drain the lubricating oil.
5. Investigate the reason for the liquid carry-over and rectify as required.
6. Replenish the lubricating oil and purge air from the compressor.
7. Open the compressor discharge stop valve and start the compressor.
8. Gradually open the compressor suction stop valve (high side of compound compressor, followed by the low side). Continue operation, ensuring that the oil pressure remains satisfactory, no foaming occurs and frost does not form on the crankcase.
9. When the compressor suction valve is fully opened and the suction line thermometer indicates approximately 18°F (10°C) superheat, then proceed to gradually open the expansion valve and return to normal operation.

A methodical, patient approach will be required to rectify a heavy liquid carry-over, an operation that may require several hours before normal operation can be restored.

- Action in the event of liquid carry-over in the high side of a compound compressor

Liquid carry-over to the high side of a compound compressor is a rare occurrence but can originate from an incorrectly set expansion valve of the intermediate cooler. The following actions are required to remove liquid refrigerant from the high side chamber:

1. Fully close all expansion valves.
2. Regulate the high side suction stop valve and ensure the intermediate pressure does not exceed 100 psi. (7Kg/cm″ [0.7Mpa]).
3. Simultaneously regulate the low side suction stop valve and open the unloader solenoids to maintain full oil pressure.
4. Continue regulating the high side suction stop valve until the indications of liquid carry-over have returned to normal.
5. In the event that liquid carry-over has not occurred when the high side suction stop valve is fully open and the thermometer indicates 18°F (10°C) superheat, then stop compressor operation, perform further investigation and rectify. Return to normal operation and gradually open the expansion valves.

On Freon systems not equipped with a high side suction stop valve continue normal operation with caution, as refrigerant will exist in the intermediate cooler.

2.8 Fault Diagnosis and Rectification

FAULT INDICATION		REASON	RECTIFICATION
I. Starting	A. No reaction of the motor, when start is selected.	1. OPS and HPS are not reset. 2. Power or control fuse ruptured. 3. Incorrect contact of magnetic switch. 4. Over-current relay has operated. 5. Connections incorrect, wire severed.	1. Investigate and reset as required. 2. Investigate and replace. 3. Inspect and repair. 4. Investigate and reset. 5. Inspect and repair.
	B. Current flows when switch is operated but disconnects when released.	1. Failed auxiliary contact. 2. Incorrect connection (on auto control).	1. Investigate and replace. 2. Investigate and repair.
	C. Motor groans but does not turn.	1. Belts too tight. 2. Malfunction in the electrical system. 3. Voltage drop. 4. Crankcase pressure high. 5. Compressor internal failure.	1. Adjust as required. 2. Investigate and repair. 3. Confirm power supplies. 4. Lower pressure. 5. Investigate and repair.
	D. Motor stops after 45 seconds.	1. OPS operates 2. No increase in oil pressure. 3. Water flow switch – no contact.	1. Investigate electrical and oil system. 2. Refer to IV. 3. Investigate electrical and water system.
	E. Motor stops after short period.	1. LPS / HPS operate. 2. Discharge stop valve is closed. 3. Refrigerant pressure too high. 4. Refrigerant pressure too low.	1. Investigate and repair. 2. Open. 3. Refer II. 4. Refer II.

FAULT INDICATION		REASON	RECTIFICATION
II. Abnormal pressure	A. Suction pressure does not decrease and discharge pressure does not increase.	1. Expansion valve opened excessively. 2. Safety relief valve leaks (when piped to suction). 3. Unloader system inoperative. 4. Oil return valve open (compound compressor). 5. Suction or discharge valve plate defective. 6. Piston ring or cylinder liner defective.	1. Investigate and reset as required. 2. Replace. 3. Inspect and repair. 4. Investigate and close. 5. Inspect and repair. 6. Inspect and repair.
	B. Discharge pressure too high.	1. Inadequate supply of water or air to the condenser. 2. Condenser tubes are fouled. 3. Air in the condenser. 4. Refrigerant over-charge.	1. Investigate and supply as required. 2. Investigate and clean. 3. Investigate and purge. 4. Decant refrigerant as required.
	C. Suction pressure too low.	1. Expansion valve insufficiently open. 2. Liquid line filter / drier blocked. 3. Liquid solenoid valve inoperative. 4. E.P.R. out of adjustment. 5. Refrigerant low charge. 6. Inadequate supply of water or air to the cooler. 7. Excessive frost / ice on the cooling coil. 8. Oil accumulation in the cooling coil.	1. Investigate and reset as required. 2. Investigate and clean. 3. Confirm power supplies / repair. 4. Repair / reset as required. 5. Investigate and replenish. 6. Examine fans / pumps and repair. 7. Defrost and monitor. 8. Investigate and drain as required.

FAULT INDICATION			REASON	RECTIFICATION
III.	Abnormal temp.	A. Discharge temperature too high.	1. Inadequate water supply. 2. Discharge pressure too high. 3. Suction gas temperature too high. 4. Water jacket fouled.	1. Increase water supply and examine tubes. 2. Refer IIB. 3. Adjust expansion valve superheat setting. 4. Inspect and clean.
		B. Crankcase temperature too high.	1. Gas leakage from lapping part of discharge assembly and cylinder liner. 2. Discharge valve plate is defective. 3. Piston rings or cylinder liner defective.	1. Investigate and clean as required. 2. Investigate and replace. 3. Investigate and replace.
		C. Oil temperature too high – exceeding 140°F (60°C)	1. Oil pressure too high. 2. Defective bearing. 3. Inadequate supply of water (water-cooled oil cooler). 4. Oil cooler fouled (water type). 5. Inadequate supply of refrigerant (refrigerant cooled oil cooler). 6. Oil accumulation in refrigerant side of cooler.	1. Adjust (Refer 2-3). 2. Investigate and replace. 3. Increase water supply. 4. Investigate and clean. 5. Clean filter and adjust expansion valve. 6. Warm oil cooler and drain oil.
IV.	Low oil pressure	A. Oil pressure too low.	1. Oil foaming in the crankcase due to refrigerant carry-over. 2. Crankcase heater is not energized. 3. Oil pressure gauge defective. 4. Oil temperature too high. 5. Suction pressure too low. 6. Oil strainer is clogged. 7. Suction strainer is clogged. 8. Bearing wear. 9. Oil pump wear. 10. Oil pump relief valve stuck open.	1. Investigate the refrigerant carry-over and change oil. 2. Confirm power supplies. 3. Replace. 4. Refer to IIIC. 5. Refer to IIC. 6. Investigate and clean. 7. Investigate and clean. 8. Replace. 9. Replace. 10. Examine and clean.
		B. Oil pressure gauge reading fluctuates (10 – 20 psi) [0.1 – 0.2 MPa]	1. Oil strainer is clogged.	1. Investigate and clean as required.

FAULT INDICATION		REASON	RECTIFICATION
V. Oil usage.	A. Excessive oil consumption.	1. Oil in the crankcase is foaming.	1. Raise oil temperature or pressure in the crankcase.
		2. Poor oil return from oil separator or gas counter flow.	2. Investigate and repair.
		3. Piston ring or cylinder liner worn.	3. Replace.
		4. Discharge valve plate defective (sudden rise in consumption).	4. Investigate and replace.
		5. Oil return valve open (compound compressor).	5. Close.
		6. Cylinder liner O-ring is defective.	6. Replace.
VI. Abnormal noise	A. Safety head rising.	1. Metallic noise (oil hammer). Excessive oil on the piston.	1. Refer to V.
		2. Safety head spring defective.	2. Replace (refer to 3-5).
		3. Broken valve plate, foreign matter on piston.	3. Investigate and replace.
	B. Liquid hammer, no superheat, frost formation on the crankcase, oil foaming and pressure down.	1. Liquid carry-over.	1. Refer to 2-7.
		2. Expansion valve is over-opened.	2. Adjust as required.
		3. Rapid change in evaporator load.	3. Adjust controls as required.
		4. Refrigerant is over-charged.	4. Decant to the correct level.
		5. Liquid separator fails to function.	5. Investigate and repair.
		6. Liquid supply controls defective.	6. Investigate and repair.
	C. Crankcase	1. Bearing, piston ring or oil pump defective.	1. Investigate and replace.
	D. Transmission	1. Belts slip	1. Adjust as required.
		2. Incorrect coupling or loose coupling.	2. Investigate and adjust (refer to 3-23).

2.9 Pressure vs. Condensing Temperature and Evaporating Temperature

Refrigerant pressures always correspond to condensing and evaporating temperatures; this relationship must be comprehended in order to operate correctly refrigerating equipment.
High pressure relative to saturated pressure corresponding to the condensing temperature leads to decreasing compressor capacity and ultimately mechanical failure.
A normal condition of operation will exist when the suction gas temperature of the compressor is 18° to 36°F (10° to 20°C) [superheat] higher than the temperature corresponding to suction pressure (evaporating temperature). Liquid carry over is more likely to occur when the temperature difference [superheat] between suction gas temperature and the temperature corresponding to suction pressure (evaporating temperature) decreases.
Should the temperature difference increase a reduction in compressor capacity will be observed with possible mechanical failure of the compressor due to the rising discharge temperature.
Close attention should be maintained during the operation of refrigeration equipment to the pressure and temperature ratios.

Condensing & Evaporating Temperature		Saturated Pressure							
		R 717				R 22			
		Gauge Pressure	Absolute Pressure	Gauge Pressure	Absolute Pressure	Gauge Pressure	Absolute Pressure	Gauge Pressure	Absolute Pressure
		MPa	MPa	PSIG	PSI	MPa	MPa	PSIG	PSI
- 70° C	- 94° F	67.8cmHg	0.01			60.7cmHg	0.02	24.07"Hg	2.87
- 60° C	- 76° F	59.6cmHg	0.02			47.9cmHg	0.04	18.85"Hg	5.44
- 50° C	- 58° F	45.4cmHg	0.04	17.8"Hg	5.93	27.6cmHg	0.06	10.90"Hg	9.34
- 40° C	- 40° F	22.2cmHg	0.07	8.7"Hg	10.41	0.04MPa	0.10	0.53	15.22
- 35° C	- 31° F	6.20cmHg	0.09	2.4"Hg	13.52	0.03	0.13	4.36	19.10
- 30° C	- 22° F	0.02MPa	0.12	2.6	17.34	0.06	0.16	9.01	23.71
- 25° C	- 11° F	0.05	0.15	8.5	23.15	0.10	0.20	15.81	30.50
- 20° C	- 4° F	0.09	0.19	12.9	27.59	0.14	0.25	20.81	35.50
- 15° C	5° F	0.13	0.24	19.6	34.27	0.19	0.30	28.11	42.81
- 10° C	14° F	0.19	0.29	27.5	42.18	0.25	0.36	36.69	51.38
- 5° C	23° F	0.25	0.36	36.8	51.47	0.32	0.42	46.37	61.13
0° C	32° F	0.33	0.43	47.6	62.29	0.40	0.50	57.47	72.17
5° C	41° F	0.41	0.52	60.1	74.80	0.48	0.58	70.00	84.65
10° C	50° F	0.51	0.61	74.5	89.19	0.58	0.68	84.03	98.73
15° C	59° F	0.63	0.73	90.9	105.6	0.68	0.79	99.30	114.52
20° C	68° F	0.76	0.86	109.6	124.3	0.80	0.91	117.28	131.97
25° C	77° F	0.90	1.00	130.7	145.4	0.94	1.04	136.65	151.45
30° C	86° F	1.07	1.17	154.5	169.2	1.09	1.19	158.17	172.87
35° C	95° F	1.25	1.35	181.1	195.8	1.25	1.36	182.00	196.40
40° C	104° F	1.45	1.55	210.7	225.4	1.43	1.53	207.72	222.42
45° C	113° F	1.68	1.78	243.7	258.4	1.63	1.73	236.05	250.7

1Kg/cm″ = 0.09807MPa = 98.07kPa

3. MAINTENANCE

The following maintenance procedures explain the construction, disassembly, inspection, reassembly and adjustment, which should be fully comprehended prior to performing maintenance tasks.

3.1 Preparation

To confirm the existence of defects and to effectively perform compressor maintenance the following daily observations should be performed:

1. Suction and discharge pressure.
2. Suction and discharge temperature.
3. Lubricating oil pressure and temperature.
4. Oil consumption and condition.
5. Mechanical noise and vibration.

3.2 Precautions

Prior to maintenance activity ensure that:

1. Mechanical and electrical safety precautions are completed in accordance with current regulations.
2. The air purge valve, (both low and high side) is fully opened and pressure is released and confirmed at atmospheric pressure.
3. The external casing of the compressor is cleaned of dust, oil and moisture to prevent ingress of foreign matter into an ‘open’ compressor.
4. Maintenance equipment must be clean.
5. Disassembled parts should be placed in a logical order and in a clean environment.
6. Fresh kerosene should be used for cleaning parts prior to examination.
7. For extended periods of disassembly, a water-repellent coating should be applied to parts.
8. Reassembly should be completed only after removing any applied protective coatings and applying fresh refrigerant oil to all parts.

3.3 Maintenance Schedule

The following table shows a general standard for periodic preventative maintenance, however due consideration must be given to the operating condition and environment of the compressor.

Inspection Item	Inspection Points	Inspection period
Running condition	Refer to (2.3) and (3.1).	Daily / Monthly / Annually
Lubrication oil	Sample and replace as required.	Monthly / Annually
Oil screen, oil filter and gas suction screen	Examine, if metallic particles are visible inspect bearings / pistons etc. Clean crankcase internally and change oil.	Monthly / Annually
Coupling	Examine rubber element and replace as required. Ensure attachment bolts secure.	Monthly / Annually
Belt	Examine belts and replace as required.	Monthly / Annually
Oil protection switch	Check set-value and test.	Monthly / Annually
High / Low switch	Check set-valve and test.	Monthly / Annually
Thermometer and Pressure gauges	Check for indication error against calibrated equipment.	Monthly / Annually
Safety relief valve	Check working pressure.	Annually
Maintenance		
Discharge & suction valves	Inspect for wear and defects. Check height of safety headspring. Change valve springs. Inspect for defects and carbon deposits.	 Annually / 5,000 run hours Annually / 5,000 run hours Annually / 5,000 run hours
Piston, piston ring, piston pin & piston pin bearing	Inspect for defects. Inspect for wear and pitting. Inspect for wear and pitting.	Annually / 5,000 run hours 20,000 hours R717 or 10,000 hours R22
Cylinder liner	Clean	Annually / 5,000 run hours
Crank pin bearing	Inspect for wear and pitting.	Annually / 5,000 run hours
Oil cooler	Clean	Annually / 5,000 run hours
Crankshaft bearing journal	Inspect for wear and oval. Inspect for wear leakage.	15,000 run hours 15,000 run hours
Front bearing	Inspect for wear and oval.	15,000 run hours
Mechanical seal	Inspect for wear pitting.	15,000 run hours
Rear bearing	Replace	15,000 run hours
Oil pump	Inspect for wear	15,000 run hours
Motor bearing	Change	15,000 run hours

3.4 Maintenance Procedures (M.P.)

CONTENTS

M.P. 1 Cylinder Cover

Associated Instructions Refer: 2.2, 2.3, 2.5,2.6, 2.7 & 3.2
Required Tools Hasegawa & General purpose

A. Removal Refer: 2.5, 2.6, 2.7 & 3.2

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves, including intermediate valves (if applicable).
c) Vent refrigerant gas and confirm pressure is indicated at 0 psi.
d) Isolate cooling water supply and drain cooling water.
e) Remove water pipes and clean compressor casing to prevent foreign material ingress.
f) Remove unloader oil pipes (as required).
g) Loosen bolts quantity 14, size (M16).
h) Remove two opposite bolts and fit guide bolts.
i) Remove remaining 12 bolts in diagonal format. The cover will lift by the force of the safety headspring.
j) Remove cylinder cover and strip gasket; ensure foreign material does not enter the cylinder.

Torque Loading:	178 – 193 lb. ft (25 – 27 kg-m)[245 – 265Nm]

Table 1

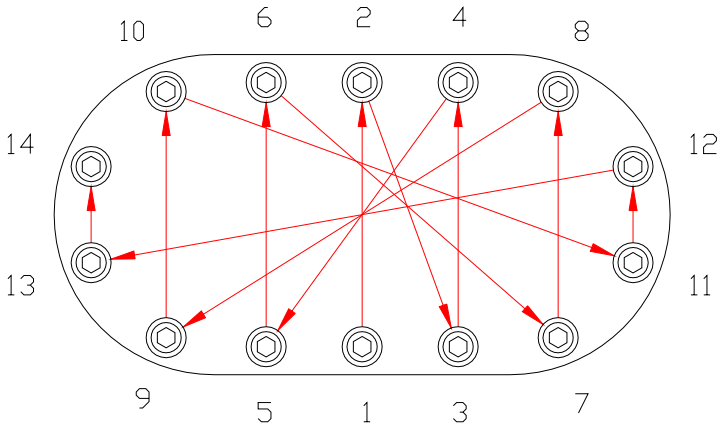


Fig. 1

Inspection

a) Examine cylinder cover for indications of impact damage and cracks.

C. Refitting Refer: 2.7, 2.2 & 2.3

a) Apply refrigerant oil to both sides of a new gasket and place on casing with guide bolts to correctly locate the gasket.
b) Fit 12 bolts and engage threads, remove guide bolts and fit the 2 remaining bolts.
c) Fasten bolts in a diagonal format, in accordance with (Fig. 1).
d) Torque-load the bolts to the setting above in accordance with Table1.
e) Refit the external unloader oil pipes as required.
f) Refit the water pipes and re-establish the jacket cooling water supply.
g) Restart the compressor using the correct procedure.
h) Perform the appropriate leak checks.

M.P. 2 Suction and Discharge Valves

Associated Instructions — Refer: M.P. 1
Required Tools — Hasegawa & General purpose

A. Description

The suction valve assembly is comprised of the following components, outer seat (1), which is recessed to locate six springs (2) that sit on the valve plate (3). This valve assembly is held in place by the cylinder cover. The discharge assembly comprises three safety springs (4), valve guide (5), eight springs (6), plate (7) and inner seat (8). Components 5, 6, 7 and 8 are bolted together, the unit is held in place by the action of the safety springs on the cylinder cover.

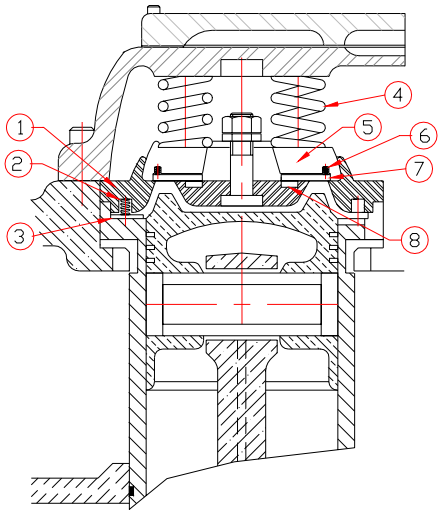


Fig. 2

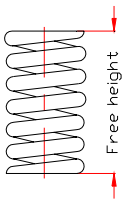


Fig. 3

Removal

a) Remove the cylinder cover in accordance with M.P. 1.
b) Remove the discharge valve assembly and safety-head springs from the outer seat.
c) Remove the outer valve seat including springs and suction plate from the compressor casing.

B. Inspection

Place components on a clean work surface and clean with new kerosene.

a) Remove the safety springs from the discharge valve assembly. Examine springs for deformation and cracking. Test springs for height in accordance with Table-2 (Fig 3). Replace as required.

Safety Head Spring	Tolerance
Free height standard (L)	2.2" (56mm)
Limit for use(L)	2.1” (53.5mm)

Table 2

b) Remove suction valve springs from the outer seat. Examine springs for deformation and cracking. Test in accordance with Table-3 (Fig 4). Replace as required.
c) Disassemble the discharge valve assembly by removing the lock nut and loosening the nut to allow spring removal, ensuring the locating pin is not dislodged. Examine springs for deformation and cracking. Test the springs in accordance with Table-3 (Fig 4). Replace as required.
d) Examine inner and outer seats for damage. Replace as required.
e) Examine suction and discharge plates for scoring (maximum allowable 0.2mm) and cracking. Replace as required.

Suction and Discharge Valve Spring	Suction Tolerance	Discharge Tolerance
Free height standard (L)	0.55” (14mm)	0.53” (13.5mm)
Limit for use (L)	0.51” (13mm)	0.49” (12.5mm)
Coil outer diameter (A)	0.37” (9.4mm)	0.35” (8.9mm)
Seat outer diameter (B)	0.48” (12.2mm)	0.39” (10mm)
Spring line diameter (d)	0.035” (0.9mm)	0.035” (0.9mm)
Quantity fitted	6	8

Table 3

f) Refit springs into the recesses of the outer seat and inner seat, by winding the larger coil (Fig 4 [B]) into the recess.
g) Torque load the male and female nuts of the discharge valve assembly in accordance with Table 4 below, ensuring the male nut is fitted before the female and the locator pin remains in the seat.
h) Refit safety springs to the valve guide by locking the coil with the flat washer.

Torque Lbs.ft (Kg-m)[Nm]	Male	Female
	78 – 85 (11 – 12)[110 –120]	57 – 64 (8 – 9)[80 – 90]

Table 4

C. Refitting
This operation must be undertaken using clean refrigeration oil and lint free cloths, ensuring no foreign particles are allowed to enter the compressor.
a) Place the suction plate on to the top of the cylinder liner.
b) Ensure 6 springs are fitted to the outer seat; place the outer seat inside the casing on top of the suction plate. The seat will remain proud of the casing by spring tension but can be pushed flush with the casing to ensure correct positioning.
c) Fit the discharge assembly to the outer seat and rotate to ensure a correct fit.
d) Refit the cylinder cover in accordance with M.P. 1.

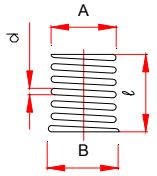


Fig. 4

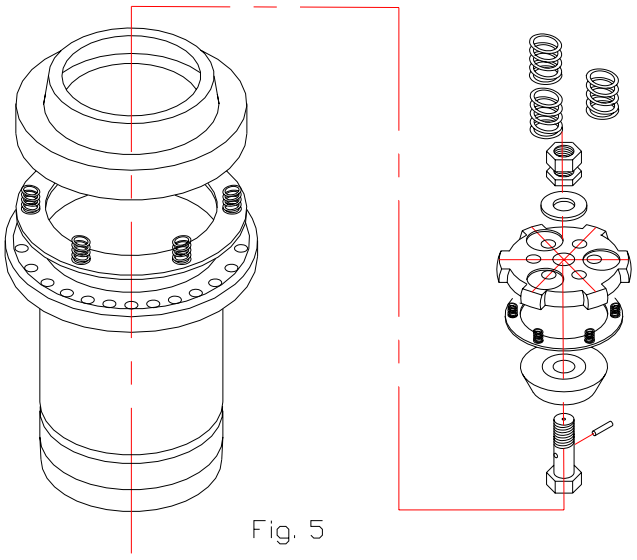


Fig. 5

D. Servicing Notes
a) As shown in (Fig. 2) both the suction valve assembly and discharge valve assembly are held in place by the cylinder cover, therefore under no circumstances can the compressor be operated without these components or the cylinder cover being correctly fitted.

b) On all models identifying stamp marks (A, B, C etc.) are applied to each cylinder and its associated components, therefore components being refitted should be done so at the correct location.

c) Compressor conversion from Ammonia to Freon or vice versa should only be attempted after consultation with Hasegawa as some components are unique to each application, for example the outer seat shown in (Fig. 6).

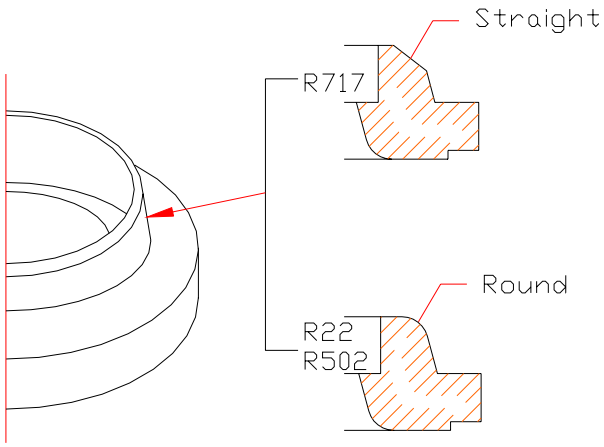


Fig. 6

M.P. 3 Piston and Connecting Rod Assembly

Associated Instructions Refer M.P. 1 & 2
Required Tools Hasegawa & General Purpose

A. Description

The piston and connecting rod assembly can be disassembled for inspection purposes and are identified as piston (1), piston rings quantity three (2), piston pin (3), plain bearing or needle bearing (4), connecting rod (5), crankshaft plain bearing (6) and rod bolts (7). The needle bearing (4) is fitted to the high side of a compound compressor only.

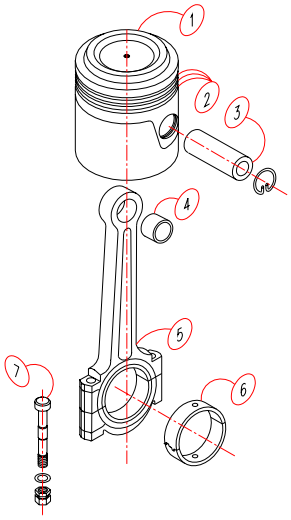


Fig. 7

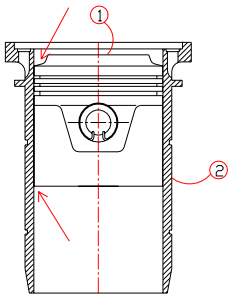


Fig. 8

Removal

a) Remove the cylinder cover in accordance with M.P. 1.
b) Remove the suction and discharge valve assemblies in accordance with M.P. 2.
c) Drain lubricating oil from the lower casing.
d) Remove side-cover quantity two and discard the gaskets.
e) Identify the correct piston assembly end cap, rotate the crankshaft to the most suitable position and remove quantity two female lock nuts and two male nuts securing the end cap. Remove the end cap with the lower half of the plain bearing.
f) Screw the eyebolt ancillary tool into the locating hole in the crown of the piston and rotate the crankshaft so that the appropriate piston is at the lowest position.
g) Gradually ease the piston up and out of the liner and keep the connecting rod central within the liner, ensuring that the connecting rod bolts do not become jammed under the bottom of the liner.

Note: For RM type compressor remove the plug at the center of the motor, attach the hexagonal bolt ancillary tool and turn the shaft by a motor T wrench ancillary tool to the lowest position.

B. Inspection

Piston and Piston Ring

a) Place piston and connecting rod assembly on a clean work surface and clean with new kerosene.
b) Remove lower half of the plain bearing from the end cap and the upper half from the connecting rod. Remove connecting bolts.
c) Remove the piston rings quantity three from the piston.
d) Examine the piston, connecting rod and associated cylinder liner for defects.
e) Using the eyebolt refit the piston into the liner and measure the clearance between the piston (1) and liner (2) at the first and second land (Fig. 8). This measurement must be observed at the thrust

direction of the piston (at right angle to the piston pin) and the tolerances within the limits as specified in Table 5.

Piston	First Land in.(mm)	Second Land in.(mm)
Standard	0.0087 – 0.0110 (0.22 – 0.28)	0.0067 – 0.0091 (0.17 – 0.23)
Maximum Tolerance	0.0236 (0.60)	0.0236 (0.60)

Table 5

f) Remove the piston and connecting rod from the cylinder liner and examine each piston ring.
g) Three rings are fitted to each piston (Fig. 9):
- 1st ring – compression ring, chrome plated square section
- 2nd ring – compression and oil control ring under cut
- 3rd ring – oil scrapper ring, chrome plated.

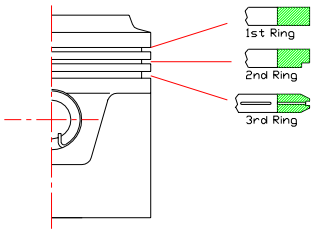


Fig. 9

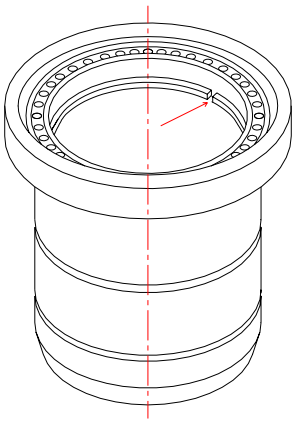


Fig. 10

h) Each ring should be fitted to the associated liner (Fig. 10) and the joint clearance checked in accordance with Table 6. Replace rings with excessive clearance.

Piston Ring	Clearance in.(mm)
Standard	0.0118 – 0.0197 (0.30 – 0.50)
Maximum Tolerance	0.063 (1.60)

Table 6

Piston Pin and Piston Pin Bearing

i) The piston and pin assembly, do not require to be disassembled unless movement or irregular motion is observed during examination.
j) The piston and pin are ‘close tolerance’ fitted and require heating in oil at 160° to 180°F to facilitate separation. After heating, separation can be achieved by the application of pressure to the pin.
k) A plain bearing is fitted to the small end of the connecting rod on single stage compressors and the low side of compound compressors. A needle roller bearing is fitted to the small end of the high side of compound compressors and although interchangeable, a plain bearing cannot be used on the high side, as rapid deterioration of the bearing will occur.
l) The plain bearing is a ‘pressed fit’ and the tolerances are in Table 7.

Piston Pin Bearing	Tolerances in.(mm)
Standard	0.001 – 0.002 (0.025 – 0.050)
Maximum Tolerance	0.0079 (0.20)

Table 7

m) The needle roller bearing is a 'close tolerance' fit and to facilitate replacement remove the lock ring and heat components in oil is required.
n) Ensure that the oil passage is horizontal when replacing the needle roller bearing.

Crank Pin Bearing and Connecting Rod

o) The crank pin bearing is manufactured by applying white metal to a steel backing and is in two parts, upper and lower.
p) It is not permitted to perform any manner of adjustment to the bearing or connecting rod big end as strict tolerances are adhered to during manufacture. Installation tolerances (Fig. 11) are in Table 8.

Crank Pin Bearing	Tolerances in.(mm)
Standard	0.0012 – 0.0039 (0.03 – 0.10)
Maximum Tolerance	0.012(0.30)

Table 8

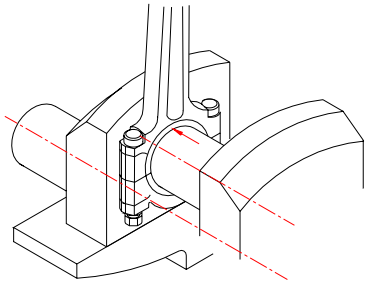


Fig. 11

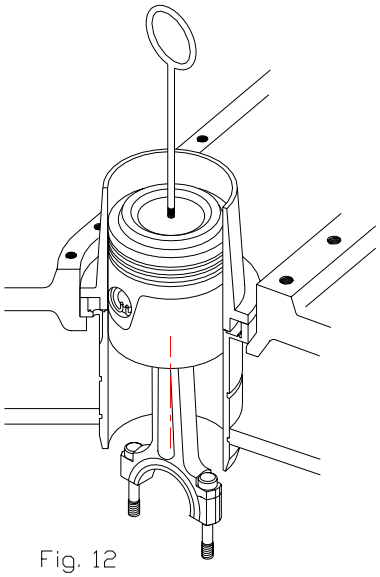


Fig. 12

q) The connecting rod big end and the bearing are stamped during manufacture to ensure correct assembly.
r) Reassembly of the piston and connecting rod assembly is the reverse of the removal procedure.
s) Utilize the oil bath or hydraulic press to facilitate the fitting of the piston pin bearing (plain or needle), piston pin and piston.
t) Piston rings should be fitted so that the manufacturers mark is up and arranged so that the three joints are 120° apart, avoiding the piston thrust direction.
u) Fit the rings in reverse order commencing with the 3rd ring and ensuring that each ring is fitted in the correct manner (Fig. 9).

C. Refitting

a) Place the piston ring guide tool on the cylinder liner (Fig. 12), ensure that the upper half bearing, connecting rod bolts and eye bolt are fitted to the piston assembly and lower the piston assembly into the cylinder liner using liberal quantities of lubricating oil.
b) Pay attention to the cylinders, which have pistons fitted without covers, as the cylinder liners are likely to rise with the piston during crankshaft rotation.
c) Place the crank at the lowest position and guide the connecting bolts over the crankshaft ensuring that the bolts do not score the crank journal.
d) Fit the bearing lower half to the end cap and install the end cap. Place flat washer and male nut on each bolt, torque load in accordance with Table 8 using a long reach socket.
e) Fit the female nut to each bolt, torque load in accordance with Table 9 using a standard socket, as extreme care must be taken not to further tighten the male nut.

Rod Bolt Nut	Male Nut	Female Nut
Torque Lbs.ft (Kg-m)[Nm]	43 – 50 (6 – 7)[60 – 70]	25 – 32 (3.5 – 4.5)[35 – 45]

Table 9

f) Ensure internal casing is clean and using new gaskets refit the side covers.
g) Refit the suction and discharge valve assemblies in accordance with M.P. 2.
h) Refit the cylinder covers in accordance with M.P. 1.
i) Replenish the lubricating oil system.

M.P. 4 Cylinder Liner

Associated Instructions Refer M.P. 1, 2 & 3
Required Tools Hasegawa & General Purpose

A. Description

Two types of cylinder liners are fitted to compressors, type A and type B. Type A liners are fitted with a locating peg in the rim to ensure correct engagement of the unloader cam ring, a groove and pin lugs of the unloader mechanism. Type B liners are fitted to the high side of compound compressors and to the non-unloading cylinders of the low side.

B. Removal

a) Remove the cylinder cover in accordance with M.P. 1.
b) Remove the suction and discharge valve assemblies in accordance with M.P. 2.
c) Remove the piston assembly in accordance with M.P. 3.
d) Fit the eyebolts (Fig. 13) to the liner.
e) Lift the cylinder liner from the casing with steady force. Caution: as soon as the resistance of the O ring has been over come the cylinder liner is 'free' to be removed.

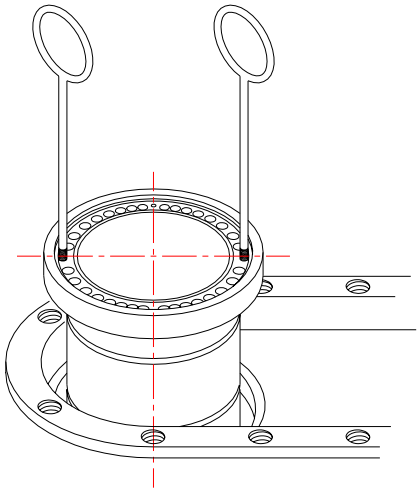


Fig. 13

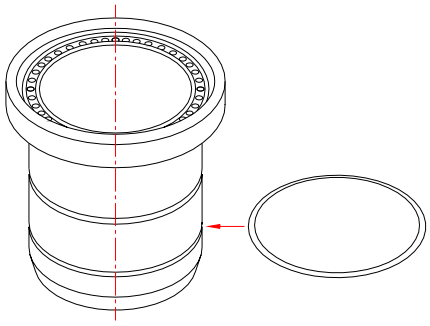


Fig. 14

C. Inspection

a) Remove and discard the cylinder liner shim.
b) Place the cylinder liner on a clean work surface and clean with new kerosene.
c) Clean and examine the cylinder liner-casing seat.
d) Remove and discard the cylinder liner O-ring.
e) For inspection information on cylinder liners fitted with an unloader mechanism refer to M.P. 5.
f) Examine the upper and lower surfaces of the flange, damage is not permitted as these surfaces form a gas tight seal with the discharge valve outer seat and the casing.
g) Examine the suction valve seat for defects, damage is not permitted.
h) Examine the inner surface of the liner for excessive wear, cracks or roughness. The limits for use are stated in M. P. 3, Table 6 (Fig. 10) and should the tolerances not be achieved when new piston rings are tested, replacement of the cylinder liner is required.
i) Fit a replacement O-ring (Fig. 14), ensuring that when fitted into the groove on the liner that twisting or over-extending has not taken place. Failure of these practices could result in low efficiency and excessive oil consumption.
j) Fit a replacement cylinder liner shim to the casing seat.

D. Refitting

a) Apply refrigerant oil to the O-ring.
b) Using the eyebolt tools, place the liner into the casing at the same time ensuring that the shim is not damaged.
c) For liners with the unloader mechanism, ensure that the correct orientation has been achieved and engagement of the cam ring with the unloader piston.
d) Apply steady pressure to the eyebolt tools until the liner descends onto the casing seat (Fig. 15).
e) Refit the piston and connecting rod assembly in accordance with M.P. 3.
f) Refit the suction and discharge valves in accordance with M.P. 2.
g) Refit the cylinder head cover in accordance with M.P. 1.

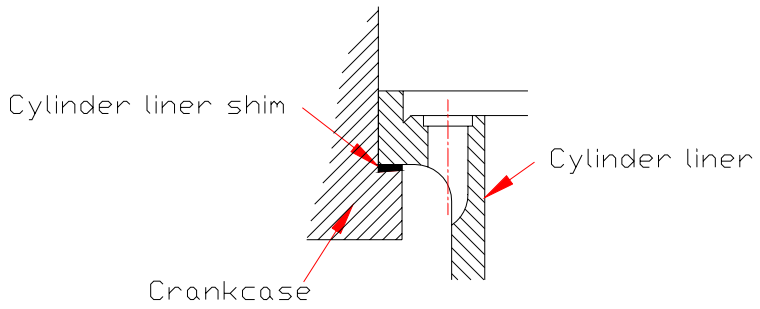


Fig. 15

M.P. 5 Unloader Operating Mechanism

Associated Instructions Refer M.P. 1, 2, 3 & 4
Required Tools Hasegawa & General Purpose

A. Description

The unloader mechanism for each bank of cylinders (Fig. 16) which are designated to be unloaded consists of the following components, operating piston assembly (secured to the casing), cam ring, pins with springs and stop ring (assembled on the liner). Oil pressure is fed via external piping from the pump to a 'tee' connection, the return line to the casing is via a solenoid and the supply line to the piston assembly is via a restrictor and a tapping. When a 'load' signal is generated a solenoid will close and oil pressure is fed via the restrictor to the piston assembly, over coming internal piston spring pressure to force the piston off its seat. This provides rotational movement of the cam rings, lowering the cam pins to enable the suction plate to lower on to its seat, which ensures that the only passage open for the compressed gas is to 'discharge'. Conversely when an 'unload' signal is generated a solenoid will open and provides a passage for oil in to the crankcase. Internal spring pressure in the piston assembly forces the oil out, through the restrictor and open solenoid in to the crankcase, enabling rotation of the cam ring, raising the cam pins thereby allowing recirculation of the refrigerant gas around the head assembly.

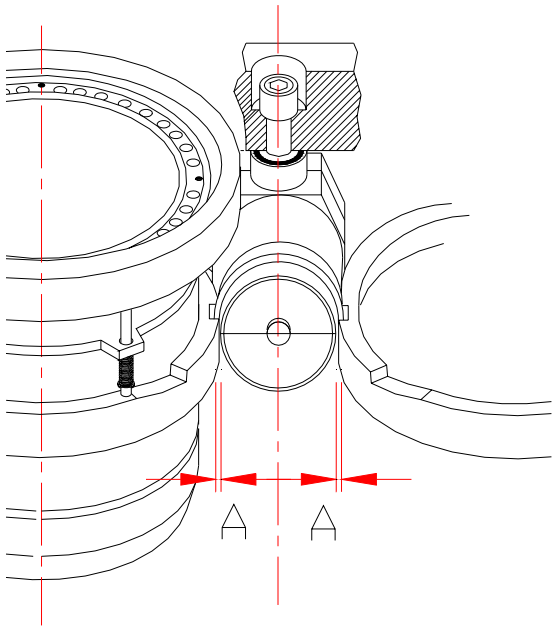


Fig. 16

B. Removal

a) Remove the cylinder cover in accordance with M.P. 1.
b) Remove the suction and discharge assemblies in accordance with M.P. 2.
c) Remove the piston assembly in accordance with M.P. 3.
d) Remove the cylinder liner in accordance with M.P. 4.
e) Locate the hollow bolt, which secures the unloader piston assembly to the casing and remove, thereby releasing the piston assembly from the casing.

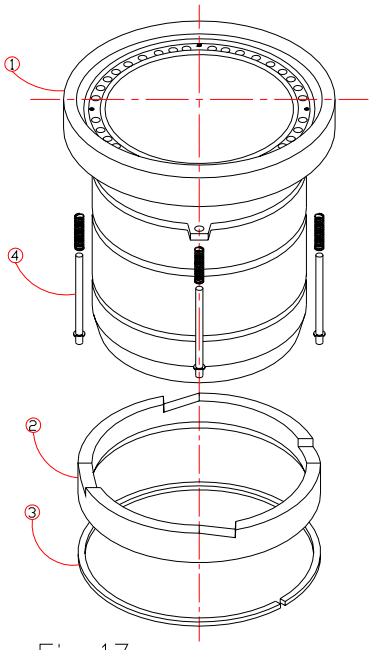


Fig. 17

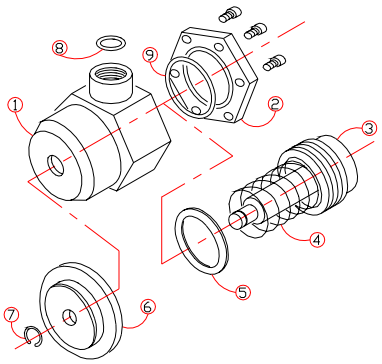


Fig. 18

C. Inspection

a) Invert the cylinder liner (Fig. 17) (1) and push down on the cam ring (2), this will expose the two halves of the stop ring (3) and facilitate removal.
b) Remove the cam ring from the liner and remove the four pins along with the spring's (4).
c) Clean and examine the pins and springs for cracks and deformation, replace as required.
d) Reassemble the components ensuring that the cam ring is correctly orientated (rings are right and left-handed).
e) Disassemble the piston assembly (Fig. 18) by first removing the clip (7) and working plate (6) from the piston stem.
f) Remove the end plate (2) securing bolts with extreme caution due to spring pressure; remove the piston (3) and spring (4).
g) Clean and inspect the cylinder (1) and piston (3) for excess wear and the spring (4) for deformation.
h) Replace the packing (5) and o-rings (8 & 9).
i) Reassemble the piston assembly using extreme care that no foreign matter enters the cylinder as damage to the packing may occur which, will cause excessive oil consumption.

D. Refitting

a) Refit the piston assembly to the casing but do not tighten fully the hollow bolt.
b) Refit the cylinder liner on the oil pump side in accordance with M.P. 4, ensuring that the pins are seated on the highest portion of the cam (unloaded position) (Fig.19).
c) Ensure that the piston assembly working plate engages the slot on the cam ring and that outward movement of the piston would rotate the cam ring allowing the pins to run in to the indent on the cam ring.
d) Place a locally manufactured tool, (0.0393in. 1mm thick steel sheet) between the working plate and the cam ring (Fig. 16) dimension 'A' to obtain the correct clearance on the installed liner cam ring.
e) Tighten the piston assembly-locating bolt and confirm dimension 'A' as correct.
f) Fit the adjacent cylinder liner in accordance with M.P. 4, ensuring that the working plate engages correctly with the cam ring and thereby confirming that the four cam ring pins are positioned correctly on the upper portion of the cam ring.

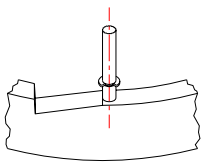
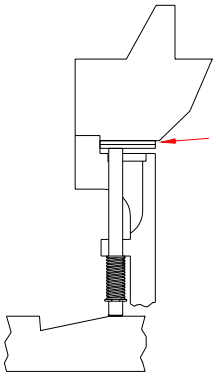


Fig. 19



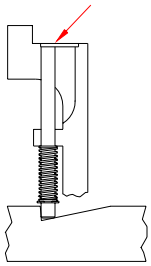


Fig. 20

g) Cross check the pin height to the adjacent cylinder and then by placing both the suction valve plate and outer seat in the correct position on each liner that the outer seat sits in the correct position (Fig. 20).
h) Ensure that a gap exists between the plate and outer seat as indicated and that the suction plate is able to sit fully in its seat when the pin is lowered for loading (Fig 20).
i) Refit the piston assemblies in accordance with M. P. 3.
j) Refit the suction and discharge valve assemblies in accordance with M. P. 2.
k) Refit the cylinder cover in accordance with M. P. 1.

M.P. 6 Mechanical Seal Assembly

Associated Instructions Refer 2.2, 2.3, 2.5, 2.6, 2.7 & 3.2
Required Tools Hasegawa & General Purpose

A. Description

The mechanical seal assembly (Fig. 21) is composed of a cover plate (1), seal ring (2), bellow type rubber packing (3), spring (4) and spring retainer. Lubricating oil and refrigerant gas are prevented from escaping by the action of the bellows on the shaft and the seal ring on the cover plate.

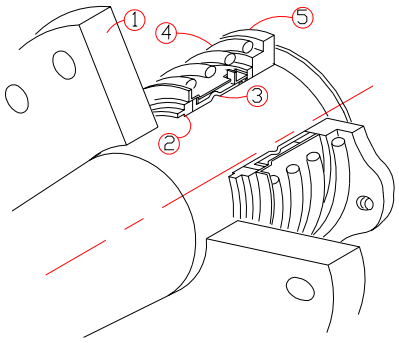


Fig. 21

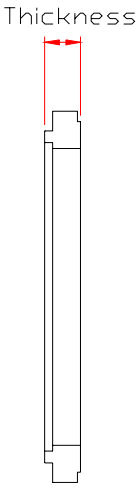


Fig. 22

B. Removal Refer: 2.5, 2.6, 2.7 & 3.2

a) Close the suction and discharge valves, including intermediate valves (if applicable).
b) Vent the compressor to equalize atmospheric pressure.
c) Ensure the compressor is electrically locked out.
d) Remove the V-belts, belt guard and flywheel or coupling guard and coupling.
e) Remove the cover plate mounting bolts, cover plate and seal ring.
f) Attach the two-extractor bolts to the spring retainer, which will ease off the front bearing seat. Avoid wrenching and forced pulling.

C. Inspection

a) Examine the spring for deformation and replace as required.
b) Measure the seal ring in accordance with Table 10 (Fig. 22).

Seal Ring	Tolerances in.(mm)
Standard Thickness	0.433 (11)
Limit for Use	0.394 (10)

Table 10

c) Examine the rubber bellows and crankshaft for indications of abnormal wear.
d) The rubber bellows should be discarded and replaced by a new item.
e) The plate and seal ring may be returned to the factory for re-lapping and then kept as spare for the original compressor.

D. Refitting Refer: 2.7, 2.2 & 2.3

a) Apply copious amounts of clean lubricating oil the crankshaft.
b) Carefully slide the seal assembly on to the shaft until the spring retainer abuts the front bearing.
c) Fit the cover plate ensuring that the drain orifice is at the lowest position and tighten bolts gradually in a diagonal format to seat the seal correctly.
d) Refit the flywheel, belt guard and belts or coupling and guard. Tension belts or ensure correct alignment of the coupling.
e) Re-establish the compressor both mechanically and electrically. Purge the compressor as required.

NOTE: On compressor start-up observe the seal drain point, after a period of 'bedding in' the new seal the oil leakage rate should not exceed 2 – 3 drops per minute. Only in the event of excessive oil or gas leakage should the compressor be stopped and the fault investigated.

f) On RM, AM type compressors the seal assembly can only be accessed after removing the motor rotor and then the cover plate. Drain the lubricating oil prior to removing the cover plate to ensure that no oil is able to contaminate the motor stator. To facilitate oil-draining remove the oil supply pipe from the oil filter and the drip tube, after which proceed as described above.

M.P. 7 Front Bearing

Associated Instructions Refer M.P. 6
Required Tools Hasegawa & General Purpose

A. Description

The front plain bearing is designed to bear the thrust load in an axial direction, the shaft load and lateral movement of the shaft. Externally set in to the casing the bearing is secured in place with four bolts. Bearing inspection may be undertaken with or without the crankshaft installed.

B. Removal

a) Remove the compressor driving system and mechanical seal assembly, in accordance with M.P. 6.
b) Remove the four mounting bolts (Fig. 23).
c) Fit the extractor tool and ease the bearing from the casing.

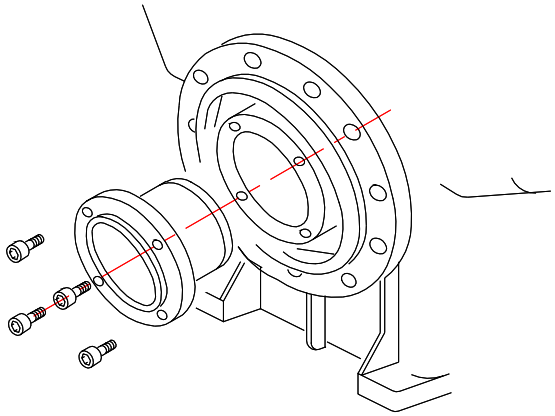


Fig. 23

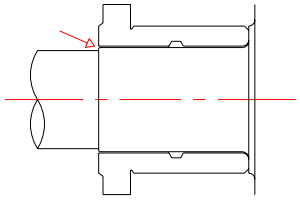


Fig. 24

C. Inspection

a) Clean the bearing with new kerosene.
b) Examine the bearing surface for an irregular wear pattern, metal flow to the oil passages and signs of foreign object damage.

NOTE: Slight metal flow may be observed in the direction of rotation and is symptomatic of oil priming on start-up or oil foaming due to liquid carry-over. Such a bearing may be used, however consult the factory for guidance.

c) Refit the bearing on to the crankshaft and measure the clearance, Table 11 (Fig. 24).

Front Bearing	Tolerance in.(mm)
Standard clearance	0.003 ~ 0.005 (0.07 ~ 0.12)
Limit for use	0.012 (0.3)

Table 11

d) Should the bearing clearance exceed the limits in Table 11, replace the bearing.

D. Refitting

a) Apply copious quantity of lubricating oil to the bearing surface, set the bearing so that the oil holes align with the oil grooves in the crankcase (horizontal) and tighten the bolts.
b) Refit the mechanical seal in accordance with M.P. 6.
c) Refit the compressor drive system in accordance with M.P. 5.

M.P. 8 Oil Pump Assembly

Associated Instructions Refer 2.2, 2.3, 2.5, 2.6, 2.7 & 3.2
Required Tools Hasegawa & General Purpose

A. Description

The oil pump assembly is fitted to the casing rear cover and is of the spur gear type (Fig. 25). Oil is drawn through a strainer located in the lower casing and an external pipe to the pump base (1). The pump is located in the body (2), which is driven by a shaft (3) that connects to the rear of the crankshaft. Oil is supplied at pressure through a fitting located on the top of the pump base. Standard rotation of the pump is counter clockwise as indicated by the directional arrow, however if due to installation requirements the compressor is required to rotate in the reverse direction, the pump body must be rotated 180° (Fig. 26).

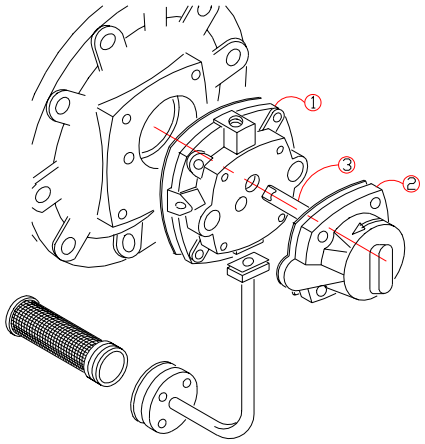


Fig. 25

B. Removal Refer: 2.5, 2.6, 2.7 & 3.2

a) Close the suction and discharge valves, including intermediate valves (if applicable).
b) Vent the compressor to equalize atmospheric pressure.
c) Ensure the compressor is electrically locked out.
d) Remove the four bolts, which attach the external oil feed pipe to the pump base.
e) Disconnect the oil outlet pipe from the pump base.
f) Remove the four bolts, which secure the pump body to the base and withdraw the pump complete with shaft (Fig. 25).
g) Remove the four bolts, which secure the pump base to the casing and remove the casing.
h) Discard the pump base, pump body and feed pipe gaskets.

C. Inspection

a) Observe the plate and gear orientation within the body to ensure that reassembly is correctly completed (Fig. 26).
b) Remove the bolts, which secure the end plate (1), withdraw the plate from the locating taper pin and gear (2).
c) Examine the pump gears for indications of excessive wear and foreign object damage, particularly the tooth areas.
d) Examine the shaft and bearing surfaces for indications of excessive wear and alignment.

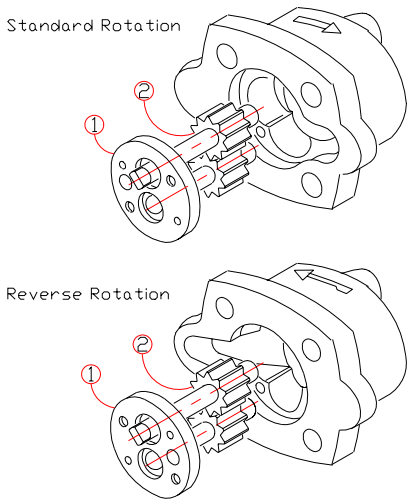


Fig. 26

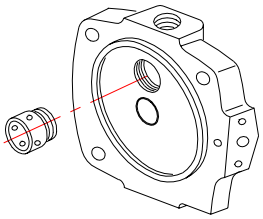


Fig. 27

e) Examine the inner surfaces of the pump body for excessive indications of wear and foreign object damage.
f) Remove the oil pump relief valve from the pump base (Fig. 27).
g) The valve is designed to bleed excess oil pressure to the crankcase and is to be cleaned with new kerosene as low oil pressure may occur if the valve seat is contaminated.
h) Refit the valve to the pump base and secure in place by center punching the threads to lock the valve in place.
i) Refit the pump gears and end plate, ensuring that the plate is fitted in accordance with the standard direction (Fig.26) unless the compressor is configured for reverse operation.
j) Ensure the end plate locates on the taper pin and fit the bolts to secure the plate.

NOTE: For marine compressors an additional oil tank is fitted below the casing to ensure positive oil supply to the pump (Fig. 28). The oil strainer is removed from the casing and is located in the oil tank.

D. Refitting <u>Refer: 2.7, 2.2 & 2.3</u>

a) Refit the pump base to the casing with a new gasket and fit mounting bolts.
b) Reconnect the oil feed pipe with a new gasket and oil outlet pipe to the pump base.
c) Orientate the oil pump drive spindle end key to the mating slot on the crankshaft and fit the oil pump body to the base with a new gasket.
d) Ensure the correct pump orientation and that the pump is flush with the pump base.
e) Fit the pump body mounting bolts.
f) Rotate the compressor by hand to ensure positive oil feed to the pump.

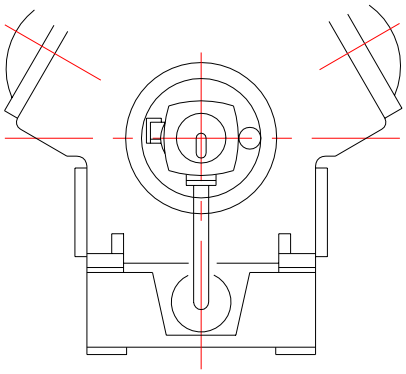


Fig. 28

M.P. 9 Rear Bearing

Associated Instructions Refer M.P. 8
Required Tools Hasegawa & General Purpose

A. Description

The rear plain bearing is designed to bear the thrust load in an axial direction as well as the shaft load and functions as thrust metal on an edged surface. Located in the rear casing the bearing is secured in place with two bolts. Bearing inspection may be undertaken with or without the crankshaft installed.

B. Removal

a) Remove the oil pump assembly in accordance with M.P. 8.
b) Remove the rear cover and discard the gasket.
c) Remove the two bolts and using the extractor tool ease the bearing from the housing (Fig 29).

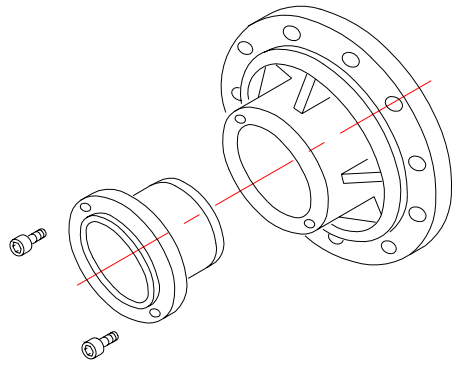


Fig. 29

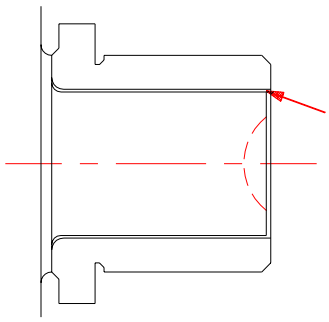


Fig. 30

C. Inspection

a) Clean the bearing with new kerosene.
b) Examine the bearing surface for an irregular wear pattern, metal flow to the oil passages and signs of foreign object damage.

NOTE: Slight metal flow may be observed in the direction of rotation and is symptomatic of oil priming on start-up or oil foaming due to liquid carry-over. Such a bearing may be used, however consult the factory for guidance.

c) Refit the bearing on to the crankshaft and measure the clearance, Table 12 (Fig. 30).
d) Should the bearing clearance exceed the limits in Table 12, replace the bearing.

Rear Bearing	Tolerance in.(mm)
Standard clearance	0.0028 ~ 0.005 (0.07 ~ 0.12)
Limit for use	0.012 (0.3)

Table 12

D. Refitting

a) Apply copious quantity of lubricating oil to the bearing surface, set the bearing so that the oil holes align with the oil grooves in the crankcase (horizontal) and tighten the bolts.
b) Refit the rear cover with a new gasket.
c) Refit the oil pump assembly in accordance with M.P. 8.

M.P. 10 Crankshaft

Associated Instructions Refer M.P. 1, 2, 3, 6, 8 & 9
Required Tools Hasegawa & General Purpose

A. Description

The crankshaft is constructed of forged steel with an internal passage for lubrication of the crank pin bearing, piston pin bearing and cylinder liner. Removal of the crankshaft is under taken from the oil pump side of the compressor.

B. Removal

a) Remove each cylinder cover in accordance with M.P. 1.
b) Remove the suction and discharge assemblies in accordance with M.P. 2.
c) Remove the piston assemblies in accordance with M.P. 3.
d) For RM, AM type compressors remove the motor rotor assembly.
e) Remove the mechanical seal assembly in accordance with M.P. 6.
f) Remove the oil pump assembly in accordance with M.P. 8.
g) Remove the rear bearing assembly (casing rear cover) in accordance with M.P. 9.
h) Support the crankshaft and withdraw through the rear casing using extreme care not to damage the bearing surfaces.

C. Inspection

a) Remove oil passageway plugs and clean the crankshaft with new kerosene.
b) The crankshaft is factory balanced and the bolts should not be tampered with.
c) Refit the oil passageway plugs.
d) Examine the crankshaft journals for signs of excessive wear and damage (scoring and pitting etc.). Should excessive wear be suspected (greater than 0.006" - 0.15 mm) consult the factory for dimensional data, tolerances and the appropriate repair method.
e) Repair methods include:
   - Over-sized bearings, (0.01" – 0.02", 0.25mm & 0.5mm)
   - Rebuilding the journal with spray metal and polishing.

Note: This procedure should not be attempted without prior consultation.

D. Refitting

a) Lubricate the front bearing and mating surface of the crankshaft.
b) Support the crankshaft and insert through the rear casing exercising extreme caution not to damage the bearing surfaces.
c) Fit the rear bearing assembly (casing rear cover) in accordance with M.P. 9.
d) Refit the oil pump assembly in accordance with M.P. 8.
e) Refit the mechanical seal assembly in accordance with M.P. 6.
f) Refit the piston assemblies in accordance with M.P. 3.
g) Refit the suction and discharge valve assemblies in accordance with M.P. 2.
h) Refit the cylinder covers in accordance with M.P. 1.
i) For RM, AM type compressors refit the motor rotor assembly.

M. P. 11 Oil Pressure Regulating Valve

Associated Instructions Refer 2.2, 2.3, 2.5, 2.6, 2.7 & 3.2
Required Tools Hasegawa & General Purpose

A. Description

Located to the right of the oil pump on the rear casing the valve comprises a piston, spring, spindle and a hand wheel for adjustment purposes (Fig. 31). Turning the hand wheel clockwise increases oil pressure, while anti-clockwise rotation decreases oil pressure.

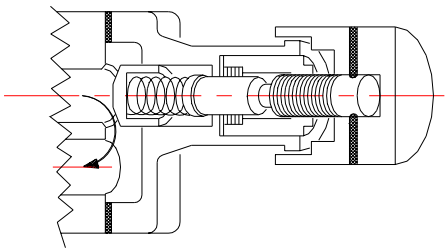


Fig. 31

B. Removal Refer: 2.5, 2.6, 2.7 & 3.2

b) Close the suction and discharge stop valves, including intermediate valves (if applicable).
c) Vent the compressor until equal with atmospheric pressure.
d) Isolate the compressor power supplies with the appropriate 'lock out – tag out' method.
e) Remove the four mounting bolts.
f) Remove the valve from the casing.

C. Inspection

a) Remove the spring and valve seat from the body.
b) Using a parallel punch lightly tap the spring clip from the hand wheel and remove the hand wheel.
c) Remove the spindle by rotating anti-clockwise.
d) Remove the valve bonnet.
e) Clean and examine the components for scoring or spring distortion.
f) Replace the spring, Teflon O-ring and Teflon packing as required.
g) Refit the valve spindle.
h) Refit the valve bonnet.
i) Align the hand wheel on the stem and insert the spring clip.
j) Insert the spring and valve seat.

D. Refitting Refer: 2.7, 2.2 & 2.3

a) Mount the valve on the casing with a gasket and the four attachment bolts.
b) Tighten the attachment bolts evenly to ensure the valve seat remains correctly located.
c) Exercise the valve to ensure a smooth operation.
d) Using the correct procedure restart the compressor.

M. P. 12 Oil Return Valve

Associated Instructions Refer 2.2, 2.3, 2.5, 2.6, 2.7 & 3.2
Required Tools Hasegawa & General Purpose

A. Description

The oil return valve is fitted to two stage compressors only and the purpose of the valve is to return oil from the high side casing to the lower oil casing (fig 32). The valve is normally closed and should only be opened for a brief period on a weekly basis to permit oil to drain.

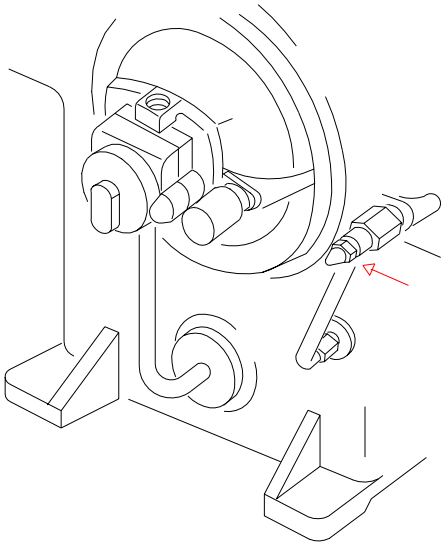


Fig. 32

B. Removal Refer: 2.5, 2.6, 2.7 & 3.2

Note: Unless abnormally high pressure is observed in the lower casing (with the valve fully closed), valve maintenance is not required.

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves, including intermediate valves (if applicable).
c) Vent the compressor internal pressure using the correct procedure.
d) Disconnect the external drainpipe from the valve and casing.
e) Remove the valve from the casing.

C. Inspection

a) Remove the valve bonnet, withdraw the valve stem and clean the valve with new kerosene.
b) Examine the Teflon seat and replace as required.
c) Insert the valve stem and install the valve bonnet.

D. Refitting Refer: 2.7, 2.2 & 2.3

a) Refit the valve to the casing.
b) Reconnect the external drainpipe.
c) Ensure the valve is fully closed.
d) Using the correct procedure restart the compressor.

M. P. 13 Oil Screen and Oil Filter

Associated Instructions Refer 2.2, 2.3, 2.5, 2.6, 2.7 & 3.2
Required Tools Hasegawa & General Purpose

A. Description

The oil screen is located internally in the lower casing or in an additional oil tank located below the casing for marine type compressors. The screen can be accessed by removing the external cover plate and pump oil feed pipe for land and marine type compressors or through a side cover for land type compressors only. The screen is removable and is designed to protect the oil pump, therefore should be cleaned on a regular basis. The oil filter, located in the system after the oil cooler is of spacer and filter plate type with a removable drain plug in the bowl. The plates must be rotated two to three times per week by operating the bar handle located on the filter cover assembly to remove embedded foreign particles.

B. Removal Refer: 2.5, 2.6, 2.7 & 3.2

Oil Screen

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves, including intermediate valves (if applicable).
c) Vent the compressor internal pressure using the correct procedure.
d) Remove the four bolts from the oil pump flange.
e) Place a receptacle below the oil screen cover plate and remove the four locating bolts.
f) Remove the cover plate with the screen attached.
g) Allow the oil to drain into the receptacle.

Oil Filter

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves.
c) Vent the compressor internal pressure using the correct procedure.
d) Remove the drain plug and drain the oil into a receptacle.
e) Remove the four bolts, which secure the filter bowl to the cover assembly.
f) Remove the filter bowl and retain contents for examination purposes.

C. Inspection

Oil Screen

a) Detach the screen from the cover plate by anti – clockwise rotation.
b) Clean the screen with new kerosene and examine the residue for foreign particles.
c) Dry and examine the screen for penetrations to the screen material, replace as required.
d) Refit the screen to the cover plate.

Oil Filter

a) Place a receptacle below the screen plates containing clean kerosene.
b) Clean the plates using a soft brush.
c) Dry the plates and examine any residue for foreign particles.
d) Clean and dry the filter bowl, examine the kerosene for foreign particles.
e) Refit the drain plug to the bowl.

D. Refitting Refer: 2.7, 2.2 & 2.3

Oil Screen

a) Fit a replacement gasket to the screen cover plate and insert the screen assembly into the casing.
b) Fit a replacement packing to the flange assembly.
c) Fit the four locating bolts to the pump flange and tighten.
d) Fit the four locating bolts to the cover plate and tighten.
e) Replenish the oil system as required.
f) Using the correct procedure restart the compressor.
g) Perform a leak check on the cover plate gasket.

Oil Filter

a) Fit a replacement gasket to the filter bowl and partially fill the bowl with new lubricating oil.
b) Fit the bowl to the cover assembly with the four bolts and tighten.
c) Replenish the oil system as required.
d) Using the correct procedure restart the compressor.
e) Perform a leak check on the filter assembly.

M. P. 14 Oil Cooler

Associated Instructions Refer 2.2, 2.3, 2.5, 2.6, 2.7 & 3.2
Required Tools Hasegawa & General Purpose

A. Description

Two different types of oil coolers may be installed, water cooled (Fig. 33) and refrigerant cooled (Fig. 34). Water type coolers are of the annular coil in shell type and can be readily maintained; oil passes through the coil and water around the shell. The refrigerant type cooler is of the double shell type, oil flow is between the inner and an outer shell; refrigerant is evaporated in the inner shell to cool the oil. The refrigerant type oil cooler is maintenance free apart from external inspection but must be operated under strict conditions, which are explained later in this M.P. under 'Handling Precautions – Refrigerant Type Oil Cooler'.

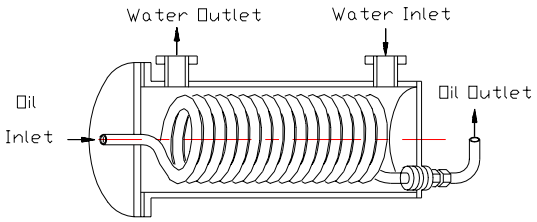


Fig. 33

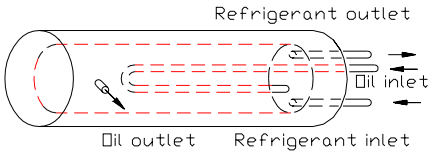


Fig. 34

B. Removal Refer: 2.5, 2.6, 2.7 & 3.2

Water Cooled Oil Cooler

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves, including intermediate valves (if applicable).
c) Vent the compressor internal pressure using the correct procedure.
d) Isolate the water supply and remove the drain plug to drain the water.
e) Disconnect the water supply and return pipes.
f) Disconnect the oil inlet and outlet pipes.
g) Remove the oil cooler from the mounting structure.

C. Inspection

Water Cooled Oil Cooler

a) Remove the oil outlet-securing nut.
b) Remove the flange bolts.
c) Withdraw the flange and coil assembly from the shell.
d) Clean using a non-abrasive method and examine the coil.
e) Clean and examine the shell.
f) Replace as required the rust preventative plug (magnesium for fresh water and zinc for seawater).
g) Fit a replacement gasket to the flange and install the coil assembly.
h) Fit a replacement packing to the coil and fit the oil outlet-securing nut.
i) Fit the water drain plug.

D. Refitting Refer: 2.7, 2.2 & 2.3

a) Install the cooler on the support frame and secure.
b) Connect the oil inlet and outlet pipes.
c) Connect the water supply and return pipes.
d) Re-establish the water-cooling system supply.
e) Replenish the oil system as required.
f) Using the correct procedure restart the compressor.
g) Perform a leak check on oil and water connections.

E. Handling Precautions – Refrigerant Type Oil Cooler

a) Ensure a refrigerant supply is maintained during compressor operation, refrigerant isolate valves should be open.
b) Ensure correct adjustment of the expansion valve to prevent liquid carry-over. Suction pipe routing to a remote location from the compressor is desirable, however for two stage compressors the outlet pipe should be connected to the intermediate cooler. With multiple compressor systems special care should be taken when suction pressure is varied due to the change in number of operating compressors.
c) Due to the filtration characteristics of the thermostatic expansion valve strainer regular cleaning is required, as a decrease in refrigerant flow will lead to an increase in oil operating temperature.
d) Correct sizing of the thermostatic expansion valve is essential, as liquid carry-over is liable to occur due to lag on starting leading to the valve over-opening.
e) Careful adjustment of the control valve is required to ensure that the evaporating temperature does not go below -40°F (-40°C), as the cooling effect will be reduced due to increased oil viscosity.
f) Refrigerant feed to the cooler must cease while the compressor is stopped, care should be taken to ensure that no leakage across the solenoid occurs, that refrigerant is not drawn and evaporated by parallel running compressors, as this will lead to high oil viscosity due to low oil temperature. Due to the increased oil viscosity and the increased resistance to flow, an increased wear rate of compressor components is possible which, could ultimately lead to premature failure of the compressor. Careful monitoring of the oil pressure is recommended.
g) A decrease in the coolers performance (high oil temperature) is likely if oil accumulates in the refrigerant side, therefore draining of the oil is to be performed on a regular basis by opening the valve on the cooler for a short period.
h) In order to prevent super cooling of the oil and overcharging of refrigerant while the compressor is stopped due to possible leakage of the solenoid valve, open slightly the outlet valve. When the compressor is to be started ensure the outlet valve is opened fully but monitor the system for indications of liquid carry-over.

M. P. 15 Crankcase Heater

Associated Instructions Refer 2.2, 2.3, 2.5, 2.6, 2.7 & 3.2
Required Tools Hasegawa & General Purpose

A. Description

The crankcase heater is fitted in the lower casing and is of the screw plug type, available in either 110V, 115V, 220V or 230V at a rating of 200W (alternative sizes are available on request). The heater should be energized while the compressor is stopped to maintain the oil at a suitable temperature; this is particularly relevant in cold climates.

NOTE: During periods of maintenance the electrical supply to the heater must be isolated to prevent personal injury or damage to the heater, this is particularly relevant when oil changes or work in the lower casing are in progress.

B. Removal Refer: 2.5, 2.6, 2.7 & 3.2

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves, including intermediate valves (if applicable).
c) Vent the compressor internal pressure using the correct procedure.
d) Drain the lubricating oil from the crankcase.
e) Remove the junction box cover and disconnect the heater power supply cables.
f) Unscrew the heater from the casing.

C. Inspection

a) Examine the power supply cables for signs of damage or deterioration.
b) Examine the casing and probe for signs of damage or overheating.
c) Perform a resistance check.

D. Refitting Refer: 2.7, 2.2 & 2.3

a) Refit the heater to the casing.
b) Reconnect the power supply cables and fit the junction box cover.
c) Refill the crankcase to the correct level with lubricating oil.
d) Using the correct procedure restart the compressor.
e) Perform a leak check on heater crankcase connection.

M. P. 16 Suction Gas Strainer

Associated Instructions Refer 2.2, 2.3, 2.5, 2.6, 2.7 & 3.2
Required Tools Hasegawa & General Purpose

A. Description

The suction gas strainer is located below the suction valve on single stage compressors, with an additional strainer fitted below the high stage suction of a compound compressor. Access to both is under taken in the same manner and for the initial compressor or system 'run in' period the strainers are wrapped in cloth which is secured by steel wire.

B. Removal Refer: 2.5, 2.6, 2.7 & 3.2

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves, including intermediate valves (if applicable).
c) Vent the compressor internal pressure using the correct procedure.
d) Remove the cover plate.
e) Extract the strainer.

C. Inspection

a) Should the strainer is fitted with a cloth wrap, remove the cloth.
b) Examine the cloth and strainer for foreign material.
c) Examine the strainer for penetrations to the screen material.
d) Replace as required the cloth wrap and secure with steel wire.

D. Refitting Refer: 2.7, 2.2 & 2.3

a) Insert the strainer.
b) Fit the cover plate using a replacement gasket.
c) Using the correct procedure restart the compressor.
d) Perform a leak check on the cover plate.

NOTE: This procedure is applicable to the high side strainer.

M. P. 17 Safety Valve, Pressure Gauge and Pressure Switch

Associated Instructions Refer 2.2, 2.3, 2.5, 2.6, 2.7 & 3.2
Required Tools Hasegawa & General Purpose

A. Description

Safety Valve

A safety valve is fitted to the discharge side of a compressor and to the low stage discharge of a compound compressor. The valve operating pressure is preset and no field adjustment is possible, each valve has a date stamp attached and this should be monitored for in service life.

Pressure Gauge

A pressure gauge is fitted to each service valve to permit recording of operating data. The gauges are glycerin filled and should be monitored for leakage and excessive pointer vibration as this will lead to incorrect readings.

Pressure Switch

Pressure switches are of the electro-mechanical type and should be monitored for leakage. In addition regular checks should be performed to ensure that the switches continue to operate at the desired settings.

B. Removal Refer: 2.5, 2.6, 2.7 & 3.2

Safety Valve

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves, including intermediate valves (if applicable).
c) Vent the compressor internal pressure using the correct procedure.
d) Remove safety valve complete with mounting flange.

Pressure Gauge and Pressure Switch

a) Isolate the compressor both mechanically and electrically.
b) Close the appropriate service valve.
c) Release pipeline pressure at an adjacent fitting.
d) Disconnect the pressure switch electrically.
e) Disconnect the gauge / switch from the pipe.
f) Remove from the panel.

C. Refitting Refer: 2.7, 2.2 & 2.3

Safety Valve

a) Fit a replacement valve to the mounting flange.
b) Using a replacement gasket fit the safety valve assembly.
c) Using the correct procedure restart the compressor.
d) Perform a leak check on the cover plate.

Pressure Gauge and Pressure Switch

a) Fit a replacement gauge / switch to the panel.
b) Connect pressure pipe.
c) Reconnect the pressure switch electrically.
d) Open the service valve and purge the pipe through an adjacent fitting to the gauge / switch.
e) Set the pressure switch using certified test equipment.
f) Using the correct procedure restart the compressor.
g) Perform a leak check on the appropriate fittings.

M. P. 18 V – Belt Drive

Associated Instructions Refer 3.2
Required Tools Hasegawa & General Purpose

A. Description

The compressor and motor may be equipped with either C or D section sheaves and belts, refer to the equipment specification manual. The belt guard and front panel must be fitted at all times when the compressor is operational to reduce the risk of personal injury. The compressor or motor sheaves may have more grooves than the number of belts, refer to the equipment specification manual and always leave the empty grooves at the furthest point from the compressor and motor.

B. Removal

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves, including intermediate valves (if applicable).
c) Remove the belt guard front panel.
d) Release the belt tension.
e) Remove the belts.

C. Inspection

a) Examine the drive belts for signs of cracking, fraying, uneven wear and contamination.
b) Examine the sheaves for signs of uneven or excessive wear, cracks and damage.

D. Refitting

a) Fit the belts.
b) Re-tension the belts.
c) Check the compressor and motor sheaves for correct alignment across the face closest to the compressor and motor.
d) Refit the belt guard front panel.
f) Using the correct procedure restart the compressor.
g) If replacement belts have been fitted re-check belt tension after a short operational period.

M. P. 19 Coupling Drive

Associated Instructions Refer 3.2
Required Tools Hasegawa & General Purpose

A. Description

Two types of direct drive coupling may be used either the CA type (Fig. 35) or CG type (Fig. 36), both types are subject to critical alignment tolerances.

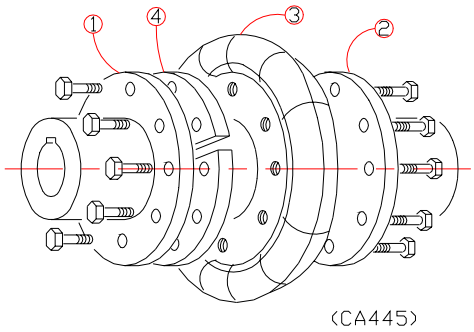


Fig. 35

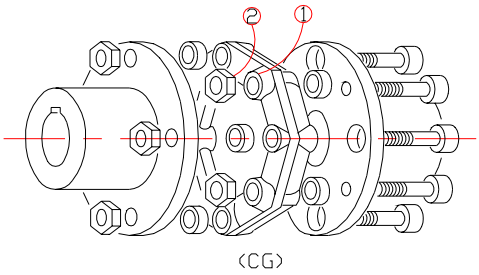


Fig. 36

B. Removal - General

a) Isolate the compressor both mechanically and electrically.
b) Close the suction and discharge valves, including intermediate valves (if applicable).
c) Remove the coupling guard.

CA coupling

a) Remove coupling bolts (Fig. 35 [1 & 2]).
b) Screw bolts in to the motor side flange to separate flange and spacers [4].
c) Remove the tire. Should the tire be adhered to the flanges on either side it may be necessary to repeat operation b) above from both sides.

CG Coupling

a) Tighten the outer circle of rubber block (Fig. 36 [1]) with the attached steel strap [2].
b) Release the setting bolts (M30) and remove rubber block. Do not slacken the steel strap at this point.

C. Inspection

a) Examine coupling for signs of distortion, cracking and fraying.
b) The life expectancy of a coupling is affected by the amount of misalignment, therefore refer to Table 13 (Fig.37) for tolerances.

	CA Type	CG Type
Deflection of outer circle in. (mm)	0.008 (0.2)	0.008 (0.2)
Deflection face to face in. (mm)	0.004 (0.1)	0.004 (0.1)
Distance face to face in. (mm)	5.433 – 5.512 (138 – 140)	6.260 – 6.338 (159 – 161)

Table 13

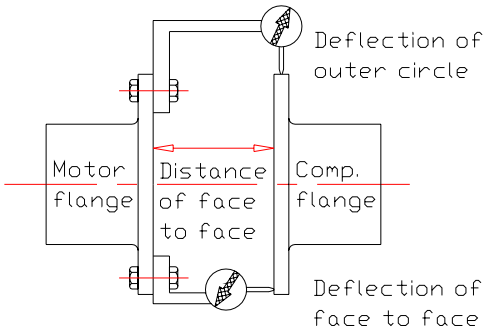


Fig. 37

D. Refitting

CA Coupling

a) Insert the rubber tire, locate the flanges and insert the bolts.
b) Tighten bolts in accordance with manufactures data sheet.

CG Coupling

a) Insert the coupling and tighten setting bolts.
b) Slacken the steel strap in accordance with the manufactures data sheet.

General

a) Fit the coupling guard.
b) Using the correct procedure restart the compressor.

NOTE: Bolts should be re-tightened two weeks after initial installation, there after every six months and at each scheduled maintenance.

M. P. 20 Flanged Motor Assembly

Associated Instructions Refer 3.2
Required Tools Hasegawa & General Purpose

A. Description

The motor is of the open drip proof squirrel cage type and is constructed with two principal components, the rotor assembly which attaches directly to the crankshaft and the stator assembly which forms part of the outer casing, which bolts directly to the compressor casing. Airflow is induced through the motor end plate and around the stator assembly for cooling purposes, before being expelled through the motor casing. To gain access to the compressor mechanical seal assembly it is necessary to remove the end plate and rotor assembly.

B. Removal

Motor Bearing

a) Remove the four bolts (M12) from the end cover.
b) Attach guide bolts to the two upper locations of the end cover.
c) Fit to the left and right tap holes bolts and tighten equally to remove the end cover.
d) Should the bearing remain on the shaft, fit the removal tool (Fig. 38) and ease the bearing from the shaft.
e) Should the bearing be removed with the end cover (Fig. 39) then use a hexagonal bolt to push the bearing from the housing applying the force to the outer ring only.

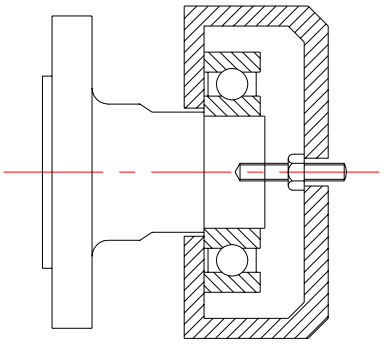


Fig. 38

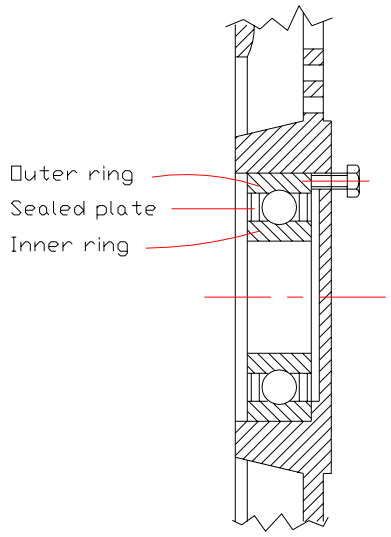


Fig. 39

Motor Rotor

a) Remove the rear cover as described above.
b) Remove the end-shaft with the rear bearing using extreme caution to prevent bearing damage.
c) Remove the crankshaft key support plate and attach the motor rotor guide to the crankshaft (Fig. 40).
d) Using the ancillary tool attach two bolts (M12) to the spider and fit the draw-out plate to the motor rotor guide and set nuts on bolts (M12).
e) Tighten the extractor nuts equally to ease the motor rotor along the shaft and then pull the bolts (M12) to remove the rotor assembly complete.

Note: Extreme care must be taken to avoid damage to the aluminum fins during the removal process.

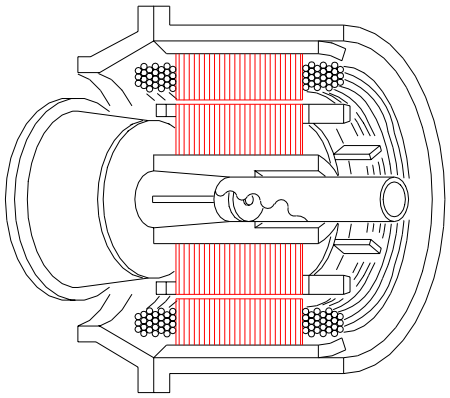


Fig. 40

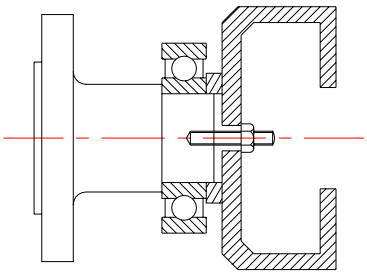


Fig. 41

C. Inspection

a) Perform the appropriate cleaning and inspection process as directed by the motor maintenance procedure supplied by the motor manufacturer.

D. Refitting

Motor Rotor

a) Refitting of the rotor assembly is the reverse of the removal process.
b) The position of the crankshaft key should be noted prior to installation.

Motor Bearing

a) Refitting of the rear bearing is the reverse of removal process, using the ancillary tool to set the bearing correctly on the shaft (Fig. 41).
b) Refit the rear cover and fit securing bolts.