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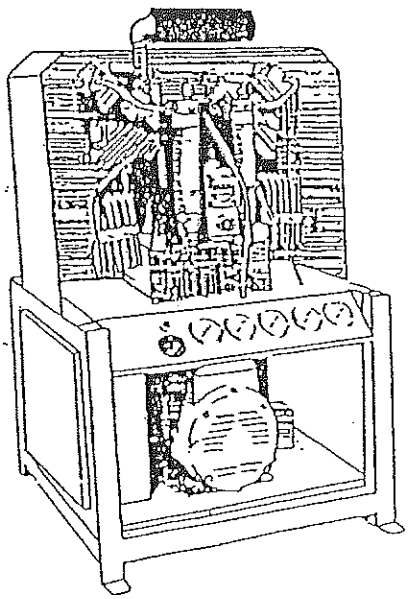
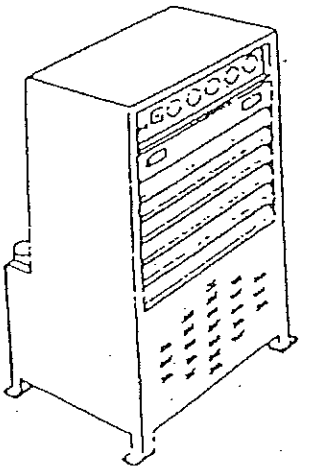
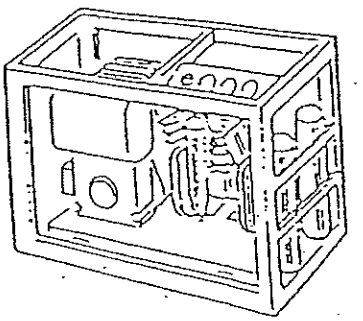
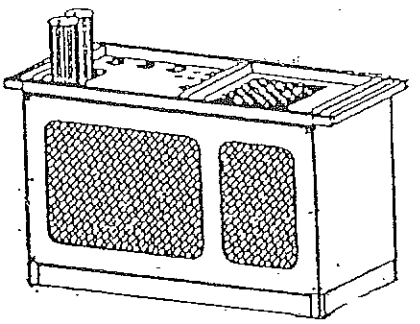
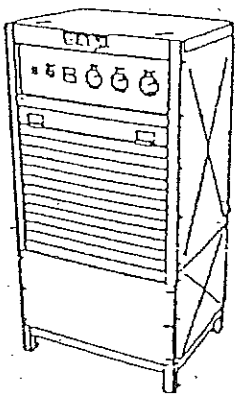
OWNERS MANUAL











COMPAIR MAKO
1634 SW 17TH STREET
OCALA, FLORIDA 34474
PHONE (352) 732-2268
FAX (352) 351-5211

MAKO®

CompAir Mako

HIGH PRESSURE BREATHING AIR/INDUSTRIAL COMPRESSORS

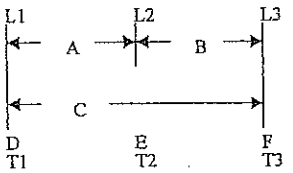
Customer Name and Address _____

Compressor Model_____ Serial Number_____

Inspect and check the following (if applicable):

1.	Total Running Hours	_____	Start	_____	Finish	
2.	Inlet Filter Condition	_____	OK	_____	Repair	
3.	Room ambient temperature	_____	°F	_____	Repair	
4.	V belts	_____	OK	_____	Repair/Realign	
5.	Idler pulley (where applicable)	_____	OK	_____	Repair	
6.	Check oil level	_____	OK	_____	Added Oil	
7.	Oil sample taken	_____	OK	_____	Shipped to Manufacturer	
8.	Inspected for air leaks	_____	OK	_____	Repair	
9.	Package set pressures (psig)	_____	High	_____	Low	
10.	Lubed main motor	_____	OK	_____	Repair	
11.	Cooling water inlet (Watercooled units)	_____	Temp	_____	Pressure	_____ OK
12.	Cooling water discharge (Watercooled units)	_____	Temp	_____	Pressure	_____ OK

13. Electrical



a.	Voltage (Full load)	A	_____	B	_____	C	_____	
b.	Voltage (No load)	A	_____	B	_____	C	_____	
c.	Motor amperage (full load)	T1	_____	T2	_____	T3	_____	
d.	Motor amperage (no load)	T1	_____	T2	_____	T3	_____	
e.	Voltage drop across starter	L1–T1	_____	L2–T2	_____	L3-T3	_____	
f.	Total package amps (full load)	L1	_____	L2	_____	L3	_____	
g.	Motor nameplate data	Voltage	_____	Hz	_____	Phase	_____	
				Amps	_____	RPM	_____	

h.	Inspected connectors	_____	OK	_____ Repair
i.	Checked electrical connections	_____	OK	_____ Repair

14. Adequate spare parts _____ YES _____ NO

Recommendations: _____

_____

_____

_____

_____

Action is needed? _____ YES _____ NO If "yes", URGENT? _____ Yes _____ No

Start-up completed by: _____ (print name)

Inspected by: _____ (Certified technician's signature)

Reviewed by: _____ (customer's signature) DATE: _____

Fax to: 352-351-5211 Attn: Field Service Manager

COMPRESSOR

COMPRESSOR	PRIME MOVER	INSTALLED AT	REF. NO.:
TYPE:	TYPE:		OIL GRADE USED:
SPEED:	B.H.P.		CHECK OIL LEVEL
SERIAL NUMBER:	DRIVE:	DATE INSTALLED:	CHECK WATER IN/OUT TEMPERATURE
			CHECK COOLING FAN BLADES

DATE	TIME	*HOURS RUN	+ STAGE TEMP.°C	FINAL STAGE TEMP. °C	STAGE PRESSURES #(BAR-PSI)					FINAL AIR PRESSURE #(BAR-PSI)	SERVICE PLAN NUMBER	REMARKS/ COMMENTS	SIGNED/ INITIALS
		#50-100			1	2	3	4	5				
		500											
		1000											
		1500											
		2000											
		2500											
		3000											
		3500											
		4000											
		4500											
		5000											
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		7500											
		8000											
		8500											
		9000											
		9500											
		10000											
		10500											
		11000											
		11500											
		12000											
		12500											
		13000											

* FILL IN HOURS RUN AS DETAILED ON SERVICE PLAN FOR PARTICULAR COMPRESSOR TYPE
# DELETE AS NECESSARY
+ FILL IN APPROPRIATE STAGE TRIP TEMPERATURE READING
SERVICE ENGINEER TO SIGN/INITIAL & FILL IN ANY OTHER COMMENTS IN REMARKS COLUMN

CompAir

COMPAIR MAKO
LIMITED WARRANTY

CompAir MAKO warrants this product to operate in accordance with its specifications free from defects in material and workmanship, under normal conditions set forth in its Operating and Maintenance Manual for twelve (12) months from initial startup or eighteen (18) months from shipment by CompAir MAKO, whichever period occurs first. Replacement parts are warranted to be free from defects in materials and workmanship for the remainder of the applicable original 12- or 18-month warranty period for the original product, or ninety (90) days from date of shipment by CompAir MAKO, whichever period occurs later. Warranty registration form should be completed and returned to CompAir MAKO.

THE WARRANTY DOES NOT COVER OPERATING FAILURES CAUSED BY MAJOR ACCESSORIES (E.G., MOTORS, ENGINES, BATTERIES) MANUFACTURED AND SEPARATELY WARRANTED BY THEIR RESPECTIVE MANUFACTURERS, OR ELECTRICAL COMPONENTS; OR FAILURES OF THE PRODUCT OR ANY PART IF EITHER HAS SUFFERED DAMAGE DUE TO ABUSE, ACCIDENT, OPERATION UNDER ABNORMAL CONDITIONS, OR REPAIR WITH PARTS OR BY PERSONS NOT AUTHORIZED BY COMPAIR MAKO.

COMPAIR MAKO'S ONLY OBLIGATION UNDER THE WARRANTY IS, AT ITS OPTION, TO REPAIR OR REPLACE ANY PARTS OF COMPAIR MAKO MANUFACTURE WHICH ARE DETERMINED BY IT TO HAVE BECOME DEFECTIVE DURING THE APPLICABLE WARRANTY PERIOD, PROVIDED THE WARRANTY CLAIM IS MADE WITHIN THIRTY (30) DAYS AFTER THE END OF THE APPLICABLE WARRANTY PERIOD. THIS IS THE BUYER/ OWNER'S EXCLUSIVE REMEDY FOR BREACH OF THE WARRANTY.

THE OWNER/USER ASSUMES ALL RISKS OF ANY OTHER DIRECT, INDIRECT, INCIDENTAL OR CONSEQUENTIAL LOSS OR DAMAGES, AND NO CLAIM FOR ANY SUCH LOSS OR DAMAGES BASED ON (i) BREACH OF WARRANTY, (ii) NEGLIGENCE, STRICT LIABILITY OR OTHER TORT, OR (iii) BREACH OF CONTRACT, WILL BE ASSERTED BY THE OWNER/USER OR ACCEPTED BY COMPAIR MAKO.

THIS WARRANTY IS MADE IN LIEU OF THE WARRANTIES OR MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE, AND ALL OTHER WARRANTIES, EXPRESS OR IMPLIED AND MAY NOT BE VARIED OR EXTENDED EXCEPT IN WRITING BY AN AUTHORIZED OFFICIAL OF COMPAIR MAKO.

PUBLICATION NUMBER 2000 UNIVERSAL

High Pressure compressor systems for a variety of commercial and industrial applications.

This book is applicable to models:

5404	5405
5404H	5405E
54044	54054
9200	9300
K51	K7
3500	4000
5406	5407
5406E	5407H
5406EH	9500
9400	K15
K14	5000
4500	
5408	5409
9600	5409H/IND
K22	54092BA/54092IA
5500	9700
6000	K27

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FIGURES

TABLES

1.0 SAFETY

The Mako compressor system has been designed to deliver safe breathing air up to 6000 PSIG working pressure depending on the installed compressor block. However, no design can remove all possibilities for error and free the user of all responsibility for safe operating and maintenance practices. The following paragraphs are intended to be a reminder of some of the more important aspects of safe operation.

1. These machines are safe and will not present a risk to health when properly used in accordance with the instruction manual.

2. All ancillary equipment must be suitable for the pressures and capacities involved, such as pipe work, connections, additional safety valves, fittings, etc. In addition, regulations applicable at site must be observed.

3. Before maintenance or dismantling, isolate all electrical supply from machine and ancillary equipment, isolate it from storage pipe work and release all pressure from the machine.

4. Read this manual carefully. If questions persist, call Mako Customer Service (352)732-2268 for clarification.

REMEMBER: THE COMPRESSOR SYSTEM IS ONE LINK IN A LIFE SUPPORT SYSTEM.

5. Check the compressor oil in accordance with the schedule. If in doubt, check the oil before operating the machine. If the oil is low, the compressor will run hotter, thus, increasing probability of carbonization and creation of carbon monoxide (CO).

6. Drain the optional auto drain reservoir frequently. Allowing the reservoir to overfill will affect the overall performance of the auto drain system which will cause premature saturation of the purification cartridges.

7. Do not attempt to tighten a leaking fitting under pressure. The fitting might be damaged, cracked or stripped. The act of tightening it still further while it is under pressure could be just enough to cause it to fail. Depressurize the machine before attempting to service any part of the compressor, purification system, or refill station.

8. Do not use compressed air to cool or blow dirt off personnel. High pressure air can penetrate the skin causing an embolism (air bubbles).

9. Do not attempt to adjust safety valves unless you first contact Mako Customer Service.

Safety valves are located to protect each stage of the compressor. The safety valves are set to snap open at predetermined pressures set at the factory. After a safety valve opens, and when the pressure drops back to a level below the set point, the valve will reset or close and does not have to be adjusted, and does not require replacement after each operation. If a valve opens at a pressure lower than "set" pressure, it should be replaced.

On Three Stage Units:
The 1st stage safety valve is located on the 2nd stage valve head.
The 2nd stage safety valve is located on the interstage separator.
The 3rd stage safety valve is located on the final separator.

On Four Stage Units:
The 1st stage safety valve is located on the 1st stage valve cover.
The 2nd stage safety valve is located on the 2nd stage interstage separator.
The 3rd stage safety valve is located on the 3rd stage interstage separator.
The 4th stage safety valve is located on the final separator.

10. Do not touch hot compressor parts. Heat generated by air compression can cause temperatures as high as 350°F on some system parts.

11. If you have any doubt about the quality of the air being drawn into the compressor, have it tested. Automobile exhaust fumes are especially laden with carbon monoxide. The Mako purification systems remove CO, but excessively high intake concentrations can cause premature saturation.

12. Pay special attention to the warning labels affixed to the final separator and purification cylinders. The separator label reads as follows:

WARNING

SEPARATOR INSPECTION AND TEST

At 1000 hour intervals remove the separator chamber from the machine and perform the following:

A. Disassemble, clean, and inspect the separator plug and cylinder for any signs of cracks at the thread roots. REPLACE CYLINDER AND PLUG IF CRACKED.

B. Hydrostatically test the separator to 1.5 times the working pressure in accordance with procedures as set forth in C.G.A. Pamphlet C-1. Permanent expansion in excess of 10% of the total expansion at the maximum test pressure shall be cause for cylinder rejection.

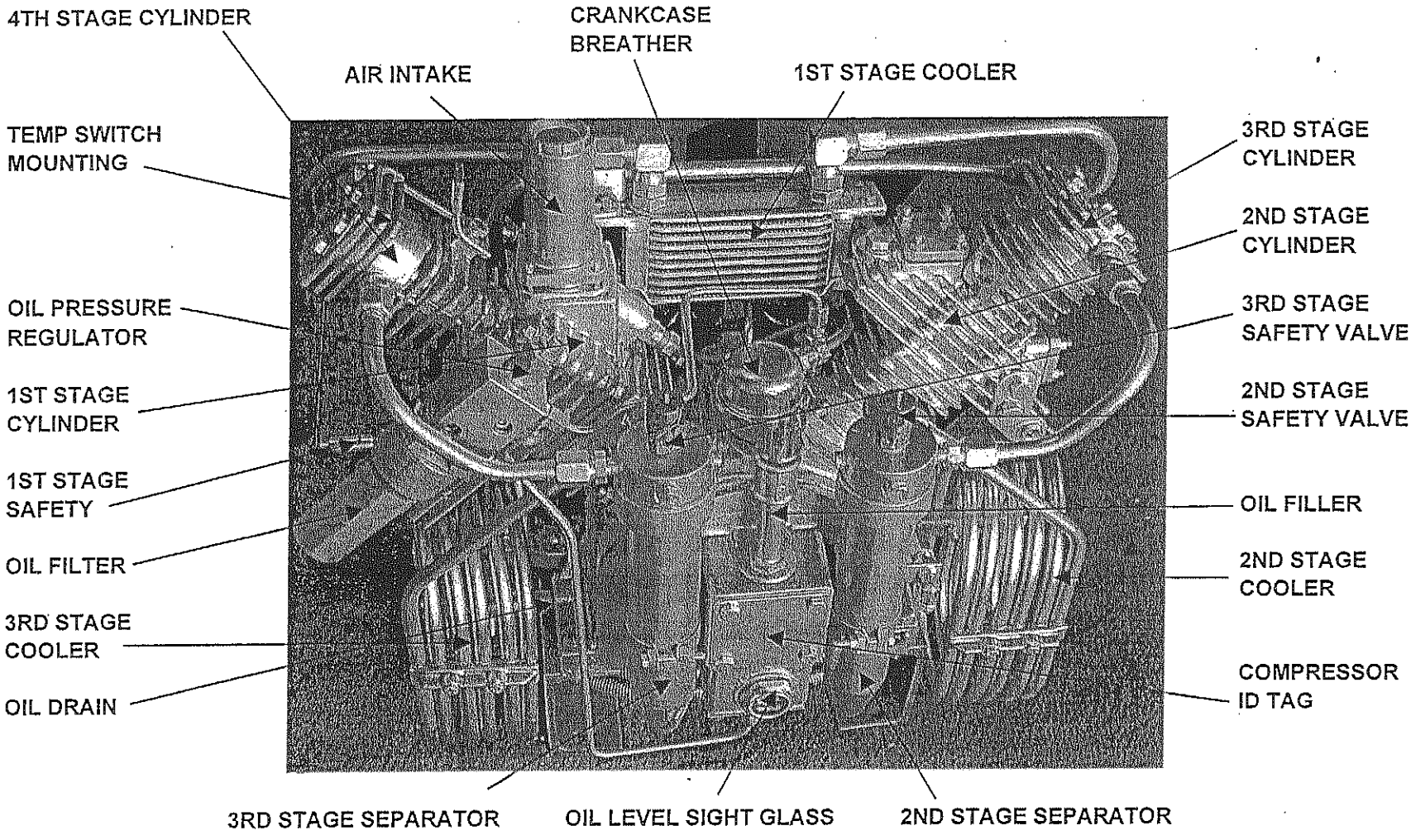


FIGURE 2-1 EXTERNAL APPEARANCE (TYPICAL 4 STAGE COMPRESSOR)

Figure 2-2 is a pictorial representation of the internal flow path of the compressor.

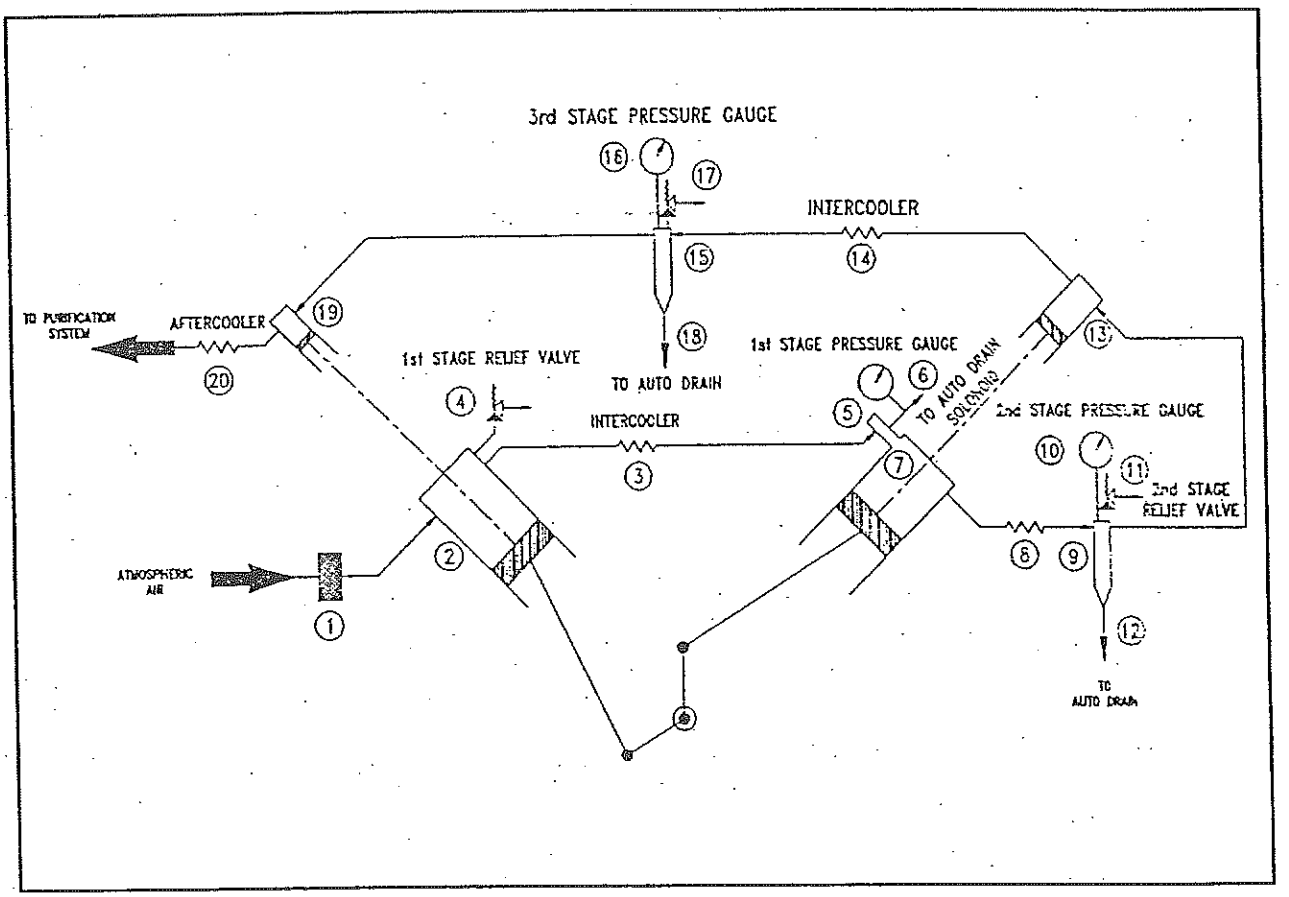


FIGURE 2-2 COMPRESSOR INTERNAL FLOW SCHEMATIC (4 STAGE MACHINE)

Air is taken into the first stage by way of a 10 micron inlet air filter (1). Piston movement within the first stage cylinder (2) compresses the incoming air to approximately 45 psi. Air leaving the first stage is cooled by an intercooler (3). Both the first stage cylinder (2) and the intercooler (3) are protected from damaging overpressure by the first stage safety valve (4). First stage pressure is measured at a tap (5) into the inlet plenum of the second stage (7). Pressure for the auto drain solenoid is also taken from a connection (6) to the tap (5).

Air entering the second stage is compressed again to 230 psi. Air leaving the second stage is cooled by the second to third stage intercooler (8). The cooled compressed air enters the interstage separator (9). Inside the interstage separator, a centrally located tube conveys the air to the mid section of the chamber where it is directed on the chamber walls via small holes in the end of the tube. The abrupt change of direction when the air/moisture mixture strikes the chamber wall causes the moisture droplets to separate from the air stream. The air stream rises and exits the separator via a small

hole in the top. The moisture collects on the inside surface of the separator chamber and flows down into the sump area at the bottom of the separator. The accumulated condensate is periodically drained by the auto drain system. The second stage cylinder, second to the third stage intercooler and interstage separator are all protected from the overpressure by the second stage safety valve (10) located on the interstage separator. Second stage pressure is measured by a pressure gauge connected to a tap located in the interstage separator.

Air entering the third stage (12) is compressed to 1050 psi. Air leaving the third stage is cooled by the third to fourth stage intercooler (13). The cooled compressed air enters a second interstage separator (14). A relief valve and pressure tap are provided in this interstage separator. Accumulated condensate is periodically drained by the auto drain system (16).

Air entering the fourth stage (17) is compressed to the desired output pressure as set by the compressor system air switch (4500 PSIG) (See Section 9). Air leaving the fourth stage is cooled by the aftercooler before entering the large separator that is considered the first stage in the purification process. This separator is mounted next to the cylinders containing the purification cartridges. Fourth stage pressure is measured down stream of the check valve located on the separator discharge line. The fourth stage safety valve is mounted on the top plug of the separator chamber.

The interstage coolers and the aftercoolers are located directly in the air flow from the compressed. Air delivered to the purification system is typically within 18°F of the ambient air temperature.

In summary, air passing through a four stage machine travels the following path:

1. Inlet air filter (10 micron)
2. First compression stage
3. Intercooler (after first stage compression)
4. Relief valve (first stage)
5. Point where first stage pressure is measured
6. Point where the auto drain solenoid is connected. Pressure at this point is used to hold the auto drain piston valves closed. See Section 7 for an explanation of how the auto drain works.
7. Second compression stage
8. Intercooler (after second stage compression)
9. Interstage separator
10. Point where second stage pressure is measured
11. Relief valve (2nd stage)
12. Moisture separator drain (piped to auto drain)
13. Third compression stage
14. Intercooler (after third stage compression)
15. Interstage separator

16. Point where third stage pressure is measured
17. Relief valve (third stage)
18. Moisture separator drain (piped to auto drain)
19. Fourth compression stage
20. Aftercooler

The externally observed features of the three stage machine are shown in Figure 2-3:

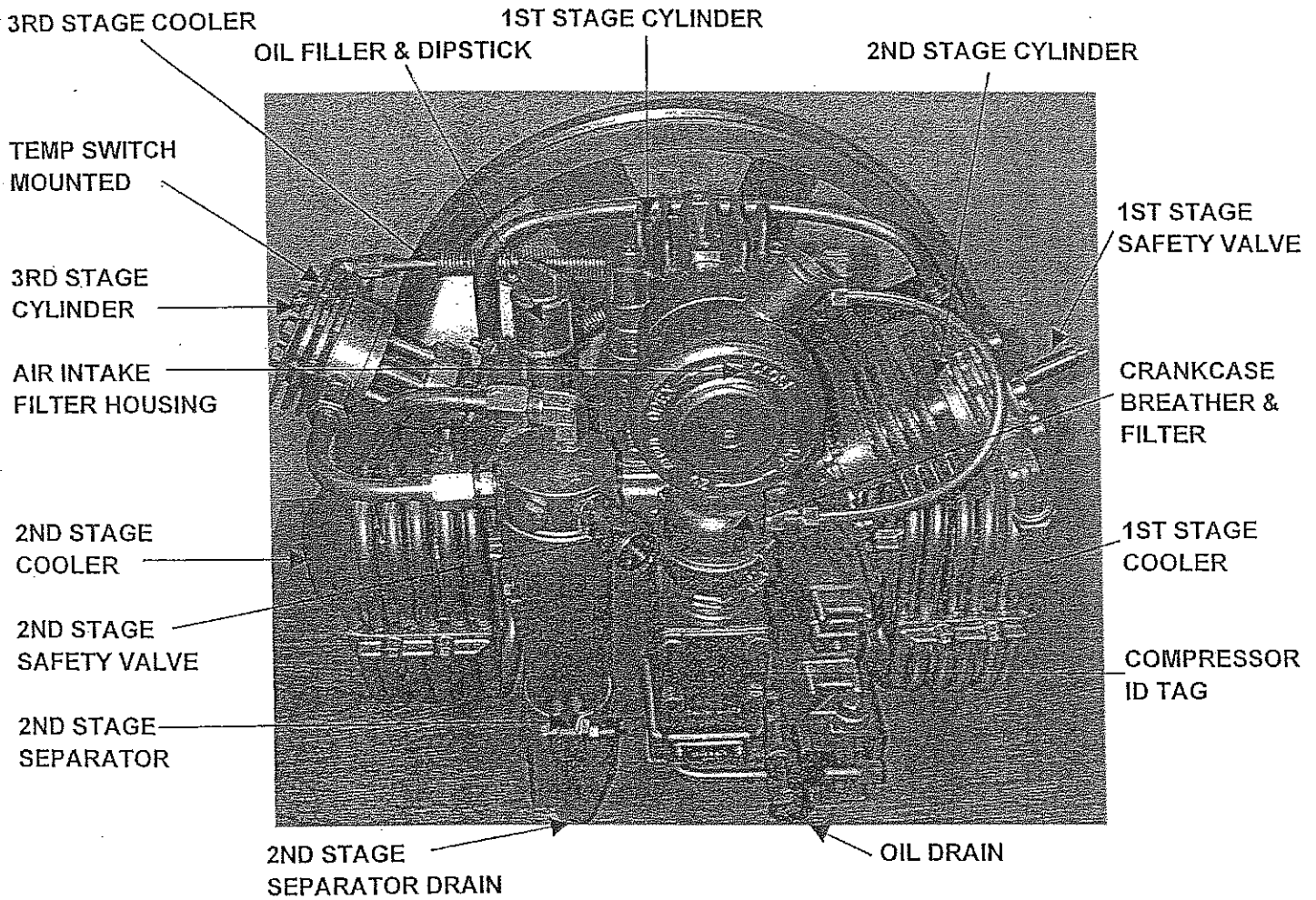


FIGURE 2-3 THREE STAGE COMPRESSOR

Figure 2-4 is a pictorial representation of the internal flow path of the three stage compressor.

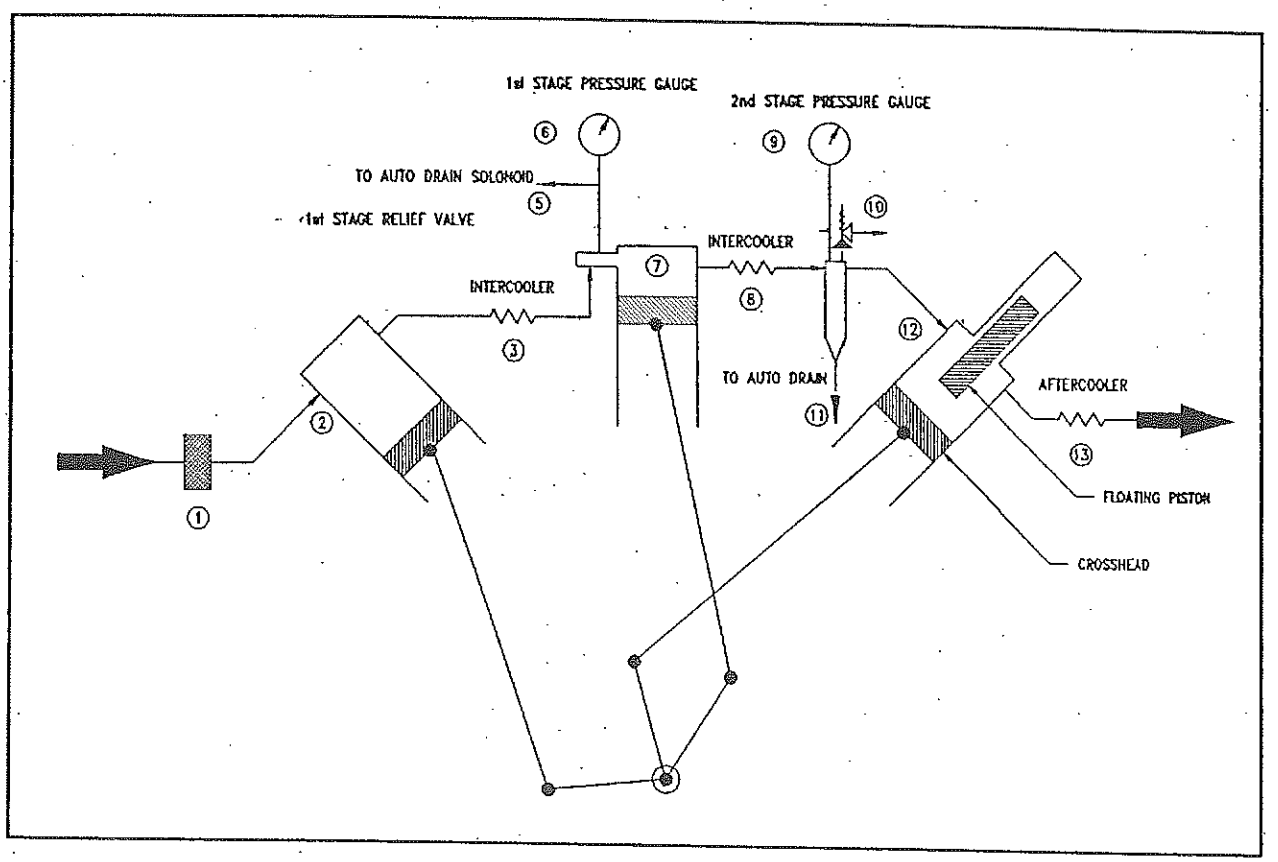


FIGURE 2-4 COMPRESSOR INTERNAL FLOW SCHEMATIC (3 STAGE MACHINE)

The flow path is very similar to the four stage machine with the following exceptions:

a. Only one interstage separator is required.

b. Only two intercoolers are required.

In summary, air passing through a three stage machine travels the following path:

1. Inlet air filter
2. First compression stage
3. Intercooler (after first stage compression)
4. Relief valve (first stage)
5. Point where the auto drain solenoid is connected. Pressure at this point is used to hold the auto drain piston valves closed.
6. Point where first stage pressure is measured
7. Second compression stage

8. Intercooler (after second stage compression)
9. Point where second stage pressure is measured
10. Relief valve (2nd stage)
11. Moisture separator drain (piped to auto drain)
12. Third compression stage
13. Aftercooler

Note, however, that the three stage compressor has three connecting rods while the four stage compressor is said to be a "V" configuration. The original style three stage machine has a floating piston in the third stage as schematically shown in Figure 2-4. When sufficient discharge pressure is reached the floating piston sits firmly on the piston like part (called the crosshead) that is actuated by a connecting rod attached to the crankshaft. New style three stage machines (54044, 5405E and 54054) have third stage captive pistons as the four stage machines.

On the four stage compressor the fourth stage piston is mechanically attached to the first stage piston and the third stage piston is part of the second stage piston (see Figure 2-2).

3.0 INSTALLATION AND START-UP PROCEDURES

CAUTION: CARE SHOULD BE EXERCISED WHEN REMOVING THE COMPRESSOR FROM THE SHIPPING CARTON TO PRECLUDE DAMAGE.

3.1 MACHINE LOCATION

The compressor requires only the following services and environment:

a. A relatively clean, debris free, dry shelter.
b. Sufficient ambient air for compressor cooling.
c. A sufficient source of clean compressor intake air.
d. An appropriate power supply, and
e. An appropriate means to handle the water/oil mixture discharged from the automatic condensate drain.

Since the compressor is an aircooled machine, the heat of compression is rejected to the surrounding air. It is important to locate the machine in a very large room or provide enough ventilation to maintain cooling air temperatures below 100°F.

It is desirable to locate the compressor in an environment free of high CO, CO_2, and other air contaminants. When the environment is less than desirable, provisions have been made to permit the connection of external source of air. Instructions for sizing and installing the intake lines are found in Section 3-3.

3.2 POWER SUPPLY (ELECTRIC DRIVEN)

The compressor is completely wired. It is, however, necessary to have a qualified electrician install the appropriate power supply in accordance with appropriate codes.

CAUTION: IT IS ESPECIALLY IMPORTANT ON THREE PHASE MACHINES TO WIRE THE MOTOR STARTER FOR PROPER COMPRESSOR ROTATION. THE COMPRESSOR SHOULD ROTATE IN A CLOCKWISE DIRECTION WHEN VIEWED FROM THE FRONT OF THE MACHINE. AN ARROW POINTING IN THE CORRECT DIRECTION OF THE ROTATION IS AFFIXED TO THE TOP SIDE OF THE FAN SHROUD.

3.3 REMOTE AIR INTAKE INSTALLATION

A remote air intake can be installed on the compressor as follows:

1. Determine the best location for the intake air port. The best location is, by definition, an air space reasonably near the compressor that is always low in contaminants that are harmful if ingested or could cause deterioration of the compressor equipment.

2. Plan the intake pipe routing.

3. Select the appropriate pipe size to minimize air flow pressure losses. Generally speaking the intake pipe can be sized in accordance with the following guide lines:

   - For runs no longer than 10 feet use 1" to 2" nominal size PVC pipe.

   - For runs over 10 feet - calculate pipe size by adding 1/4" diameter for each additional 10 feet (or portion thereof) or 90° elbow.

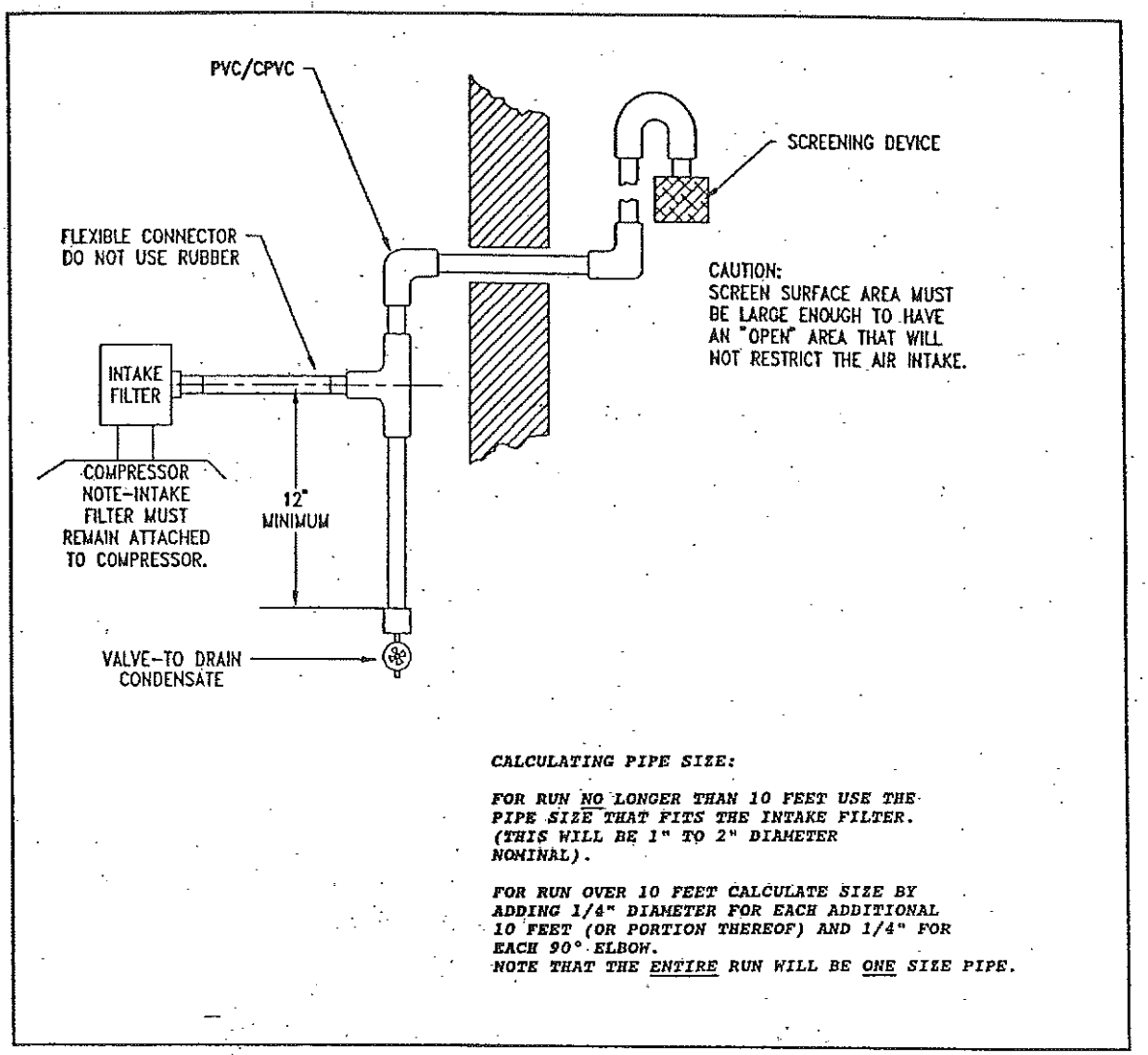


FIGURE 3-1 REMOTE AIR INTAKE INSTALLATION GUIDE LINES

WARNING: IT IS IMPERATIVE THAT MEASURES TAKEN TO PRECLUDE WATER INGESTION ARE EFFECTIVE.

3.4 INITIAL START-UP PROCEDURE

Although compressor parameters are preset in the factory tests, it is possible for some adjustments to change as a result of shipping and handling. Once the compressor is in position and energized the following initial start-up procedure should be followed to preclude maintenance damage and verify factory settings:

a. Check complete installation, including pipe work and alignment of compressor with driving unit.

b. Remove dry type suction filter element, blow over with low pressure air and re-insert in casing.

c. Ensure silencer bore and pipe work are clean.

NOTE: THE ENTIRE RUN SHOULD BE ONE SIZE PIPE.

d. Install appropriate fittings to mate with the 1 1/2 inch PVC pipe, if remote air intake is used.

e. Install the remainder of the intake system using the guidance found in Figure 3-1.

f. Ensure that the crankcase oil level is at 3/4 of the sight glass, Do not exceed this level. Do not allow it to drop below half way on the sight glass. Approved oils are identified in Section 4.

WARNING: DO NOT OVERFILL.

g. The compressor purification system is shipped from the factory with the desiccant cartridges used during factory test still in place if equipped with a cartridge monitoring system. **These cartridges must be replaced with new cartridges before the unit is started.** Warning tags are affixed to the purification chambers as a reminder. If the unit does not have a CMS no filter cartridges are installed. new cartridges must be installed before the unit is started.\

h. Install litmus paper in window type CO/Moisture Indicator in accordance with the procedure discussed in Section 5.

i. Rotate the compressor once or twice by hand to ascertain free movement.

j. Operate starter and immediately check rotation. An attached label on the fan shroud indicates correct rotation. Check pressure gauges for stage air flow.

k. Solenoid valve will be closed as soon as the compressor has attained running speed. This should be reached in five to six seconds for direct-on-line starting and eight seconds for Star Delta.

l. Check oil pressure reading nominal value 1000 PSIG. (See 5409H lubrication special specification.)

m. Moisture will be trapped in the system. It is, therefore, recommended that the system be purged prior to charging SCBA/SCUBA bottles.

n. Check and adjust, if necessary, the air pressure switch setting (See Section 8).

o. After 30 minutes operation, check valve heads. The intake pipe to the valve heads should be hand warm and the outlet pipes hot. This indicates that the valves are functioning correctly.

p. The unit must run for at least 15 minutes and bled off before any SCBA/SCUBA bottle charging operations are undertaken in order to allow the filters to reach their operational dewpoint level. The CMS will shut the unit down if the moisture level is above the set point after a preset delay period. This delay period is factory set at 7 minutes. Operation in the delay period is marked by a flashing green light. The delay period can be reset, if desired, using switches located inside the CMS electronics box. Section 16 explains how this is done. If at the end of 7 minutes the CMS shuts the machine down after new filters are installed simply push the ON/OFF button to OFF then turn the machine back ON. This will reset the CMS and allow another 7 minutes of run time. At the end of 14 minutes of operation the system should be purged of any moisture trapped during the filter change.

q. Check air purity. The CMS and CO monitor provide online indication of air impurities. The CMS is a GO/NO GO type of devise that does not indicate moisture content but allows the machine to run as long as moisture content does not exceed preset limits. If the green light on the CMS is lit, the moisture content is satisfactory. The CO monitor however, provides a readout of the CO in ppm. If the CO content reaches 10 ppm the CO monitor will shut the machine down and an alarm will sound.

A precise, quantitative, evaluation of the impurities in the compressor discharge air must be made with sophisticated laboratory instruments. Air samples taken under carefully controlled conditions should be forwarded to a qualified laboratory for analysis. Section 14 contains a detailed procedure for air sampling. The frequency of air sampling and analysis will be determined by the user to satisfy applicable regulations.

3.5 INHIBITION FOR STORAGE

3.5.1 FOR SHORT TERM STORAGE (UP TO SIX MONTHS)

Start compressor with auto condensate drains open and run for five minutes to expel all condensate from cylinders and coolers. Piping from separators to drain valves must be disconnected to perform this operation.

Stop compressor, isolate from power supply, and drain off sump oil. Remove all valve assemblies from cylinders, clean and spray with approved heavy duty preservative and allow surplus to drain off.

With valve assemblies still removed, spray bores with approved heavy duty preservative, turning compressor by hand to distribute fluid all over surfaces.

Replace valves, close all openings with plastic plugs or masking tape. Attach label with date of inhibition and warning "Do Not Rotate".

3.5.2 FOR LONG TERM STORAGE (UP TO TWO YEARS)

Start compressor with auto condensate drains open and run for five minutes to expel all condensate from cylinders and coolers.

Stop and isolate compressor, drain oil from sump while warm and refill sump with approved heavy duty preservative. Restart compressor and run with drains open for five minutes to distribute fluid over all internal surfaces. Stop and isolate compressor, drain approved heavy duty preservative from sump.

Remove all valve assemblies from cylinders, clean and spray valves with approved heavy duty preservative and allow surplus to drain off.

With valve assemblies still removed, spray bores with approved heavy duty preservative, rotating compressor slowly by hand to distribute fluid over cylinder surfaces.

Replace valve assemblies, seal all openings with plastic plugs or masking tape. Attach labels with date of inhibition and warning "Do Not Rotate".

3.6 START-UP PROCEDURE AFTER INHIBITION

If compressor has been idle for six months or more, remove oil pump bearing cover and lubricate the bearing before starting up. Insure final stage piston is well lubricated with recommended oil .

Before starting:

Ensure all plastic plugs and masking tape covering ports are removed.

Ensure crankcase is filled to the proper level by the oil level indicator with recommended oil. Do not overfill - over lubrication is harmful.

Remove valve heads and examine cylinders. Add small quantity of oil to upper cylinder and rotate compressor by hand to spread oil over cylinder walls.

Prior to start-up, rotate compressor once or twice by hand to ensure free movement.

4.0 LUBRICATION

CAUTION: THE MAKO SPECIFIED LUBRICANT MUST BE USED AT ALL TIMES TO ENSURE SAFE AND EFFICIENT OPERATION WITH MINIMUM WEAR AND MAXIMUM PROTECTION AGAINST CORROSION.

In order to maintain clean, adequate quantity of oil in the machine it is very important for the operator to know:

a. The location of the oil level sight glass on four stage models
b. The location of the oil filter cartridge
c. The location of the oil drain plug, and
d. The location of the oil fill port . . .
e. Location of the dipstick on the three stage models.

4.1 FOUR STAGE MACHINE LUBRICATION

A cam operated forced feed oil pump pressurizes the lubrication system for the final stage and delivers lubricant via an oil pressure regulator to the fourth stage cylinder plunger. Surplus lubricant is returned from the regulator to the crankcase sump. First, second and third stage cylinders, main, and big and small end connecting rod bearings are all oil mist lubricated. Lubricant returns to the sump for recirculation and filtration (see Figure 4-1). When the oil level is maintained within prescribed limits a MAKO compressor will function without mechanical damage at inclination angles as shown in Section 17. An optional monitoring system shuts down the compressor when inclination limits are exceeded.

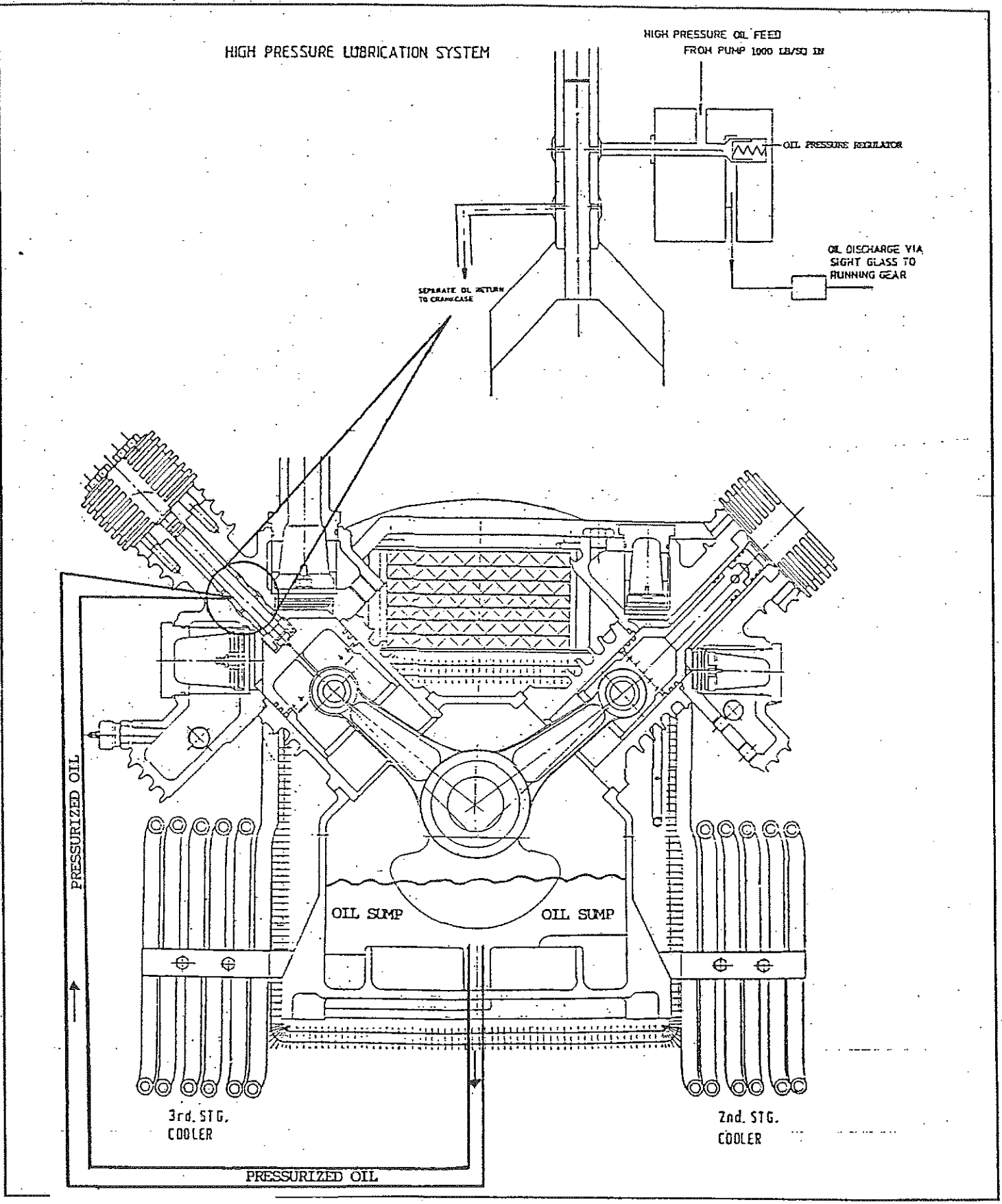


FIGURE 4-1 OIL FLOW

4.2 OIL PRESSURE STABILIZATION

Oil pressure fluctuations over 150 PSI around the nominal (1000 PSIG on four stage machines) are caused by air entrainment or debris in the regulator valve seat.

Both conditions can be corrected by flushing the oil regulator valve. This is accomplished as follows:

a. With the machine running loosen the lock nut shown in Figure 9-4.

b. Turn oil pressure adjustment screw counter clockwise to open regulating needle valve.

c. Leave the valve open for six to eight seconds.

d. Turn oil pressure adjusting screw clockwise until oil pressure reaches 1000 PSIG.

e. Reset the lock nut to hold the screw position.

WARNING: **DO NOT RUN THE COMPRESSOR MORE THAN 8 SECONDS AT A PRESSURE BELOW 750 PSIG.**

f. Repeat steps 4 and 5 as necessary to reach the nominal oil pressure level of 1000 PSIG ± 50 PSIG.

4.3 OIL LUBRICATION FOR 5409H AND 5409I BLOCKS ONLY

The lubrication system on the 5409H and 5409I compressors is a low pressure system. There is no oil pressure regulator. The normal operating pressure will be approximately 20 PSIG.

NOTE: **IT IS NOT A PROBLEM WHEN THE PRESSURE DROPS AS LOW AS 2 PSI.**

The restrictor located before the filter in the oil filter housing needs to be checked if the oil pressure suddenly increases above 40 PSIG. The oil pressure will indicate when the oil filter should be changed when a pressure of 80 PSIG is reached (with the compressor warmed up).

After each oil change, fill the oil filter housing with oil and while the compressor is running, loosen the line at the oil pressure gauge to vent the air from the system. This procedure may require several applications.

4.4 THREE STAGE MACHINE LUBRICATION

The three stage machines are splash lubricated.

4.5 LUBRICATION

The use of the correct oil is important for proper operation. Only the following oils are considered suitable for Mako compressors:

- Mako "S" Synthetic Oil for ambient operating temperatures between 32 deg F to 113 deg F.

- Mako "W" Synthetic Oil for ambient operating temperatures between 14 deg F to 59 deg F.

CAUTION: THERE ARE SOME MATERIAL, E.G. CERTAIN RUBBERS, PAINTS, PLASTICS AND METALS, WHICH ARE NOT COMPATIBLE WITH SYNTHETIC OILS. COMPONENTS ON MAKO COMPRESSORS ARE COMPATIBLE WITH SYNTHETIC OIL BUT A PROBLEM MAY EXIST WITH ANCILLARY EQUIPMENT. CONSULT EQUIPMENT MANUFACTURER TO DETERMINE COMPATIBILITY.

5.0 PURIFICATION SYSTEM

The last stage separator is considered the first step in preparing compressed atmospheric air for breathing. Air leaving the separator is saturated with moisture, contains a small amount of oil and may contain trace amounts of other undesirable gases and/or vapors. Although the air issuing from the separator is saturated, the actual quantity of water remaining has been greatly reduced as the air is compressed, cooled and mechanically separated from excess moisture. Excess moisture occurs when a given quantity of air with a given quantity of moisture is reduced in volume by compression beyond the point where all of said moisture will exist in vapor form. The maximum quantity of moisture that can exist in vapor form in the given space is a function only of the temperature of moisture. When maximum conditions prevail, the space is considered saturated. When air is also present, the air is said to be "saturated'. Further reduction of the space that a given amount of water vapor occupies beyond saturation (by compression) causes the part of the vapor to condense into liquid water. If the fluid is in motion, as in the moisture laden air stream flowing through a compressor, the liquid typically remains in small particles and is carried until it is separated from the gaseous air and the saturated state. Most of the liquid water particles are separated from the air stream in a Mako compressor by the centrifugal action established in the separators. Separation occurs when the heavier water particles drift to the outside separator chamber walls, as the air/vapor mixture swirls through the separator.

5.1 PURIFICATION SYSTEM SIZE

The Mako compressor can be equipped with one, two or three full length purification cylinders or a combination of full length cylinders and the shorter length cylinders.

A single short purification cylinder (MK-1-C) provides the capability to process approximately 9,800 cubic feet of air before the cartridge must be changed. Mako PC1801 cartridges must be used exclusively when only one cylinder is used. These cartridges contain a catalyst for converting any CO to CO_2 that might be present and charcoal to remove odors as well as a molecular sieve to remove moisture.

A single full length purification cylinder (MK-2-C) provides the capability to process approximately 24,000 cubic feet of air before the cartridge must be changed. Mako PD1803 cartridges must be used exclusively when only one cylinder is being used. These cartridges contain a catalyst for converting any CO to CO_2 that might be present and charcoal to remove odors as well as a molecular sieve to remove moisture.

A single full length cylinder and a single short cylinder purification configuration (MK-4-C) provides the capability to process approximately 43,000 cubic feet of air. The two cylinders are piped in series. The last cylinder in the flow path uses a PC1801 purification cartridge just as the single cylinder configuration. The first cylinder uses a cartridge that contains only molecular sieve.

A two full length cylinder purification configuration (MK-5-C) provides the capability to process approximately 57,400 cubic feet of air. The two cylinders are piped in series. The last cylinder in the flow path uses a PD1803 purification cartridge just as the single cylinder configuration. The first cylinder uses a PD 1503 cartridge that contains only molecular sieve. Adding the second cylinder simply increases the quantity of air that can be processed by the system before cartridge replacement.

A two full length cylinder and a single short cylinder purification configuration (MK-8-C) provides the capability to process approximately 83,000 cubic feet of air. The three cylinders are piped in series. As in the two cylinder configuration the third cylinder simply adds more moisture absorption capacity and extends the time between cartridge replacements.

A three full length cylinder purification configuration (MK-10-C) provides the capability to process approximately 120,000 cubic feet of air. The three cylinders are piped in series. As in the two cylinder configuration, the third cylinder simply adds more moisture absorption capacity and extends the time between cartridge replacements.

Figures 5-1 and 5-2 show the purification system options.

APPROXIMATE CARTRIDGE SERVICE LIFE *
Operational Hours Between Cartridge Changes

MODEL	MK1C	MK2C	MK4C	MK5C	MK8C	MK10C	MK420C
CF PROCESSED	9,800	24,000	43,000	57,400	83,000	120,000	300,000
COMPRESSOR:							
9200/5404BA/AC04/ BAM04/BAC04	28	68	123	164			
9300/5405BA/AC05/ BAM05/BAC05	19	46	83	111			
AC05X/5405XBA	14	36	64	86			
9400/5406BA/ BAM06/BAC06	12	30	55	73	106	153	
5406HBA/BAM06H/ BAC06H	11	28	51	68	98	142	
9500/5407BA/ BAM07/BAC07		21	38	51	73	106	267
5407HBA/BAM07H/ BAC07H		19	34	46	66	96	241
9600/5408BA/ BAM08/BAC08			28	37	54	79	197
5408HBA/BAM08H/ BAC08H			26	35	51	74	185
9700/5409BA/ BAM09/BAC09			23	31	45	65	163
5409HBA/BAM09H/ BAC09H			21	28	41	60	150
5415BA						62	156
5417BA						45	113
5436BA							59
5436HBA							59

* Assumptions:
(1) Delivery Pressure 5000 PSIG
(2) Process Temperature 80°F (Higher Temperature and Lower Pressure Reduces Cartridge Life)
(3) Atmospheric Dew Point -55°F Delivered Air

NOTE: PURIFICATION CARTRIDGES MUST BE CHANGED AT THEIR MAXIMUM CALCULATED HOUR LIFE OR EVERY SIX MONTHS, WHICHEVER COMES FIRST. CARTRIDGES HAVE A ONE YEAR SHELF LIFE FROM DATE OF MANUFACTURE.

REPLACEMENT CARTRIDGES CHEMICAL AND PROCESS ANALYSIS

	REMOVES					CHEMICAL				
CARTRIDGE PART NUMBER	WATER	OIL VAPOR	TASTE	ODOR	NOXIOUS GASES	CARBON MONOXIDE	ACTIVATED CARBON	MOLEC SEVE 13X	CATALYST	MAX. OPER. TEMP.
PC1801	X	X	X	X	X	X	X	X	X	150°F
PD1503	X	X						X		200°F
PD1803	X	X	X	X	X	X	X	X	X	150°F

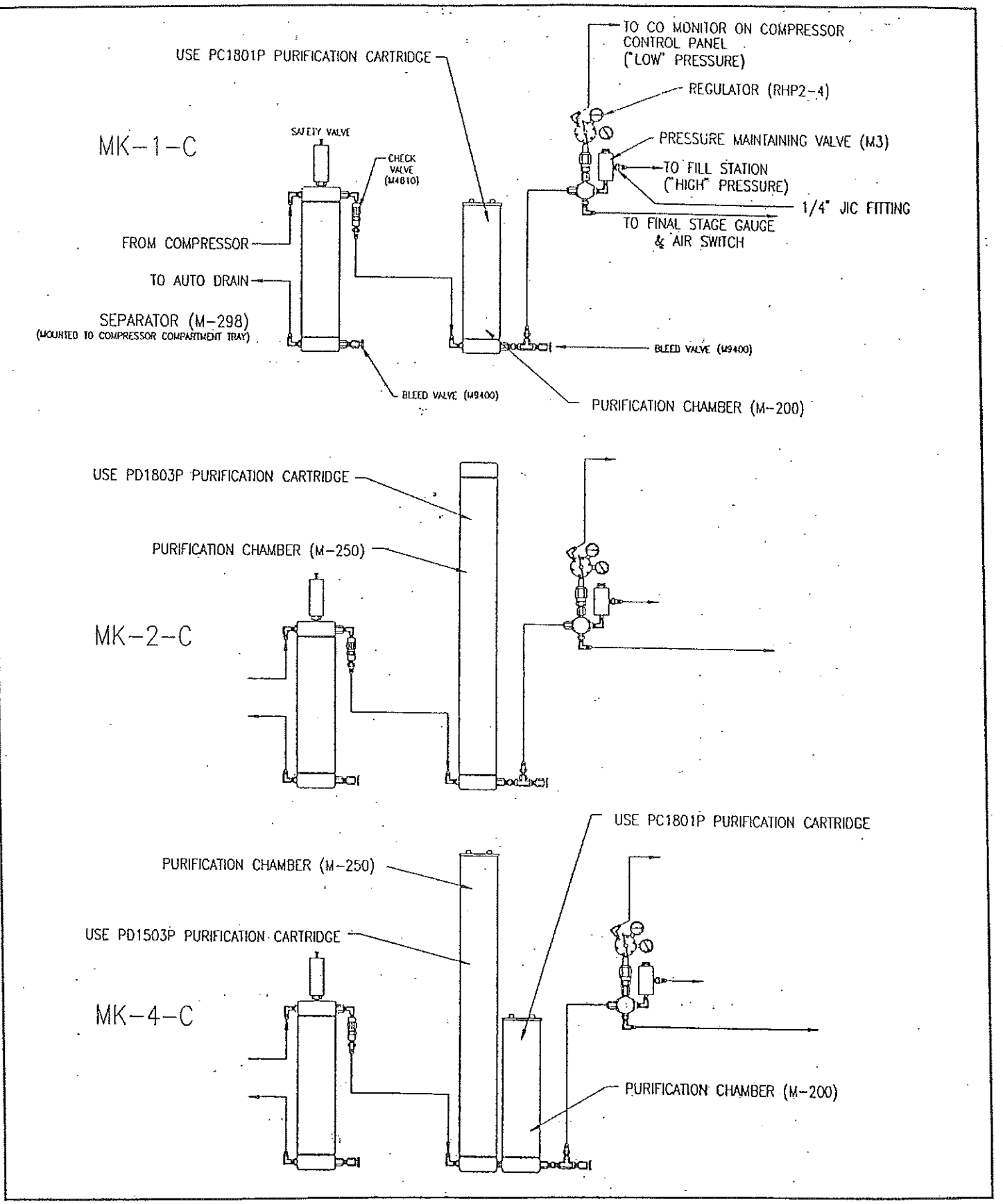


FIGURE 5-1 PURIFICATION SYSTEM OPTIONS (PAGE 1)

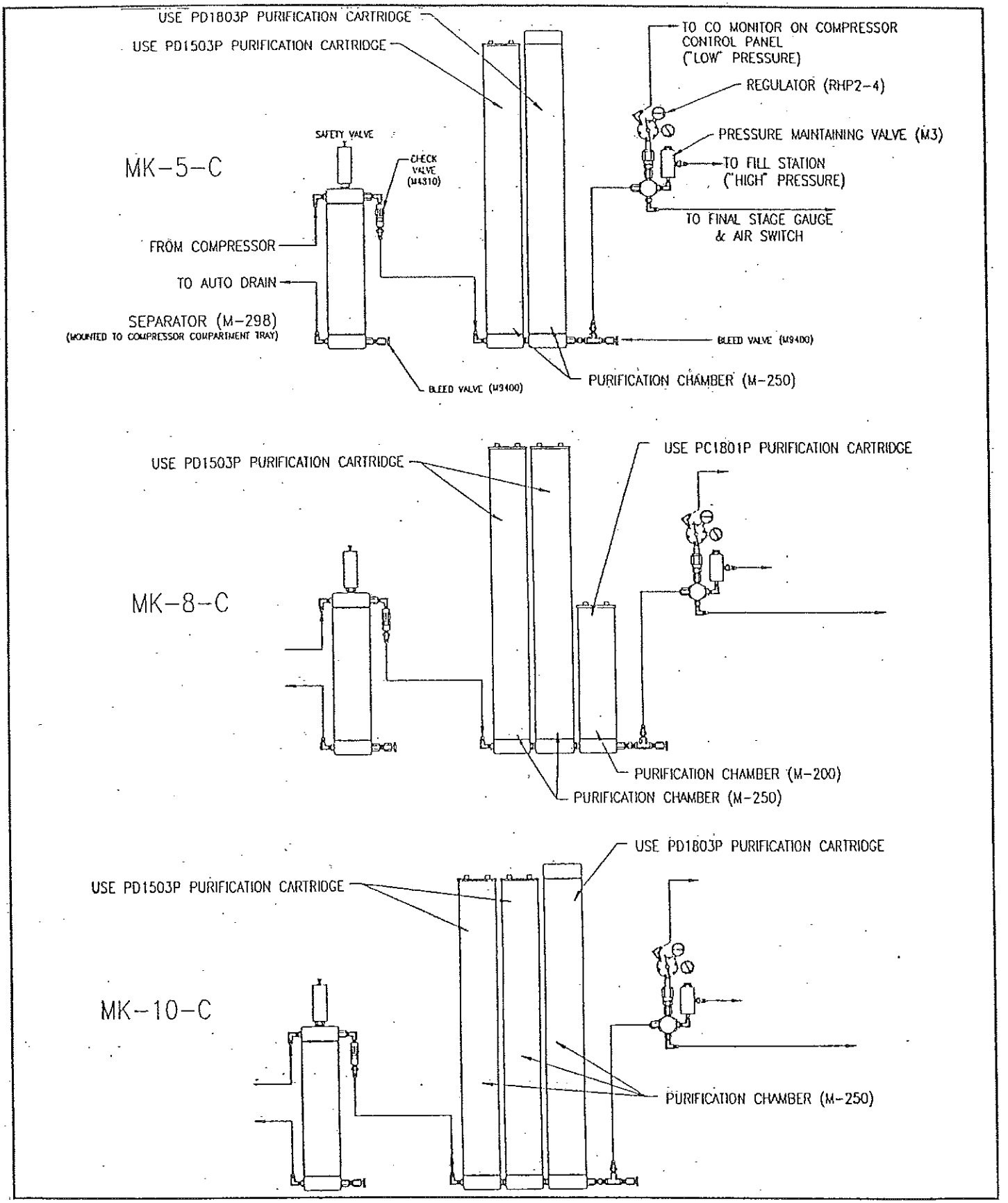


FIGURE 5-2 PURIFICATION SYSTEM OPTIONS (PAGE 2)

5.2 FILTER CARTRIDGE REPLACEMENT

Adherence to the following procedure for filter cartridge replacement will ensure that water trapped in air passages between the filter chambers and in other passages will be eliminated. Water in these passages reduces new filter life and could ultimately be transported into the SCBA/SCUBA bottles being filled. The following procedure is written for a MK-5-C purification system. Modify the procedure, as necessary, to fit the purification system installed on a particular machine.

1. Turn compressor "OFF".

2. Depressurize the system by slowly opening bleed valve (1) on the discharge of the purification system (see Figure 5-3).

CAUTION: **LEAVE BLEED VALVE (1) OPEN UNTIL STEP 23.**

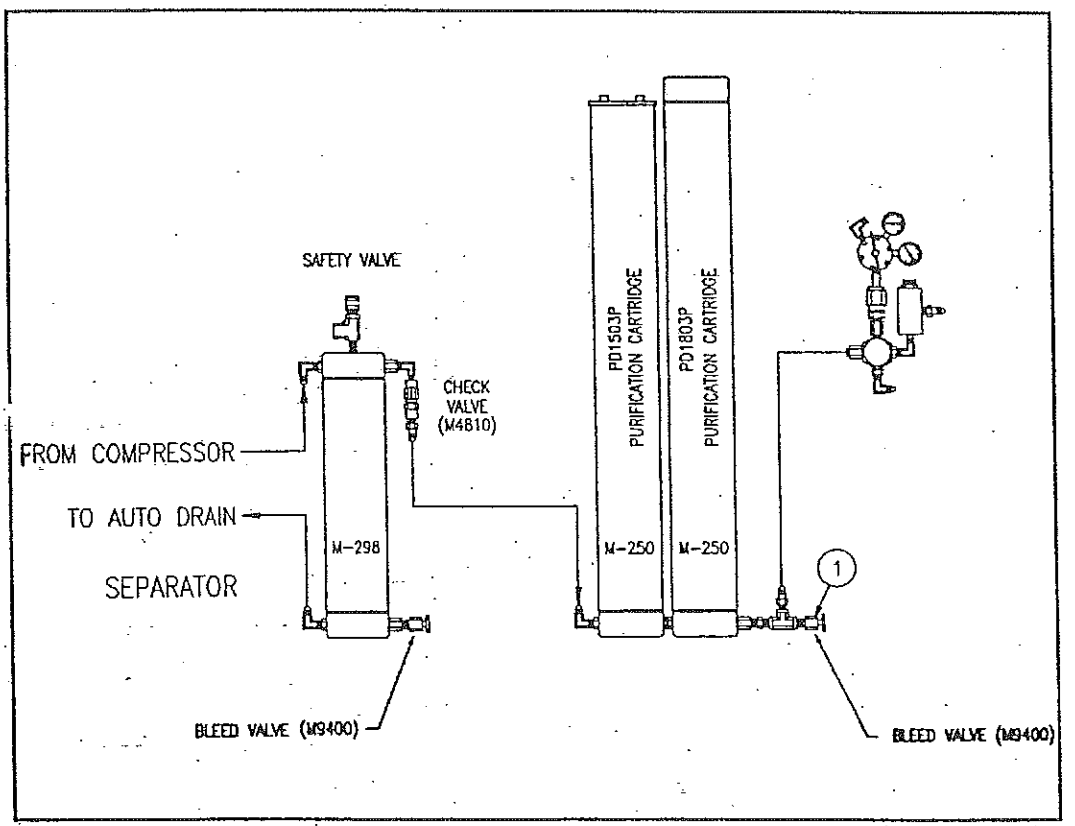


FIGURE 5-3 PURIFICATION SYSTEM COMPONENTS

3. Check the final stage pressure on the compressor panel to make sure that the purification system is depressurized.

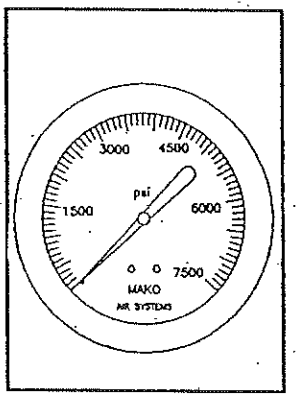


FIGURE 5-4 FINAL STAGE PRESSURE GAUGE

4. Slowly remove top plug(s) (2) and (3) from the purification system chamber (s) (see Figure 5-5).

CAUTION: YOU SHOULD BE ABLE TO TURN THE PLUG WITH MODERATE PRESSURE. IF MORE FORCE IS REQUIRED - STOP. RECHECK DRAIN AND GAUGE TO MAKE CERTAIN THAT CHAMBER IS NOT STILL PRESSURIZED. THE DRAIN VALVE (1) REMAINS OPEN UNTIL STEP 23.

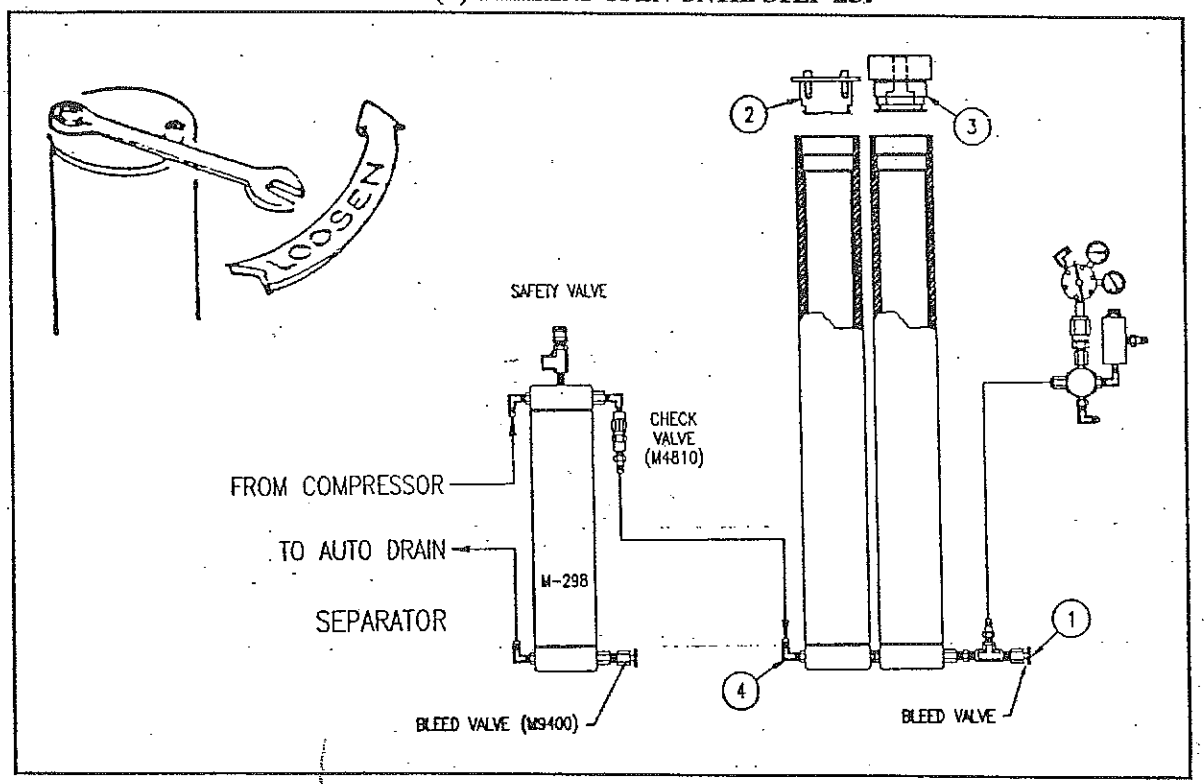


FIGURE 5-5 PURIFICATION CHAMBER PLUG REMOVAL

5. Remove line at fitting (4) (see Figure 5-5). Any water up stream of the first filter chamber will drain out.

6. Remove all old filters (5) & (6) from all chambers (see Figure 5-6).

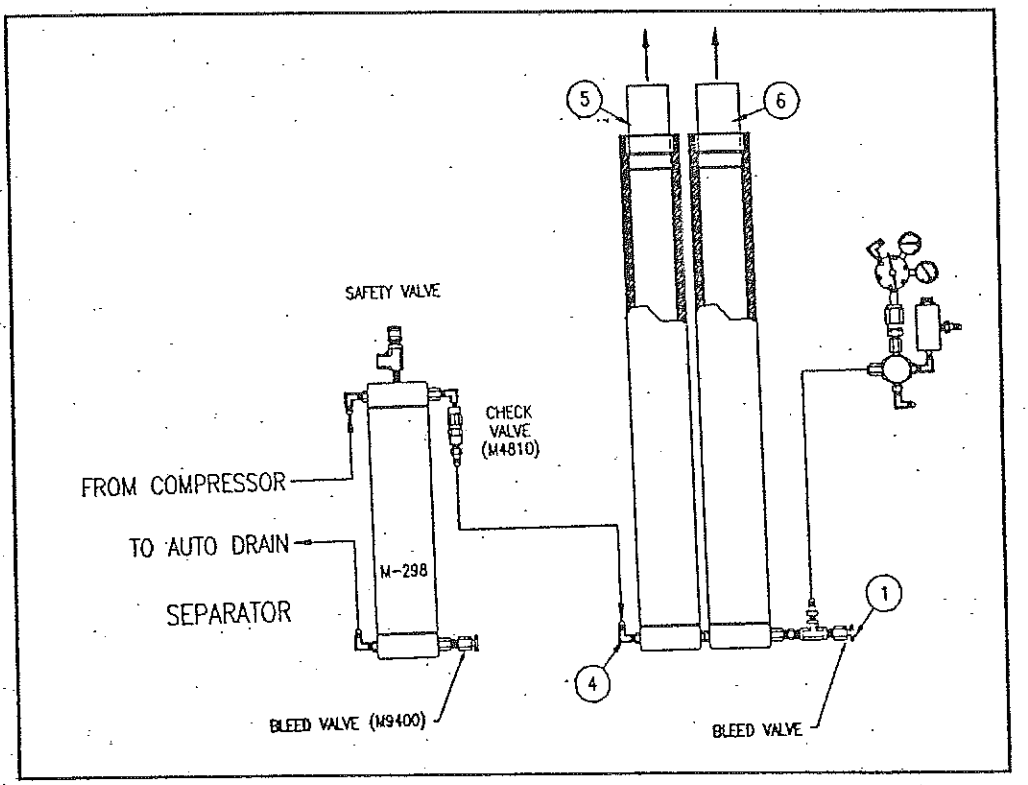


FIGURE 5-6 FILTER REMOVAL

7. Inspect chambers.

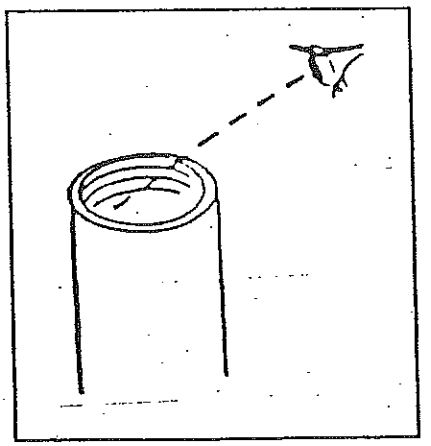


FIGURE 5-7 PURIFICATION CHAMBER INSPECTION

CAUTION: REPLACE CHAMBER IF CORROSION IS FOUND.

8. Soak up any water in the bottom of the chambers (7) (8) using clean, dry rags (see Figure 5-8).

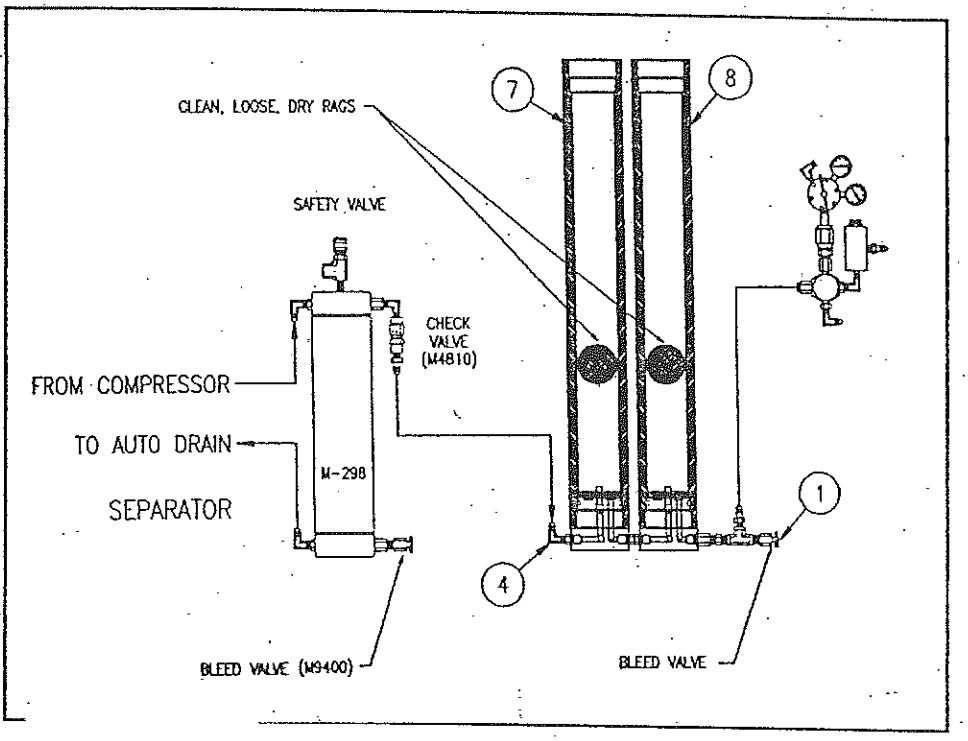


FIGURE 5-8 CHAMBER DRYING

If oily substances are found; disassemble entire chamber and wash all parts in hot, soapy water. Rinse thoroughly and blow dry. Reassemble and continue procedure.

9. Reconnect the line at fitting (4) (see Figure 5-8).

10. Form a loose "wad" of clean, dry rags and push them in the first chamber (7) as shown in Figure 5-9.

NOTE: RAGS MUST BE LOOSE ENOUGH TO ALLOW AIR TO ESCAPE AROUND THEM. HOLD THE RAGS IN PLACE WITH A ROD OR STICK.

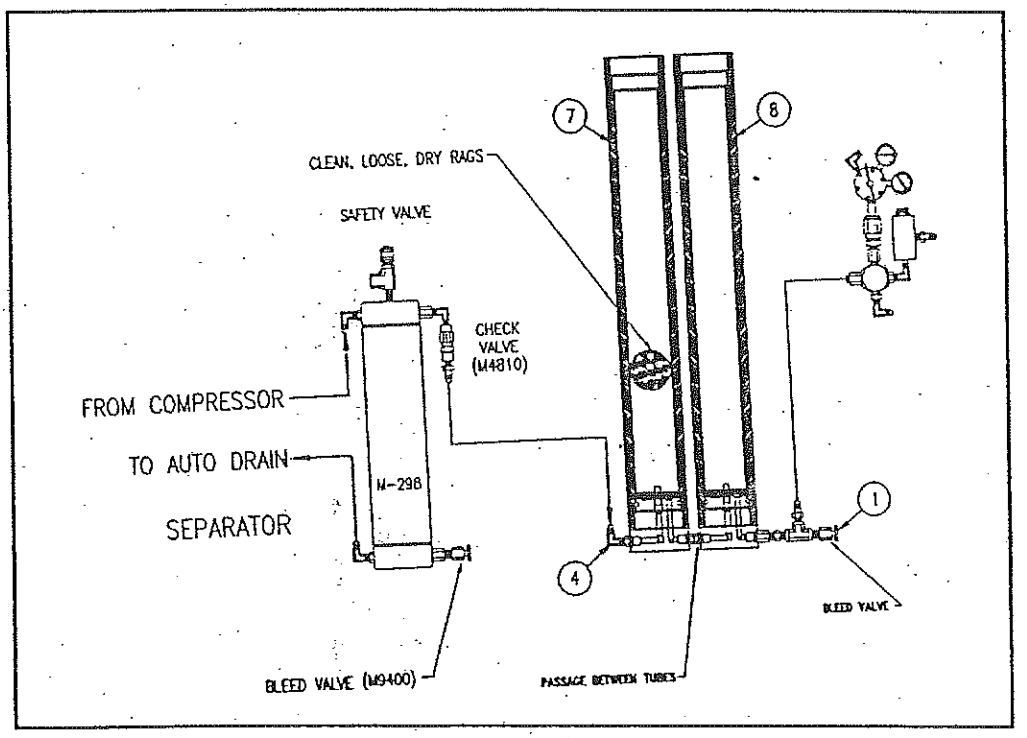


FIGURE 5-9 DRYING TECHNIQUE

11. Turn on compressor for a brief period (8 seconds) to blow water out of passage ways between purification chambers.

12. Dry the water forced into the second chamber (8) using clean, dry rags.

13. Install a new filter cartridge, PD1503P, (9) in the first chamber (7) (see Figure 5-10)

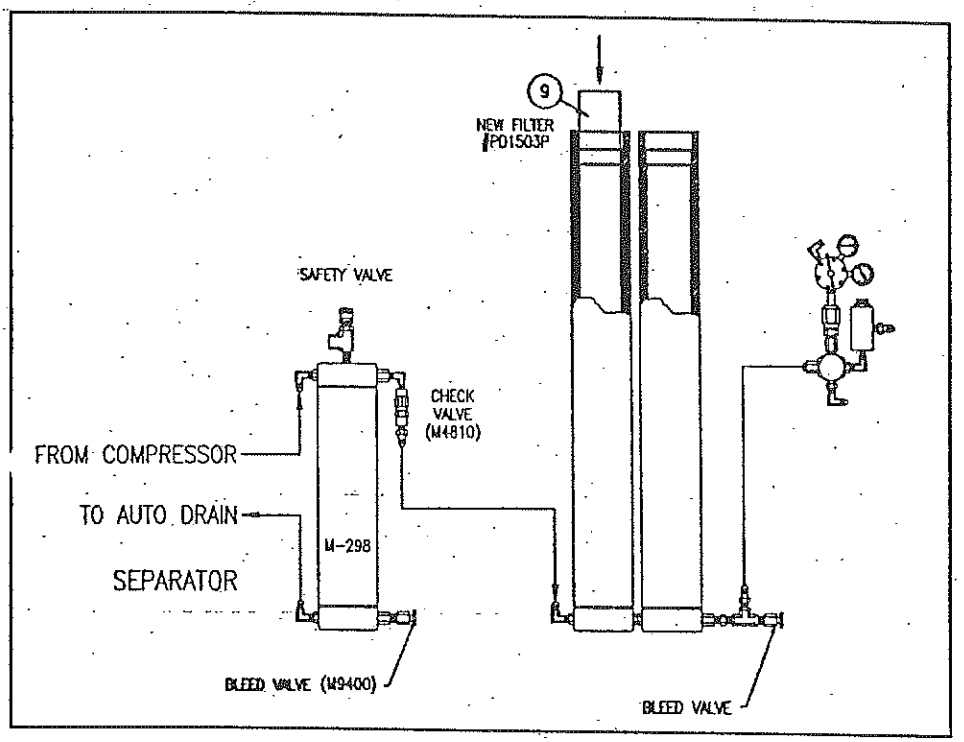


FIGURE 5-10 FILTER CARTRIDGE INSTALLATION

CAUTION: HANDLE FILTER CARTRIDGE VERY CAREFULLY. DO NOT TOUCH NEW CARTRIDGE WITH BARE SKIN. OIL FROM SKIN WILL AFFECT THE PERFORMANCE OF THE SYSTEM.

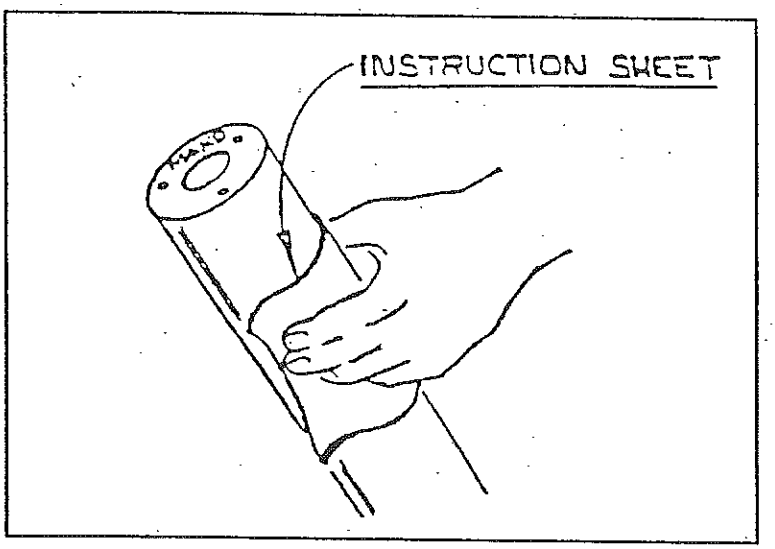


FIGURE 5-11 NEW CARTRIDGE HANDLING

a. Remove seal from cartridge top and remove protective plastic plug from cartridge bottom.

b. Lower cartridge into chamber. It will slide over the mating tube in the bottom of the chamber. This should require only slight pressure.

Caution: **Do Not Use Excessive Pressure. If Cartridge Does Not Fully Slide Down, Remove It And Check For Problems.**

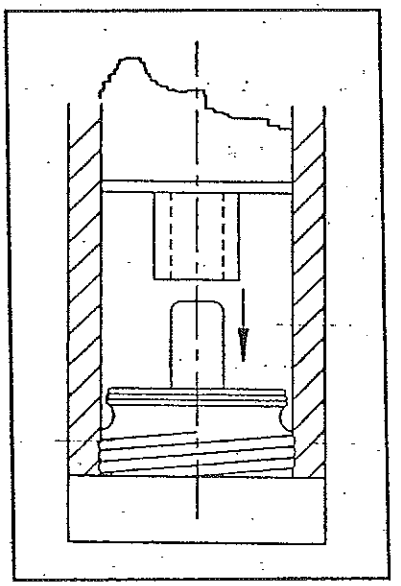


FIGURE 5-12 SEATING NEW PURIFICATION CARTRIDGE

c. Lubricate the top plug O-rings with Dow Corning Type III silicone grease.

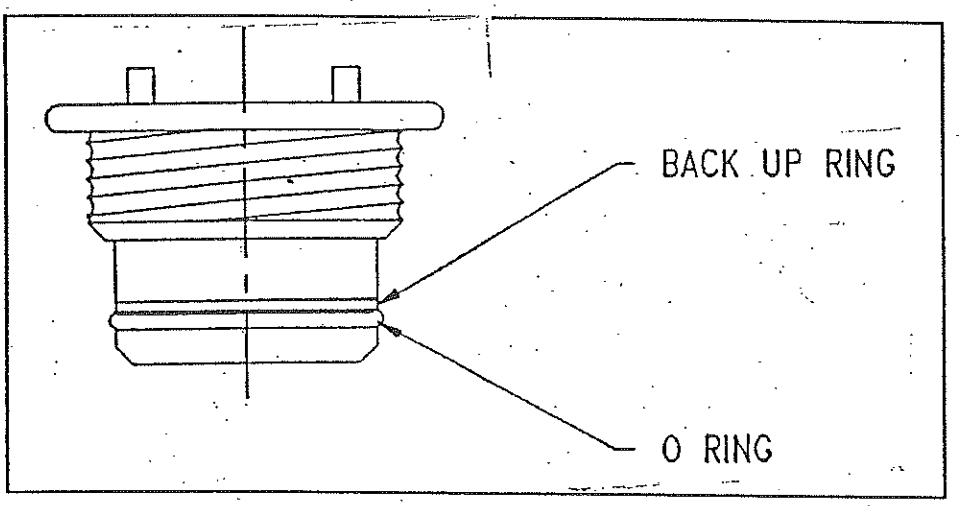


FIGURE 5-13 TOP PLUG "O"-RING AND THREAD LUBRICATION

d. Apply a small amount of silicone grease to the top plug threads.

NOTE: IF BOTTOM PLUG WAS REMOVED FOR CLEANING, IT SHOULD BE PREPARED IN THIS SAME MANNER.

14. Install the top plug (2) on the first chamber (7) (see Figure 5-14). Tighten plug until dust cover hits, then back out 1/8 turn. If binding is encountered, check cartridge position and clean the threads.

CAUTION: DO NOT OVER TIGHTEN.

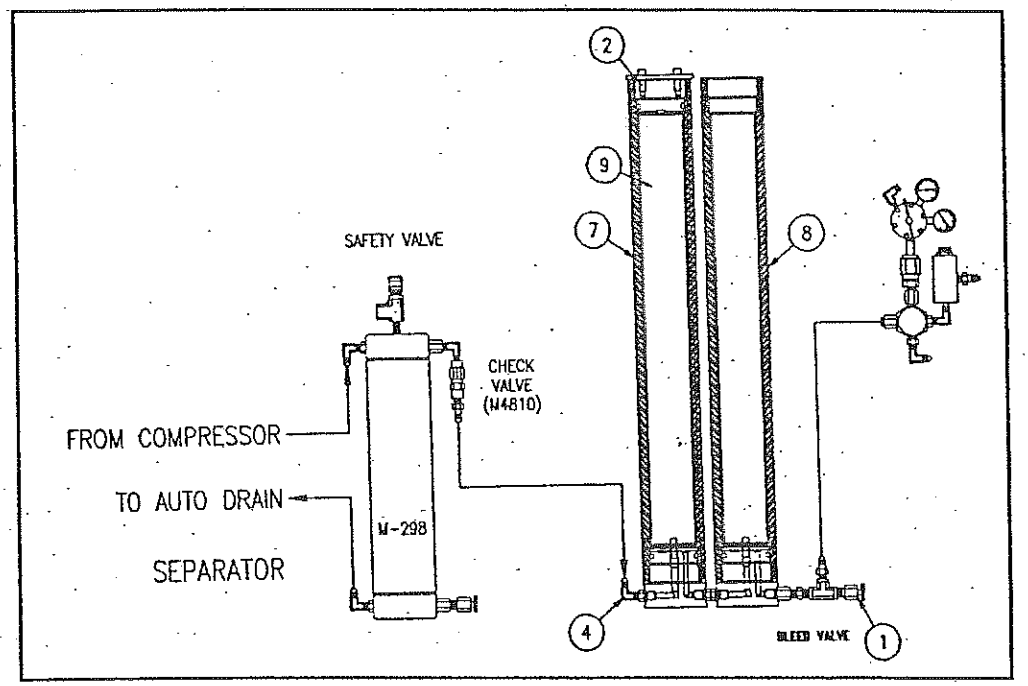


FIGURE 5-14 TOP PLUG REPLACEMENT

15. Make sure the bleed valve (1) is open (see Figure 5-14).

16. Form a loose "wad" of clean, dry rags and push them in the second chamber (8) as shown in Figure 5-15.

NOTE: RAGS MUST BE LOOSE ENOUGH TO ALLOW AIR TO ESCAPE AROUND THEM. HOLD THE RAGS IN PLACE WITH A ROD OR STICK.

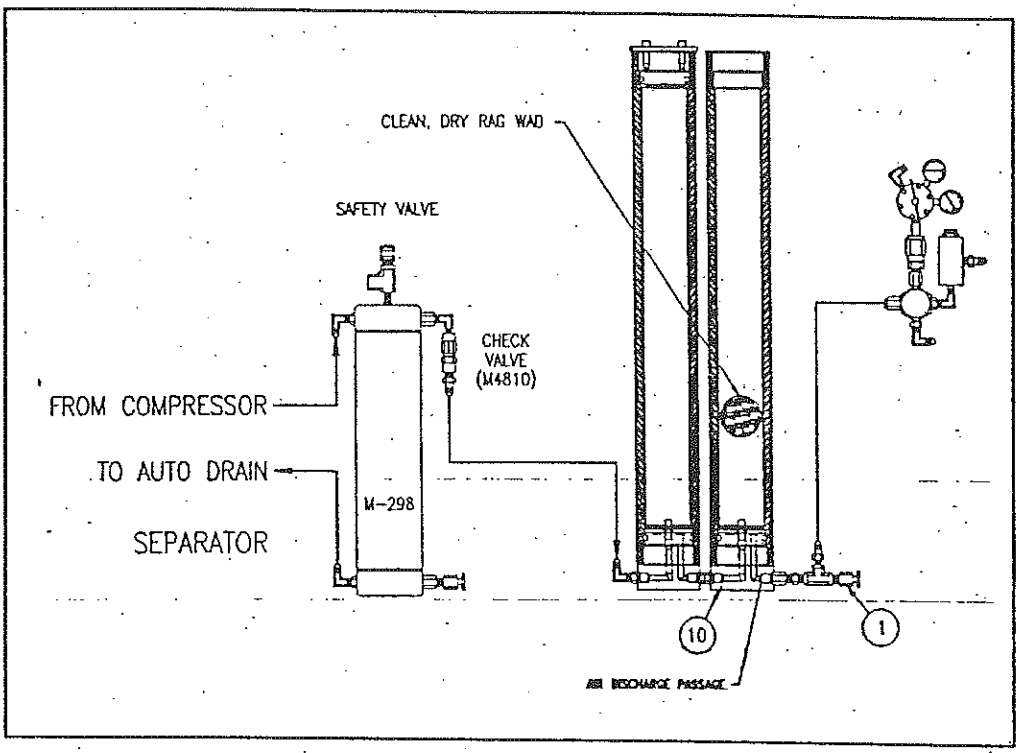


FIGURE 5-15 DRYING FINAL PASSAGEWAYS

17. Turn on compressor for a brief period of time (8 seconds) to blow water out of the passage ways from the bottom plug (1) on the las purification chamber to the bleed valve (1).

18. Soak up any water in the filter chamber using clean, dry rags. If oily substances are found; disassemble entire chamber and wash all parts in hot, soapy water. Rinse thoroughly and blow dry. Reassemble and continue procedure.

19. Install a new filter (24), PD1803P, in final chamber (8) (see Figure 5-16). Observe the precautions discussed in Step 13.

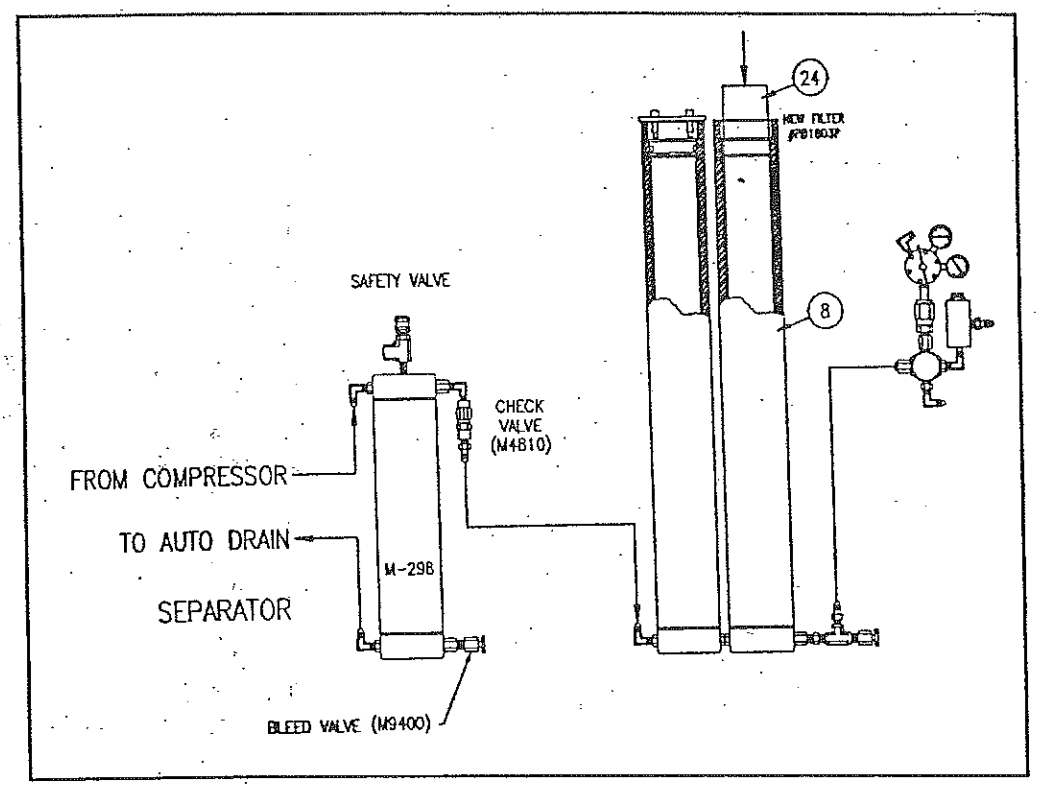


FIGURE 5-16 FINAL FILTER INSTALLATION

20. Install top plug (3) on filter tube (8) and reconnect cartridge monitor wires if optional CMS system is implemented (see Figure 5-17).

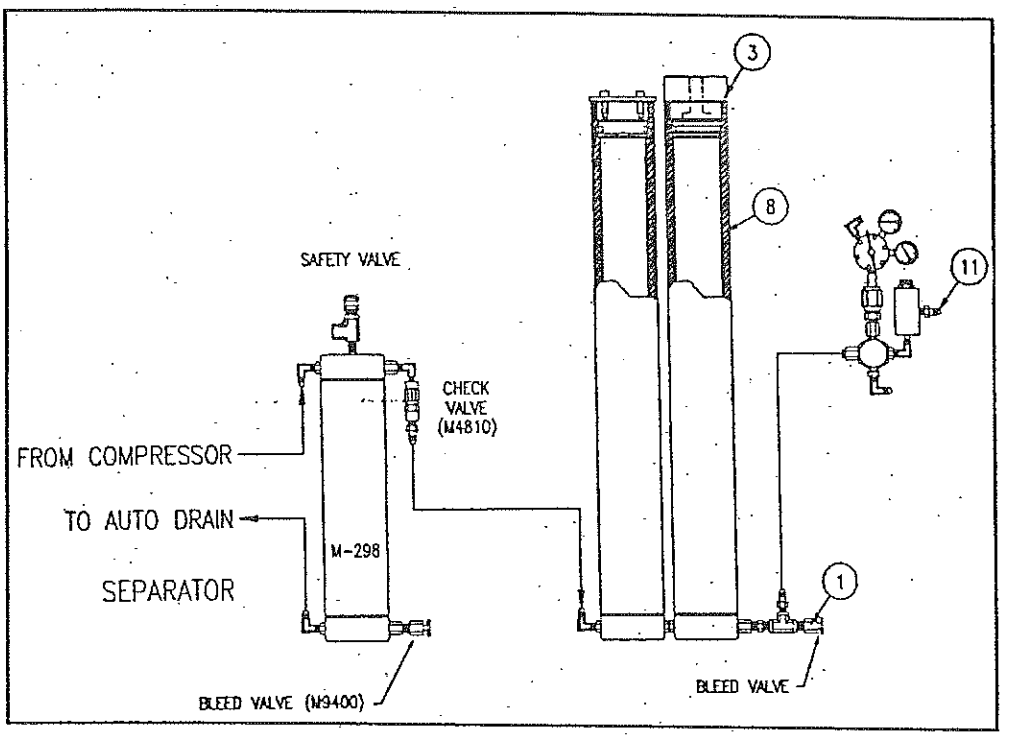


FIGURE 5-17 FINAL PURIFICATION CHAMBER TOP PLUG INSTALLATION

21. Remove line from Pressure Maintaining Valve (PMV) outlet (11).

22. Start and run the compressor for approximately 25 seconds with the bleed valve (1) open.

23. Close bleed valve (1).

24. Run compressor for 15 to 20 minutes.

25. Shut down compressor.

26. If an air test is planned, go directly to Step 1 in the air testing procedure. If not, reconnect the line to the discharge of the PMV valve (11).

WARNING: MAINTAIN 1500 PSIG MINIMUM ON THE PURIFICATION SYSTEM. RUN MACHINE TO ESTABLISH THIS PRESSURE BEFORE COMPLETING TEST AND/OR MAINTENANCE WORK.

5.3 CO/MOISTURE INDICATOR INSTALLATION

The litmus paper ring and the CO button in the CO/Moisture indicator have to be installed before the compressor is run. It is not factory installed because of contamination from ambient air during shipping.

CAUTION: DO NOT OPEN SEALED PACKAGE UNIT READY TO INSTALL; OTHERWISE, CONTAMINATION WILL RESULT.

WARNING: ALL PRESSURE MUST BE OFF THE SYSTEM BEFORE INSTALLING THE INDICATOR.

5.3.1 INLINE TYPE

CO/Moisture indicator installation is accomplished as follows:

a. Remove large nut.

b. Remove small plug from back of monitor.

c. Push window out with thin instrument (pipe cleaner, paper clip, etc.).

d. Reinstall small plug.

e. Check "O"-ring.

f. Open sealed package.

g. Install paper ring first.

h. Install button over center of ring.

i. If window is dirty, wash it with soapy water and blow dry. Be careful not to let foreign matter into system.

j. Reinstall window.

k. Reinstall large nut and tighten firmly.

5.3.2 TOP PLUG TYPE

NOTE: TO CHECK INDICATOR WHILE RUNNING COMPRESSOR, TOP SCREWS MUST BE REMOVED TO ACCESS DUST COVER. ALWAYS REINSTALL DUST COVER.

CO/Moisture indicator installation is accomplished as follows:

a. Unscrew top plug by locating wrench between top screws and apply torque.

b. Remove top screws and remove bottom of plug.

c. Remove snap ring on bottom of plug.

d. Remove screen.

e. Remove spring.

f. Remove CO washer.

g. Open sealed package. Install paper ring inside of CO washer (tight fit), then install button over center of ring.

h. Reinstall washer, ring and button assembly in plug.

i. Reinstall spring.

j. Reinstall screen.

k. Reinstall snap ring

l. Reinstall dust cover and top screws.

m. Reinstall plug.

THE MAKO SYSTEM

After compression, the air passes through the separator and enters the dryer section of the purification process. Within the dryer, long chain hydrocarbons, additional moisture and vapors are removed by a chemical. Further processing removes objectionable odors and taste prior to entering a catalyst bed that converts carbon monoxide (CO) to carbon dioxode (CO2). Carbon dioxide can be more readily removed from the system utilizing an adsorbant bed. However, if your needs require large quantities of conversion or large quantities of CO2 removal, a special chemical cartridge should be requested.
If you have special requirements for the removal of a specific gas or gases, we would be pleased to discuss the type of chemical to fill your requirement.

All compressed air purification system packages are complete with final air separators, dryers and purification as a standard part of the unit. However, the ability to purify more air per cartridge change may be required in special instances. Therefore, this booklet includes larger systems so that you may select a larger system than normally is supplied with your unit. If this is true, you can obtain the time between cartridge changes by dividing the output of your compressor in cubic feet into the purification capacity of the system you are contemplating. The formula for this is:

CFM* x 60 = CFH**

$$\frac{\text{cartridge capacity}}{\text{CFH}} = \text{cartridge life}$$

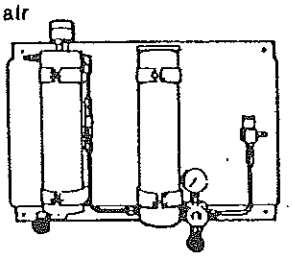
For example, cartridge life of the MK-2-C on a 5 CFM compressor is 80 hours:

$$\frac{24{,}000 \text{ CF}}{300 \text{ CFH}} = 80 \text{ hours}$$

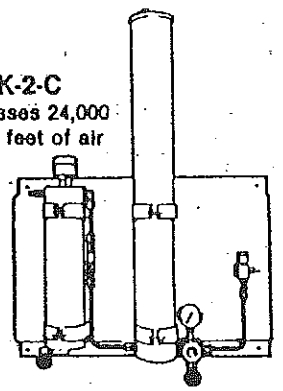
After the air system processing, the air is stored to furnish a higher CFM at the fill station.
Two storage systems are currently available: one for 3600 PSI and one for 5000 PSI.

* Cubic feet per minute
** Cubic feet per hour

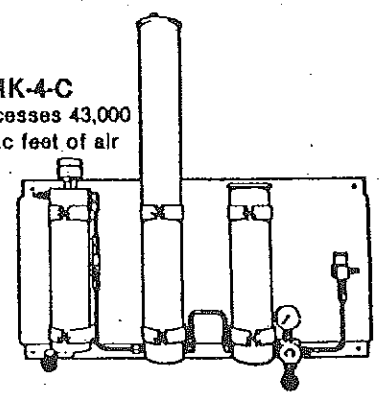
MK-1-C
Processes 9,800 cubic feet of air



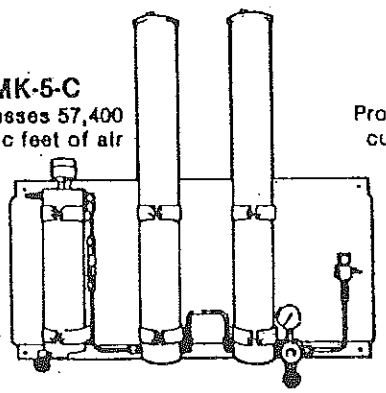
MK-2-C
Processes 24,000 cubic feet of air



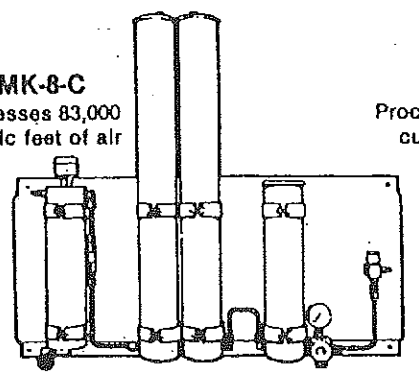
MK-4-C
Processes 43,000 cubic feet of air



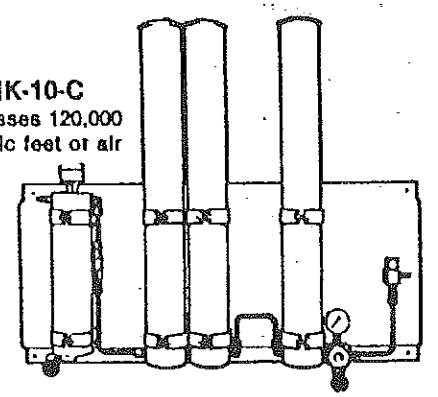
MK-5-C
Processes 57,400 cubic feet of air



MK-8-C
Processes 83,000 cubic feet of air



MK-10-C
Processes 120,000 cubic feet of air



AIR PURIFICATION

The air we breathe is a combination of gasses and is sometimes contaminated by foreign substances. Air purification (necessary when compressing air for breathing purposes) is even more important. In its cleanest form, air contains 11 different gasses, Nitrogen and Oxygen are critical to the human respiratory system. A typical sample of uncontaminated air will contain 78% Nitrogen and 21% Oxygen. The remaining nine gases represent approximately 1%.

The average person consumes, during a 24 hour period, approximately 26 cubic feet of oxygen. The weight of this oxygen is approximately equal to the weight of food consumed during the same period or about 2 1/2 lbs. In removing oxygen from inhaled air, over 500 cubic feet of air must be breathed to obtain the 26 cubic feet of oxygen.

When oxygen drops to about 16% (by volume) the individual is said to experience anoxia. Symptoms are blurred vision, mental confusion, and impaired muscular coordination. These symptoms intensify as the oxygen content is further reduced, and at about 11%, unconsciousness results. Prolonged exposure below 11% will cause death.

The oxygen content of compressed air for human respiration should be held within fairly narrow limits. A value of 21% provides adequate oxygen content for physiological needs and is the customary standard for breathing systems. Oxygen content above 25% sharply increases fire and health hazards for the user.

OPTIONAL PURIFICATION ACCESSORIES

AUTOMATIC CONDENSATE DRAIN

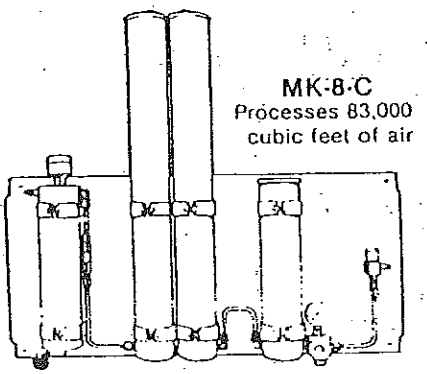
An electro-pneumatic device, that drains the moisture separators every 15 minutes automatically, without system decompression.

FINAL SEPARATOR

The M298 chamber contains a mechanical separator that filters down to 20 micron and is rated to 5000 PSI working pressure.

CARBON MONOXIDE MONITOR (Electronic)

An electronic monitor samples the airstream to determine the CO content. A light and a direct reading meter indicates from 0 to 50 parts per million. It will also shut down the machine upon reaching a preset contamination level.



MK-8-C
Processes 83,000 cubic feet of air

NOXIOUS GAS DETECTOR

The entire kit comes packaged in its own carrying case. Hand-held, this chemically activated unit is used to make periodic checks of the output air. Detects Carbon Dioxide (CO_2) and Carbon Monoxide (CO).

VISUAL MOISTURE / CO INDICATOR

A new addition to the Mako purification systems. A dual airstream indicator, detecting Carbon Monoxide content above .02% and relative humidity above 40%. Activation time is within 1 to 4 minutes and rejuvenation time is between 30 to 60 minutes in a pure air environment.

PRESSURE MAINTAINING VALVE (PMV)

Preset at the plant, this valve holds the air flow until it reaches a preset pressure to prevent decompression of the purification chambers.

AIR STANDARDS

To protect human life, limits have been established for breathing air quality. Air suitable for human respiration must meet minimum standards as established by various governing bodies, including the U.S. Navy, Compressed Gas Association, The Federal Government, and The State of California.

The standards cited on the following page are usually referred to as "Grade D", in reference to The Compressed Gas Association Table #1. These standards apply to compressed air for use in filling open circuit breathing systems.

All standards reviewed define minimum acceptable standards. An increase in any component is reason to reject that air as unsuitable for breathing purposes.

TOXIC EFFECTS ON THE HUMAN BODY

(Toxic symptoms developed by a stationary person exposed to Carbon Monoxide)

Concentration of CO in air	Inhilation time and toxic symptoms developed.
0.02% (200 ppm)	Slight headache within 1 -3 hours.
0.04% (400 ppm)	Frontal headache within 1 - 2 hours, becoming widespread in 2.5 to 3.5 hours.
0.08% (800 ppm)	Dizziness, nausea and convulsions within 45 minutes. Insensible within 2 hours.
0.16% (1.600 ppm)	Headache, dizziness and nausea within 20 minutes. Death within 2 hours.
0.32% (3.200 ppm)	Headache, dizziness and nausea within 5 - 10 minutes. Death within 30 minutes.
0.64% (6.400 ppm)	Headache, dizziness in 1 - 2 minutes. Death in 10 - 15 minutes.
1.28% (12.800 ppm)	Death in 1 - 3 minutes.

AIR PURITY REQUIREMENTS:

The contaminates can be grouped into two categories:

1. Those that ultimately cause a disease of lung tissue or damage to any part of the lungs.
2. Those which have no direct effect upon the lungs but pass into the bloodstream either impairing the oxygen carrying capacity of the red blood cells or being carried to other parts of the body with direct toxic effect upon other tissues.

COMPOSITION OF AIR

Component	% by Volume
Nitrogen	78.0840000
Oxygen	20.9476000
Argon	0.9340000
Carbon Dioxide	0.0314000
Neon	0.0018180
Helium	0.0005240
Methane	0.0002000
Kryton	0.0001140
Hydrogen	0.0000500
Nitrous Oxide	0.0000500
Xenon	0.0000087

AIR SPECIFICATIONS C.G.A. 7.1

Limiting Characteristics	TYPE I (GASEOUS)							
	A	B	C	D	E	F	G	H
% O_2 (v/v) Balance Predominantly N_2 (Note 1)	atm.	atm.	atm/ 19.5-23.5	atm/ 19.5-23.5	atm/ 19.5-23.5	atm/ 19.5-23.5	atm/ 19.5-23.5	atm/ 19.5-23.5
Water		none condensed (per 5.3.1)	note 2	note 2	note 2	note 2	note 2	note 2
Hydrocarbons (condensed) in Mg/m³ of gas at NTP (Note 3)		none (per 5.4.1)	5	5	5			
Carbon Monoxide			50	20	10	5	5	5
Odor			see 5.1.5	see 5.1.5.	see 5.1.5	see 5.1.5	see 5.1.5	see 5.1.5
Carbon Dioxide				1000	500	500	500	500
Gaseous Hydrocarbons (as methane)						25	15	10
Nitrogen Dioxide							2.5	0.5
Nitrous Oxide								
Sulfur Dioxide							2.5	0.5
Halogenated Solvents							10	1
Acetylene								
Permanent Particulates								

Note 1: The term "atm" (atmospheric) denotes the oxygen content normally present in atmospheric air; the numerical values denote the oxygen limits for synthesized air.

Note 2: The water content of compressed air required for any particular grade may vary with the intended use from saturated to very dry. If a specific water limit is required, it should be specified as a limiting dewpoint or concentration in ppm (v/v). Dewpoint is expressed in temperature °F at one atmosphere absolute pressure (760 mmHg). To convert dewpoint °F to °C, ppm (v/v), or mg/liter, see 7.1.

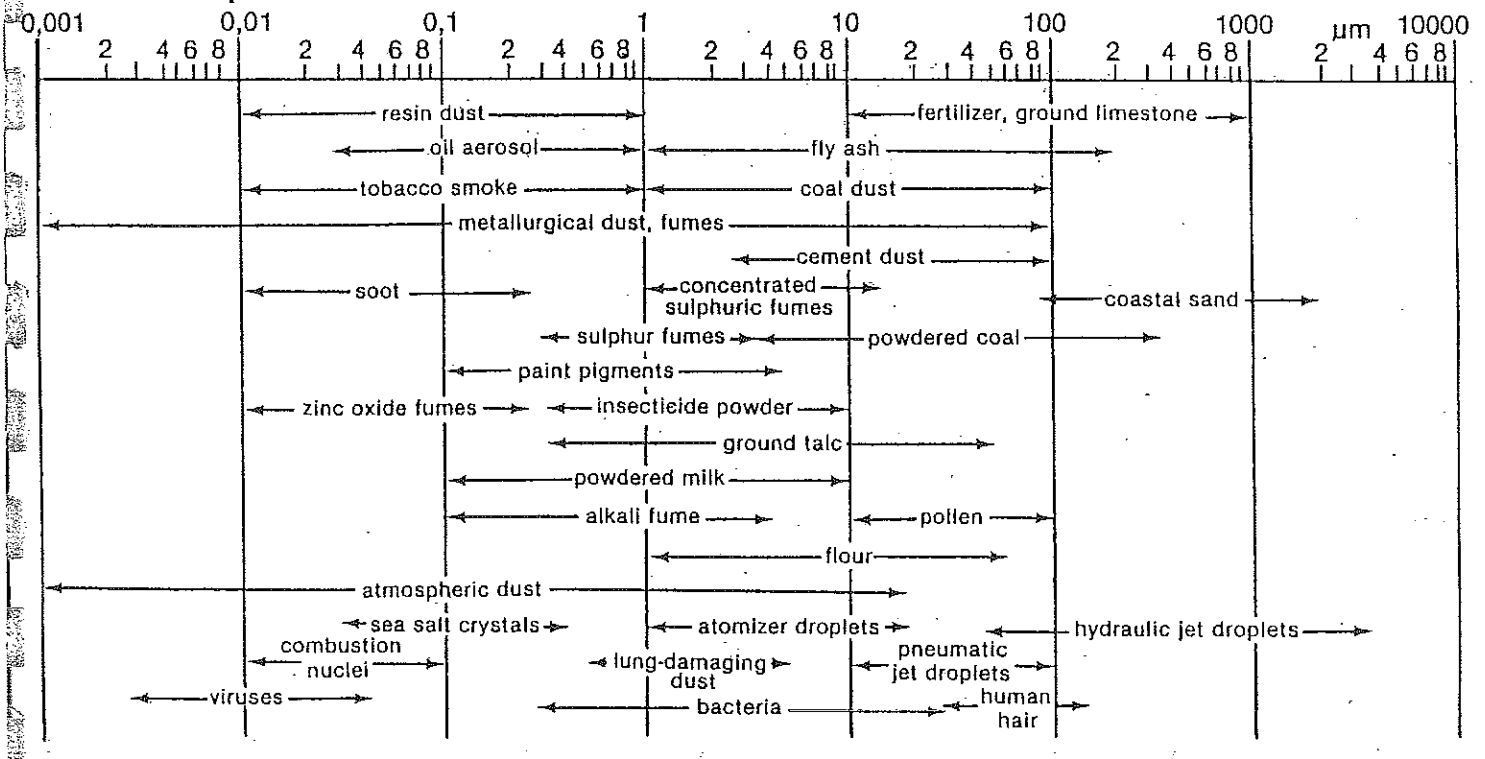
Note 3: No limits are given for condensed hydrocarbons beyond grade E since the gaseous hydrocarbon limits could not be met if condensed hydrocarbons were present.

WORLD AIR STANDARDS

COMPONENT	U.S. FEDERAL II-C	U.S. NAVY	OSHA	U.S. C.G.A.	CALIFORNIA	GERMANY 200	SWEDEN	ENGLAND	MAKO PURIFICATION SYSTEMS
Oxygen O_2	20-22%	20-22%	19-20%	19-23%	19-21%	20	STD's	BS 400 + Bart .2	note 1
Carbon Dioxide CO_2	0.10% Max. 500ppm	0.05% Max. 500ppm	1000 ppm	0.10% Max. 1000ppm	300 ppm	4000 ppm		500 ppm	Less than 200 ppm*
Carbon Monoxide CO	10ppm	20ppm	10ppm	20ppm	10ppm	80 ppm	30ppm	10ppm	un-detectable
Water H_2O	SAT.	SAT.	70 ppm	1 Mg/ M3	70 ppm	50 Mg/ M3	50 Mg/ M3	.5°c	SAT.
Dewpoint									-100°F
Oil Vapor Hydrocarbons	.005 Mg/L	5 Mg/M3		1 Mg/M3			5 Mg/M3	1 Mg/M3	Less than 1 Mg/M3
Noxious Gas									less than 1 ppm/w
Odors		NONE							NONE

note 1 Oxygen is not affected by MAKO systems. Content depends on air being processed. SAT. - Saturated *Cartridges can be supplied to lower or remove CO_2.

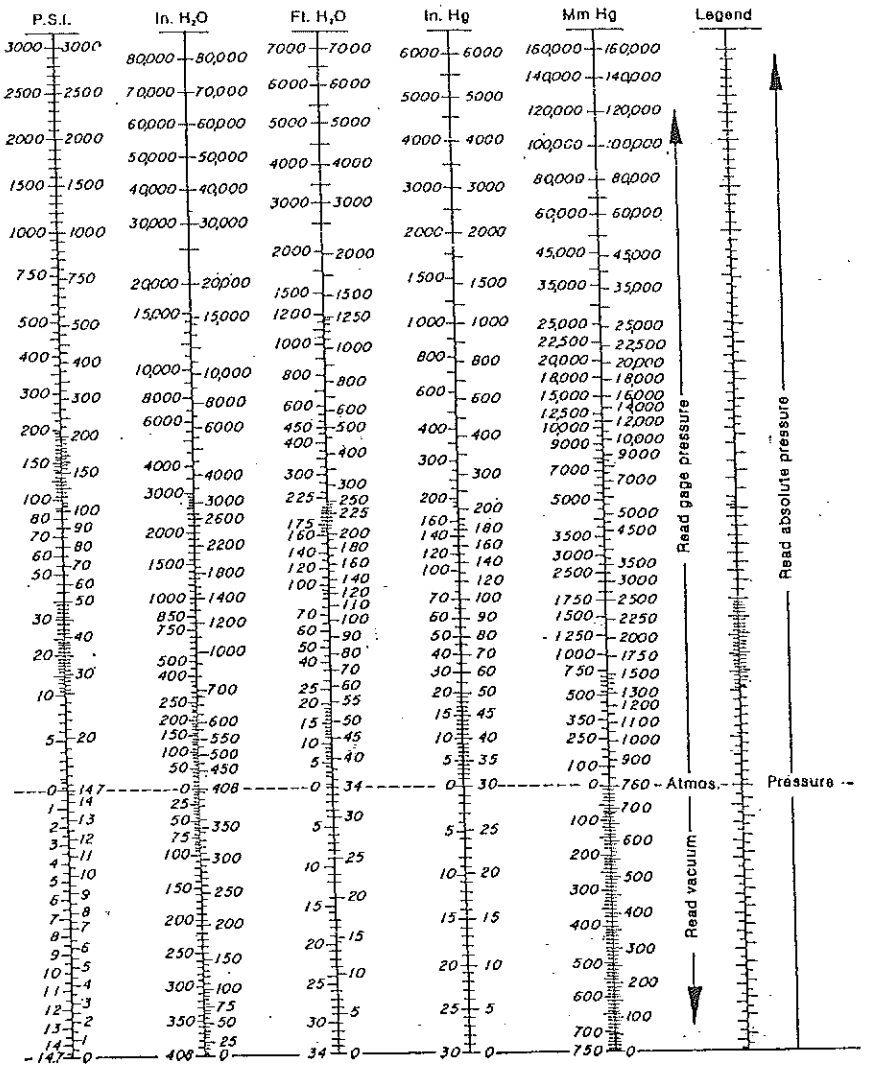
Diameter of particles and aerosols



Diameter, red blood corpuscles (warmed) 7.5 microns ± 0.3 micron

PRESSURE CONVERSION

Absolute pressure values are on the right side of all vertical scales. Vacuum values are on the left side and are read from atmospheric pressure down. Gauge pressure values are also on the left, but read from atmospheric pressures up. A straight edge placed on the chart through any known value will cross all other vertical scales at the correct conversion.



Dew point to P.P.M. conversion table

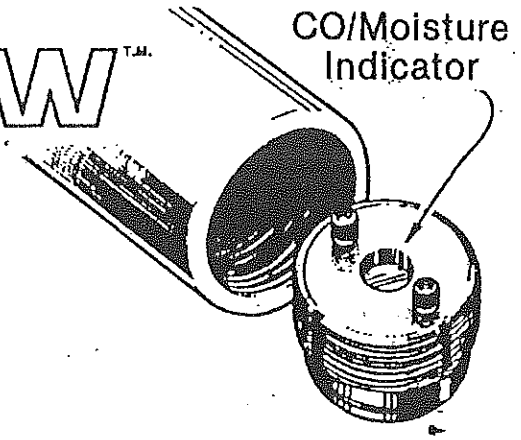
To convert parts per million by volume of water vapor to dew points, use this convenient table.

D.P.	ppm	D.P.	ppm	D.P.	ppm	D.P.	ppm	D.P.	ppm	D.P.	ppm
—130 °F	0.1	— 96 °F	2.15	— 84 °F	5.7	— 72 °F	14.3	— 60 °F	34.0	— 48 °F	76
— 120	0.25	— 95	2.35	— 83	6.2	— 71	15.4	— 59	36.5	— 47	82.
— 110	0.63	— 94	2.54	— 82	6.6	— 70	16.6	— 58	39.0	— 46	87.
— 105	1.00	— 93	2.76	— 81	7.2	— 69	17.9	— 57	41.8	— 45	92.
— 104	1.08	— 92	3.00	— 80	7.8	— 68	19.2	— 56	44.6	— 44	98.
— 103	1.18	— 91	3.28	— 79	8.4	— 67	20.6	— 55	48.0	— 43	105.
— 102	1.29	— 90	3.53	— 78	9.1	— 66	22.1	— 54	51.	— 42	113.
— 101	1.40	— 89	3.84	— 77	9.8	— 65	23.6	— 53	55.	— 41	119.
— 100	1.53	— 88	4.15	— 76	10.5	— 64	25.6	— 52	59.	— 40	128.
— 99	1.66	— 87	4.50	— 75	11.4	— 63	27.5	— 51	62.	— 39	136.
— 98	1.81	— 86	4.78	— 74	12.3	— 62	29.4	— 50	67.	— 38	144.
— 97	1.96	— 85	5.3	— 73	13.3	— 61	31.7	— 49	72.	— 37	153.

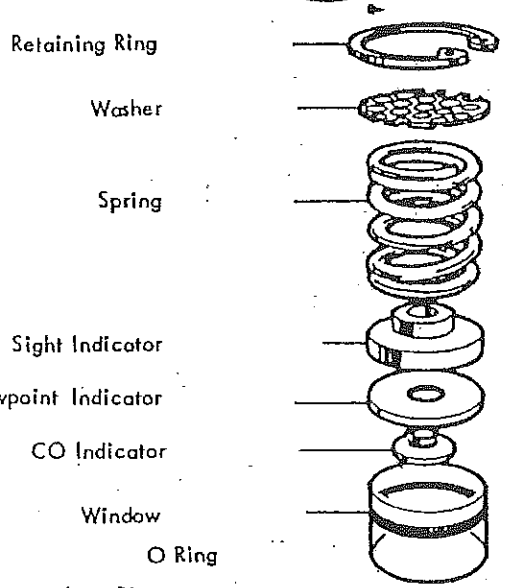
Conversion of Parts per Million (ppm) to Per cent: 1 ppm = 0.0001 %, 10 ppm = 0.001 %, 100 ppm = 0.01 %, 1,000 ppm = 0.1 %, 10,000 ppm = 1.0 %, etc.

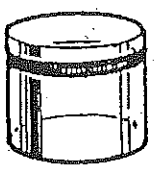
NOTE: THE VISUAL MOISTURE/CO INDICATOR KIT IS BEING SHIPPED TO YOU SEPARATELY - PLEASE INSTALL.

COview™

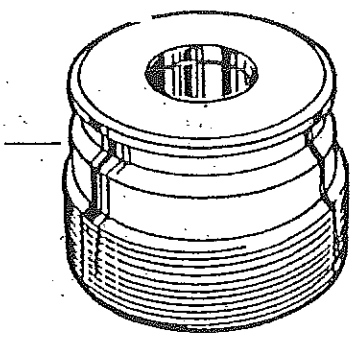


Features:
Integral monitoring of moisture and Carbon Monoxide.
Interchangeable with existing Mako purification system chambers.
Rates at 5000 psi working pressure (20,000 psi test).
Dual air stream monitor for Carbon Monoxide (.02% threshold) and relative humidity above 40%.
Activates within 1 to 4 minutes.
Rejuvenates between 30 to 60 minutes in a pure air environment.
Replacement indicator kit available (M7414).





NOTE.
Failure to install window properly will damage unit and could cause serious injury!



Patent #1,188,454

THE MAKO AIR PURIFICATION SYSTEM

The Respiratory Air Purification System is constructed of aluminum alloy. Ultimate tensile strength is 83,000 PSI. Equipment is designed to meet the ASME "Unfired Pressure Vessel Code, Section VIII". A 4 to 1 safety factor results when used at 5000 PSI.

The first component of this multistage system is a separator. This eliminates oil and water vapor, and solid particles larger than 20 microns. Subsequent stages remove vaporized and gaseous contaminants. The Respiratory Air Purification System exceeds U.S. Navy Diving Standards and specifications set by the National Fire Protection Association (NFPA), OSHA and the Compressed Gas Association.

MAKO'S FILTER SEPARATOR

This separator eliminates oil and water vapors from the compressed air by filtering through a sintered screen. Water and oil is collected in the sump for subsequent draining. The separators are efficient in the 20 micron range.

The element should be inspected every 250 hours or when 100,000 cubic feet of air are processed. When the air leaves the separator, it will be further processed in the purification chambers.

MAKO'S PURIFICATION CHAMBERS

The purification chambers remove undesirable gases, odors and any remaining traces of oil and water. The gases removed depend upon the cartridge used. Consult the cartridge table to find the right one for you.

The air purifier system must be maintained on a regular basis, based upon volume of air processed and age of purification cartridges. Other factors such as ambient moisture, temperature and dew point will also effect cartridge life.

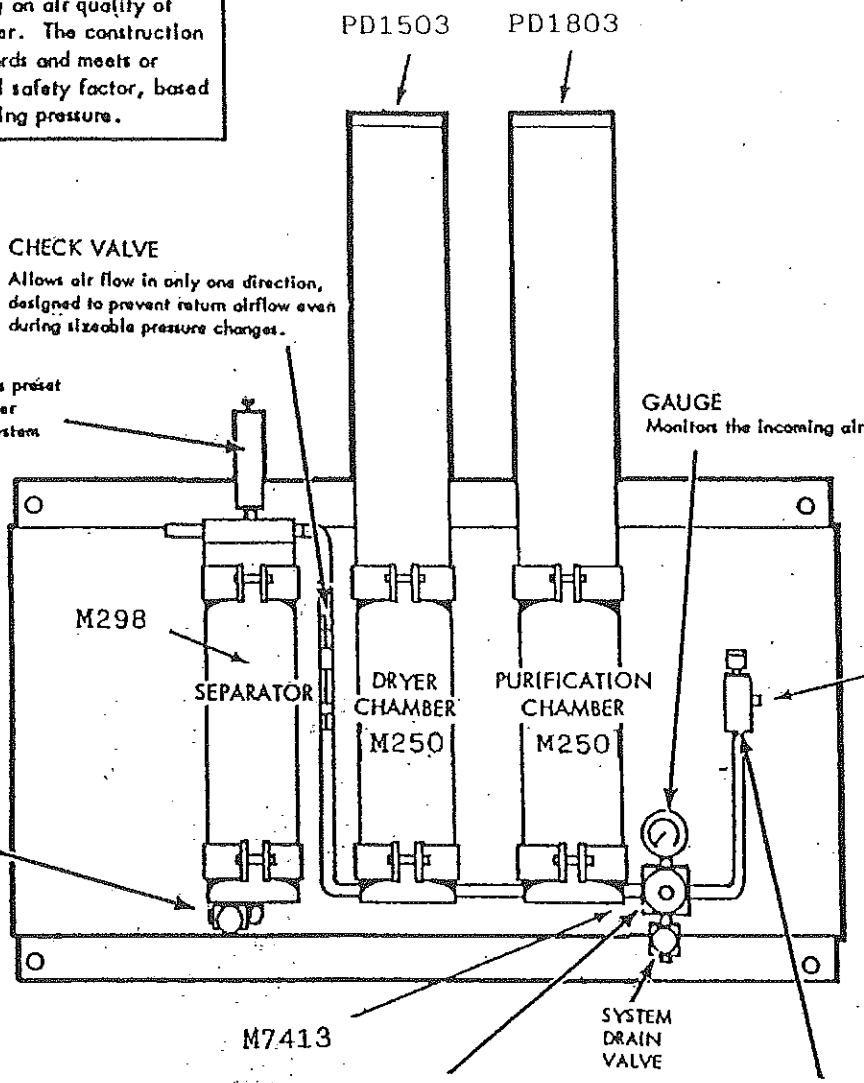
Cartridges should be replaced every six (6) months regardless of the volume of air processed during this time. A table is supplied to give supplied to give specific intervals for changing cartridges based upon amount of air processed and system operating temperature.

From the diagram you see a complete MK-5-C and its added components.

Other optional accessories are available to provide maximum flexibility in any system you may choose. Visual moisture/CO indicator can be mounted on top of final purifier.

Mako purification systems meet the standards of the Compressed Gas Association (CGA) specification G-7.1, producing an air quality of grade "D" or better. The construction is to ASME standards and meets or exceeds the 4 to 1 safety factor, based on 5000 PSI working pressure.

PURIFICATION CARTRIDGE REPLACEMENT



CHECK VALVE
Allows air flow in only one direction, designed to prevent return airflow even during sizeable pressure changes.

SAFETY VALVE
Releases air pressure above its preset pressure to protect against over pressurizing the system and system safety.

GAUGE
Monitors the incoming air pressure.

MANUAL VALVE
For draining condensate from the separator.

VISUAL MOISTURE/CO INDICATOR
An in-line monitor that keeps a constant check on the quality of the air stream. Warning indicators warn when moisture or carbon monoxide reach unsafe levels. (Standard on wall-mount units, optional on compressor packages.)

PRESSURE MAINTAINING VALVE (PMV)
A preset valve which keeps the airflow from moving until it reaches its preset value. It also provides a certain amount of back pressure to the compressor and maintains an effective pressure for the purification chambers.

MAKO DRYER CHAMBER

The dryer chamber contains a chemical cartridge which removes moisture by adsorption. This chamber must be properly maintained to obtain maximum efficiency.

DRYER MAINTENANCE

Depressurize the system and remove the top plug. Place a wrench between the two allen head cap screws on top of the dryer chamber and turn (counter clockwise).
Remove the old cartridge and inspect the inside of the pressure vessel. Clean the inside with a (Clean) lint free cloth.
If oily substances are found, disassemble the entire chamber and wash all parts in hot soapy water, rinse with clean water and blow dry.

DO NOT OVER TIGHTEN

Before reassembly, the O rings should be lubricated with silicone grease.
Apply a small amount of "Never-Seeze" to the threads, then reassemble the unit.

A new cartridge should be installed with the utmost care.

After the seals are removed from the cartridge ends, lower the cartridge into the chamber.
The cartridge slides over the mating tube in the bottom plug.
Each cartridge has a new O-ring installed in the adaptor fitting.

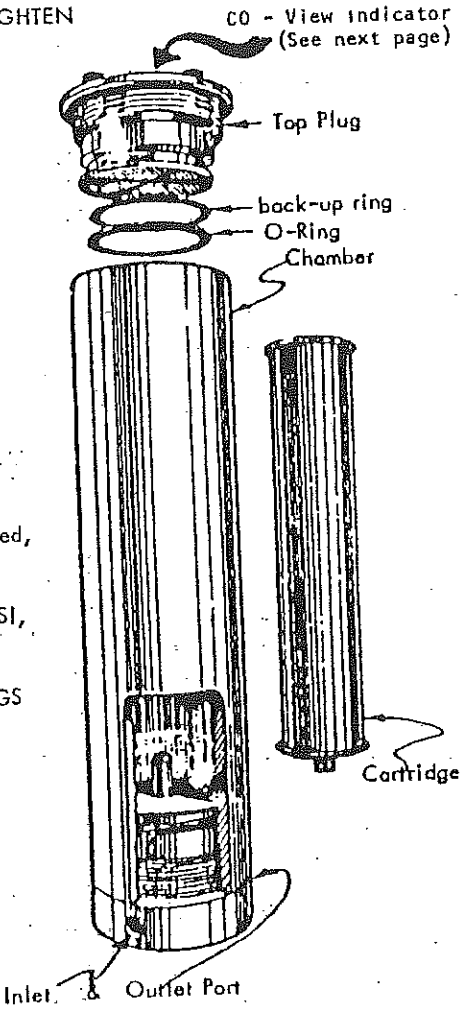
Replace the top plug, making sure that the threads engage properly. If binding is encountered, check cartridge position and clean the threads.

Pressurize SLOWLY and make leak test at 500 PSI, and at final pressure.

WARNING: DO NOT TIGHTEN ANY FITTINGS UNDER PRESSURE

SEALS: Back up ring
O-Ring

PORT SIZE: Inlet & Outlet 9/16 - 18 UNF 2B straight thread O ring seal



Patent #4,278,453

CARTRIDGE CHANGE

1. Release all pressure from system, then unscrew top of pressure vessel.

2. Remove cartridge by lifting cartridge straight out.

3. Check interior of pressure vessel to be certain there is no foreign matter within the chamber.

4. Replace with new cartridge. When replacing cartridge, use polyethelyne bag to hold the cartridge. Avoid using your hands directly on the cartridge. Be certain to remove the plug from the lower end of the cartridge; otherwise, it cannot be pressed into position. Also, a restriction will result if this plug is not removed. Lower the cartridge into the chamber. Once it reaches its stop, it can then be pressed an additional 1/2" with finger pressure. It is now sealed in place.

5. Remove the seal from the top of the new cartridge.

6. Lubricate the threads and o-rings on the end plug. Use a silicone type lubricant.

7. Screw the top plug back in until it is screwed all the way down. Back off the top plug until the closing marks are opposite one another. The top plug should be flush with the top of the cylinder. It should not be necessary to use excessive force in replacing this plug or screwing it down into place. If excessive effort is required, check the internal portion of the chamber and particularly the cartridge.

8. Use cartridges from sealed bags only. If cartridge is left out of sealed plastic bag with end plugs removed, it is possible that the chemicals have become ineffective due to moisture adsorption.

CARE OF HIGH PRESSURE BREATHING AIR CYLINDERS

1. MARKING - Cylinders used for breathing service should be clearly marked "COMPRESSED AIR ONLY". Never put oxygen in a cylinder used for breathing air. The danger of explosion is greatly increased.

2. CYLINDERS - Use only the cylinders which are stamped with Interstate Commerce Commission, Department of Transportation or American Society of Mechanical Engineers (ICC, DOT, ASME) markings. Never exceed the pressure indicated by this stamped marking. (Example: ICC, DOT, ASME - 3AA - 2150.) The last four numbers designate the pressure to which the cylinder may be charged in pounds per square inch (PSI) at 70° F.

3. PRESSURE TEST - Every 5 years, DOT cylinders should be inspected and hydrostatically tested by a qualified inspection station, following the regulations of the Interstate Commerce Commission, Department of Transportation, etc.

4. CLEANING - Insure the outside of the cylinders remain properly protected against salt water corrosion by paint or other suitable coating. Do not lubricate any of the valve parts or connecting fittings since this may contaminate the air, making it unsafe for breathing.

5. INTERNAL CORROSION - Cylinder valves should be kept closed on empty cylinders to prevent atmospheric moisture from entering the cylinder causing internal corrosion. NOTE: It is best to maintain at least 25 PSI of compressed air in the cylinders at all times. This will prevent water or atmospheric air from entering the unused cylinder.

6. MOISTURE - Cylinder should be visually inspected and cleaned if moisture is found. NOTE: If any trace of oil is found, thoroughly clean the cylinder of all oil before further use.

7. AVOID DROPPING - Avoid dropping or rough handling when transporting. Insure that the cylinders are secured firmly so they cannot shift about.

8. RECHARGE WITH PURE AIR ONLY - Recharging should be accomplished only by a competent charging station which has the proper facilities to insure that the compressed air is free from oil, moisture, other impurities, and is fit for breathing.

9. FIBERGLASS CYLINDERS - Glass-wound cylinders should not be filled in water (cooling) tank. Care should be taken not to damage glass windings in any way.

KEEP CHARGED CYLINDERS COOL

A charged cylinder lying in the hot sun will cause the pressure to rise rapidly, possibly to the point where the safety relief valve will release and discharge the air. Possible damage to the valve and/or seals may occur.

6.0 PRESSURE MAINTAINING VALVE (PMV)

A pressure maintaining valve (PMV) (MAKO Part No. M-3 -- see Figure 6-1) is located downstream of the purification system as shown in Figures 5-1 and 5-2. The purpose of this valve is to prevent flow until a preset upstream pressure (typically 1500 to 1800 PSIG) is achieved. The final stage pressure gauge located on the compressor control panel indicates the pressure in the purification system. When preset pressure is reached, the valve opens, if the downstream pressure is less.

The pressure maintaining valve, in conjunction with a check valve on the outlet of the final separator, hold the purification chambers (even during compressor shutdown) at preset pressure and prevents absorbed moisture from being released from the molecular sieve. Water accumulated in the purification chamber (if the system were allowed to depressurize) could be forwarded to the storage system or fill station upon compressor restart. Liquid water in the purification chamber can impair the function of the charcoal absorber and the catalyst.

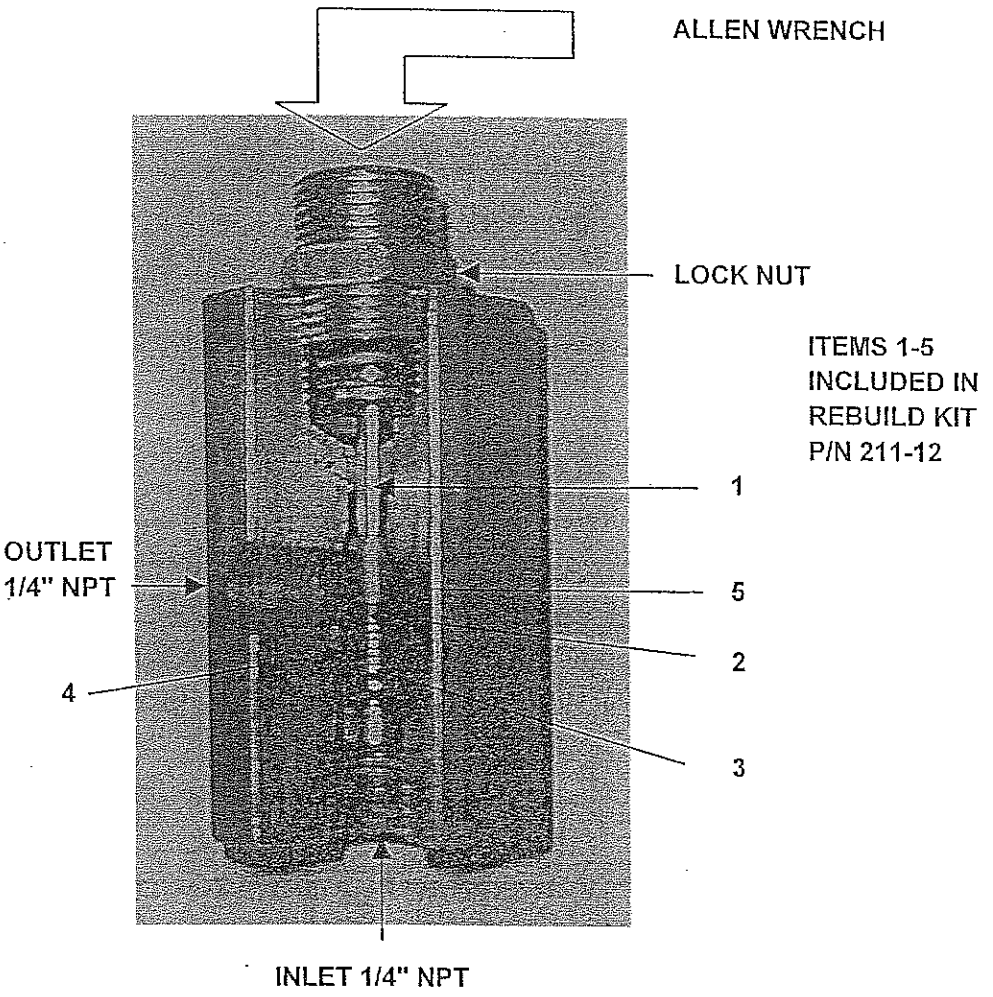


FIGURE 6-1 PRESSURE MAINTAINING VALVE (PMV - MAKO PART NO. M3)

To check the PMV set point, release all pressure after the maintaining valve and check the pressure on the final compressor stage gauge.

To adjust the PMV set point:

a. Loosen lock nut on adjusting screw using 7/8" wrench.

b. Use a 5/16" Allen wrench to adjust the pressure "up" by turning the screw in. To make the back pressure lower, back out the adjustment screw.

7.0 AUTO DRAIN SYSTEM

A water/oil mixture continuously accumulates in the separators during compressor operation. Each separator has a limited retention capacity. If the accumulated water/oil mixture is not drained periodically, the compressor will malfunction with serious results. Typically the auto drain system "blows down" the separators at 15 minute intervals. This is accomplished by an electronic timer which deactivates a solenoid valve that controls the pressure on a bank of piston type valves.

The auto drain system permits the compressor to start "unloaded" because the solenoid is de-energized when the machine is shut off and stage pressures are automatically vented. This design mitigates motor starting currents, hence, reducing demands on the other circuit components. When the compressor is restarted, the solenoid is energized and the vent port sealed.

7.1 AUTO DRAIN SYSTEM COMPONENTS

The auto drain system encompasses the following components:

1. A bank of piston type valves that progressively open when a solenoid periodically dumps the pressure in the lowest pressure line (see Figure 7-1).

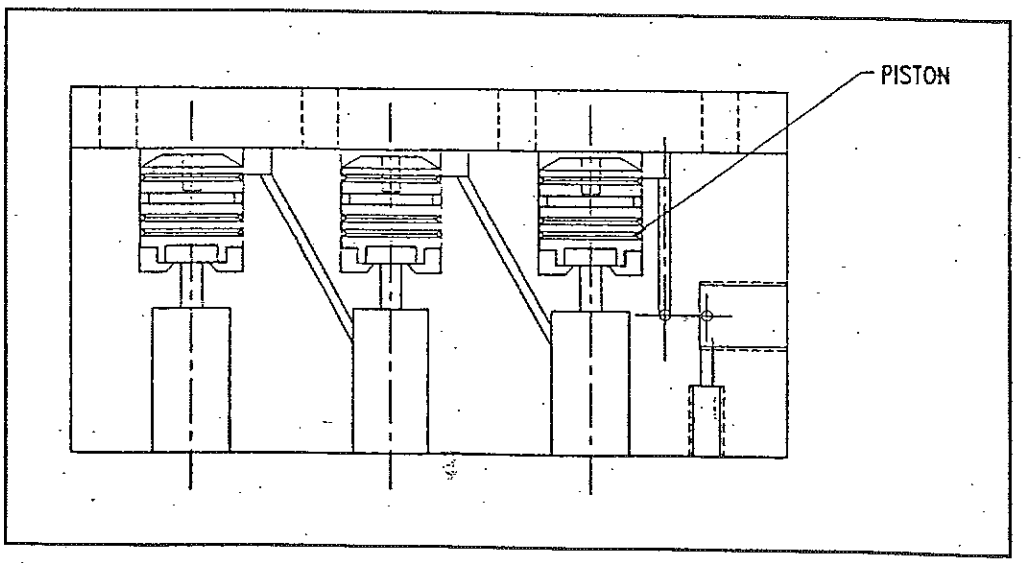


FIGURE 7-1 AUTO DRAIN (FOUR STAGE COMPRESSOR)

2. An electric solenoid valve (see Figure 7-2).

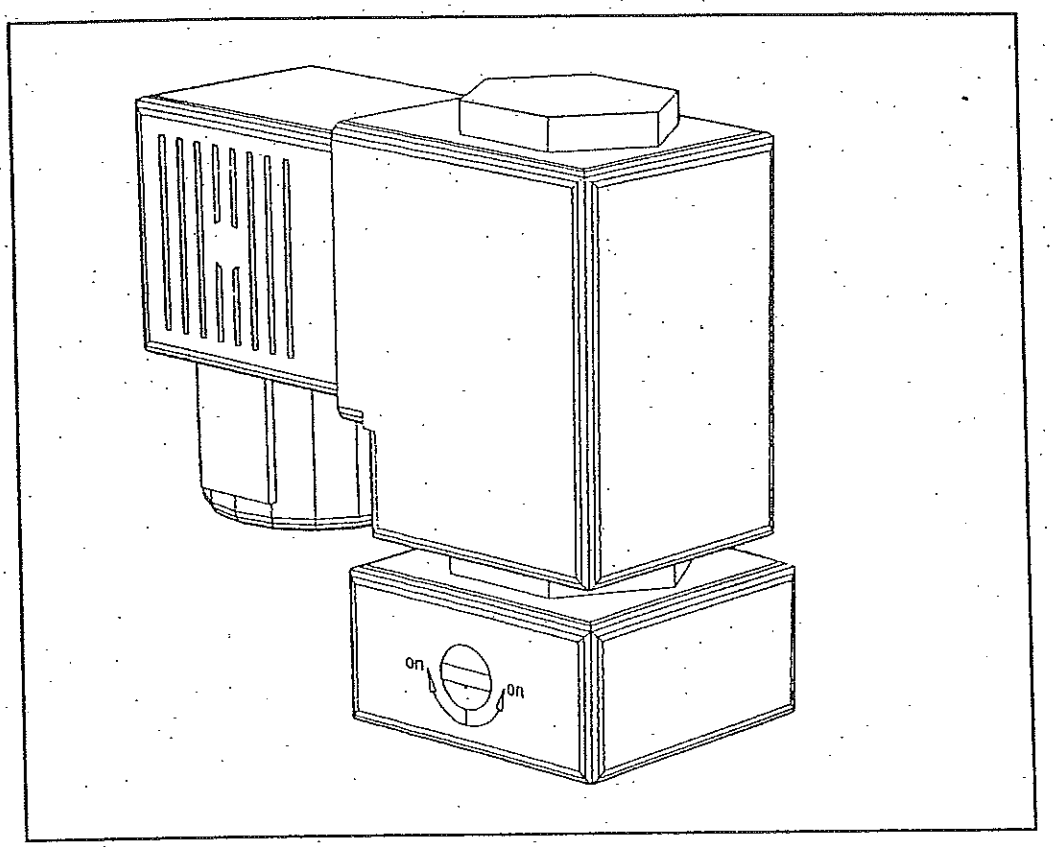


FIGURE 7-2 AUTO DRAIN SOLENOID

3. A timer that energizes the solenoid at preset intervals usually 15 minutes, (see Figure 7-3). This timer is located in the electric box.

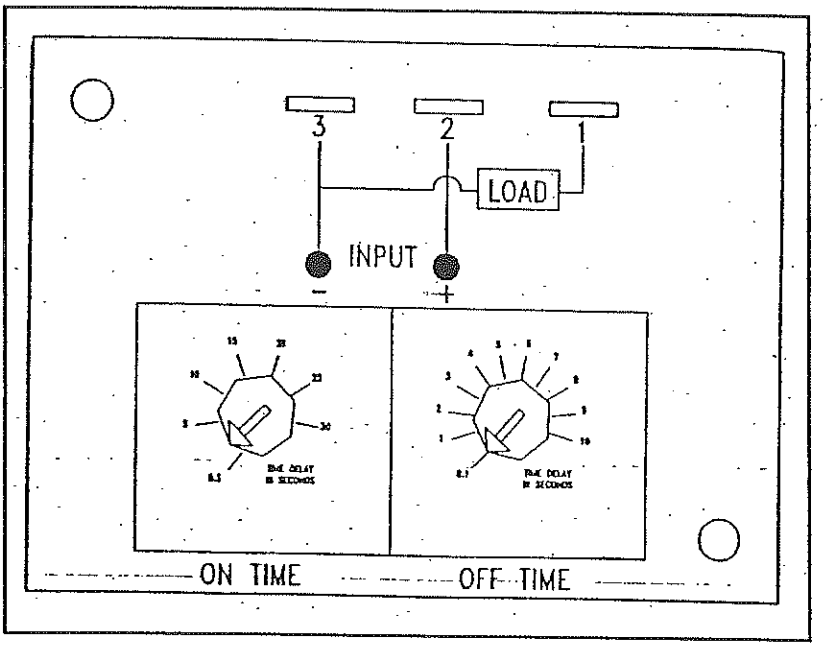


FIGURE 7-3 AUTO DRAIN SOLENOID TIMER

7.2 AUTO DRAIN TROUBLE DIAGNOSIS AND ADJUSTMENT

1. Determine if the problem is an electrical or mechanical malfunction by :

   a. Locating the brass screw on the base of the solenoid valve and
   b. Turning this screw to either side to override the electrical control and cause the drain to close.

   Turn the screw so that the mark is now pointing away from the drain body. This by-passes the electric solenoid. If the leak stops, the problem is electrical. If the problem is electrical, check for the correct voltage at the solenoid and timer. The drain is designed to dump the condensate on loss of power.

2. To check for mechanical problems:

   a. Remove the back plate using a 3/16" Allen wrench.

   b. Remove the pistons by threading an 8-32 machine screw into the top of the pistons and lifting by the screw.

   c. Inspect the pistons and "O"-rings and their seats for any debris or surface scratches. A small piece of debris running through the drain will scratch the piston or cylinder and cause a leak.

   d. Clean the inside of the block with soapy water. Small scratches may be lightly sanded out using grit paper.

   e. Put a light coat of silicone grease on the "O" -rings and re-install the pistons.

   CAUTION: EVEN THOUGH THE PISTONS ARE INTERCHANGEABLE, IT IS RECOMMENDED THEY BE REPLACED IN THE SAME ORDER.

   f. Grease the top plate "O"-ring seals with silicone grease and reassemble the drain block.

   g. Cycle the drain five or ten times to make the piston seat properly. Typically this is the problem on a new auto drain that leaks slightly.

3. Auto Drain Timer Adjustment

   The timer has two adjusting knobs:

   a. The first knob is marked ON TIME in minutes. This knob should be set slightly above the one mark for 15 minutes.

   b. The second knob is marked OFF TIME and reads 1 to 10 seconds. This knob should be set on six for six seconds.

NOTE: ALL CONTROL VOLTAGES PRIOR TO JUNE, 1990 ARE 110V.

NOTE: ALL CONTROL VOLTAGES AFTER JULY, 1990 ARE 12 VDC EXCEPT ON THE TRANSFORMER AND STARTER IN THE ELECTRIC BOX WHICH ARE HIGH VOLTAGE.

INTRODUCTION

When compressing air from atmospheric pressure to high pressure, moisture (water) is literally squeezed out of the air. The moisture condenses into droplets accumulating into water.

The interstage condensate and final separators remove liquid water and oil from the compressed air. Eventually, however, the separators will become full with water and oil. This is why, roughly once every fifteen minutes, the drain valves on each separator must be cracked open to drain off the accumulated moisture.

The purpose of the automatic drain is to perform the manual draining.

INSTALLATION

Location: The exhaust manifold must be rigidly mounted by either bolting or welding solidly. The drain block then bolts to the exhaust manifold. Locate the auto drain close to compressor (on the same frame), and in such an area that is easily plumbed and wired.

Wiring: Tap off the 120 volt control voltage from the compressor. Use the normally open contacts on the magnetic starter to control the drain (A). Run a wire from the starter contact (B) to the drain timer motor common terminal (one black motor wire). At this point, mention will be made of the drain timer (C).

Drain Timer: The drain timer actually has two timers on it. Only one is necessary for the auto drain operation. Therefore, when wiring, use the contact switch that operates off of the black cam. The red one is left blank.

The timer itself must be mounted in the electric box. This will protect the timer against ambient conditions.

Prior to mounting the timer, it is suggested that the timer cam be set. Enclosed in with the timer is a small adjusting "spoon". The black cams can be rotated to lengthen or shorten the amount of time the switch is open. This, in effect, controls the length of time that the drain is draining (open).

Set the two cams so that the contact switch will momentarily open when rotated with the spoon. The timer will then open for 10-15 seconds when actually running, due to gearing.

Further Wiring: Run a wire from pin (1) inside the drain solenoid to the drain timer (normally open) terminal. To access the solenoid pins, the solenoid cap must be removed. The screw holding the cap on must be totally removed, then the lock screw inside the cap must be removed. The cap then disassembles into two pieces. The part that has the three metal miniature screws is where the wires attach. The plastic part has the pin numbers cast into its surface. Run a wire from pin (2) inside the solenoid cap to both the neutral wire (ground) and the remaining black drain timer motor wire.

When the compressor motor is running, the drain timer motor will slowly run also. When the switch lever on the timer drops into the notch, the drain will discharge. The drain also drains on shutdown of the compressor. If the solenoid does not receive power, the compressor will not build up pressure.

Plumbing: Piping for the three stage and four stage machines is identical, with the exception that the three stage drain block has one less port.

Find where the gauge is plumbed to the compressor first stage. From this point, run a 1/8" line to the 1/8" NPT hole labeled, "first stage" on the diagram. Then, from the second stage separator base, connect a 1/4" line to the second stage port. From the third stage separator base, connect a 1/4" line to the third stage port. Then, from the final separator base (the gold anodized chamber with the relief valve on the top), run a 1/4" line to the fourth stage port. The final stage line must be stainless steel to withstand the high pressure involved.

Discharge manifold pipe: Connect a hose to pipe away the condensate. Clear flexible hose is recommended. Clear hose enables easy examination of the condensate.

CAUTION: When the drain dumps upon shutdown and at timed intervals, a blast of air and condensate is blown from the manifold pipe end at high pressure.

TROUBLESHOOTING

Make sure the separator lines are sized correctly and connected in the correct order. The first stage pressure port is the 1/8" NPT hole underneath the solenoid valve and is 1/8" o.d. line. The others are 1/4" NPT. The 1/8" line supplies the control air for the proper operation of the drain actuator.

PROBLEM: CONTINUOUS BLEEDING OF DRAIN SYSTEM

I. First, isolate the problem between electrical or mechanical malfunction. To determine if the problem is electrical, locate the brass screw on the base of the solenoid valve. Turn the screw so that the mark is now pointing away from the drain body. This by-passes the electric solenoid. If the leak stops, the problem is electrical. Check for the correct voltage at the solenoid and timer. The drain is designed to dump the condensate on loss of power.

II. To check for mechanical problems, remove the back plate, using a 3/16" Allen wrench. Remove the pistons by threading an 8-32 machine screw into the top of the piston and lifting by the screw. Inspect the pistons and O-rings and their seats for any debris or surface scratches. A small piece of debris running through the drain will scratch the piston or cylinder and cause a leak. Clean the inside of the block and pistons with soapy water.

III. If no debris was found, the gold anodizing may be causing

the pistons to stick. Take a piece of very fine sandpaper and lightly polish the piston bores inside the drain block. Clean the inside of the block with soapy water. It may be added here that a small scratch may be lightly sanded out.

Put a light coat of silicone grease on the O-rings and re-install the pistons. Even though the pistons are interchangeable, it is recommended they be replaced in the same order. Grease the top plate O-ring seals with silicone grease and reassemble the drain block.

IV. The drain must be cycled five or ten times to make the pistons seat properly. This, typically, is the problem on a new auto drain that leaks slightly. Leave the brass screw in the "up" position as was done in Step I. Bring the compressor to maximum working pressure. If you have a "manual" position on the compressor selector switch, turn to that position. When maximum pressure is reached, open the manual drain valve. After pressure has bled out, close the valve. Let the system build back up to maximum pressure and repeat the process five more times.

After the last dump cycle, turn the brass screw on the solenoid so that the mark aligns with the point closest to the drain block. The drain should not leak.

For additional service, write or call:

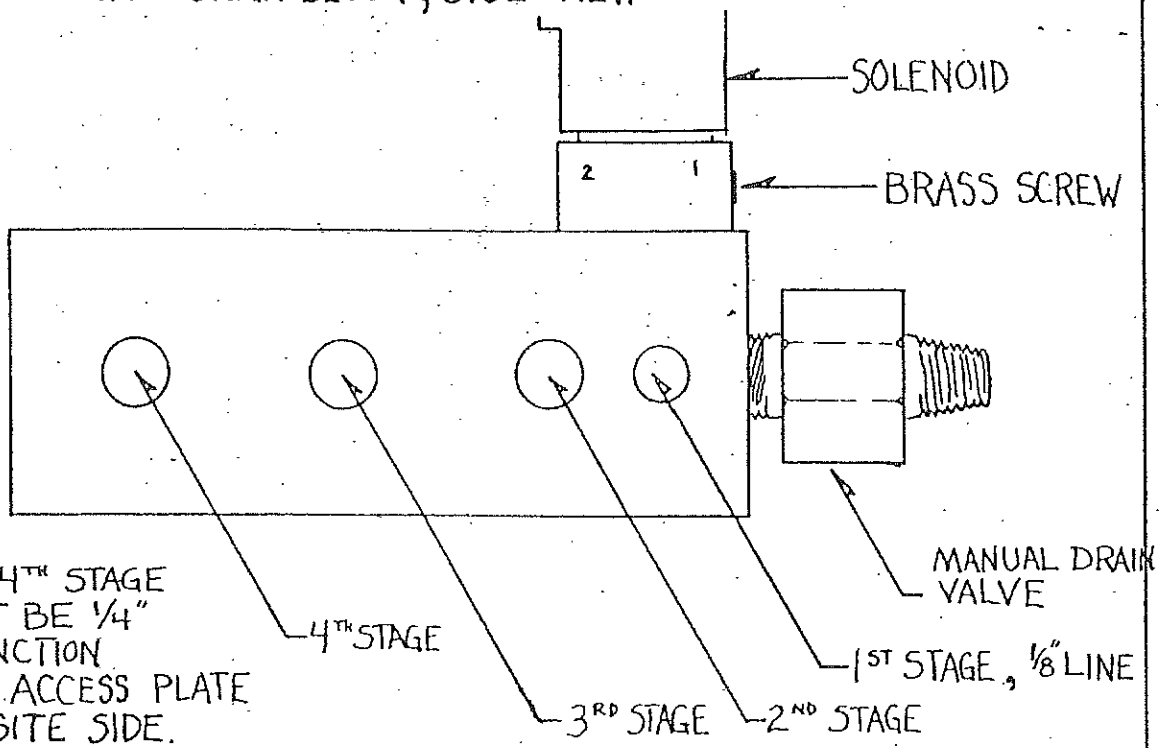
CompAir Mako
1634 SW 17th Street
Ocala, Florida 32678

732-2268

NOTE: On the early production runs of the automatic drain block, a three stage compressor used a four stage block by the following modifications: The third stage port was blocked off and piston was removed. The third stage was pumped into the fourth stage port.

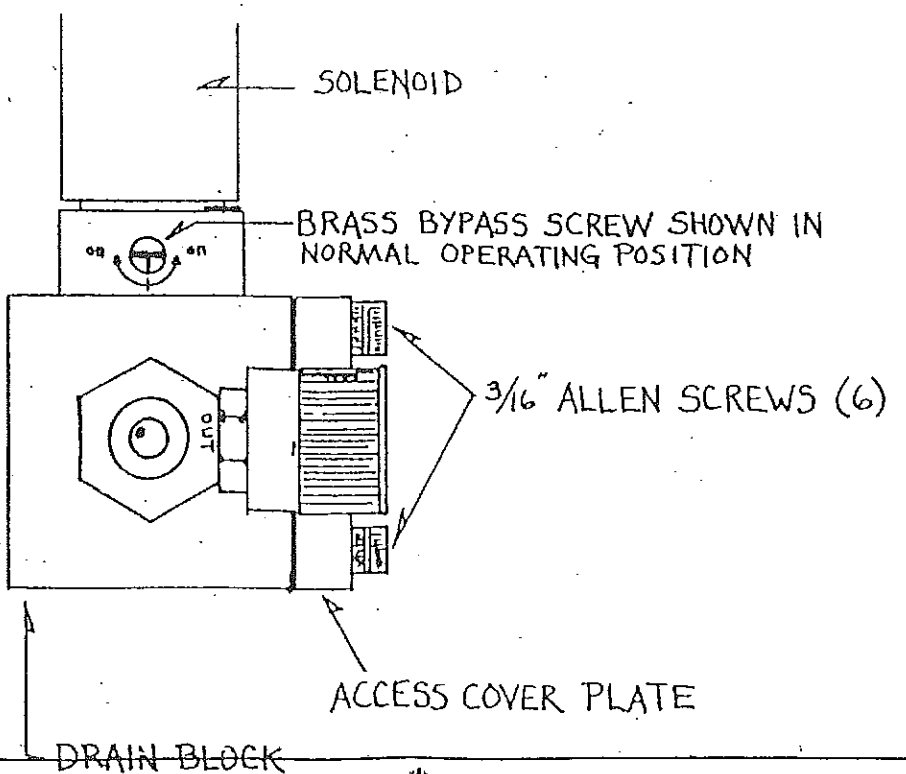
NOTE: The plastic plug located on the top of the solenoid must be removed for the drain to function properly. It is recommended that a 1/8" NPT vent tube be attached and pointed downward.

4 STAGE DRAIN BLOCK, SIDE VIEW

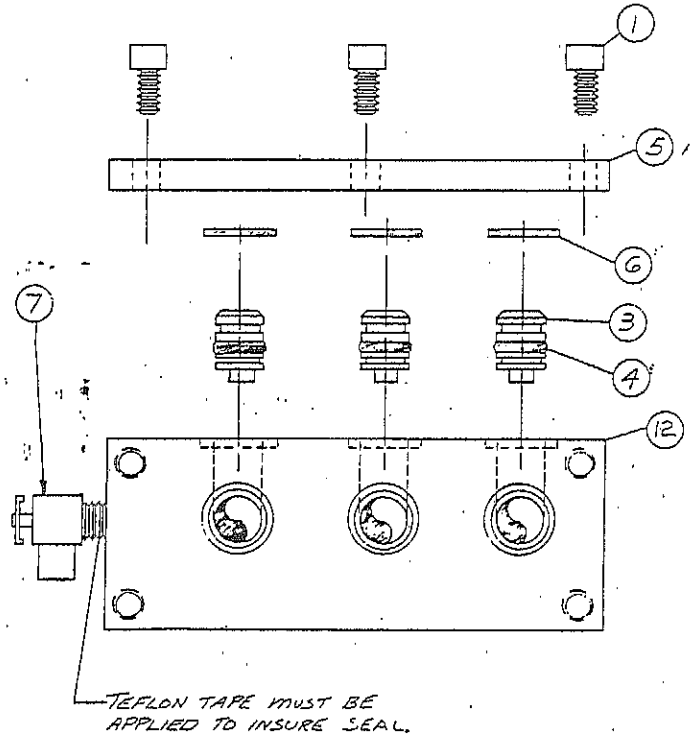


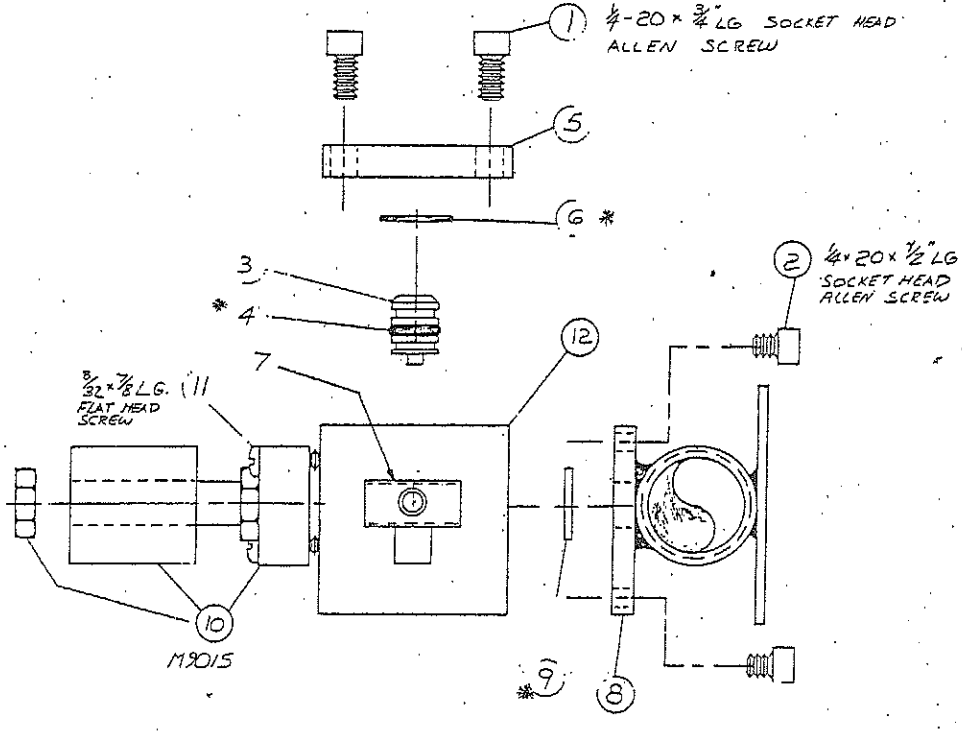
2ND 3RD AND 4TH STAGE LINE MUST BE 1/4" LINE TO FUNCTION CORRECTLY. ACCESS PLATE IS ON OPPOSITE SIDE.

4 STAGE DRAIN BLOCK, END VIEW



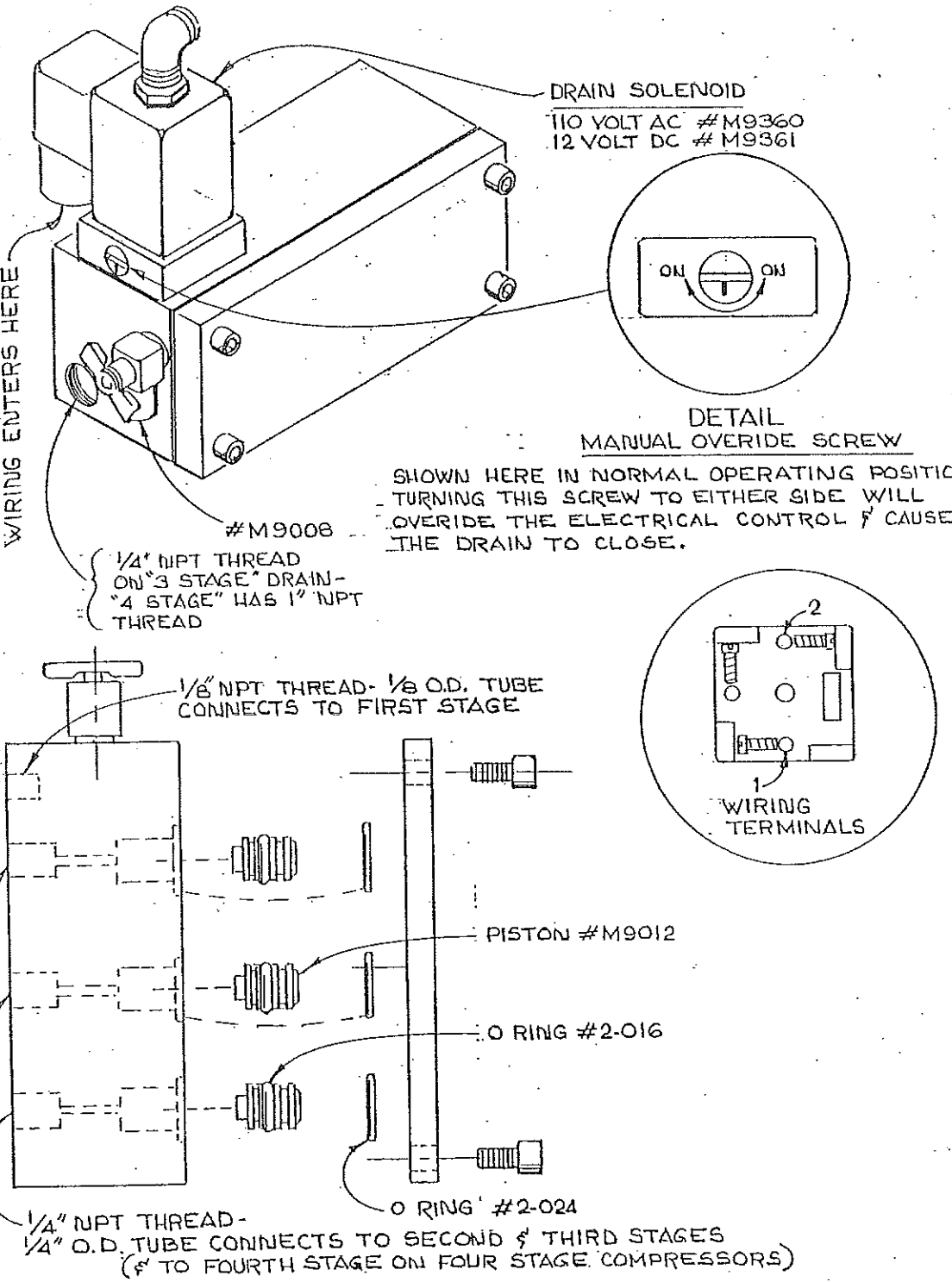
NOTE: * SHOWS WHERE SILICONE GREASE SHOULD BE APPLIED LIGHTLY.





AUTOMATIC CONDENSATE DRAIN

DIAGRAM C



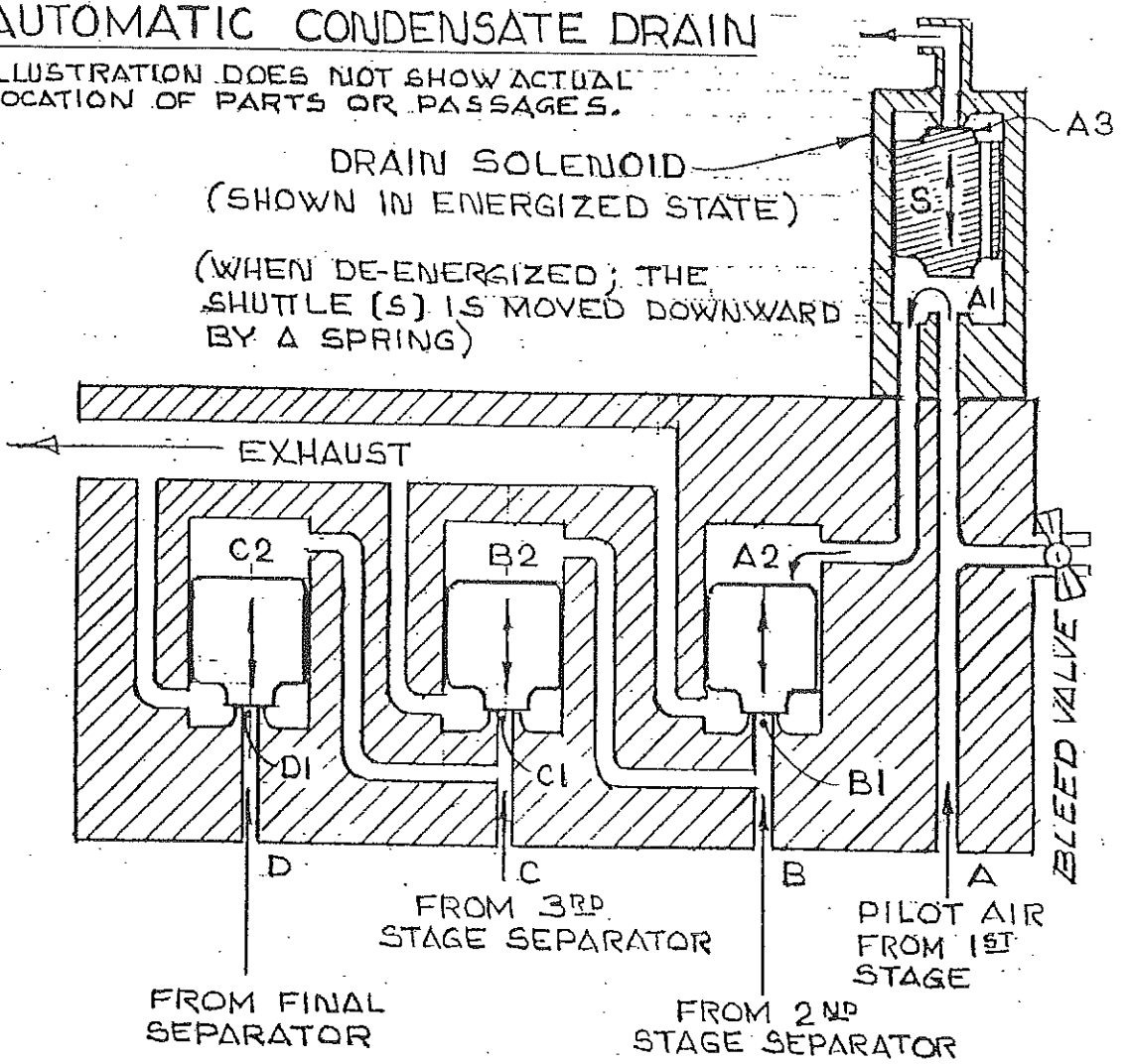
NOTE: THIS ILLUSTRATION IS NOT INTENDED TO SHOW ALL PARTS OR PASSAGES.
(THE 3 STAGE UNIT HAS 2 PISTONS
THE 4 STAGE UNIT HAS 3 PISTONS)

NOTE: APPLY A SMALL AMOUNT OF SILICONE GREASE TO O-RINGS BEFORE ASSEMBLY.

DIAGRAM B

AUTOMATIC CONDENSATE DRAIN

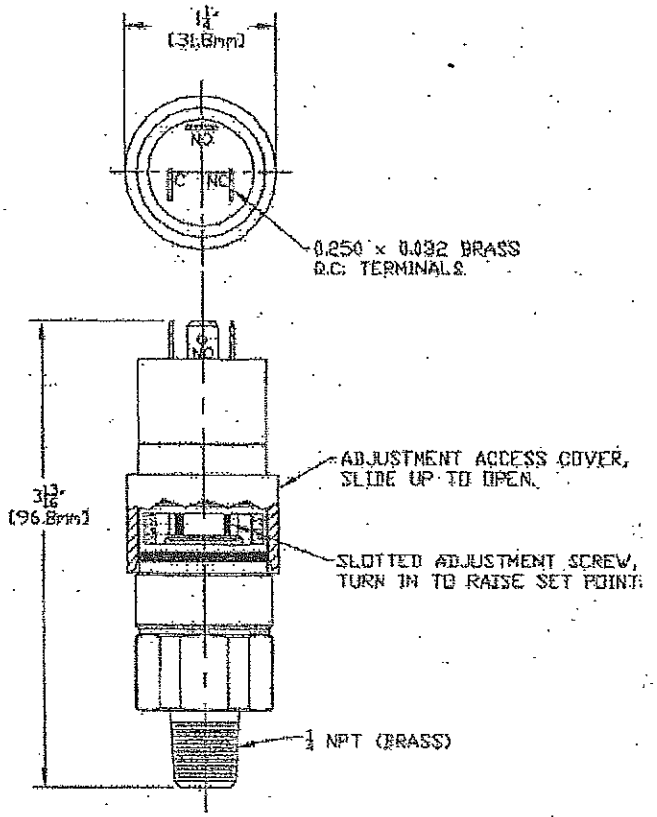
ILLUSTRATION DOES NOT SHOW ACTUAL LOCATION OF PARTS OR PASSAGES.



8.0 COMPRESSOR AIR SWITCH

NEW STYLE AIR SWITCH

The compressor air switch regulates the automatic shutoff and restarting of the compressor.



If the compressor air switch requires adjustment, use the following procedure:

This product only requires a screwdriver to adjust the set point. The following procedure outlines the steps required to adjust the pressure switch.

1. Connect control to pressure source.
2. With power disconnected, slide cover toward electrical terminations while twisting it to overcome friction.
3. Connect power to terminals or leads.
4. Insert screwdriver into adjustment slot and turn left (clockwise) to increase setting or right (counterclockwise) to decrease setting.
5. After completing adjustments, slide cover closed over adjustment compartment. Recheck set point.

For setting on rise, apply desired pressure and turn adjustment left until switch clicks (circuit across N.O. and COM terminals closes.) For Setting on fall, apply pressure equal to normal system operating pressure. Reduce source pressure to setpoint value. Turn adjustment right until switch clicks (circuit across N.C. and COM closes).

9.0 OIL PRESSURE SWITCH ADJUSTMENT

9.1 NEW STYLE OIL PRESSURE SWITCH

The oil pressure switch on four stage machines, in conjunction with the time delay relay, shuts the compressor off if the oil pressure is lost or drops below 750 PSIG. Occasionally, oil pressure switches may require readjustment due to age, vibration or the change in oil viscosity between winter and summer. Determine first if the oil pressure is correct (nominal 1000 PSIG, 900 PSIG minimum, 1100 PSIG maximum). If the oil pressure switch requires adjustment, use the following procedure:

1. Start the compressor. Make sure the oil pressure is correct (nominal 1000 PSIG). If not, make the appropriate adjustments as discussed in Section 4.2 before resuming this procedure.

2. Turn the oil pressure time delay to zero (see Figure 9-1).

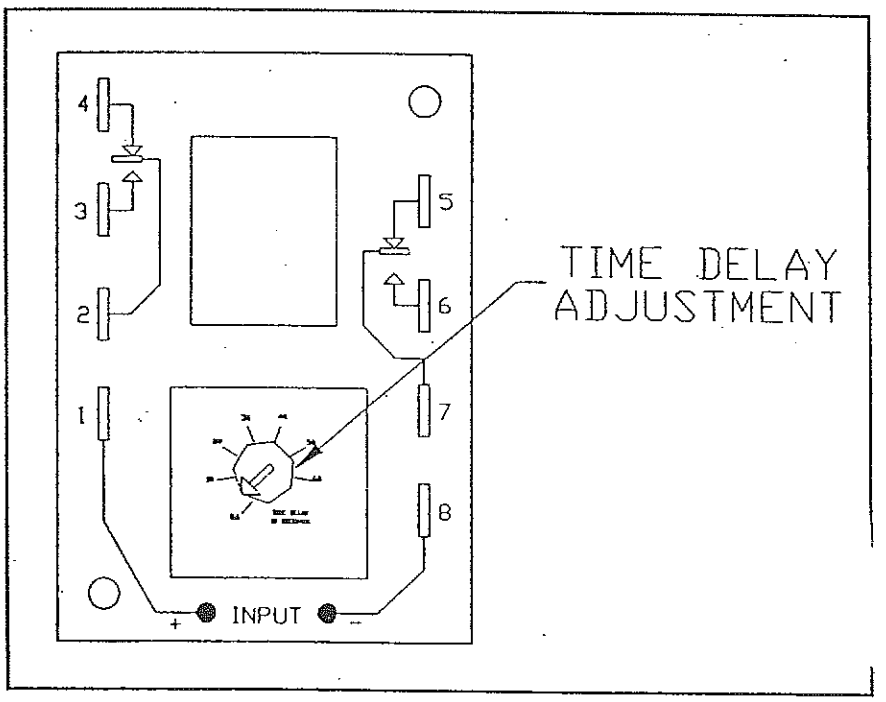


FIGURE 9-1 TIME DELAY RELAY

3. Slowly turn the switch adjustment sleeve shown in Figure 9-2 clockwise one quarter of a turn at a time. Prevent the switch body from rotating using a 1 1/4" end wrench.

4. When the machine shuts down or the low oil light comes on, turn the run switch OFF.

5. Rotate the adjustment sleeve on the switch counter clockwise one and one half turns.

6. Turn the time delay up to twenty to thirty seconds.

7. Determine at what pressure the light goes out. This is the oil pressure where the machine will shut down. Typically this pressure is 750 PSIG.

CAUTION: IF IT IS NECESSARY TO REMOVE THE ELECTRICAL LEADS DURING THE ADJUSTMENT PROCESS BE SURE THEY ARE REINSTALLED CORRECTLY. THE ELECTRICAL CONNECTORS ARE CLEARLY MARKED ON EACH SWITCH AS SHOWN IN FIGURE 9-2.

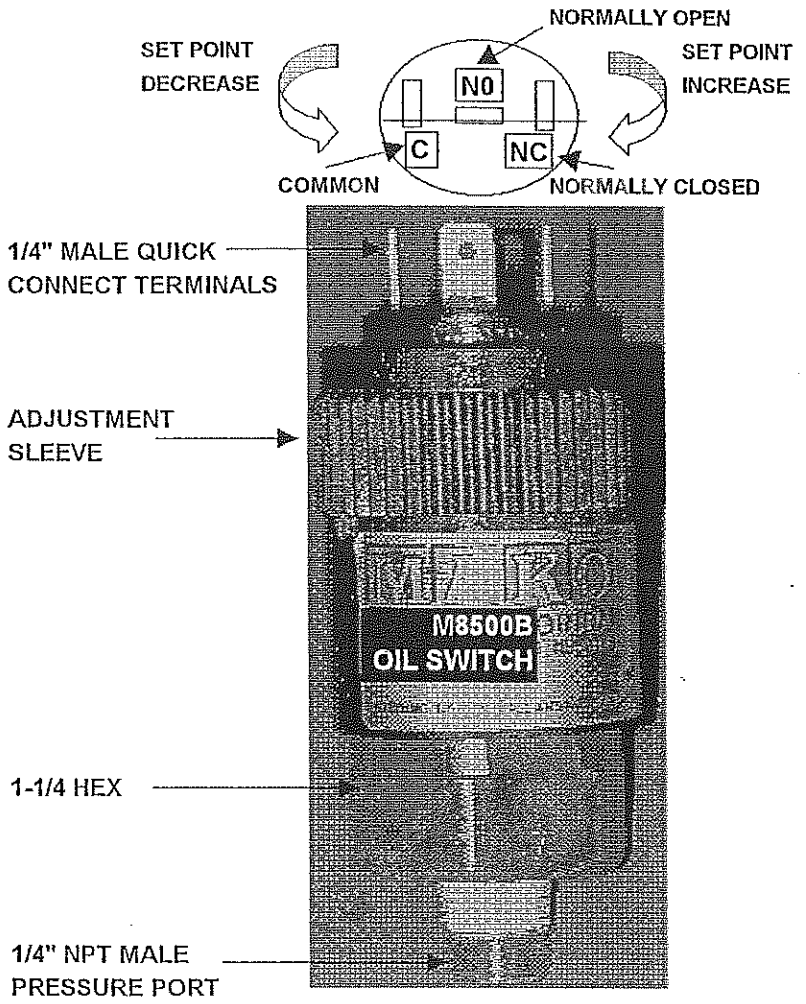


FIGURE 9-2 BARKSDALE OIL SWITCH

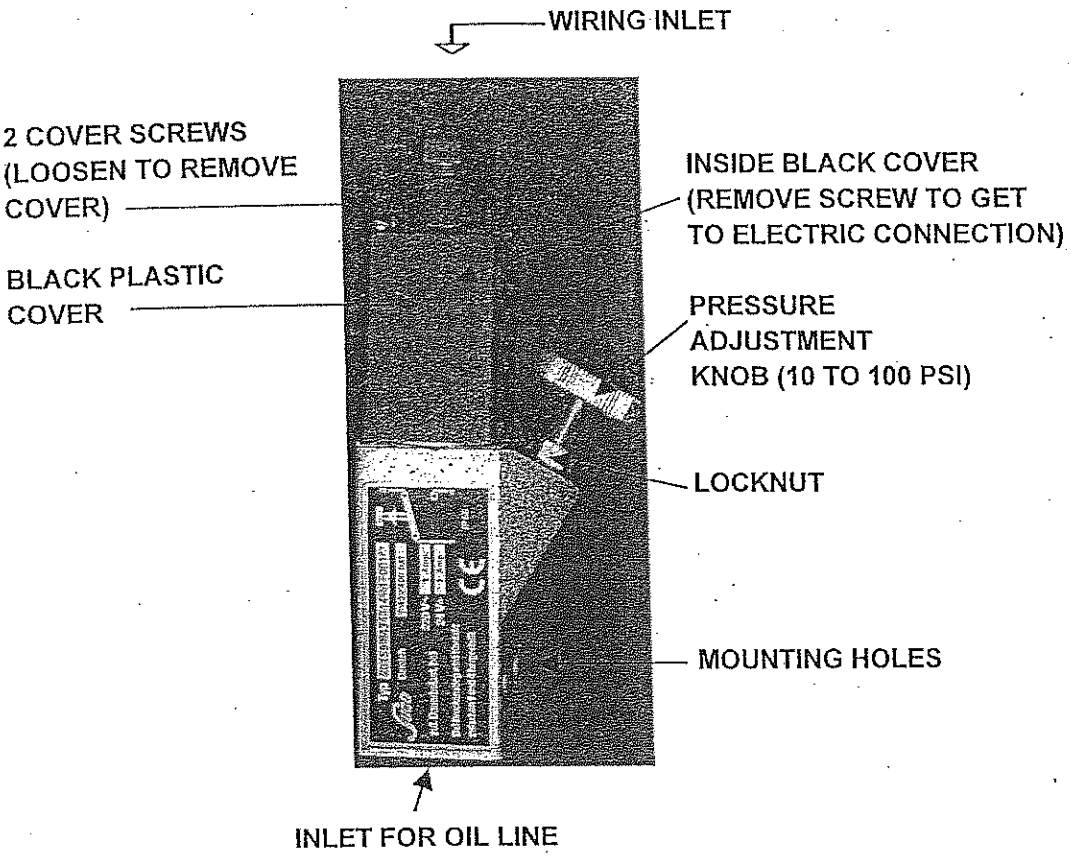


FIGURE 9-3 SUCO COMPRESSOR OIL SWITCH

The oil pressure switch, in conjunction with the time delay relay, shuts the compressor off in the event of a loss of oil pressure. Occasionally, oil pressure switches may require readjustment due to age, vibration or the change in viscosity between winter and summer. Should readjustment be required, use the following procedures:

1. Loosen the 10mm lock nut on the oil switch knob. The oil switch is identified by the numbers 10-100 on the adjustment knob.

2. Turn the knob counterclockwise until seven threads show above the lock nut.

3. Start up the compressor and wait until the oil pressure is built up to the proper level. Turn the time delay to zero.

4. Slowly turn the knob clockwise until the machine shuts off.

5. Turn the knob counterclockwise one turn and lock in place with the 10mm nut.

6. Reset the time delay to mid range and tap in place.

9.3 OIL PRESSURE REGULATOR ADJUSTMENT

The oil pressure regulator is mounted on the final stage cylinder and is adjusted to 1000 to 1050 PSIG on four stage machines (see Figure 9-4). The regulator may be adjusted by loosening the lock nut in the rear and turning the set screw. Adjustment should be made with the compressor in operation.

Turning the set screw clockwise will increase the pressure and turning counter-clockwise will decrease the pressure.

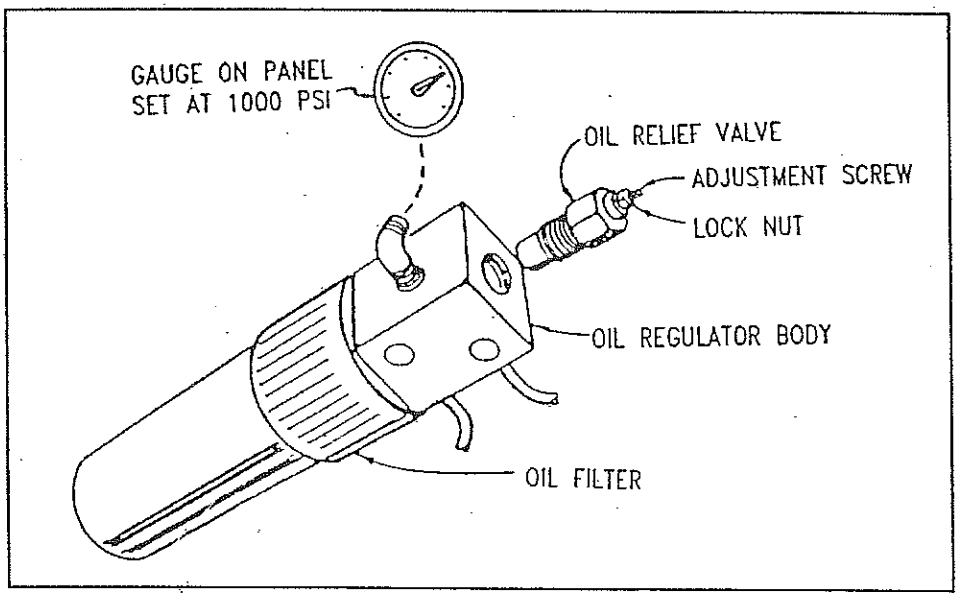


FIGURE 9-4 OIL PRESSURE REGULATOR

9.4 OIL PRESSURE STABILIZATION

Oil pressure fluctuations over 150 PSI around the nominal (1000 PSIG on four stage machines) are caused by air entrainment or debris in the regulator valve seat.

Both conditions can be corrected by flushing the oil regulator valve. This is accomplished as follows:

1. With the machine running, loosen the lock nut shown in Figure 9-4.

2. Turn oil pressure adjustment screw counter clockwise to open regulating needle valve.

3. Leave the valve open for six to eight seconds.

4. Turn oil pressure adjusting screw clockwise until oil pressure reaches 1000 PSIG.

5. Reset the lock nut to hold the screw position.

WARNING: **DO NOT RUN THE COMPRESSOR MORE THAN 8 SECONDS AT A PRESSURE BELOW 750 PSIG.**

6. Repeat Steps 4 and 5 as necessary to reach the nominal oil pressure level of 1000 PSIG ± 50 PSIG.

9.5 LOW PRESSURE OIL SWITCH ADJUSTMENT

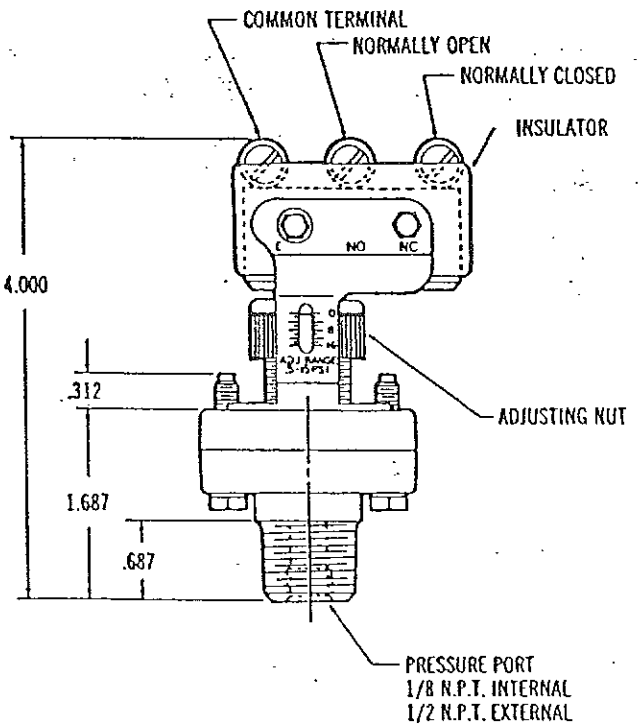
Adjustment procedures for the low pressure oil switch are as follows:

1. The adjusting nut with a line should be used for pressure adjustments.

2. Turn the adjustment nut clockwise to raise and counterclockwise to lower the actuation point.

When a decrease in oil pressure is required, move the adjustment nut Counterclockwise until line on nut is on the scale mark equalling two.

NOTE: It is not a problem when the pressure drops as low as 2 PSI.



10.0 ADJUSTABLE SAFETY VALVE

NOTE: ASME RATED SAFETY RELIEF VALVES ARE NOT ADJUSTABLE.

An adjustable type safety valve is installed on the final separator.

This valve is set and sealed (wired) by Mako during machine testing. Normally this valve doe not require field attention. If, for any reason, the poppet lifts and a small flake of debris is trapped between the poppet and its seat, a small continuous leak will occur. A leak due to debris can be easily corrected in the field using the procedure discussed below. Before making any adjustments, however, verify that the safety valve is in fact leaking using the following procedure:

1. Override the auto drain solenoid as discussed in Section 7.

2. Start the compressor and bring the system up to the air switch shut off pressure.

3. Listen for leakage through the safety valve. You have only a few seconds before the compressor decays from leakage back through the machine.

If indeed the safety valve is leaking, assume that a small piece of debris has become lodged between the poppet and its seat and performance following corrective action:

1. Note or mark the position of the adjusting cap with respect to the bonnet (see Figure 10-1).

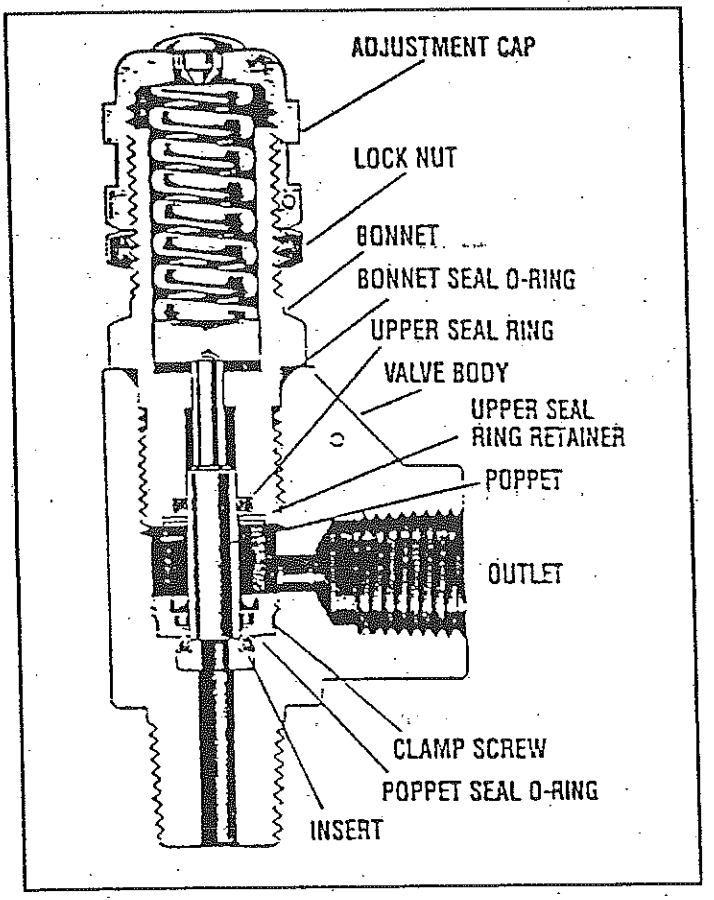


FIGURE 10-1 VALVE PART IDENTIFICATION

2. Cut the seal wire to permit adjustment cap movement.

3. Start the compressor and bring the system up to within 500 PSI

4. Using a 3/4" end wrench, turn the adjustment cap approximately 1/2 turn counterclockwise to cause the poppet to lift and blow the debris out of the valve seat.

NOTE: **VALVE ADJUSTMENT IS A SAFE OPERATION BECAUSE THE POPPET IS TRAPPED IN THE VALVE BONNET. WHEN THE SPRING FORCE IS RELIEVED, THE POPPET WILL MOVE UPWARD AND RESTART.**

5. After a short (1 to 2 second) blow down, turn the adjustment cap clockwise until the leakage stops.

6. Visually note the position of the adjustment cap with respect to the marked place in the valve bonnet in Step 1.

7. Turn the adjustment cap 1/8 turn to set the valve relief point to 10% above the operating pressure.

8. Using another 3/4" end wrench, turn the lock nut counterclockwise to lock the adjusting cap in-place.

9. Make sure the auto drain override has been reset.

11.0 ELECTRICAL FAULT DIAGNOSIS

11.1 FAULT DIAGNOSIS - 12 VOLT

Electrical trouble diagnosis requires the wiring diagram, a multimeter and a jumper wire.

CAUTION: DO NOT OPEN ELECTRIC BOX UNTIL THE INCOMING POWER IS OFF. HIGH VOLTAGE IS PRESENT EVEN IF MACHINE IS NOT RUNNING.

WARNING: YOU MAY HAVE TO TURN THE POWER ON TO CHECK SOME OF THE ITEMS. REMEMBER TO TURN IT OFF AGAIN BEFORE YOU TOUCH ANYTHING IN THE ELECTRIC BOX.

NOTE: ALL CONTROL VOLTAGES ARE 12 VDC EXCEPT ON THE TRANSFORMER AND STARTER IN THE ELECTRIC BOX WHICH ARE HIGH VOLTAGE.

The electrical system has a magnetic starter and switches to turn it on and off. Under normal conditions the switches are closed and the machine runs. If a wire comes loose, a switch opens or breaks and the machine stops or doesn't run. The one exception to this rule is the oil switch.

Electrical System Fault Diagnosis is conducted as follows:

1. Before checking the circuits make sure:

   a. Power is available to the machine.

   b. The red reset button on the starter has been pressed.

   c. The fuses have been checked.

2. Locate the identification numbers of the wires going to and from each switch on the wiring diagram. Wire numbers are characterized by a number and a letter A through O.

   NOTE: MOST OF THE TROUBLESHOOTING CAN BE DONE AT THE TERMINAL STRIP MOUNTED ON THE CO CALIBRATION GAS BRACKET.

   NOTE: THE MOST COMMON ELECTRICAL PROBLEM IS LOOSE WIRES. TO CHECK THIS, TURN THE POWER OFF AND GIVE EACH WIRE A GENTLE PULL.

3. Place the meter on the same wire number on each side of the switch. If the contacts on the switch are open, the switch is bad or a wire going to the switch is loose. You can temporarily put the jumper between the wires around the switch to determine if the switch is faulty.

CAUTION: REMEMBER YOU ARE BYPASSING A SAFETY SWITCH IN THE SYSTEM AND YOU NEED TO REPLACE THE SWITCH IMMEDIATELY.

The jumper wire can also be used in the absence of a meter. Place the jumper on each of the wire numbers around the switch and turn the power on to see if the machine runs.

Remove the electric box cover to check to relays and timers.

CAUTION: THERE IS HIGH VOLTAGE IN THE ELECTRIC BOX.

A terminal strip in the electric box expedites trouble shooting. Follow the wiring diagram to determine which wire numbers will jump out each relay. Be careful not to jump between the high and low voltages. A relay about one inch by three quarters of an inch is located in the electric box just below the transform. This relay is controlled by the 12 VDC control system and switches the 120 VAC that operates the coil on the starter. To bypass all the switches on the machine and check the starter, turn the main power off and connect a jumper between the number 5 wire and the number 13 wire. When the main power is turned on the machine should run, even with the panel switches in the off position. Use a meter to check the voltage between the 13 wire and ground. The meter should read 12 to 16 VDC. On the other side of the relay (on the B wire) you should have 120VAC.

4. To check the oil switch:

   a. Make sure you have correct oil pressure.

   b. Remove wires noting location from the oil switch.

   c. Turn on the power. If the machine runs, the oil switch is bad.

NOTE: THIS ONLY APPLIES IF YOU HAVE A PRESSURE OIL SYSTEM.

11.2 FAULT DIAGNOSIS - 110 VOLT

CAUTION: DO NOT OPEN ELECTRIC BOX UNTIL THE INCOMING POWER IS OFF. HIGH VOLTAGE IS PRESENT EVEN IF MACHINE IS NOT RUNNING.

You may have to turn the power on to check some of the items. Remember to turn it off again before you touch anything in the electrical box.

The electrical system is simple. It is composed of a magnetic starter and switches to turn it on and off.

Under normal conditions the switches are closed and the machine runs., If a wire comes loose, a switch opens or breaks. The machine stops or doesn't run. The one exception to this rule is the oil switch.

Before checking the circuits make sure you:

1. Have power coming to machine.

2. Have pressed the read test button on the starter.

3. Have checked the fuses in the system.

Trouble shooting is simple, but be careful - TURN OFF POWER. Before you start you will need wiring diagram, a multimeter and a jumper wire.

The first step is to locate the numbers of the wires going to and from each switch on the wiring diagram. Wires are identified by a number and/or a letter A through O.

Most of the trouble shooting can be done at the terminal strip. Place the meter on the wire number on each side of the switch. If the contacts on the switch are open, the switch is bad or a wire going to the switch is loose. You can temporarily put the jumper between the wires around the switch to determine if the switch is faulty. If this is done, remember you are by-passing a safety switch in the system and you need to replace the switch immediately.

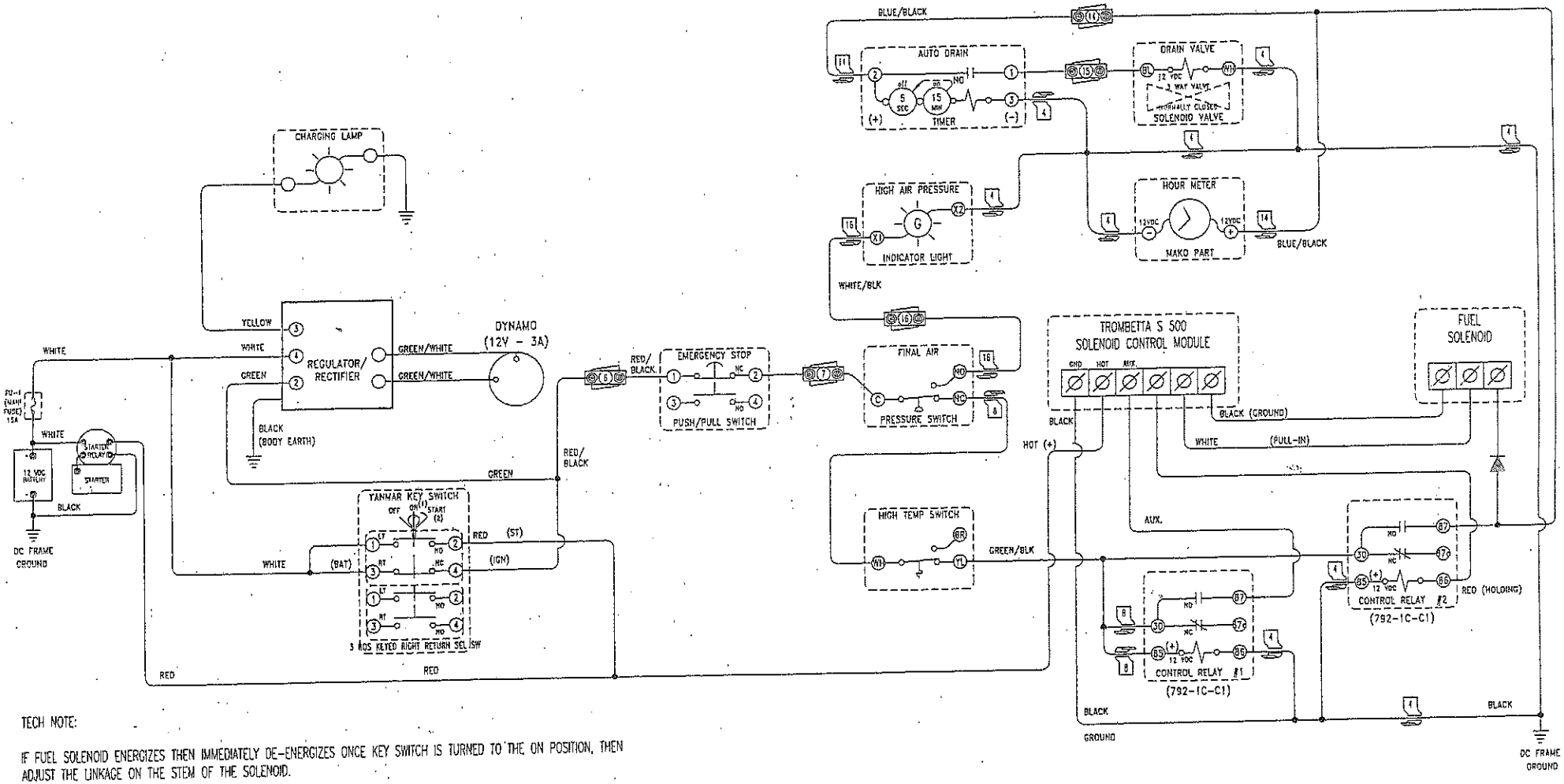
The jumper wire can also be used in the absence of a meter. Place the jumper on each of the wire numbers around the switch and turn the power on to see if the machine runs.

The only wire you cannot check on the terminal strips is the one from the time delay (TD) to the starter (m-1). To check this wire number locate the black plastic timer with the black adjusting knob near the bottom. Find the wire numbers going to the (TD) and check to see if the circuit is closed.

NOTE: THIS ONLY APPLIES IF YOU HAVE A PRESSURE OIL SYSTEM.

MAKO COMPRESSORS INC.

5400BA-D YANMAR DIESEL-POWERED HORIZONTAL B.A. COMPRESSOR
ELECTRICAL DIAGRAM



TECH NOTE:

IF FUEL SOLENOID ENERGIZES THEN IMMEDIATELY DE-ENERGIZES ONCE KEY SWITCH IS TURNED TO THE ON POSITION, THEN ADJUST THE LINKAGE ON THE STEM OF THE SOLENOID.

DIESEL MUST CRANK AND BUILD OIL PRESSURE BEFORE THE FUEL SOLENOID UNIT WILL ENGAGE. ADJUSTMENTS CAN BE MADE TO THE OIL PRESSURE SWITCH IF FUEL SOLENOID DOES NOT ENGAGE DURING CRANKING.

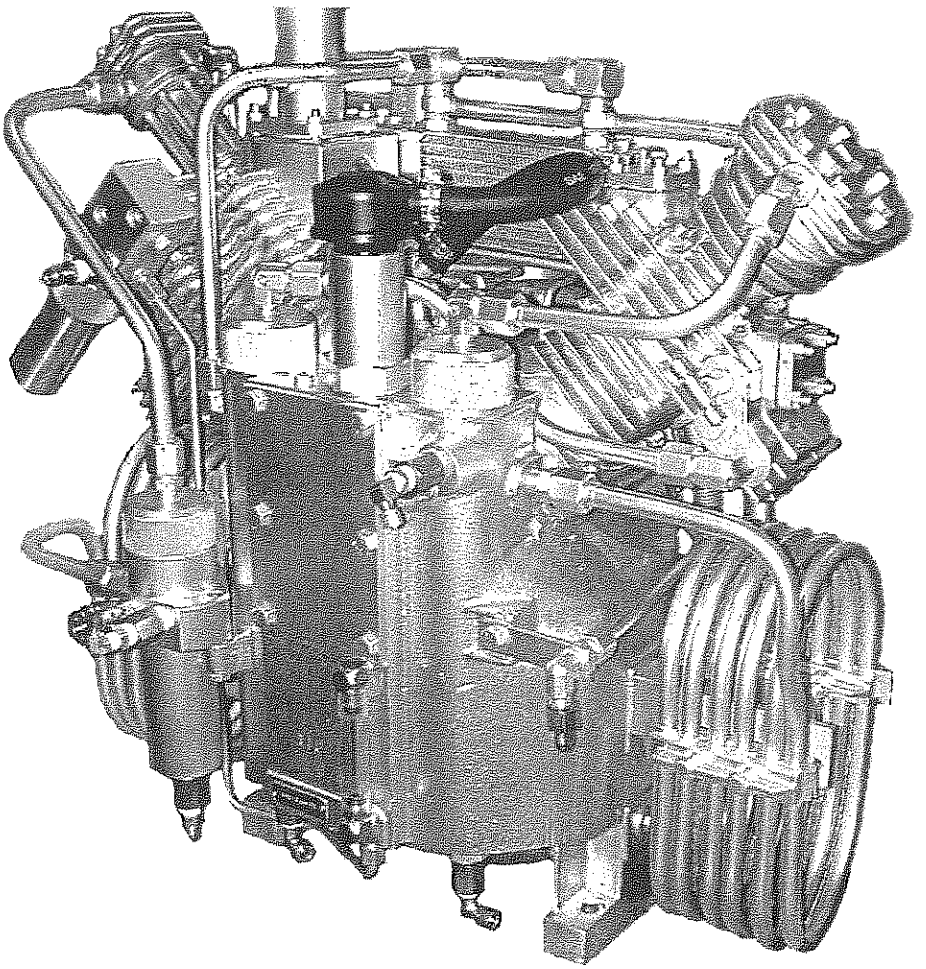
DRAWING NUMBER AND/OR FILE: D:\STDLN\5400\ DE049342.DWG

SCALE: FULL DRAWN BY: J DOWNING DATE: MAR. 11, 2004

REPLACES DWG: DE049341.DWG APPROVED BY: J DOWNING PART NO: -------

1634 SW 17th STREET, OCALA, FLORIDA 34474 TELEPHONE (352) 732-2268 FAX (352) 732-7873

Addendum Publication
For
5407.3.IAH
Aircooled Air Compressor



In any correspondence please quote:

Compressor Model Number:
Compressor Serial Number:

Publication number: 5407.001
Publication date: Apr. 29, 2005

Mako Compressors 1634 SW 17th St. Ocala, FL 34472 Ph. (352) 732-2268 Fx (352) 732-7873

GENERAL DESCRIPTION AND OPERATION

1.1 5407.3.IAH

This compressor is a high pressure, reciprocating 'V' configuration, four cylinder machine cooled by a large pulley driven variable pitch fan.

Air enters via the intake filter and passes to the first stage cylinder where it is compressed before passing through a heat exchanger to the second stage. On exit from the second stage it flows round a cooling system positioned in the fan airstream and then into a separator for condensate removal. On entering the third stage the air is further compressed before passing through the second cooling coil and condensate removal separator. Final compression takes place in the fourth stage before passing through a finned final cooling system.

1.2 RUNNING GEAR

Main bearings are replaceable, but big end and small end bearings are renewable only as a connecting rod assembly.

1.3 VALVES

First and second stage valves are separate flat plate units for suction and delivery duties whilst the third and fourth stage utilise integral cylinder head combined suction and delivery valve assemblies. All valves are easily accessible, for maintenance and replacement when required.

1.4 LUBRICATION

5407.3.IAH A cam operated force feed oil pump feeds oil through an oil filter to the bottom of the final stage liner/plunger and then returns to the crankcase.

First, second and third stage cylinders, main, big and small end bearings are all oil mist lubricated.

Lubricant returns to the sump for filtration and re-circulation. The specified lubricant must be used at all times to ensure safe and efficient operation with minimum wear and maximum protection against corrosion.

Recommendations are the result of extensive research at Mako Compressors and all responsibility for the use of any oil other than that recommended is placed on the purchaser and his oil company.

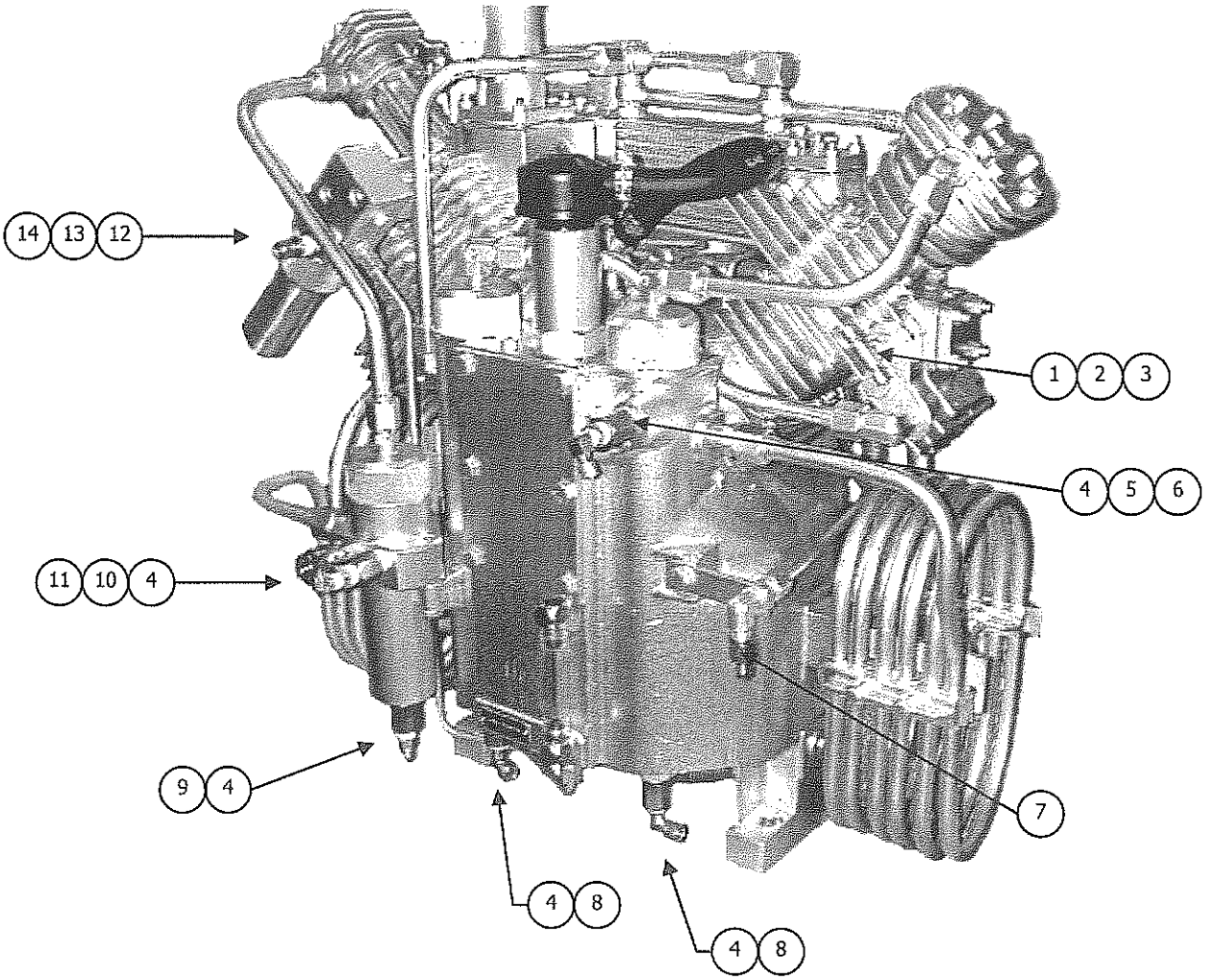
1.5 GAUGES

The 5407.3.IAH low pressure lubrication system requires the use of a 0-200 PSI gauge (003M2256).

1.6 OIL PRESSURE SWITCH

An oil pressure switch (003X0331) will be used in the compressor system to monitor the oil pressure and ensure pressure remains above 10 PSI. If the oil pressure drops below 10 PSI for more than 30 seconds then the compressor system will shut down and an indicator light will illuminate.

1.7 FITTINGS FOR COMPRESSOR BLOCK



REF	Part Number	Description	Qty
1	001PS1322/1	Seal-Dowty	1
2	CONSM316	Fitting-1/8 Metric-1/8 NPT/M	1
3	003M1406	Fitting-Brass Tee 1/8 MNPT – 1/8 Tube	1
4	003F70400404	Fitting-1/4FNPT-1/4MBSPT	5
5	003M1345-1	Fitting-Brass	1
6	003M1402	Fitting-Brass Elbow 1/8 MNPT-1/8 Tube	1
7	003M1254	Fitting-Reducer 5/16 TFJ-1/4 TMJ	1
8	003M309	Fitting-Brass Elbow ¼ M-1/4 Tube	2
9	CONSM2001	Fitting-Adaptor ¼ NPT/M x ¼ JIC/M Straight	1
10	CONSM1345	Fitting-Reducer ¼-1/8 NPT	1
11	003M1331	Fitting-90 Deg 1/8NPT-1/8 Tube	1
12	001PS1322/2	Seal-Dowty ¼ Nitrile	1
13	003M1275	Fitting-Cajon	1
14	003M1423	Fitting-Brass ¼ M/NPT-1/4 Tube	1

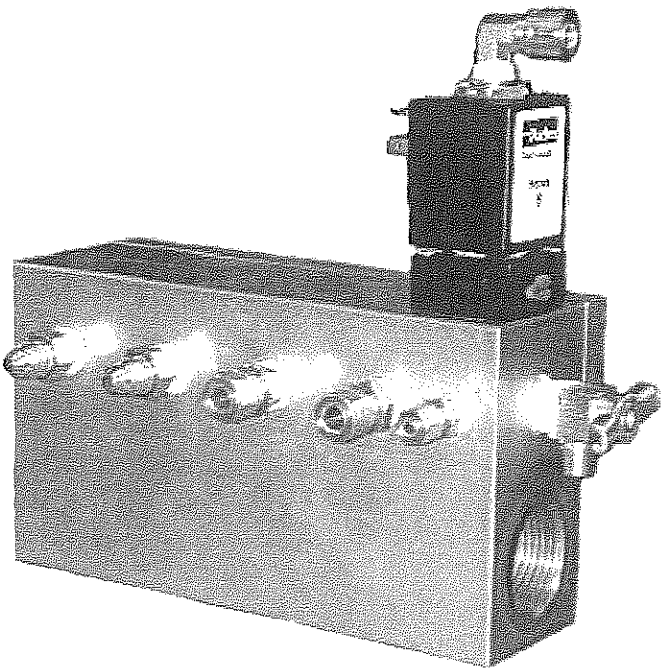
Fitting kit (095BAMBLK67) may be purchased which includes the above.

Auto Drain System

2.1 Description

The 5407.3.IAH compressor has 3 separators, which are located between the 1^{st}-2^{nd}, 2^{nd}-3^{rd}, and 3^{rd} – 4^{th} stages, collecting the water/oily mixture created by the compressor. The auto drain system will have 4 stages.

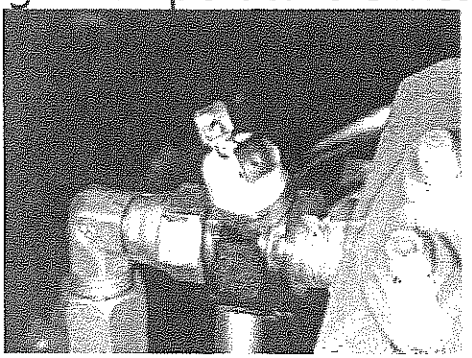
2.2 Auto Drain System Components



4 stage Auto-Drain (005M7000-5-12V)

The auto drain system requires four piston and o-ring sets (005M9012).
An o-ring only kit is also available which contains all o-rings needed for an auto-drain (005ADMK#5)

High Temperature Switch



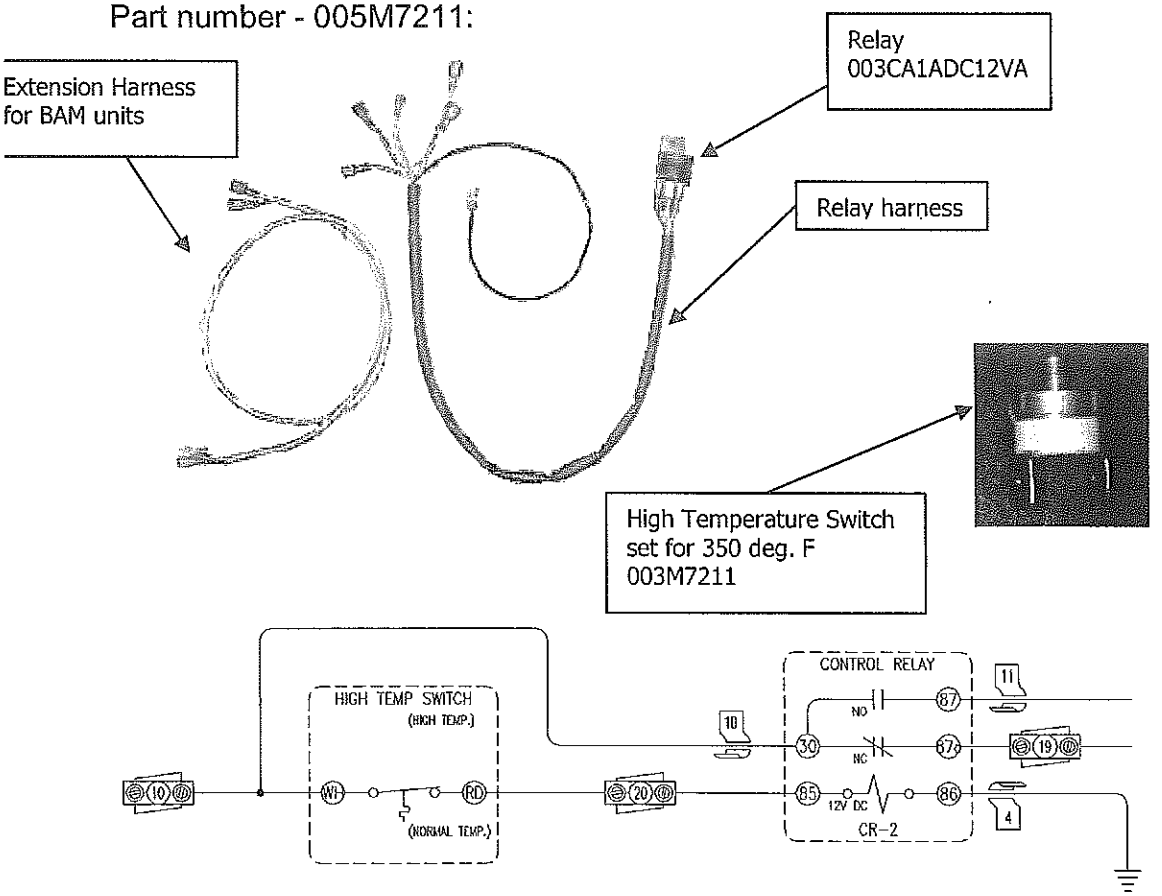
3.1 Description

Mako Compressors is introducing a new 2-pole high temperature switch which will protect the compressor and the quality of the air supply by shutting down the system if temperatures reach 350 deg. F. This switch will be on each compressor sold after March 1, 2005.

To retro-fit from the 3-pole temperature switch to the 2-pole switch a High Temperature Switch Kit (005M7211) needs to be purchased.

3.2 Parts and Harness

Part number - 005M7211:



PARTS LIST & DRAWINGS

CONTENTS

Note: Standard parts are available where indicated by either a number or letters. The letters indicate that an item is available as a component of an assembly. Non-listed or individual items of assemblies where reference numbers are not indicated, are not standard replacement parts and can only be obtained at the discretion of Mako Compressors. The assemblies have been chosen based on the experience gained by our own Parts and Service Departments.

The right is reserved to modify the contents of this list, without notice, and the information given is in no way binding on the manufacturers.

PARTS LIST J - 1st STAGE VALVES

SEE PAGE 25 FOR ILLUSTRATIONS

ITEM No.	DESCRIPTION	No PER MACHINE	PART No.	ASSEMBLY REF.
	VALVE COMPLETE - 1st STAGE SUCTION	1	98650.1247	—
	OVERHAUL MAINTENANCE KIT	1	98650.1760	NB
J1	NUT	1	—	—
J2	WASHER	1	—	—
J3	VALVE SEAT	1	—	—
J4	VALVE PLATE	1	—	NB
J5	SPRING PLATE	1	—	NB
J5/1	SPRING PLATE	1	—	NB
J6	LIFT WASHER	1	—	NB
J7	VALVE GUARD	1	—	—
J8	BOLT	1	—	NB
J9	PEG	1	—	—
	VALVE COMPLETE - 1st STAGE DELIVERY	1	98650.1248	—
	OVERHAUL MAINTENANCE KIT	1	98650.1760	NB
J10	VALVE SEAT	1	—	—
J11	LIFT WASHER	1	—	NB
J12	VALVE PLATE	1	—	NB
J13	SPRING PLATE	1	—	NB
J13/1	SPRING PLATE	1	—	NB
J14	VALVE GUARD	1	—	—
J15	WASHER	1	—	—
J16	NUT	1	—	—
J17	STUD	1	—	—
J18	PEG	1	—	—

PARTS LIST K - 2nd STAGE VALVES

SEE PAGE 27 FOR ILLUSTRATIONS

ITEM No.	DESCRIPTION	No PER MACHINE	PART No.	ASSEMBLY REF.
	VALVE COMPLETE - 2nd STAGE SUCTION	1	98650.1181	—
	OVERHAUL MAINTENANCE KIT	1	98650.1751	NC
K1	NUT	1	—	NC
K2	WASHER	1	—	NC
K3	VALVE SEAT	1	—	—
K4	VALVE PLATE	1	—	NC
K5	LIFT WASHER	1	—	NC
K6	SPRING PLATE	3	—	NC
K7	VALVE GUARD	1	—	—
K8	BOLT	1	—	NC
K9	PEG	1	—	—
	VALVE COMPLETE - 2nd STAGE DELIVERY	1	98650.1182	—
	OVERHAUL MAINTENANCE KIT		98650.1751	NC
K10	VALVE SEAT	1	—	—
K11	LIFT WASHER	1	—	NC
K12	VALVE PLATE	1	—	NC
K13	SPRING PLATE	4	—	NC
K14	VALVE GUARD	1	—	—
K15	WASHER	1	—	NC
K16	NUT	1	—	NC
K17	STUD	1	—	—
K18	PEG	1	—	—

PARTS LIST L - 3rd STAGE CONCENTRIC VALVE

SEE PAGE 29 FOR ILLUSTRATIONS

ITEM No.	DESCRIPTION	No PER MACHINE	PART No.	ASSEMBLY REF.
	VALVE COMPLETE	1	98650.1883	—
	OVERHAUL MAINTENANCE KIT		98650.1215	ND
L1	UPPER BODY	1	—	—
L2	'O' RING	1	95602.54	ND
L3	VALVE / BACKING PLATE - Delivery	2	—	ND
L4	SPRING PLATE - Delivery	2	—	ND
L5	VALVE / BACKING PLATE - Suction	2	—	ND
L6	SPRING PLATE - Suction	2	—	ND
L7	LOWER BODY	1	—	—
L8	PEG	1	—	—
L9	'O' RING	1	95602.50	ND
L10	SETSCREW	2	95018.134	ND

PARTS LIST M - 4th STAGE CONCENTRIC VALVE

SEE PAGE 31 FOR ILLUSTRATIONS

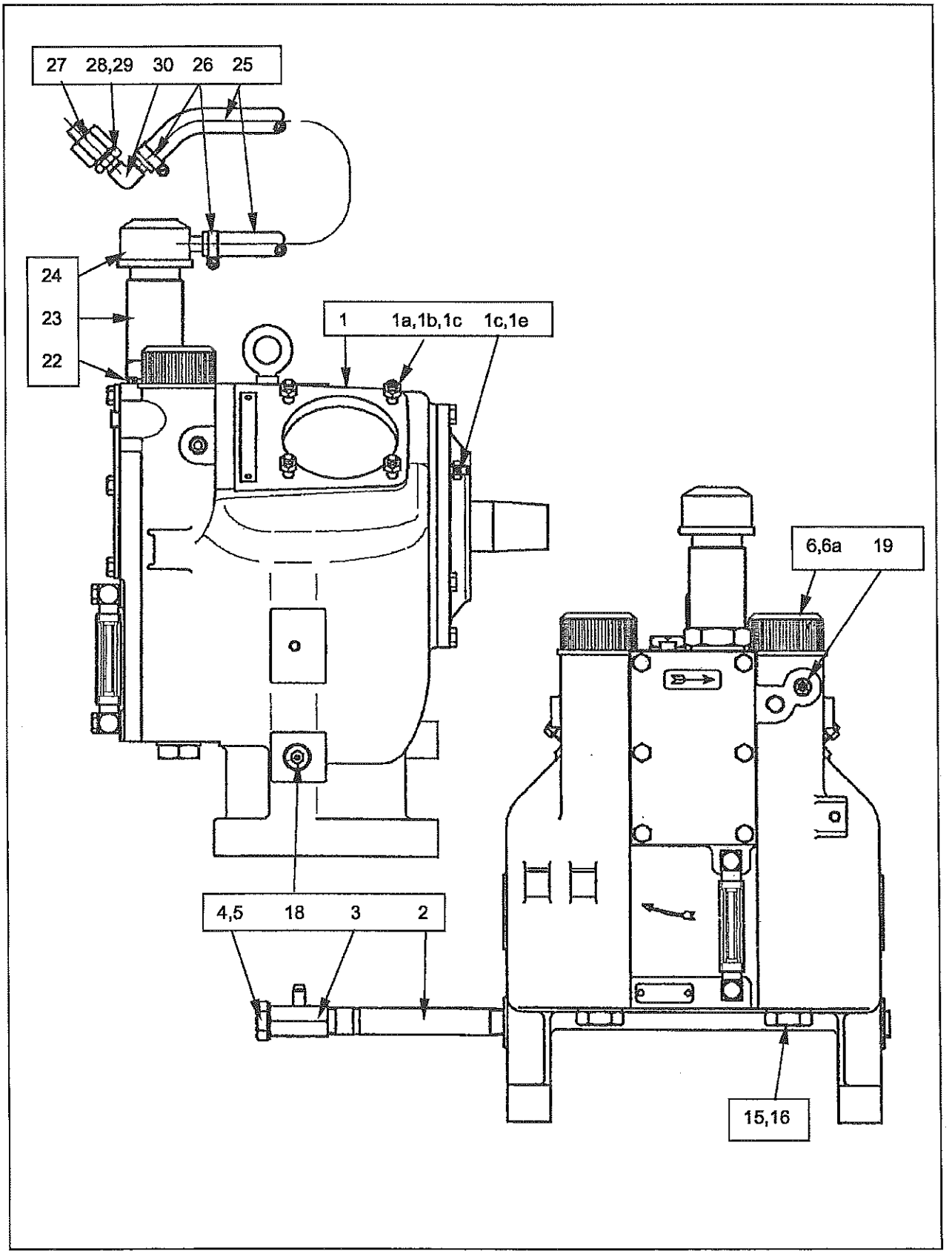
ITEM No.	DESCRIPTION	No PER MACHINE	PART No.	ASSEMBLY REF.
	VALVE COMPLETE	1	C201654	—
	OVERHAUL MAINTENANCE KIT	1	98650.1199	NE
M1	UPPER BODY	1	—	—
M2	'O' RING	1	95602.16	NE
M3	VALVE / BACKING PLATE	4	—	NE
M4	VALVE SPRING	4	—	NE
M5	CENTRE PLATE	2	—	NE
M6	MIDDLE BODY	1	—	—
M7	'O' RING	2	95602.18	NE
M8	LOWER BODY	1	—	—
M9	PEG	2	—	—
M10	SETSCREW	2	95018.106	NE

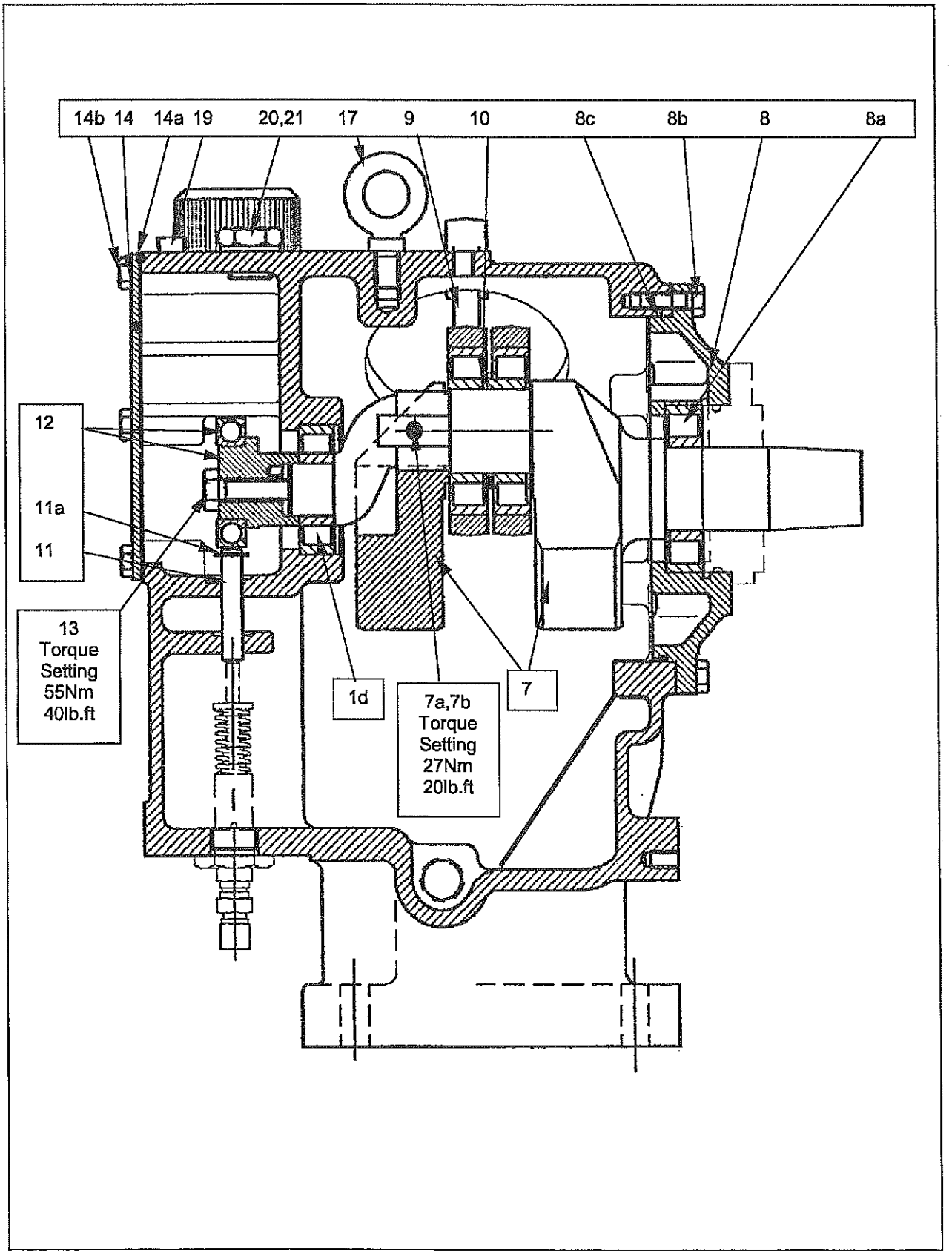
LIST N

MAINTENANCE KITS

ASS/Y REF.	DESCRIPTION	No PER MACHINE	PARTS ASS/Y No
NA	OVERHAUL - MAINTENANCE JOINT KIT	1	98504.1119
NB	OVERHAUL - VALVE MAINTENANCE KIT - 1st STAGE	1	98650.1760
NC	OVERHAUL - VALVE MAINTENANCE KIT - 2nd STAGE	1	98650.1751
ND	OVERHAUL - VALVE MAINTENANCE KIT - 3rd STAGE	1	98650.1215
NE	OVERHAUL - VALVE MAINTENANCE KIT - 4th STAGE	1	98650.1199

Note: The maintenance kits may have more items than listed, but this is to allow for a standard kit being used on all current and past versions of the **5407** and **5307**.compressors.


27 28,29 30 26 25
24
23
22
1 1a,1b,1c 1c,1e
6,6a 19
4,5 18 3 2
15,16


14b 14 14a 19 20,21 17 9 10 8c 8b 8 8a
12
11a
11
13
Torque
Setting
55Nm
40lb.ft
1d
7a,7b
Torque
Setting
27Nm
20lb.ft
7

CRANKCASE ASSEMBLY -A30175
AIR COMPRESSORS PARTS LIST

REF	PART No	DESCRIPTION	NO OFF
1	A30166.50 includes 1a, 1b, 1c, 1d, 1e, 1f	Crankcase Kurbelgehäuse Carter Krukaskast Cárter Carter	1
1a	D54019.8.28	Stud Schaubbolzen Goujon Tapeind Espárrago Perno	8
1b	PS1113.13	Washer, Shakeproof Unterlegscheibe, Rüttelfest Rondelle-frein non desserrable Schokvaste sluitring Arandela antivibratoria Rondella dentata	8
1c	95111.5	Nut Mutter Ecrou Moer Tuerca Dado	10
1d	96064.174	Bearing, Roller Rolenlager Palier ò rouleaux Rollager Cojinete de rodillos Cuscinetto	1
1e	D100171.8.41	Stud Schaubbolzen Goujon Tapeind Espárrago Perno	2
1f	C203468	Gauge, Level Niveauanzeiger Indicateur de niveau Niveaumeter Indicador de nivel Indicatore di livello	1
2	C203470	Pipe, Drain Ablaßrohr Tuyau de vidange Aftappijp Tubo de drenaje Tubo di Scarico	1
3	98650.1983	Valve, Oil drain Ölablaßventil Purgeur d'huile Olieaftapklep Válvula, drenaje de aceite Valvola di scarico olio	1

4	98660.1155	Seal Dichtung Joint Afdichting Sello Guarnizone	1
5	PS1068.4	Plug, Blanking Blindstopfen Bouchon d'obturation Blindplug Tapón obturador Tappo cieco	1
6	C203369.100 includes 6a	Cap Deckel Couvercle Deksel Tapa Tappo	2
6a	95602.78	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	2
7	D101496.50 includes 7a, 7b	Crankshaft & Balance Weight - C203386 Kurbelwelle - mit Gegengewichten Vilebrequin - avec contrepoids Krukas - met contragewichten Cigüeñal - con contrapesos Albero a gomiti con contrappesi	1
7a	95006.155	Bolt Schraube Boulon Bout Perno Bullone	1
7b	98422.1009	Locknut Kontermutter Contre-écrou Borgmoer Contratuerca Dado di serraggio	1
8	D101488.100 includes 8a, 8b	Housing, Bearing Lagergehäuse Logement de palier Lagerhuis Alojamiento de cojinete Alloggiamento del cuscinetto	1
8a	98076.1126	Bearing, Roller Rollenlager Papier à rouleaux Rollager Cojinete de rodillos Cuscinetto a rulli	4

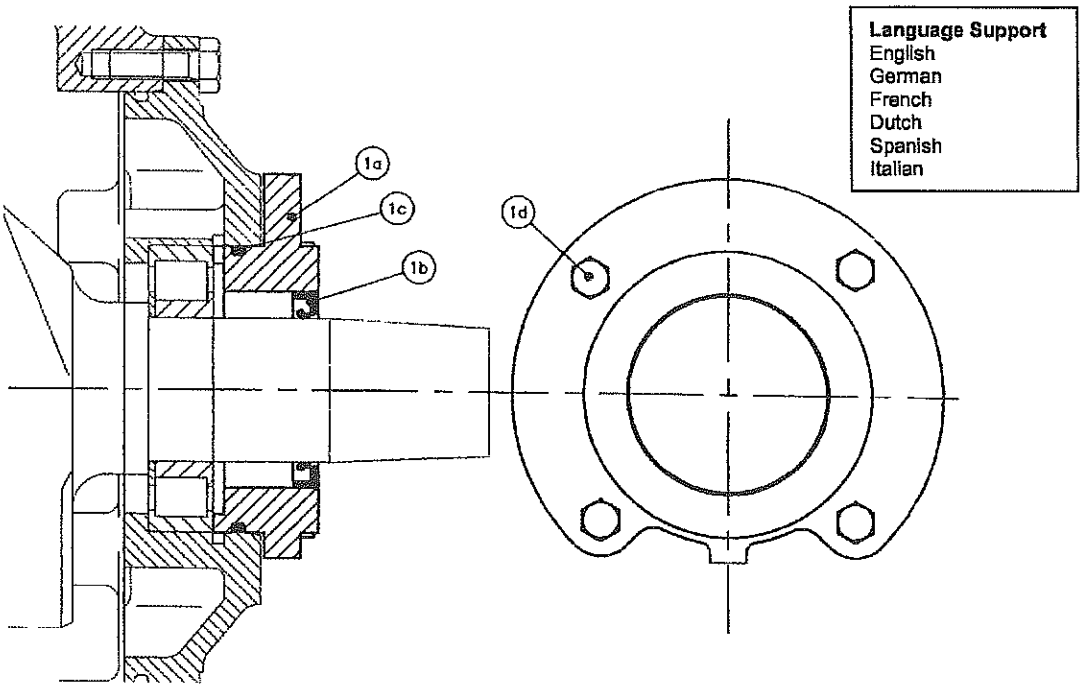
8b	95602.60	Screw, Hexagon Head Sechskantschraube Vis à tête 6 pans Zeskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	4
9	D101485	Rod, Connecting - includes bearings Pleuelstange Bielle Drijfstang Biela de conexión Biella con cuscinetti	2
10	C203378	Spacer Distanzring Entretoise Afstandring Espaciador Distanziale	1
11	C203391.50	Plunger Kolben Plonqeur Plunjer Embolo Stantuffo	1
11a	98650.1010	Circlip Sprengring Circlip Borgring Presilla	1
12	C201452	Cam Nocke Came Nok Leva Camma	2
13	98500.1003	Screw, Hexagon Head - LH Thread Sechskantschraube Vis à tête 6 pans Zeskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale con filettatura sinistra	1
14	C203394.100 includes 14s, 14b	Cover plate Verkleidungsblech Tôle de carénage Bekledingsplaat Placa tapadera Piastra di copertura	1
14a	C203393	Gasket Dichtungsblech Joint Pakking Junta Guarnizione	1

14b	95000.255	Screw, Hexagon Head Sechskantschraube Vis à tête 6 pans Zeskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	6
15	PS1322.6	Seal Dichtung Joint Afdichting Sello Guarnizione	2
16	98156.3639	Bush, Reducing Reduzierbuchse Bague de réduction Reductiebus Buje reductor Boccola di riduzione	2
17	98086.1001	Eye, lifting Hebeöse Anneau de levage Hijsooq Cáncarmo para levantamiento Anello di sollevamanto	1
18	PS1454.4	Plug, Blanking Blindstopfen Bouchon d'obturation Blindplug Tapón obturador Tappo cieco	1
19	PS1454.2	Plug, Blanking Blindstopfen Bouchon d'obturation Blindplug Tapón obturador Tappo cieco	2
20	PS1322.4	Seal Dichtung Joint Afdichting Sello Guarnizione	1
21	PS1814.3	Plug, Blanking Blindstopfen Bouchon d'obturation Blindplug Tapón obturador Tappo cieco	1
22	PS1322.8	Seal Dichtung Joint Afdichting Sello Guarnizione	1

23	C203396	Pipe Dichtung Tuyau Pijp Tubo Tubo	1
24	98262.1166	Filler - Oil Öleinfüllstutzen Remplisser d'huile Olievulplug Rellenador de aceite Bocchettone olio	1
25	98315.1127	Hose, Rubber Gummischlauch Flexible en caoutchouc Rubber slang Manquera de caucho Tubo flessibile, gomma	1
26	PS1180.3	Clip, Worm drive Schneckengewindeschelle Attache p. filetage vis sans fin Slangklem (met wormwiel) Presilla para tronillo sin fin Manica	2
27	PS1295.17	Adapter Adapter Raccord Verloopstuk Adaptador Adattatore	1
28	PS1285.7	Sleeve Muffe Manchon Verloopstuk Manquito	1
29	PS1286.7	Nut, coupling Spanmutter Ecrou d'accouplement Moer koppeling Tuerca, acoplamiento Dado	1
30	98156.3102	Elbow Bogenstück Coude Kniestuk Codo Gomito	1

Language Support
English
German
French
Dutch
Spanish
Italian

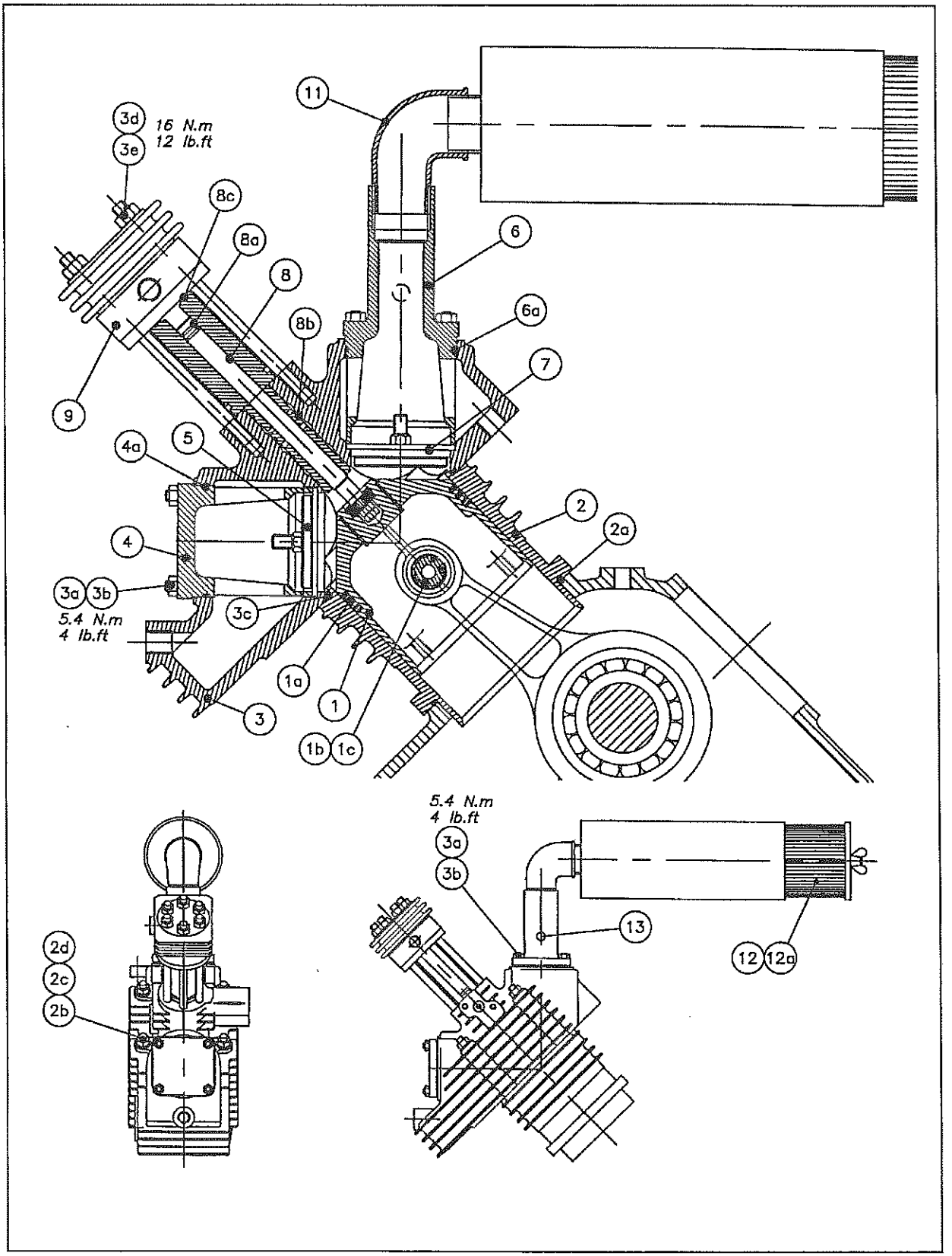
OIL SEAL ASSEMBLY D101501
STANDARD COMPRESSORS



REF	PART No	DESCRIPTION	NO OFF
1	D101501 Includes 1a, 1b, 1c & 1d	Seal, Shaft Dichtung, Welle Joint, d'arbre Asafdichting Sello de eje Guarnizione albero comprendente	1
1a	D101489	Housing, Seal Gehäuse, Dichtung Carter d'étanchéte Afdichtingshuis Alojamiento de sello Guarnizione alloggiamento	1
1b	95605.87	Seal, Oil Dichtung. Öl Joint, d'huile Olieafdichting Sello de aceite Paraolio	1
1c	95602.85	'O' Ring O-Ring Joint torigue O-Ring Aro tórico O-Ring	
1d	95000.229	Screw, Hexagon Head Sechskanantschraube Vis à tête 6 pans Zeskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	4

E61441 CYLINDER ASSEMBLY - 1st & 4th STAGE.

AIR COMPRESSORS



E61441 CYLINDER ASSEMBLY - 1st & 4th STAGE.
AIR COMPRESSORS PARTS LIST

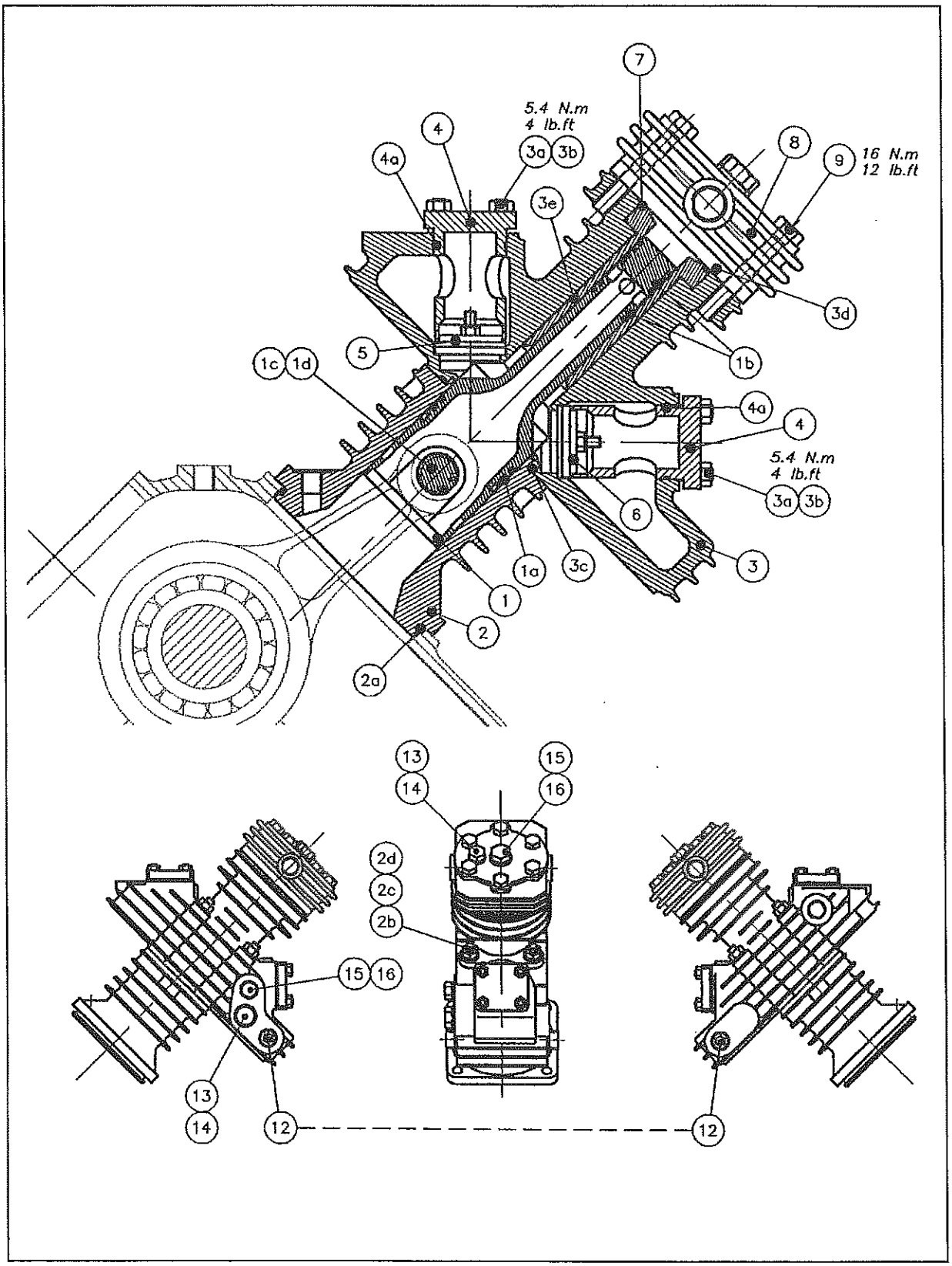
REF	PART No	DESCRIPTION	NO OFF
1	D101506.50 includes 1a, 1b,1c	Piston - 1st Stage Kolben - 1. Stufe Piston - 1er étage Zuiger - 1e trap Pistón - 1ª etapa Pistone - 1° stadio	1
1a	98477.1090	Ring kit, Piston - 1st Stage Kolbenring-satz - 1. Stufe Jeu segment de piston - 1 er stage Ringenset zuiger - 1e trap Juego anillo pistón – 1ª etapa Kit anelli pistone - 1° stadio	1
1b	C203408	Pin, Gudgeon Kolbenbolzen Axe de piston Zuigerpen Clavija muñõn Spinotto	1
1c	95650.19	Circlip Sprengring Circlip Borgring Presilla Anello di fermo	2
2	D100259.100 includes 2a,2b,2c,2d	Cylinder - 1st Stage Zyinder - 1. Stufe Cylindre - 1er étage Cilinder - 1 e trap Cilindro – 1ª etapa Cilindro - 2° stadio	1
2a	95602.90	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-ring	1
2b	D100171.8.101	Stud Schaubbolzen Goujon Tapeind Espárrago Perno	4
2c	95148.14	Washer Unterlegscheibe Rondelle Sluitring Arandela Rondella	4
2d	95111.5	Nut Mutter Ecrou Moer Tuerca Dado	4

3	A30180.100 includes 3a,3b,3c,3d,3e	Cover Cylinder - 1st Stage Zylinderdeckel - 1. Stufe Couvercle ducylindre - 1er étage Cilinderdeksel - 1 e trap Tapa de cilindro – 1ª etapa Cilindro - 1° stadio	1
3a	D100171.6.28	Stud Schaubbolzen Goujon Tapeind Espárrago Perno	8
3b	95111.4	Nut Mutter Ecrou Moer Tuerca Dado	8
3c	95602.90	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	1
3d	D100171.8.150	Stud Schaubbolzen Goujon Tapeind Espárrago	6
3e	95111.5	Nut Mutter Ecrou Moer Tuerca Perno	6
4	C200815.100 includes 4a	Cover, Delivery Valve - 1st Stage Auslaßventildeckel - 1. Stufe Couvercle de soupape de refoulement-1er étage Afdekplaat uitlaatklep - 1e trap Tapa, válvula de reparto – 1ª etapa Copertura valvola - 1° stadio	1
4a	95602.57	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	1
5	98650.1248	Valve, Delivery - 1st Stage Auslaßventil - 1. Stufe Soupape de refoulement - 1er etage Uitlaatklep - 1e trap Válvula de reparto – 1ª etapa Valvola di mandata - 1° stadio	1
6	C200814.100 includes 6a	Cover, Suction Valve - 1st Stage Einlaßventildeckel - 1. Stufe Couvercle de soupape d'aspiration - 1er étage Afdekplaat zuigklep - 1e trap Topa, válvula de aspiración – 1ª etapa Copertura valvola - 1° stadio	1

6a	95602.57	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	1
7	98650.1247	Valve, Suction - 1st Stage Einlaßventil - 1. Stufe Soupape d'aspiration - 1er etage Zuigklep - le trap Válvula de aspiración – 1ª etapa Valvola di aspirazione - 1° stadio	1
8	C203410.50	Plunger/Liner Assembly - 4th Stage Laufbuchse/Kolben - 4. Stufe Ensemble Garniture/Plongeur - 4 ème étage Voering/Plunjer Montage - 4e trap Forro/Émbollo, Cjto - 4ª etapa Gruppo pistone/camicia del - 4° stadio	1
8a	98477.1181	Ring kit, Piston - 4th Stage Kolbenring-satz - 4. Stufe Jeu segment de piston - 4 ème étage Ringenset zuiger - 4e trap Juego anillo pistón – 4ª etapa Set fasce elastiche per pistone - 4° stadio	1
8b	95602.15	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	4
8c	95602.18	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	1
9	C201654	Valve 4th Stage Ventil - 4. Stufe Soupape _-. 4 ème étage Klep - 4e trap Válvula – 4ª etapa Valvola - 4° stadio	1
10			
11	95406.56	Elbow Bogenstück Coude Kniestuk Codo Gomito	1
12	98262.1075 Includes 12a	Filter/Silencer - Suction Filter/Schalldämpfer Ansaug Filtre/Silencieux d'aspiration Aanzuigfilter/demper Filtro/Silenciador de aspiración Filtro di aspirazione	1

12a	98262.1060	Element, Air Filter Luftfilterpatrone Elément de filtre à air Luchfilterelement Elemento del filtro de aire Cartuccia del filtro di aspirazione	1
13	98156.2172	Plug Stopfen Bouchon Plug Tapón Tappo cieco	1

E61442 CYLINDER ASSEMBLY - 2nd & 3rd STAGE.
AIR COMPRESSORS



E61442 CYLINDER ASSEMBLY - 2nd & 3rd STAGE.
AIR COMPRESSORS PARTS LIST

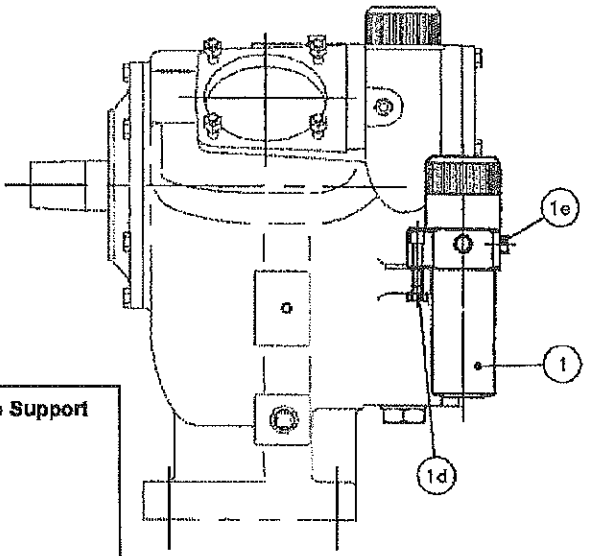
REF	PART No	DESCRIPTION	NO OFF
1	D101507.50 includes 1a, 1b,1c & 1d	Piston - 2nd Stage/3rd Stage Kolben - 2.Stufe/3.Stufe Piston - 2ème étage/3ème étage Zuiger - 2e trap/3e trap Pistón - 2ª etapa/3ª etapa Pistone - 2° stadio/3° stadio	1
1a	98477.1091	Ring kit, Piston - 2nd Stage Kolbenring-satz - 2.Stufe Jeu segment de piston - 2ème étage Ringenset zuiger - 2e trap Juego anillo pistón – 2ª etapa Kit anelli pistone - 2° stadio	1
1b	98477.1186	Ring kit, Piston - 3rd Stage Kolbenring-satz - 3.Stufe Jeu segment de piston - 3ème étage Ringenset zuiger - 3e trap Juego anillo pistón – 3ª etapa Kit anelli pistone - 3° stadio	1
1c	C203409	Pin, Gudgeon Kolbenbolzen Axe de piston Zuigerpen Clavija muñón Spinotto	1
1d	95650.19	Circlip Sprengring Circlip Borgring Presilla Anello di fermo	2
2	D100119.100 includes 2a,2b,2c,2d	Cylinder - 2nd Stage Zyinder - 2. Stufe Cylindre - 2ème étage Cilinder - 2 e trap Cilindro – 2ª etapa Cilindro - 2° stadio	1
2a	95602.87	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-ring	1
2b	D100171.8.91	Stud Schaubbolzen Goujon Tapeind Espárrago Perno	4
2c	95148.14	Washer Unterlegscheibe Rondelle Sluitring Arandela Rondella	4

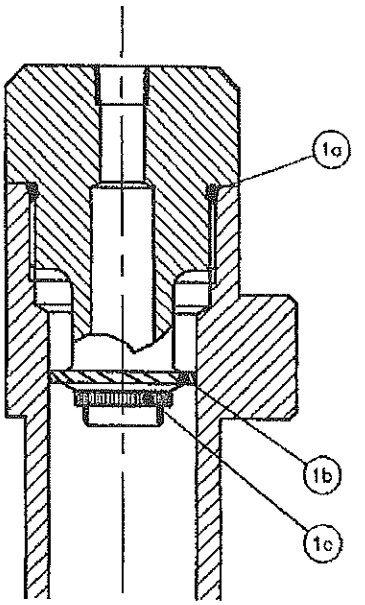
2d	95111.5	Nut Mutter Ecrou Moer Tuerca Dado	4
3	E60278.100 includes 3a,3b,3c,3d,3e	Cover Cylinder - 2nd Stage Zylinderdeckel - 2. Stufe Couvercle ducylindre - 2ème étage Cilinderdeksel - 2 e trap Tapa de cilindro – 2ª etapa Cilindro - 2° stadio	1
3a	D100171.6.28	Stud Schaubbolzen Goujon Tapeind Espárrago Perno	8
3b	95111.4	Nut Mutter Ecrou Moer Tuerca Dado	8
3c	95602.56	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	1
3d	95541.160	Pin, Locating Paßstift Goupille de positionnement Positioneringspen Pasador de colocación Perno di fermo	1
3e	C200525	Liner - 3rd Stage Buchse, Zylinder - 3. Stufe Garniture de cylindre - 3ème étage Cilindrevoering - 3 e trap Forro de cilindro - 3° etapa Camicia - 3° stadio	1
4	C200604.100 includes 4a	Cover, Valve - 2nd Stage Ventildeckel - 2. Stufe Couvercle de soupape -2ème étage Ventieldeksel - 2e trap Tapa de válvula – 2ª etapa Copertura valvola - 2° stadio	2
4a	95602.22	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	2

5	98650.1182	Valve, Delivery - 2nd Stage Auslaßventil - 2. Stufe Soupape de refoulement - 2ème etage Uitlaatklep - 2e trap Válvula de reparto – 2ª etapa Valvola di mandata - 2° stadio	1
6	98650.1181	Valve, Suction - 2nd Stage Einlaßventil - 2. Stufe Soupape d'aspiration - 2ème etage Zuigklep - 2e trap Válvula de aspiración – 2ª etapa Valvola di aspirazione - 2° stadio	1
7	95602.50	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	1
8	98650.1883	Valve 3rd Stage Ventil - 3. Stufe Soupape _-. 3 ème étage Klep - 3e trap Válvula – 3ª etapa Valvola - 3° stadio	1
9	95000.262	Screw, Hexagon Head Sechskantschtaube Vis à tête 6 pans Zeskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	6
12	PS1454.3	Plug, Blanking Blindstopfen Bouchon d'obturation Blindplug Tapón oburador Tappo cieco	1
13	PS1322.2	Seal Dichtung Joint Afdichting Sello Guarnizion	2
14	PS1814.4	Plug, Blanking Blindstopfen Bouchon d'obturation Blindplug Tapón oburador Tappo cieco	2
15	PS1322.1	Seal Dichtung Joint Afdichting Sello Guarnizion	2

16	PS1814.2	Seal Dichtung Joint Afdichting Sello Guarnizion	2

SEPARATOR ASSEMBLY D101509
STANDARD COMPRESSORS

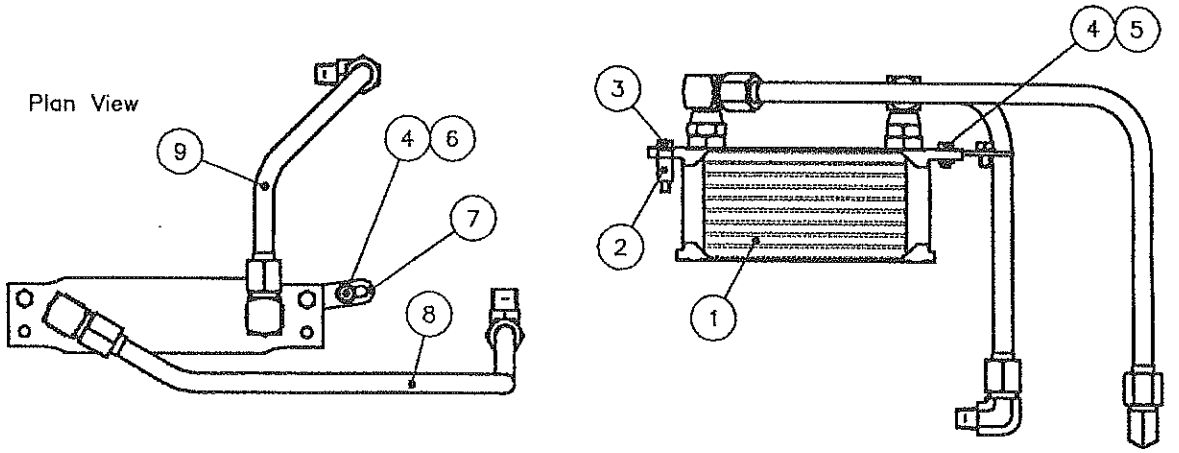




Language Support
English
German
French
Dutch
Spanish
Italian

REF	PART No	DESCRIPTION	NO OFF
1	D101509 Includes 1a, 1b, 1c, 1d & 1e	Moisture Separator - 3rd Stage Kondensatabscheider- 3. Stufe Séparteur des condensats 3 ème étage Condensafscheider - 3e trap Separador de humedad - 3° etapa Separatore di condensa 3° stadio	1
1a	95602.78	'O' Ring O-Ring Joint torigue O-Ring Aro tórico O-Ring	1
1b	98504.1002	Deflector Deflektor Déflecteur Afbuigplaat Placa deflectora Deflettore	1
1c	98152.1143	Ring, Lock Verschlßring Segment de verrouillage Sluitring Anillo de cierre Ghiera	1
1d	95000.259	Screw, Hexagon Head Sechskanantschraube Vis à tête 6 pans Zeskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	2
1e	PS1454.2	Plug, Blanking Blindstopfen Bouchon d'obturation Blindplug Tapón obturador Tappo cieco	1

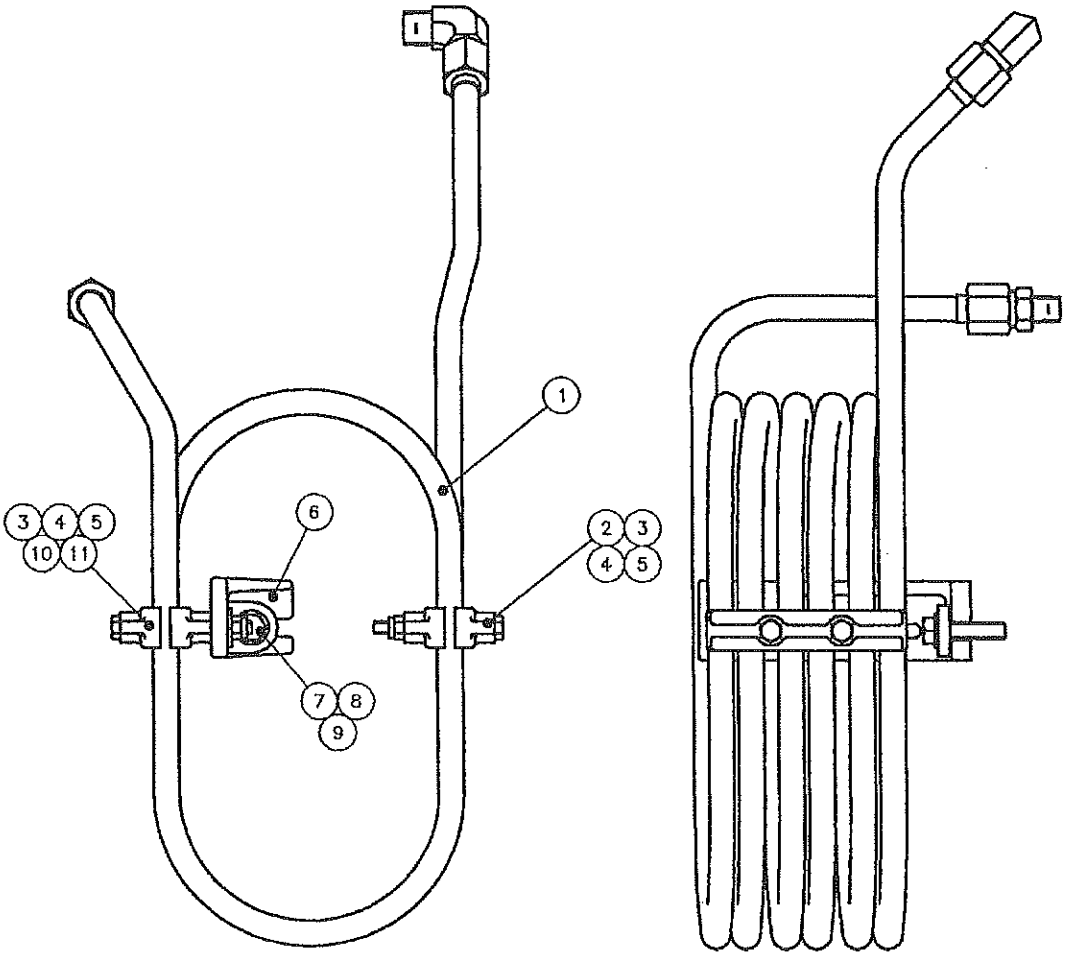
COOLER ASSEMBLY E61450 - 1st STAGE
WITH 1ST STAGE SEPARATOR - 5407.2 COMPRESSORS



REF	PART No	DESCRIPTION	NO OFF
1	C201604	Cooler - 1st Stage Kühler - 1. Stufe Réfrigérant - 1 er étage Koeler - 1e trap Enfriador - 1ª etapa Refrigeratore - 1° stadio	1
2	C201200.2	Spacer Distanzring Eintretoise Afstandring Espaciador Distanziale	1
3	95000.231	Screw, Hexagon Head Sechskantschraube Vis à tête 6 pans Zaskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	1
4	95000.227	Screw, Hexagon Head Sechskantschraube Vis à tête 6 pans Zaskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	2
5	95111.4	Nut Mutter Ecrou Moer Tuerca Dado	1
6	95149.13	Washer Kegelschiebe Rondelle Sluitring Arandela Rondella	1

7	C201109	Bracket, Cooler Halterung, Kühler Support de réfrigérant Koelerbeugel Soporte del enfriador Munire di supporo refrigeratore	1
8	C203460	Pipe, Delivery - 1st Stage Druckrohr - 1. Stufe Tuyau de refoulement - 1er étage Persleiding - 1e trap Tubo de reparto - 1ª etapa Tubo di mandata - 1° stadio	1
9	C203461	Pipe, Cooler Outlet - 1st Stage Rohr, Kühlerauslaß - 1. Stufe Tuyau de sortie du réfrigérant - 1er étage Uitlaatleiding koeler - 1e trap Tubo de salida del enfriador - 1ª etapa Tubo refrigeratore uscita - 1° stadio	1

COOLER ASSEMBLY E61447 - 2nd STAGE
5407.2 COMPRESSORS

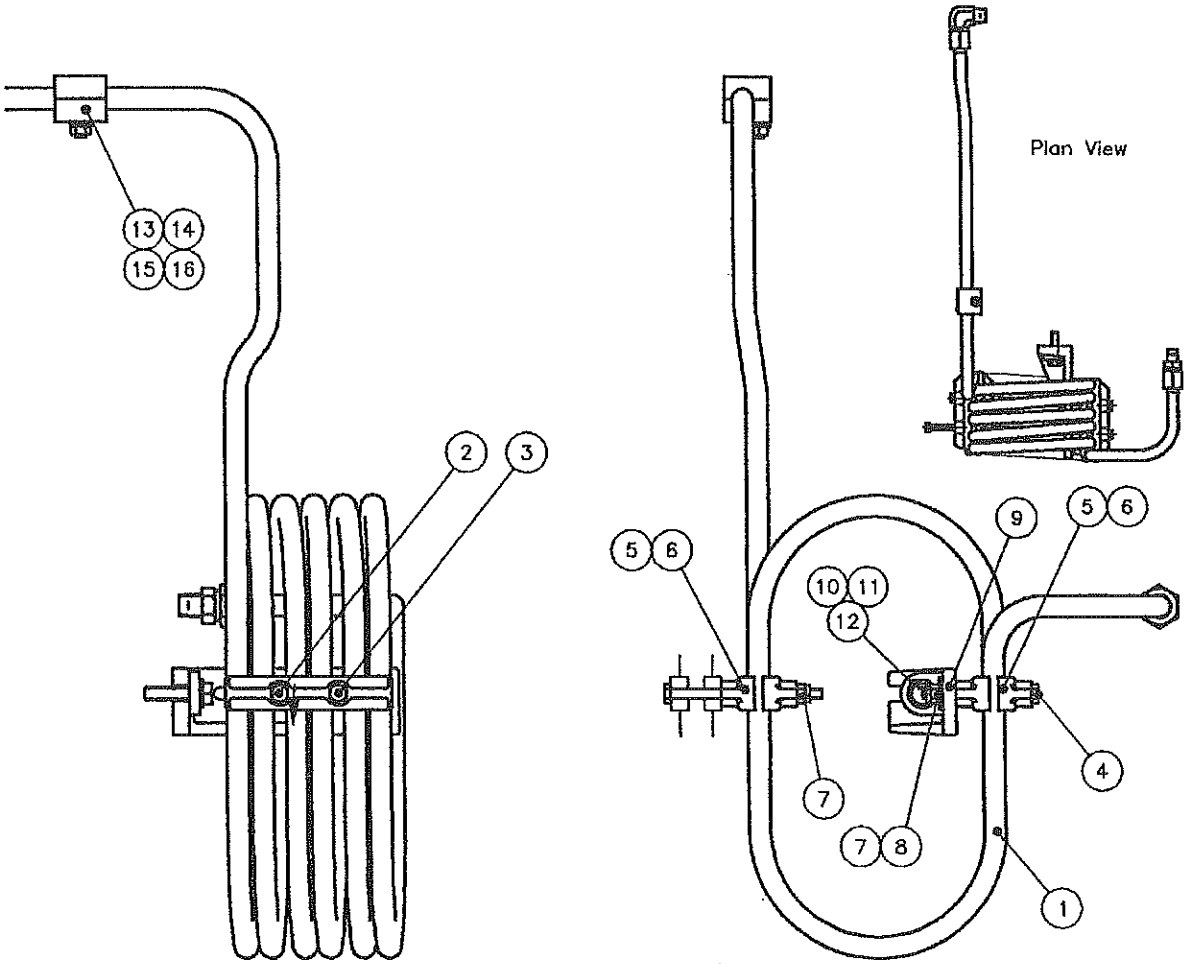


5407.2 COMPRESSORS PARTS LIST

REF	PART No	DESCRIPTION	NO OFF
1	E61448	Cooler Coil - 2nd Stage Kühlerspule - 2. Stufe Bobine de réfrigérant - 2 ème étage Pijpenwinding Koeler - 2e trap Serpentina refrigeratore - 2ª etapa Bobina refrigeratore - 2° stadio	1
2	95000.237	Screw, Hexagon Head Sechskantschraube Vis à tête 6 pans Zaskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	2
3	C202609	Strip, Rubber Gummistreifen Bande en caoutchouc Gummistrip Banda de caucho Nastro in gomma	4
4	C200576	Clamp, Cooler	4

		Halterung, Kühler Support de réfrigérant Koelerklamp Soporte del enfriador Fascetta refrigeratore	
5	95141.6	Nut, Hexagonal Self-Locking Sechskantmutter, selbstsichernd Ecrou 6 pans à auto-verrouillage Zestantige moer, zelfborgend Tuerca autobloqueante hexagonal Dado autobloccante	4
6	CU41239	Bracket, Cooler Halterung, Kühler Support de réfrigérant Koelerbeugel Soporte del enfriador Fascetta staffa	1
7	PS1742.1	Washer, Taper Kegelschiebe Rondelle conique Tapse ring Arandela cónica Rondella rastremata	1
8	95148.14	Washer Kegelschiebe Rondelle Sluitring Arandela Rondella	1
9	95000.258	Screw, Hexagon Head Sechskantschraube Vis à tête 6 pans Zaskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	1
10	95006.131	Bolt, Hexagon Head Sechskantschraube Boulon à tête 6 pans Zaskantbout Perno de cabeza hexagonal Bullone a testa esagonale	2
11	98660.1189	Washer, Large Unterlegschiebe. groß Rondelle, grande Sluitring, groot Arandela, grande Rondella grande	2

COOLER ASSEMBLY E61446 - 3rd STAGE
5407.2 COMPRESSORS



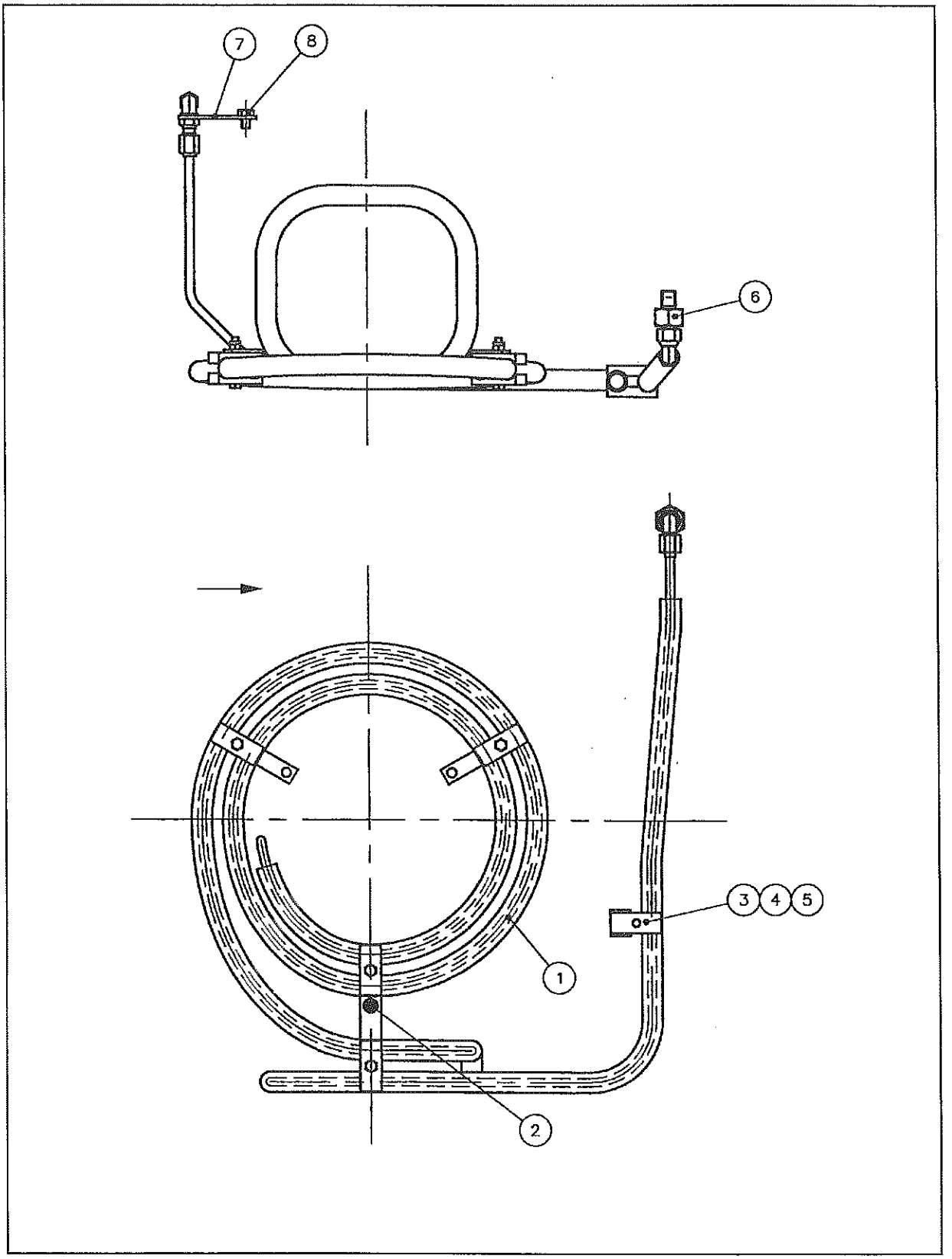
5407.2 COMPRESSORS PARTS LIST

REF	PART No	DESCRIPTION	NO OFF
1	E61443	Cooler Coil - 3rd Stage Kühlerspule - 3. Stufe Bobine de réfrigérant - 3 ème étage Pijpenwinding Koeler - 3e trap Serpentina refrigeratore - 3ª etapa Bobina refrigeratore - 3° stadio	1
2	95000.237	Screw, Hexagon Head Sechskantschraube Vis à tête 6 pans Zaskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	1
3	95006.135	Bolt, Hexagon Head Sechskantschraube Boulon à tête 6 pans Zaskantbout Perno de cabeza hexagonal Bullone a testa esagonale	1
4	95006.131	Bolt, Hexagon Head	2

		Sechskantschraube Boulon à tête 6 pans Zaskantbout Perno de cabeza hexagonal Bullone a testa esagonale	
5	C200576	Clamp, Cooler Halterung, Kühler Support de réfrigérant Koelerklamp Soporte del enfriador Fascetta refrigeratore	4
6	C202609	Strip, Rubber Gummistreifen Bande en caoutchouc Gummistrip Banda de caucho Nastro in gomma	4
7	95141.6	Nut, Hexagonal Self-Locking Sechskantmutter, selbstsichernd Ecrou 6 pans à auto-verrouillage Zestantige moer, zelfborgend Tuerca autobloqueante hexagonal Dado autobloccante	4
8	98660.1189	Washer, Large Unterlegschiebe. groß Rondelle, grande Sluitring, groot Arandela, grande Rondella grande	2
9	CU41239	Bracket, Cooler Halterung, Kühler Support de réfrigérant Koelerbeugel Soporte del enfriador Fascetta staffa	1
10	PS1742.1	Washer, Taper Kegelschiebe Rondelle conique Tapse ring Arandela cónica Rondella rastremata	1
11	95148.14	Washer Kegelschiebe Rondelle Sluitring Arandela Rondella	1
12	95000.258	Screw, Hexagon Head Sechskantschraube Vis à tête 6 pans Zaskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	1
13	98150.1040	Clamp, Pipe Rohrschelle Collier de tube Beugel Sujetador para tubo Fascetta tubo	1
14	95018.170	Capscrew	1

		Kopfchelle Vis à tête Inbusschroef Tapa roscada Vite a testa cilindrica	
15	95149.13	Washer Kegelschiebe Rondelle Sluitring Arandela Rondella	1
16	95111.4	Nut Mutter Ecrou Moer Tuerca Dado	1

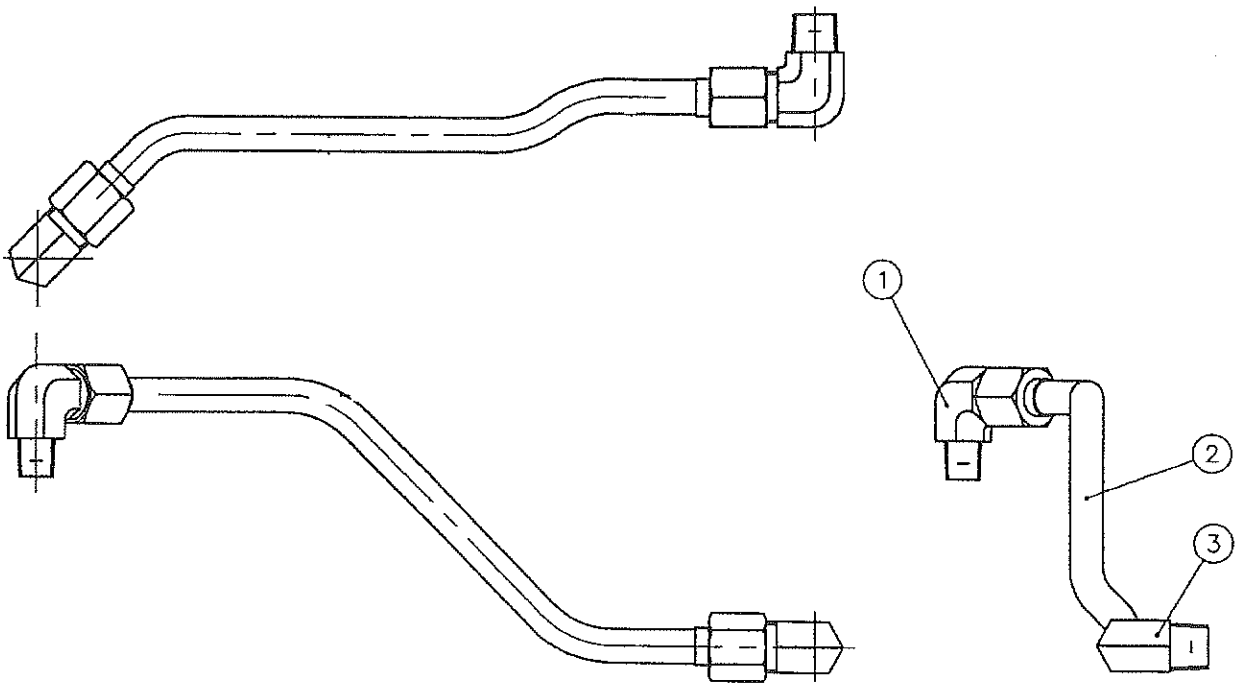
COOLER ASSEMBLY E61781 - 4th STAGE
HIGH PRESSURE INDUSTRIAL COMPRESSOR



HIGH PRESSURE INDUSTRIAL COMPRESSOR PARTS LIST

REF	PART No	DESCRIPTION	NO OFF
1	A30232	Cooler Coil - 4th Stage Kühlerspule - 4. Stufe Bobine de réfrigérant - 4 ème étage Pijpenwinding Koeler - 4e trap Serpentina refrigeratore - 4ª etapa Bobina refrigeratore 4° stadio	1
2	95018.199	Capscrew Kopfschraube Vis à tête Inbusschroef Tapa roscada Vite a testa cilindrica	1
3	C200587	Clamp, Cooler Halterung, Kühler Support de réfrigérant Koelerklamp Soporte del enfriador Fascetta refrigeratore	2
4	C200879	Packing Dichtung Garniture Pakking Empaquetadura	1
5	98241.1049	Tie, Cable Kabelklemme Etrier de câble Kabelklem Amarre de cable Vincolare, Cavo	1
6	98156.2809	Coupling, Stud - High Air Temperature Switch Einschraubstutzen - Temperaturschalter Accouplement de goujon - Thermostat Inschroefkoppeling - Temperaturschakelaar Conectador de espárrago - Termostato	1
7	C201827	Bracket Halterung Support Beugel Soporte Parentesi	1
8	95000.253	Screw, Hexagon Head Sechskantschraube Vis à tête 6 pans Zaskantschroef Tornillo de cabeza hexagonal Vite a testa esagonale	1

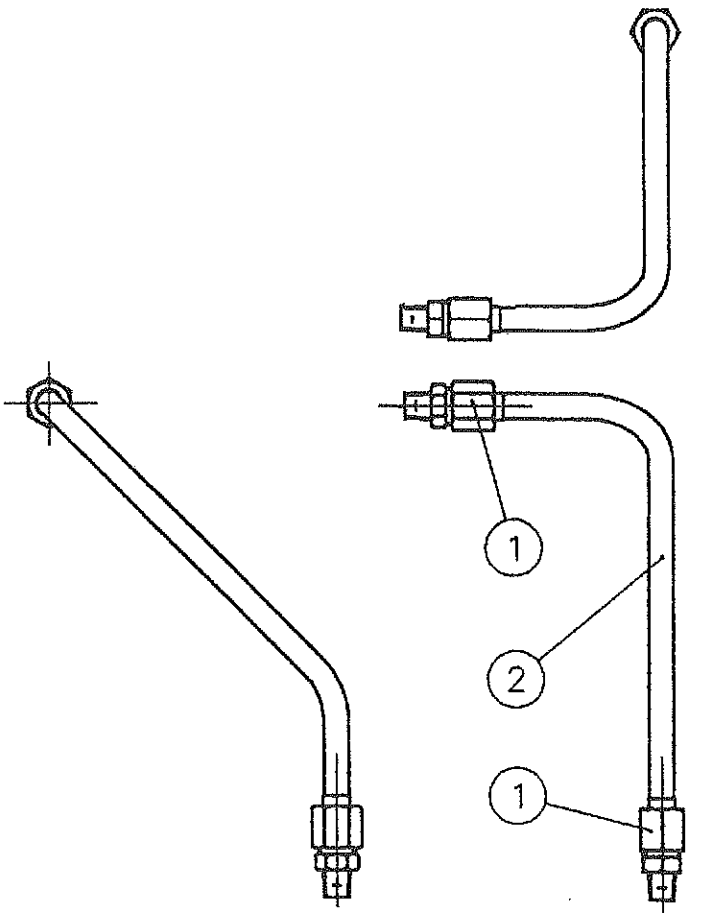
SUCTION PIPE ASSEMBLY 2ND STAGE - C203453
5407.2 COMPRESSOR



PARTS LIST

REF	PART No	DESCRIPTION	NO OFF
1	98156.2610	Elbow - 90° Bogenstück - 90° Coude - 90° Kniestuk - 90° Codo - 90° Gomito 90°	1
2	98617.1020	Tube - Aluminium Rohr - Tube - Pijp - Tubo - Tubo - alluminio	1
3	98156.2611	Elbow - 90° Bogenstück - 90° Coude - 90° Kniestuk - 90° Codo - 90° Gomito 90°	1

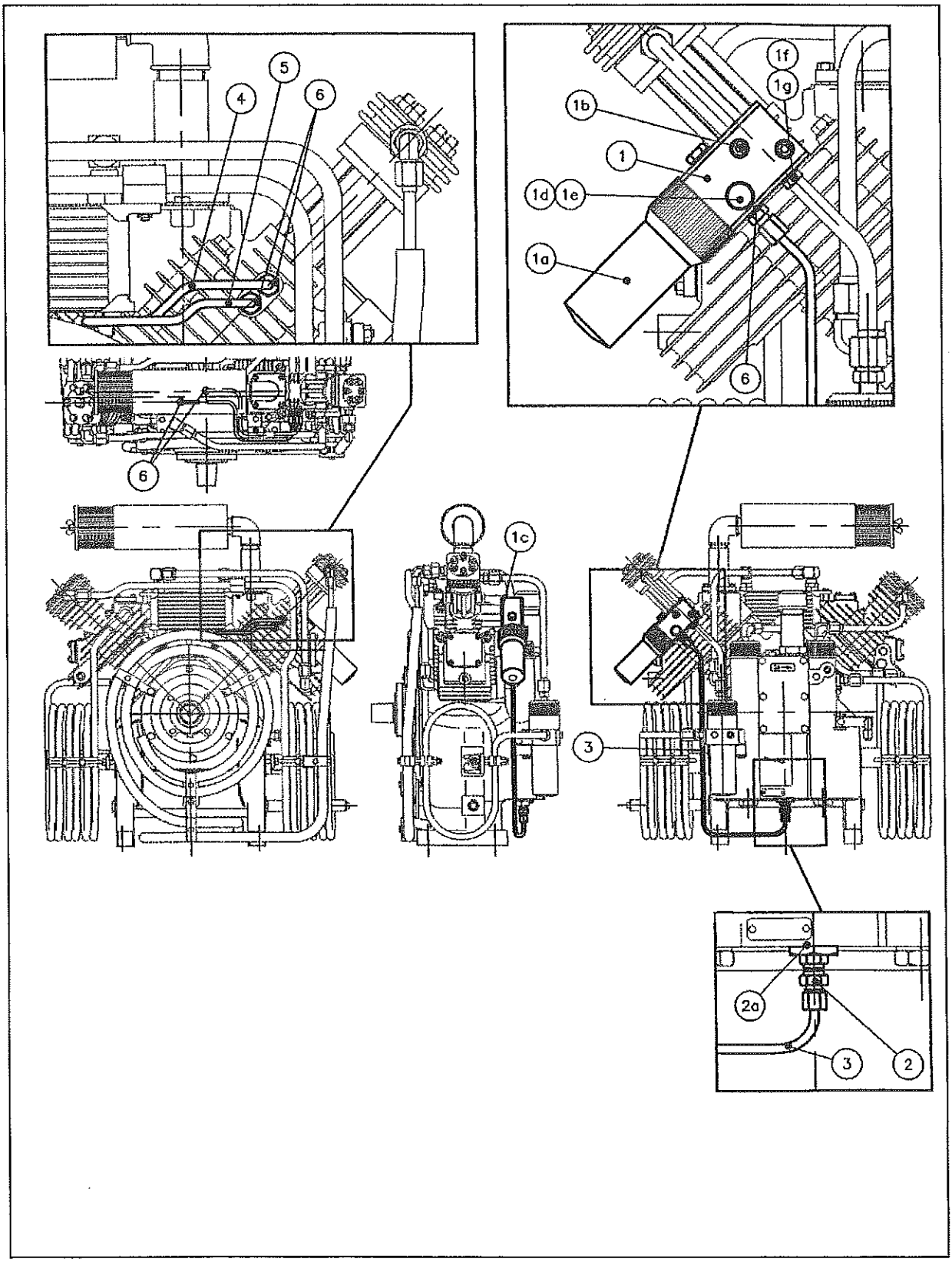
SUCTION PIPE ASSEMBLY 4TH STAGE - C203446
5407.2 COMPRESSOR



PARTS LIST

REF	PART No	DESCRIPTION	NO OFF
1	98156.1801	Coupling Kuppelstück Accouplement Koppeling Acoplamiento	2
2	98617.1020	Tube - Aluminium Rohr - Tube - Pijp - Tubo - Tubo - alluminio	1

LUBRICATION ASSEMBLY E61493
INDUSTRIAL COMPRESSORS

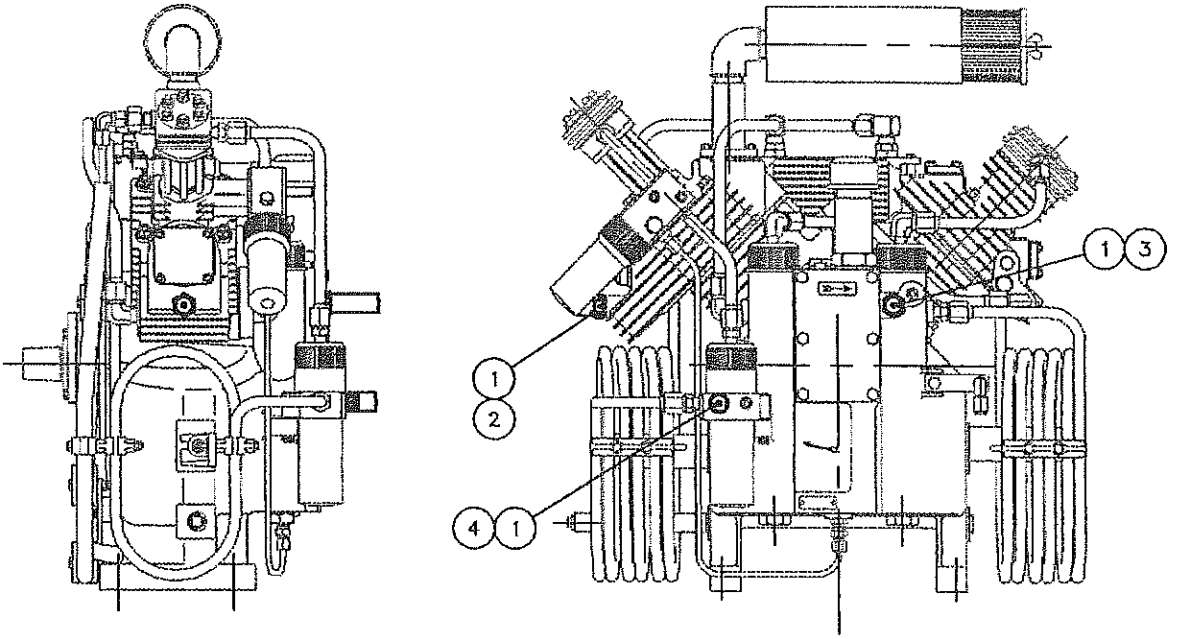


LUBRICATION ASSEMBLY
INDUSTRIAL COMPRESSORS PARTS LIST
E61493

REF	PART No	DESCRIPTION	NO OFF
1	C203458.100	Regulator, Oil Ölregler Régulateur Olieregelaar Regulador de aciete Regolatore, Olio	1
1a	98262.1148	Element, Oil Filter Einsatz, Ölfiltre Elément du filtre á huile Oliefilterelement Elemento del filtro de aciete Cartuccia del filtro olio	1
1b	95018.174	Capscrew Kopfschraube Vis à tête Inbusschroef Tapa roscada Vite a testa cilindrica	2
1c	95602.7	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	1
1d	PS1322.2	Seal Dichtung Joint Afdichting Sello Guarnizione	1
1e	PS1814.4	Plug, Blanking Blindstopfen Bouchon d'obturation Blindplug Tapón obturador Tappo cieco	1
1f	PS1322.1	Seal Dichtung Joint Afdichting Sello Guarnizione	1
1g	PS1814.2	Plug, Blanking Blindstopfen Bouchon d'obturation Blindplug Tapón obturador Tappo cieco	2

2	C203431 Includes 2a	Pump, Oil Ölpumpe Pompe d'huile Oliepomp Bomba de aciete Pompa dell'olio	1
2a	95602.40	'O' Ring O-Ring Joint torique O-Ring Aro tórico O-Ring	2
3	C203531	Pipe, Oil Feed Ölzufuhr-Rohr Tuyau d'amenee d'huile Olieaanvoerpijp Tubería sumin aciete Tubo alimentazione olio	1
4	C203643	Pipe, Oil Return Öl-Rückleitung- Baugruppe Tuyau de retour d'huile Olieaterugvoerleiding Tubería retorno aciete Tubo ritorno olio	1
5	C203644	Pipe, Oil Return Öl-Rückleitung- Baugruppe Tuyau de retour d'huile Olieaterugvoerleiding Tubería retorno aciete Tubo ritorno olio	1
6	98660.1152	Seal Dichtung Joint Afdichting Sello Guarnizione	3

SAFETY VALVES E61449
STANDARD COMPRESSORS



STANDARD COMPRESSORS PARTS LIST

REF	PART No	DESCRIPTION	NO OFF
1	PS1322.2	Seal Dichtung Joint Afdichting Sello Guarnizion	3
2	98650.1163-5.9	Valve Safety - 1st Stage Sicherheitsventil - 1. Stufe Soupape de sécurité - 1 er étage Veiligheidsklep - 1e trap Válvula de seguridad - 1ª etapa Valvola di sicurezza - 1° stadio	1
3	98650.1163-27	Valve Safety - 2nd Stage Sicherheitsventil - 2. Stufe Soupape de sécurité - 2 éme étage Veiligheidsklep - 2e trap Válvula de seguridad - 2ª etapa Valvola di sicurezza - 2° stadio	1
4	98650.1164-97	Valve Safety - 3rd Stage Sicherheitsventil - 3. Stufe Soupape de sécurité - 3 éme étage Veiligheidsklep - 3e trap Válvula de seguridad - 3ª etapa Valvola di sicurezza - 3° stadio	1

Proposal for Change

Mako Compressors welcomes your suggestions and comments. Please use the following form to submit your proposals for changes to this and other manuals. Be sure to include:

- Publication title and/or number
- Relevant clause, table, page number, and/or figure number
- Wording of the proposed change
- Rationale for the change

Name:_____

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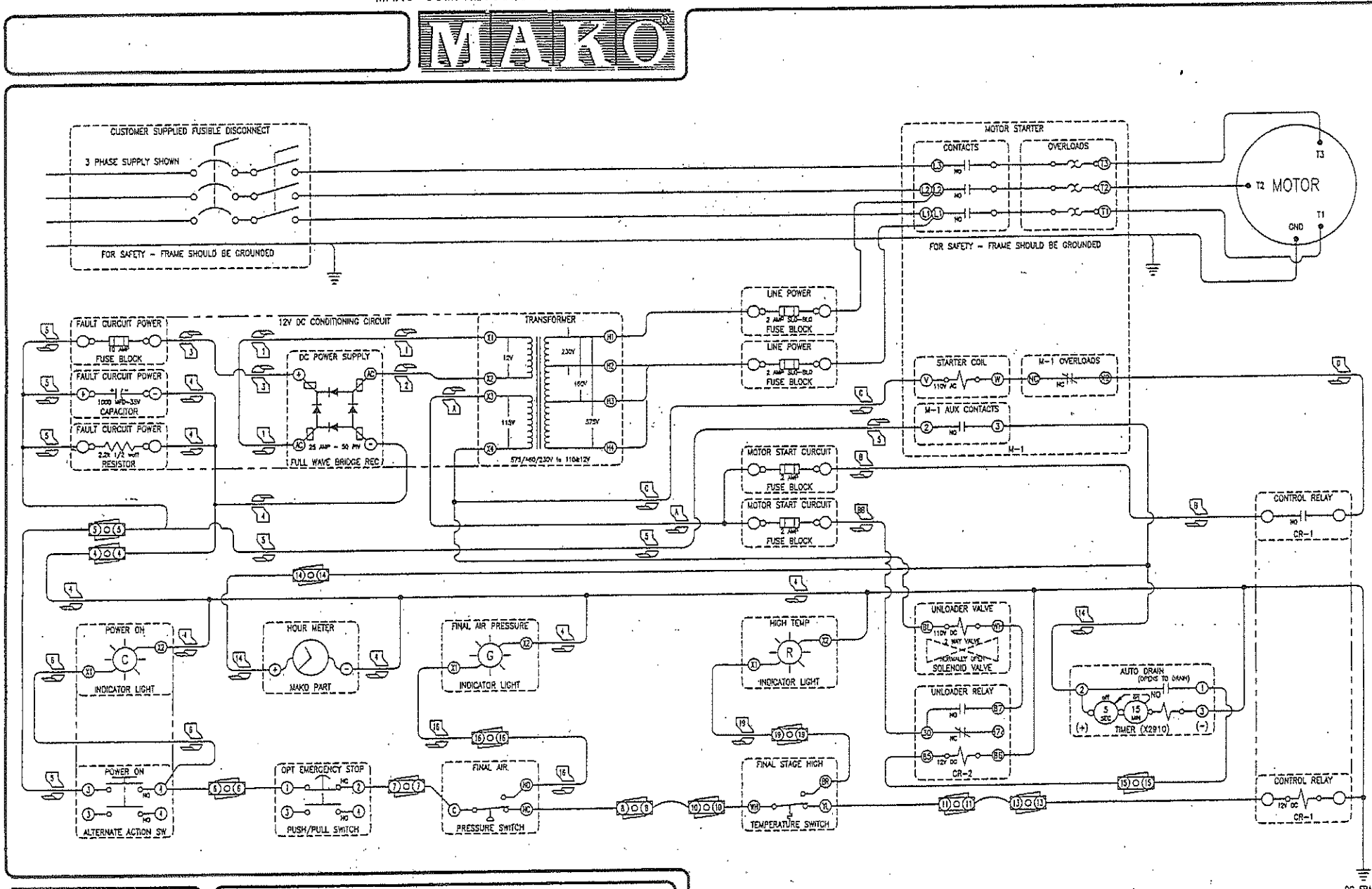
Proposed Change:

Please submit to Mako Compressors ATTN: Engineering Department

MAKO COMPRESSORS INC.



DRAWING NUMBER AND/OR FILE:
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DE054050.DWG

SCALE: FULL
REPLACES DWG: --------
DRAWN BY: J DOWNING
APPROVED BY: S M BAGGETT
DATE: NOV 8, 2001
PART NO: --------

1634 SW 17th STREET, OCALA, FLORIDA 34474 TELEPHONE (352) 732-2268 FAX (352) 732-7873

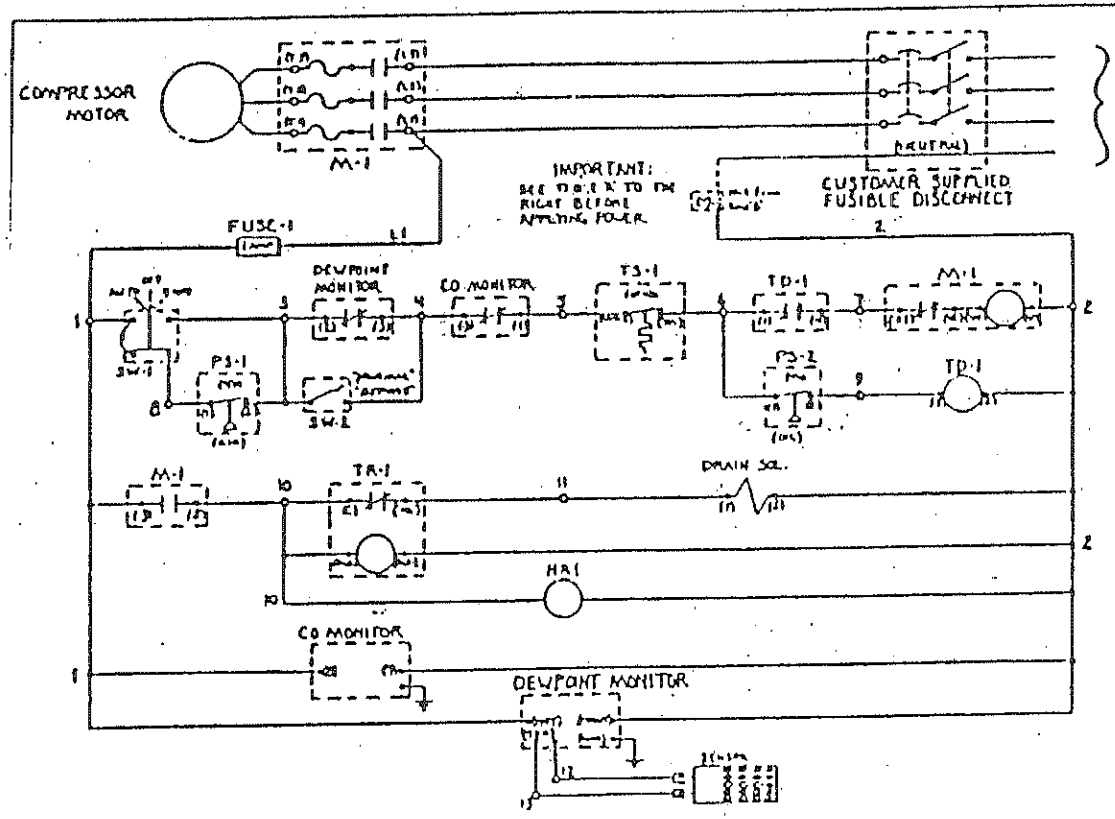


TABLE 'A'

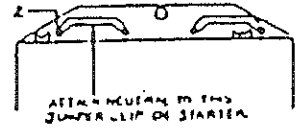
IF CUSTOMER'S SUPPLY IS:	CONNECT WIRE #2 (ON SINGLE PHASE) TO:	CONTROL VOLTAGE BECOMES
115v 1ø	L2	115v
230v 1ø	NEUTRAL	115v
208-230v 3ø	NEUTRAL	115v
460v 3ø	SEE NOTE #4	115v
575v OR OTHERS 3ø	SEE NOTE #4	115v

TABLE 'B'

DELETED OPTION	JUMPER WIRE REQUIRED
DEWPOINT MONITOR	FROM 3 TO 9
CO MONITOR	FROM 4 TO 5
LOW OIL SHUTDOWN	FROM 6 TO 7

ELECTRICIAN'S NOTES:

1. L3 IS HIGHEST VOLTAGE LEAD ON UNBALANCED THREE PHASE SYSTEMS.
2. CHECK DIRECTION OF ROTATION ON THREE PHASE MACHINES. COOLING AIR SHOULD BE DRAWN THROUGH BELT GUARD AND EXHAUSTED OUT ACROSS THE COMPRESSION CYLINDERS.
3. FOR SINGLE PHASE MACHINES, L3 IS OMITTED AND POWER IS BROUGHT INTO L1 AND L2. THERE IS ONLY ONE HEATER OVERLOAD ELEMENT (~~).
4. ON DELTA SYSTEMS AND SUPPLIES GREATER THAN 230 VOLTS, A TRANSFORMER IS REQUIRED. ON MAKO'S STANDARD 230/460v TRANSFORMER, CONNECT AS FOLLOWS: L1 TO PIN(1), L2 TO PIN(4), WIRE 2 TO PIN(5), INPUT OF FUSE 1 TO PIN(8)
   FOR 460v SUPPLY; JUMPER PIN(3) TO(1)
   FOR 230v SUPPLY; JUMPER PIN(3) TO(2) AND PIN(2) TO(4)
   THE NEUTRAL WIRE IS NOT REQUIRED WHEN A TRANSFORMER IS USED IN THE CONTROL CIRCUIT.
5. LETTERS AND NUMBERS IN PARENTHESIS ARE THE DEVICE TERMINAL LABELS. PLAIN NUMBERS ARE WIRE NUMBERS AS AN EXAMPLE 3——9 IS WIRE 9 AND PIN(3).
6. ON INITIAL INSTALATION, IF COMPRESSOR WILL NOT TURN ON, MAKE SURE THE NEUTRAL WIRE (IF REQUIRED) IS SECURELY ATTACHED TO WIRE 2 ON TOP OF THE MAGNETIC STARTER.



THIS MACHINE WAS FACTORY WIRED FOR:

- ☐ 115v
- ☐ 208v ☐ SINGLE PHASE
- ☐ 230v
- ☐ 460v ☐ THREE PHASE
- ☐ 575v
- ☐ OTHER ____v

THE FOLLOWING OPTIONS ARE INCLUDED IF CHECKED:

- ☐ DEWPOINT MONITOR
- ☐ CO MONITOR
- ☐ OIL PRESSURE SHUTDOWN
- ☐ HOUR METER
- ☐ AUTOMATIC DRAIN SYSTEM

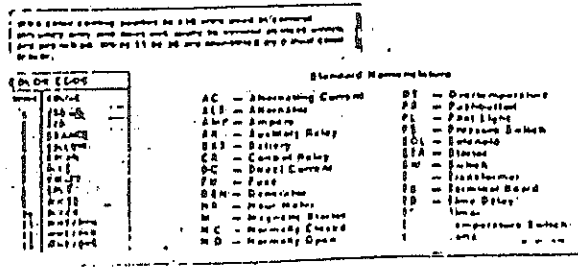
COMPRESSOR MODEL

- ☐ K-31
- ☐ K-7
- ☐ K-14
- ☐ K-18
- ☐ K-22
- ☐ K-27

ASSEMBLY NOTES:

- WHEN DEWPOINT MONITOR IS OMITTED, SW-2 IS ALSO OMITTED. SEE TABLE 'B'.
- WHEN CO MONITOR IS OMITTED, SEE TABLE 'B'.
- WHEN OIL PRESSURE SHUTDOWN IS OMITTED, PS-2 AND TD-1 ARE REMOVED. SEE TABLE 'B'.
- WHEN THE AUTODRAIN IS OMITTED, TR-1 AND THE DRAIN SOLENOID ARE REMOVED.

THERE ARE TWO TYPES OF NORMALY CLOSED TEMPERATURE SWITCH BODIES. ONE IS A METAL CASE WITH THREE WIRES OF WHICH THE WHITE AND YELLOW WIRES ARE USED. THE OTHER IS A RED BODY WITH TWO BLACK WIRES. BOTH SWITCHES OPEN AT 350°F AND SHUTDOWN THE COMPRESSOR. THE FIRST SWITCH IS SHOWN ABOVE IN THE DIAGRAM.



AUTHENTICATION			
DRAWN			
CHECKED			
APPROVED			
QUALITY ENGINEER			

ELECTRIC DIAGRAM
K-SERIES, E-V MODELS
5 TO 25 hp, 1 AND 3ø
STANDARD MACHINES

Compair
MAKO COMPRESSORS, INC.
1624 S.W. 17 STREET
OCALA, FLORIDA 32670

SIZE	DRAWING NO.	REV.
C	221-063	0

SCALE: NONE | SHEET 1 OF 1

FIGURE 11-6 ELECTRICAL SCHEMATICS

MAINTENANCE SCHEDULE

WARNING:-

1. BEFORE PROCEEDING WITH MAINTENANCE ON THE COMPRESSOR IT MUST BE STOPPED AND ISOLATED ELECTRICALLY AND MECHANICALLY AND VISIBLE WARNING NOTICES DISPLAYED.
2. IN ADDITION ALL INTERNAL PRESSURE MUST BE RELEASED WITH THE UNIT ISOLATED FROM THE SUPPLY AND STORAGE RESERVOIR.

Note:-
An O&M manual must cater for a wide variety of operating duties, ambient conditions and methods of control. Periods given in this manual allow for the worst combination and are also based on preventative maintenance rather than operation until failure occurs.

GENERAL

It is useful to record pressure, temperatures, oil used etc., in a log against hours run, as this builds up a detailed record of machine condition. It can also give an indication of impending problems.

TORQUE WRENCH SETTINGS FOR NON-LUBRICATED FASTENERS

SEE BUILD LIST PAGE 29

DAILY

Check oil level in crankcase and top up if necessary.

Check stage pressures and temperatures.

Ensure finned cooler is clean and free from any build-up of dirt.

WEEKLY

Check for oil or air leaks, rectify if necessary.

Check correct operation of all controls.

Check all nuts, screws and fittings for tightness.

RECOMMENDED MAINTENANCE

SYNTHETIIC OIL	RUNNING HOURS (X1000)						
ACTION REQUIRED	0.05	0.5	1	1.5	2	2.5	3
Change OIL	X	X	X	X	X	X	X
Change plates & springs all valves				X			X
Change valves							X
Fit new piston rings 3rd Stage			X		X		
Fit new plunger/liner assembly							X
Check belt tension	X	X	X	X	X	X	X
Clean unloader valves, re-lap seats & replace diaphragms as necessary				X			X
Complete check & overhaul, hydraulic test coolers						X	

Note:- * Change after first 50 hours, after major overhaul and annually if less than 500 hours use.

MAINTENANCE

1. After First 15 hours running time
   Ensure that alignment and belt tensioning is correct.

2. After First 50 hours running time
   Change oil in crankcase. When changing oil drain whilst warm, (') then slowly pour fresh oil into filler neck. Wait five minutes, then start compressor and run for five minutes. Stop machine and top-up crankcase. Examine valves. For tightening torques, see SECTION TWO.

3. The next oil change will be after 500 hours running time or annually.

4. Periodically
   Remove and renew disposable suction filter.

5. Every 500 Hours running time or 16 weeks,
   Drain crankcase and refill with recommended oil.
   Check belt alignment and tension are correct.

6. Every 1000 Hours running time (or 32 weeks)
   Drain crankcase oil after compressor has been running and oil is still warm. Refill with recommended oil. Re-check level after oil has had time to settle.
   Fit new 3rd stage piston rings.
   Check belt alignment and tension are correct.

7. Every 1500 Hours running time
   Change crankcase oil and refill with recommended oil. Oil must be changed annually even if running hours do not amount to service time.
   Refurbish or replace all valves.
   Change valve plates and springs on all valves.
   Check belt alignment and tension are correct.
   Clean unloader valves and re-lap seats & replace diaphragms as necessary.

8. Every 2000 Hours
   Drain crankcase oil after compressor has been running and oil is still warm. Refill with recommended oil. Re-check level after oil has had time to settle.
   Fit new 3rd stage piston rings.
   Check belt alignment and tension are correct.

9. Every 2500 Hours
   Drain crankcase and refill with recommended oil.
   Check belt alignment and tension are correct.
   Complete check and overhaul. Hydraulically test all cooler assemblies.

10. Every 3000 Hours running time
    Drain crankcase oil after compressor has been running and oil is still warm. Refill with recommended oil. Re-check level after oil has had time to settle.
    The compressor should be given a full mechanical check.
    Check pressure gauges, for correct reading.
    Replace all valves.
    Fit new 3rd stage plunger and liner assembly.
    Check belt alignment and tension are correct.
    Clean unloader valves and re-lap seats & replace diaphragms as necessary.

* *When draining crankcase, always remove lower drain plug.*

12.0 MAINTENANCE

CAUTION: BEFORE CARRYING OUT ANY MAINTENANCE WORK, BE SURE THAT AIR IS RELEASED AND THE MACHINE IS ELECTRICALLY ISOLATED. NEVER ATTEMPT TO STRAIGHTEN BADLY BENT TUBING OR RE-USE DAMAGED UNION FITTINGS.

WARNING: TAMPERING WITH SAFETY VALVES INVALIDATES THE WARRANTY. SEE SECTION 10 FOR THE SINGLE EXCEPTION TO THIS RULE.

12.1 MAINTENANCE SCHEDULE

Regular servicing is essential to maintaining compressor design performance. Maintenance intervals will depend on operating conditions. The following intervals can be used as a guide when the machine is operated under normal conditions. These intervals may be extended with operating experience. Examination and monitoring during commissioning will give a good indication of the machine's maintenance requirements.

12.1.2 DAILY OR EACH TIME MACHINE IS OPERATED

1. Check compressor oil level.
2. Examine for oil/air leaks. Any such leaks must be rectified immediately.
3. Check stage pressures to determine if they are within stated limits (see Section 17). Abnormal stage pressures are an indication of a valve problem. If a stage pressure increased, investigate the valves in the next stage. For a lower pressure than expected check the valve on that stage. Always stop the machine if a safety valve opens.

CAUTION: NEVER TIGHTEN ANY FITTING WHEN IT IS UNDER PRESSURE.

12.1.3 WEEKLY

Operate compressor for a period of not less than one hour allowing for at least four condensate drain cycles. This will prohibit moisture buildup in the system and provide proper lubrication.

Inspect all nuts, screws and fittings for tightness. Inspect for oil or air leaks. Leaks must be rectified immediately.

12.1.4 PERIODICALLY

Remove and replace disposable suction filter.

12.1.5 AFTER FIRST 25 HOURS RUNNING TIME

1. Check belt alignment and tension. Adjust if necessary.
2. Check tightness of all nuts and bolts.

12.1.6 AFTER FIRST 50 HOURS RUNNING TIME

1. Drain crankcase and refill with Mako synthetic oil.
2. Change oil filter and O-ring.

12.1.7 EVERY 500 HOURS RUNNING TIME (OR SIX MONTHS)

1. Check alignment and belt tension.
2. Remove and service all suction and delivery valves.

NOTE: VALVE PLATES AND SPRINGS SHOULD BE REPLACED AT VALVE INSPECTION PERIODS IF THEY SHOW ANY WEAR. WEAR MANIFESTS ITSELF BY A GROOVE IN THE SEATING AREA.

12.1.8 1000 HOURS RUNNING TIME

1. Change piston rings on final stage plunger.
2. Clean external surfaces of all coolers, especially the first stage unit and finned area of final delivery cooler. Use a soft brush and low pressure air. DO NOT USE gasoline, diesel fuel, or other toxic substances. Ensure fan blades are clean.
3. Remove final separator chamber and have hydrostatically tested.

12.1.9 EVERY 1500 HOUR RUNNING TIME

Refurbish or replace all valves.

12.1.10 EVERY 2000 HOURS RUNNING TIME

Fit new final stage plunger and liner.

12.1.11 EVERY 3000 HOURS RUNNING TIME

1. Conduct a full mechanical check.
2. Check pressure gauges for correct reading.
3. Replace all valves.
4. Hydrostatically test intercooler and aftercooler (if fitted) to minimize the risk of tube failure during operation. Test pressure should be 1.5 times the working pressure experienced by the component.

12.2 MAINTENANCE SCHEDULES (TABLES)

TABLE 12-1 THREE STAGE AIRCOOLED COMPRESSORS

NUMBER OF HOURS FOR REPLACEMENT

PART NO.	25	50	500	1000	1500	2000	3000	PERIODICALLY	EVERY 6 MOS. OR SOONER
FINAL SEPARATOR HYDROSTAT TEST				X		X	X		
SYNTHETIC OIL CHANGE*		X	X	X	X	X	X		
VALVE MAINTENANCE KIT (ALL STAGES)			X		X		X		
3RD STAGE PISTON RINGS				X					
N70 AIR INTAKE FILTER								X	
PURIFICATION FILTER (S)									X
M212 SEPARATOR SINTERED ELEMENT								X	

TABLE 12-2 4 STAGE AIRCOOLED COMPRESSORS

NUMBER OF HOURS FOR REPLACEMENT

PART NO.	25	50	500	1000	1500	2000	3000	PERIODICALLY	EVERY 6 MOS. OR SOONER
FINAL SEPARATOR HYDROSTAT TEST				X		X	X		
SYNTHETIC OIL CHANGE*		X	X	X	X	X	X		
98262/1148 OIL FILTER / ORING *		X	X	X	X	X	X		
VALVE MAINTENANCE KIT (ALL STAGES)			X		X		X		
4TH STAGE PISTON RINGS				X					
4TH STG PLUNGER/LINER						X			
X0225 AIR INTAKE FILTER								X	
PURIFICATION FILTER (s)									X
M212 SEPARATOR SINTERED ELEMENT								X	

TABLE 12-3 4 STAGE AIRCOOLED COMPRESSORS INDUSTRIAL APPLICATIONS

NUMBER OF HOURS FOR REPLACEMENT

PART NO.	25	50	500	1000	1500	2000	3000	PERIODICALLY	EVERY 6 MOS. OR SOONER
FINAL SEPARATOR HYDROSTAT TEST				X		X	X		
SYNTHETIC OIL CHANGE*		X		X		X			
98262/1148 OIL FILTER / ORING *		X		X		X			
VALVE MAINTENANCE KIT (ALL STAGES)			X		X		X		
4TH STAGE PISTON RINGS				X					
4TH STG PLUNGER/LINER						X			
DRYER FILTER (S)									X
M212 SEPARATOR SINTERED ELEMENT								X	

13.O VALVES

13.1 FOUR STAGE MACHINE VALVES

First and second stage compressor valves are separate flat plate units for suction and delivery duties, while the third and fourth stages use integral cylinder head combined suction and delivery valve assemblies. All valves are easily accessible for maintenance and replacement when required. A recommended service schedule is discussed in Section 12.

13.2 THREE STAGE MACHINE VALVES

First stage valves on the three stage compressors are of the reed type. Combined inlet / outlet flat plat valves are used on the second and third stages. The first stage reed valve assemblies differ in size on the 5404 and 5405 models. Second and third stage valves are integral cylinder head and valve units. A recommended service schedule is discussed in Section 12.

13.3 COMPRESSOR VALVE SERVICE

13.3.1 MODELS 5404/5404H/54044/5405/5405E/54054

13.3.1.1 FIRST STAGE SUCTION AND DELIVERY VALVES

TO REMOVE CYLINDER HEAD

Remove all pipe work from the cylinder head. Unscrew and remove the air filter body. Unscrew and remove the head and suction/delivery valve from the cylinder. Remove and discard the "O"-ring located between the cylinder and valve and the gasket located between the valve and head.

CYLINDER HEAD CLEANING AND ASSEMBLY

Clean all traces of old gasket from the cylinder head and valve and inspect the joint faces for cracks or damage liable to impair sealing efficiency. Clean or decarbonize the cylinder as necessary, ensuring that all loose deposits are removed after cleaning. Valve overhaul procedures are detailed below.

CYLINDER HEAD REPLACEMENT

Fit a new "O"-ring to the cylinder liner groove. Place the suction/delivery valve in position, ensuring the face marked "TOP" is uppermost and align the cap screw holes in the cylinder block and valve to locate correctly. Fit the cylinder head joint, cylinder head and cap screws. Evenly torque cap screws to the values shown then reconnect air filter.

13.3.1.2 FIRST STAGE SUCTION/DELIVERY VALVE OVERHAUL

TO DISMANTLE

Using a suitable drift punch, knock roll pins from the valve plates and separate the components.

FIRST STAGE SUCTION/DELIVERY VALVE CLEANING AND INSPECTION

Carefully remove all traces of carbon and other deposits from the upper and lower valve plates, taking care not to damage the faces in any way, similarly clean the tongues of the central plates. After cleaning ensure that all loose deposits are removed.

Closely inspect the valve components for any cracks, wear or other damage especially around the seating faces. The valve tongues should be clean and free from pitting etc., over the area in contact with the valve plates.

Renew defective items or complete valve as necessary.

FIRST STAGE SUCTION/DELIVERY VALVE ASSEMBLY -

The uppermost plate is marked "TOP", with the recesses in the upper and lower plate innermost and aligning the cap screw and roll pin holes in each plate. Carefully tap the roll pins into position from either side of the valve until flush with the plate surface. If removed, refit the locating pin to the upper plate.

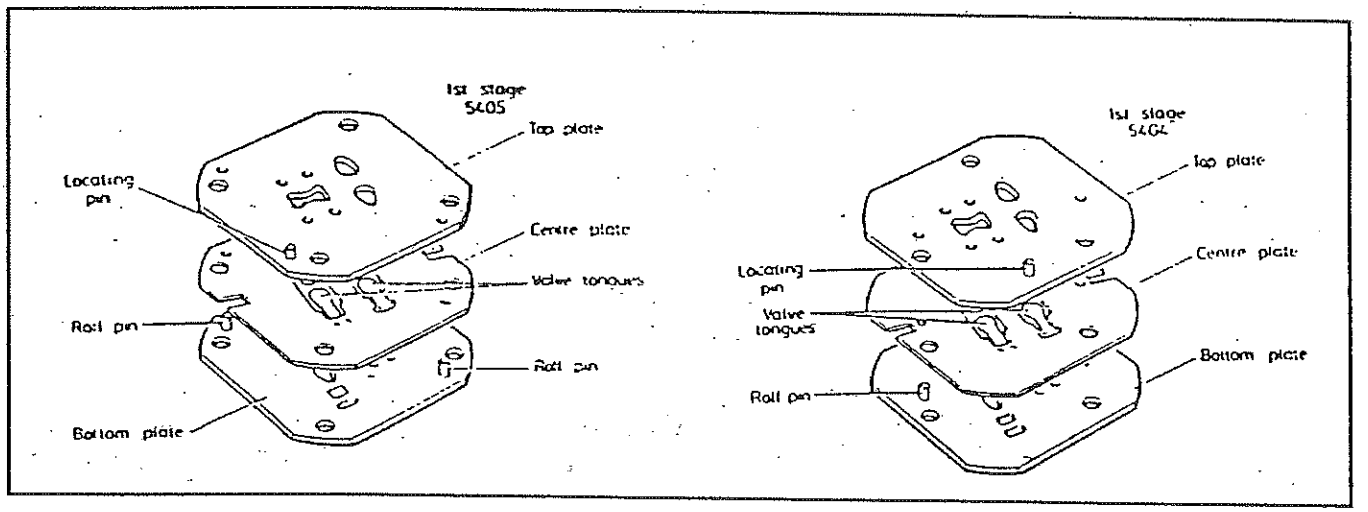


FIGURE 13-1 FIRST STAGE VALVES

13.3.1.3 SECOND STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY

TO REMOVE

Disconnect all pipe work from the third stage cylinder head. Unscrew the six retaining bolts and remove the head from the compressor. Remove and discard the sealing "O"-ring from the cylinder.

CLEANING AND INSPECTION

Ensure the "O"-ring groove in the cylinder is free from dirt or damage etc., and that the piston and cylinder wall are free from excessive deposits of carbon. The overhaul procedure for the cylinder head assembly is detailed below.

TO REPLACE

Ensuring that joint faces are clean, fit a new "O"-ring to the cylinder liner top and fit the head/valve assembly and its retaining bolts. Evenly torque bolts to the valves.

13.3.1.4 SECOND STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY OVERHAUL

TO DISMANTLE

Invert the assembly and remove cap screws (10) which retain base (8) to cylinder head (1). Remove suction plate (7), springs (6) (2 off), and plate (5). Remove delivery plate (4), delivery valve springs (12) (2 off), and plate (3). Remove and discard "O"-ring (2).

CLEANING AND INSPECTION

The valve components should be degreased using a suitable solvent and stiff brush. Carbon deposits may be removed by placing components in boiling water. Do not attempt to remove carbon by scraping as this may cause damage to the sealing faces.

The sealing faces of valve plate and seat should be clean and bright over the whole seat area without any evidence of uneven contact. Renew plate if cracked, indented, not flat or having a wear groove which exceeds 1/10th of the plate thickness. If the plate or seat shows severe indentation the complete valve assembly must be renewed.

Inspect the remaining components for cracks, distortion or other damage liable to impair valve operation.

TO ASSEMBLE

Invert base (8) and fit plate (7) followed by springs (6) which should be arranged as shown in Figure 13-2. Fit suction plate (5).

Invert cylinder head (1) and fit plate (3), followed by springs (12), which should be arranged as shown in Figure 13-2. Fit delivery plate (4), and place new "O"-ring (2) into the cylinder head groove. Ensure the delivery plate (4) is centralized.

With a small steel ruler, or a similar thin-bladed implement, place across base (8) to retain the suction valve components in position, invert the assembly and fit to the cylinder head. Correct location of the base is assured by the offset pins (9 and 11) which engage with corresponding holes in the cylinder head. Ensuring the locating pins are correctly engaged and keeping downward pressure on the base, carefully withdraw the ruler; check the base is now in full contact with the cylinder head around its circumference and fit cap screws (10). Evenly torque the cap screws to the values shown in Table 13-1. This setting is critical. If the base does not correctly engage with the head, separate the components and repeat the assembly procedure.

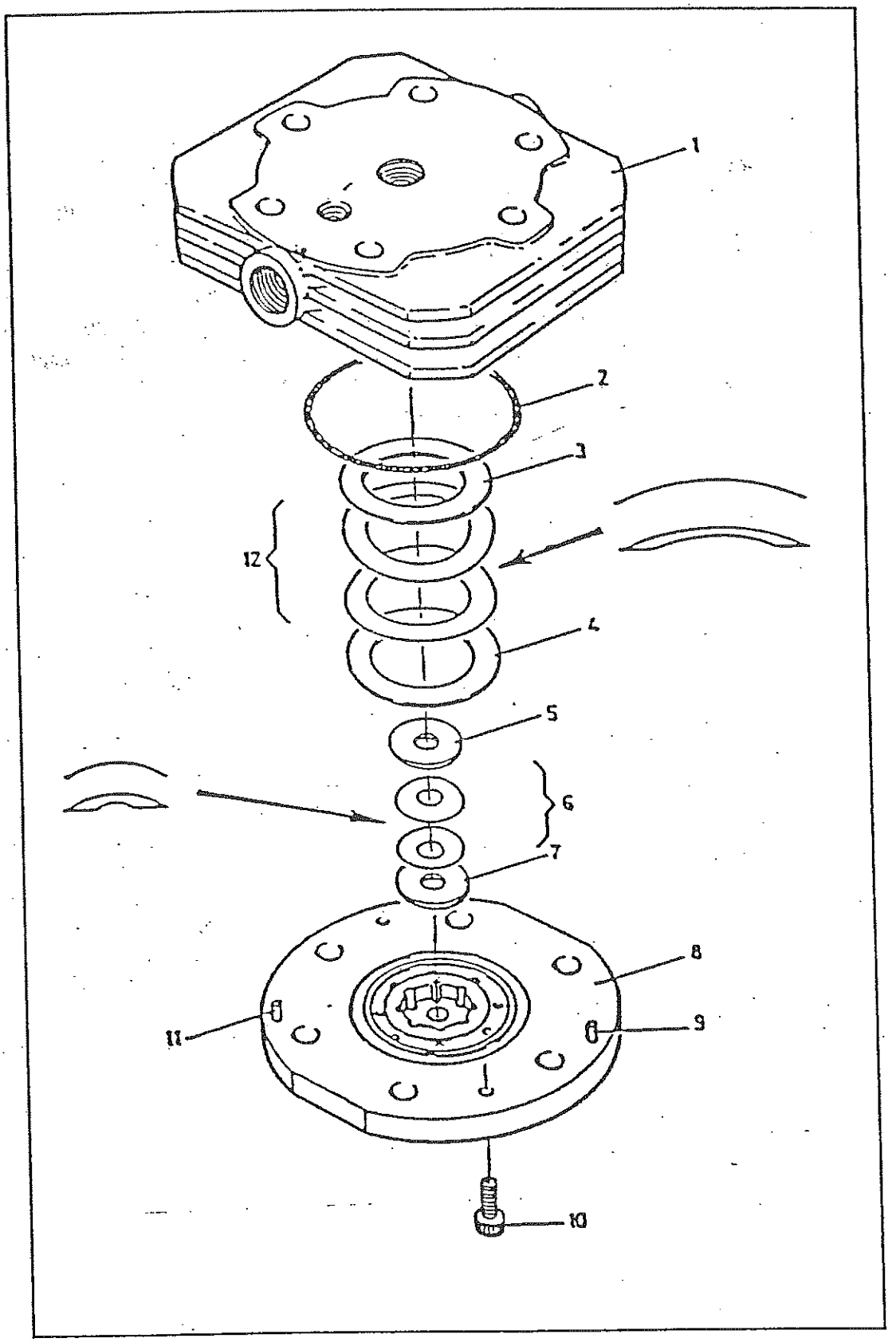


FIGURE 13-2 SECOND STAGE VALVE

13.3.1.5 THIRD STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY

The removal and replacement procedure for this assembly is identical to that for the second stage unit, excepting that the assembly is retained by nuts and studs. Torque setting for the nuts (see Table 13-1).

13.3.1.6 THIRD STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY OVERHAUL (Figure 13-3)

Invert the head assembly and remove cap screws (6 and 7). Separate valve base (5) from the valve seat (3) and remove "O"-ring (4), suction plate (9), spring (10), shim (11), spring (12) and plate (13).

Separate delivery valve seat (3) from the cylinder head (1) and remove "O"-ring (2), delivery plate (14), spring (15), shim (16), spring (17) and plate (18).

CLEANING AND INSPECTION

The valve components should be degreased using a suitable solvent and stiff brush. Carbon deposits may be removed by placing components in boiling water. Do not attempt to remove carbon by scraping as this may cause damage to the sealing faces.

The sealing faces of valve plate and seat should be clean and bright over the whole seat area without any evidence of uneven contact. Renew plate if cracked, indented, not flat or having a wear groove which exceeds 1/10th of the plate thickness. If the plate or seat shows severe indentation the complete valve assembly must be renewed.

Inspect the remaining components for cracks, distortion or other damage liable to impair valve operation.

TO ASSEMBLE

Place valve base (5) with pegs (8) uppermost. Fit plate (9), spring (10), shim (11), spring (12) and suction plate (13). Fit "O"-ring (4) to its groove.

Fit valve seat (3) to the base, taking care not to disturb the valve components (the offset locating pins (8) of the base prevent incorrect assembly of the seat).

Place cylinder head (1) with the valve recess uppermost and fit plate (18), spring (17), shim (16), spring (15) and delivery plate (14), to the recess. Fit "O"-ring into groove.

Keeping base (5) and seat (3) held firmly together, fit this assembly to the cylinder head (1), taking care not to disturb the valve components. The offset locating pins ensure correct alignment of the seat and head.

Screw in cap screws (6 and 7) and evenly torque to the value shown in Table 13-1. This torque is critical.

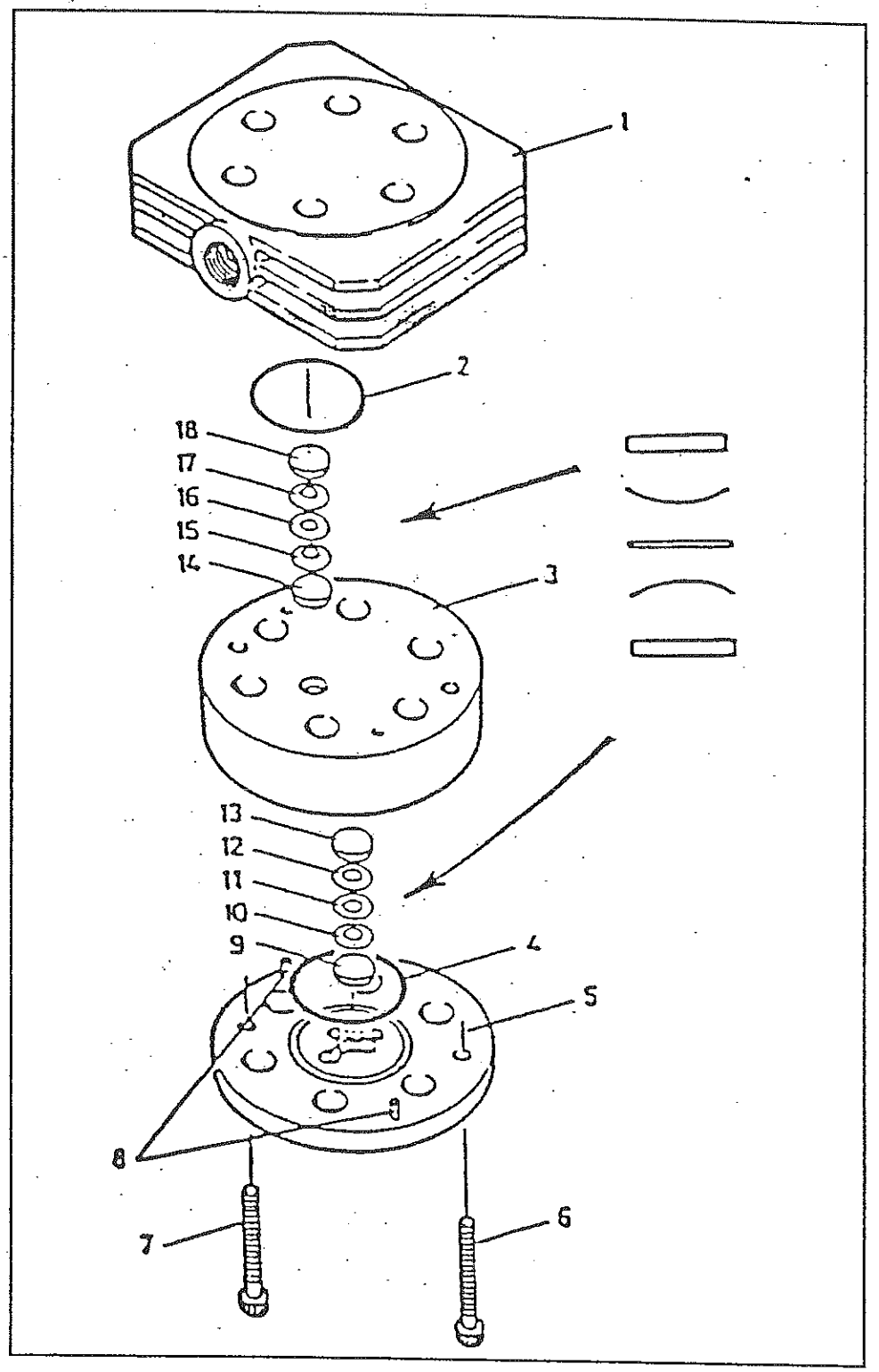


FIGURE 13-3 THIRD STAGE VALVE

13.3.2 MODELS 5406/5406E/5406EH/5407/5407H

13.3.2.1 GENERAL

Valves should have a thin carbon layer and be slightly moist with oil.

Valve removal is a simple procedure and the following guidelines should be observed.

13.3.2.2 VALVE REMOVAL (FIRST STAGE SUCTION AND DELIVERY VALVES)

TO REMOVE

Unscrew and remove the four, 10mm AF nuts securing the suction valve cover/air filter assembly, and remove from its locating studs. Similarly remove the delivery valve cover. The suction and delivery valves will now be free in the cylinder head and may be removed from their seats.

CLEANING AND INSPECTION

Check that the airways are not obstructed or heavily coated with carbon. If de-carbonizing is necessary, blank the valve apertures to prevent loose particles entering the cylinder. Ensure all loose deposits are removed after cleaning. Inspect the valve seats for cracks or other damage liable to impair sealing efficiency.

Valve overhaul and inspection is detailed below.

TO ASSEMBLE

Position the suction and delivery valves in their respective locations within the cylinder head. The suction valve has a wider top section and a deeper seat recess in the cylinder head than the delivery valve.

Refit valve covers and securing nuts, evenly torque nuts to the value shown in Table 13-2. After tightening of the valve cover nuts, there should be a gap approximately 2 mm between the covers and cylinder head; this indicates that the valves are correctly seated.

13.3.2.3 FIRST STAGE SUCTION VALVE OVERHAUL (FIGURE 13-4)

TO DISMANTLE

Holding base of stud (8) with a suitable Allen key, unscrew and remove nut (1) and washer (2). Remove seat (3), valve plate (4), spacer (5), springs (6), and base plate (7) from stud.

CLEANING AND INSPECTION

The valve components should be degreased using a suitable solvent and stiff brush. Carbon deposits may be removed by placing components in boiling water. Do not attempt to remove carbon by scraping as this may cause damage to the sealing faces. The sealing faces of valve plate and seat should be clean and bright over the whole seat area without any evidence of uneven contact. Renew plate if cracked, indented, not flat or having a wear groove which exceeds 1/10th of the plate thickness. If the plate or seat shows severe indentation the complete valve assembly must be renewed.

Inspect the remaining components for cracks, distortion or other damage liable to impair valve operation.

NOTE: **FOLLOW THIS PROCEDURE WITH ALL FIRST AND SECOND STAGE VALVES.**

TO ASSEMBLE

Place valve seat (3) with peg (9) uppermost. Fit spacer (5), engaging it with the locating peg, suction plate (4) and springs (6) which should be fitted with the angled arms pointing downward thus hold the spring centers clear of spacer (5). Ensuring the plate, spacer and springs are centralized, carefully fit guard (7), engaging

locating peg with the corresponding hole in the base plate. Check that the components are correctly located and fit stud (8), nut (1) and washer (2). Keeping the valve assembly held firmly together, tighten the nut.

13.3.2.4 FIRST STAGE DELIVERY VALVE OVERHAUL (FIGURE 13-4)

TO DISMANTLE

Unscrew and remove nut (16) and washer (15). Remove base plate (14), springs (13) (3 off), spacer (11) and delivery plate (12).

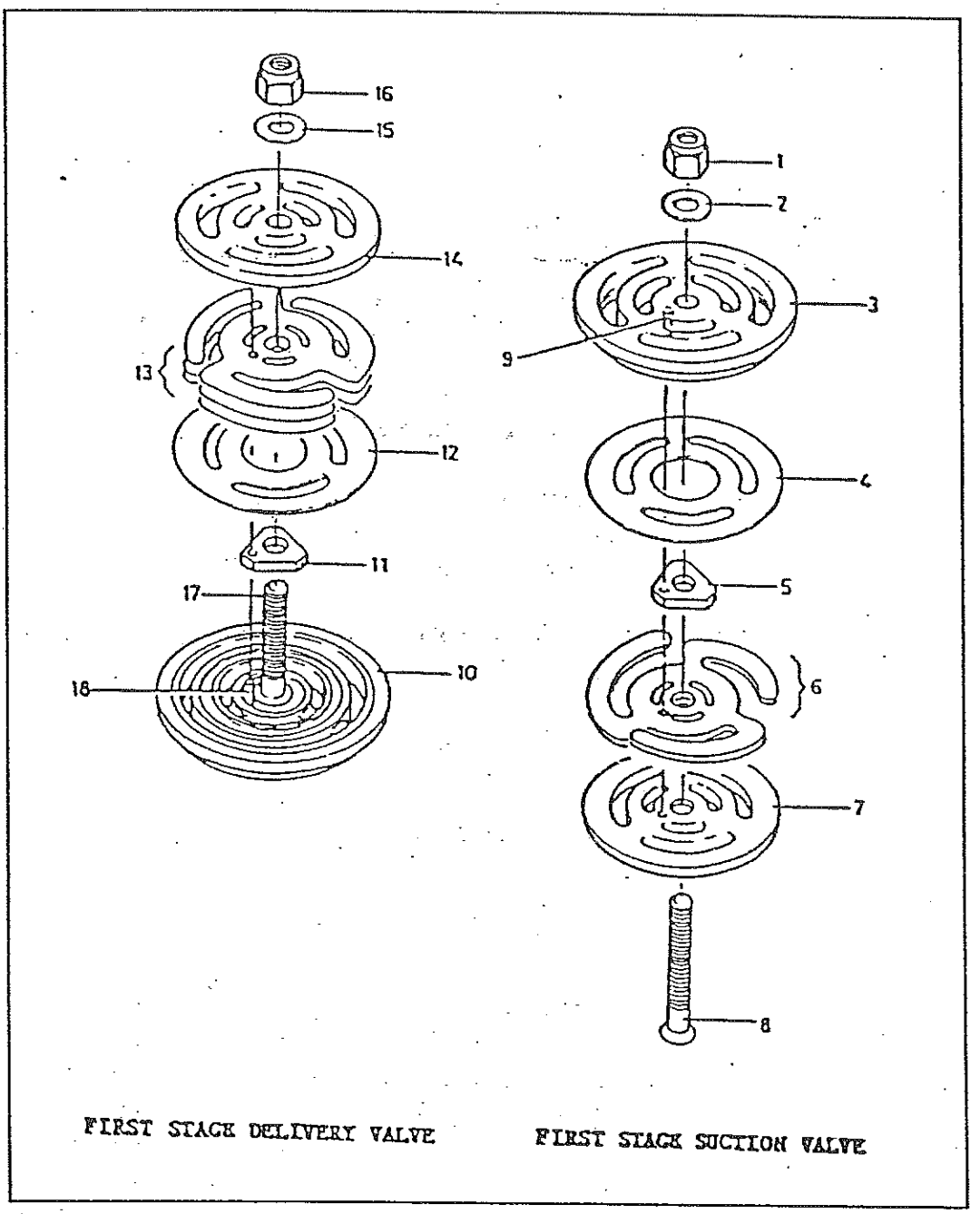


FIGURE 13-4 FIRST STAGE VALVES

TO ASSEMBLE

Fit spacer (11) to seat (10) engaging it with locating pin (18). Place delivery plate (12) in position and fit springs (13) ensuring the angled arms are pointing downward, thus holding the spring centers clear of the spacer, and that the springs are engaged with the locating pin. Taking care not to disturb the springs, fit guard (14) engaging locating pin with corresponding hole in base plate. Check that the components are correctly located and fit washer (15) and nut (16). Tighten the nut.

13.3.2.5 SECOND STAGE SUCTION AND DELIVERY VALVES

Excepting that the second stage suction valve cover is a plain cover, the valve removal and replacement procedure is identical to that for the first stage valves.

13.3.2.6 SECOND STAGE SUCTION VALVE OVERHAUL (FIGURE 13-5)

TO DISMANTLE

Unscrew and remove nut (1) and washer (2). Remove valve seat (3), suction plate (4), springs (5) (2 off) and plate (4).

TO ASSEMBLE

Fit plate (4) to base (6). Arrange springs (5) as shown in Figure 13-5 and fit to the base, followed by suction plate (4). Carefully centralize the suction plate (4) and springs (5) and fit valve seat (3). Holding the valve halves in firm contact, fit washer (2) and fit and tighten nut (1). Do not tighten the nut if the valve halves do not make full contact, separate and re-align plate and springs.

NOTE: BOLTS, NUTS, SCREW, ETC. ON THE COMPRESSOR BLOCK ARE METRIC. TORQUE VALUES FOR THE DIFFERENT SIZES OF METRIC FASTENERS ARE SHOWN IN TABLE 13-2.

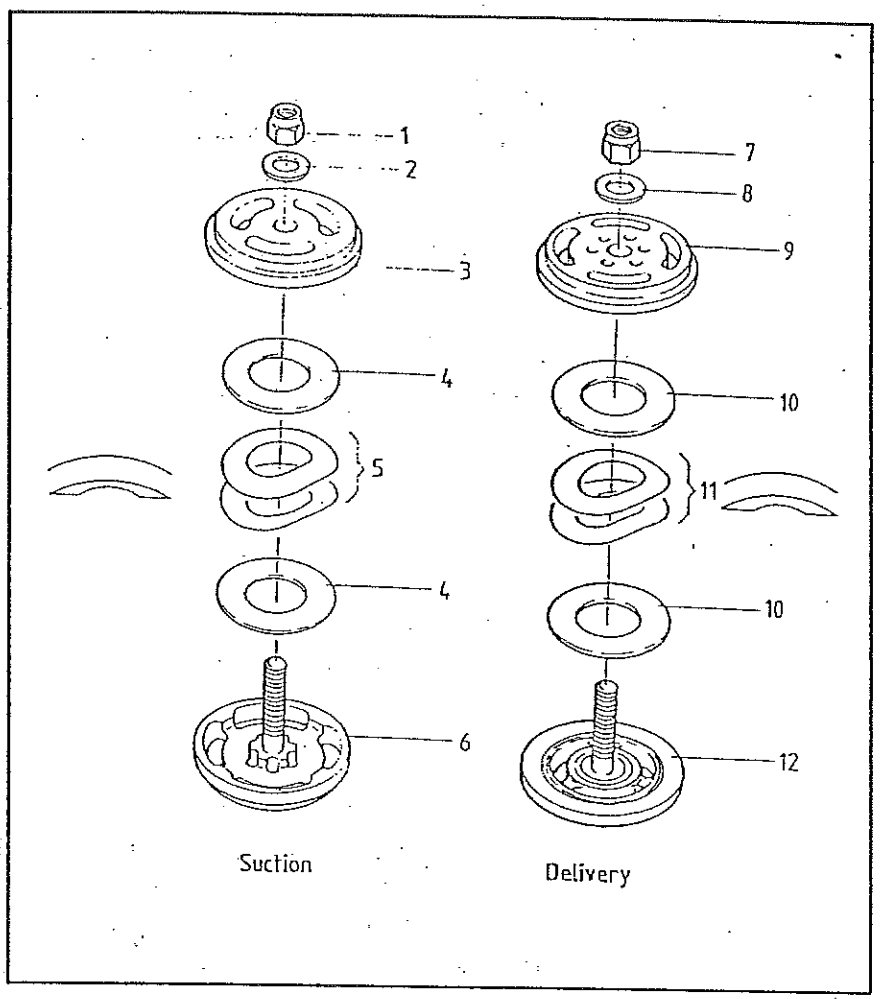


FIGURE 13-5 SECOND STAGE VALVES

13.3.2.7 SECOND STAGE DELIVERY VALVE OVERHAUL (FIGURE 13-5)

TO DISMANTLE

Unscrew and remove nut (7) and washer (8). Remove upper half of valve (9), plate (10), springs (11) (2 off), and delivery plate (10).

TO ASSEMBLE

Place upper half of valve body (9) on a tubular support. (Note that this is not part of the valve assembly). Place plate (10) into the valve body. Arrange springs (11) as shown in Figure 13-5 and place in the valve body followed by delivery plate (10). Carefully centralize the springs and plate and fit valve seat (12). Ensuring the valve halves are in firm contact, fit and tighten washer (8) and nut (7). Do not tighten the nut if the valve halves do not make full contact, separate and re-align the plate and springs.

13.3.2.8 THIRD STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY

TO REMOVE

Disconnect all pipe work from the third stage cylinder head. Unscrew the six retaining nuts and remove the head from its locating studs. Remove and discard the sealing "O"-ring from the cylinder.

CLEANING AND INSPECTION

Ensure the "O"-ring groove in the cylinder is free from dirt or damage etc., and that the piston and cylinder wall are free from excessive deposits of carbon. The overhaul procedure for the cylinder head assembly is detailed below.

TO REPLACE

Ensuring that join faces are clean, fit a new "O"-ring to the cylinder liner top and locate the head/valve assembly on the studs. Fit the six retaining nuts and evenly torque to the value shown in Table 13-2. Reconnect all pipe work.

13.3.2.9 THIRD STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY OVERHAUL (FIGURE 13-6)

TO DISMANTLE

Invert the assembly and remove cap screws (10) which retain base (7) to cylinder head (1). Remove suction plate (5), springs (6) (2 off) and plate (5). Remove delivery plate (3), delivery valve springs (4) (2 off) and plate (3). Remove and discard "O"-ring (2).

CLEANING AND INSPECTION

The valve components should be degreased using a suitable solvent and stiff brush. Carbon deposits may be removed by placing components in boiling water. Do not attempt to remove carbon by scraping as this may cause damage to the sealing faces.

The sealing faces of valve plate and seat should be clean and bright over the whole seat area without any evidence of uneven contact. Renew plate if cracked, indented, not flat or having a wear groove which exceeds 1/10th of the plate thickness. If the plate or seat shows severe indentation the complete valve assembly must be renewed.

Inspect the remaining components for cracks, distortion or other damage liable to impair valve operation.

TO ASSEMBLE

Invert base (7) and fit plate (5) followed by springs (6) which should be arranged as shown in Figure 13-6. Fit suction plate (5).

Invert cylinder head (1), and fit plate (3), followed by springs (4) which should be arranged as shown in Figure 13-6. Fit delivery plate (3) and place new "O"-ring (2) into the cylinder head groove. Ensure the delivery plate (3) is centralized. With a small steel ruler, or similar thin-bladed implement, placed across base (5) to retain the suction and fit to the cylinder head. Correct location of the base is assured by the offset pins (8) and (8) which engage with corresponding holes in the cylinder head.

Ensure the locating pins are correctly engaged and keeping downward pressure on the base, carefully withdraw the ruler; check the base is now in full contact with the cylinder head around its circumference and fit cap screws (10). Evenly torque the cap screws to the value shown in Table 13-2. This setting is critical. If the base does not correctly engage with the head, separate the components and repeat the assembly procedure.

NOTE : BOLTS, NUTS, SCREWS, ETC. ON THE COMPRESSOR BLOCK ARE METRIC. TORQUE VALUES FOR THE DIFFERENT SIZES OF METRIC FASTENERS ARE SHOWN IN TABLE 13-2.

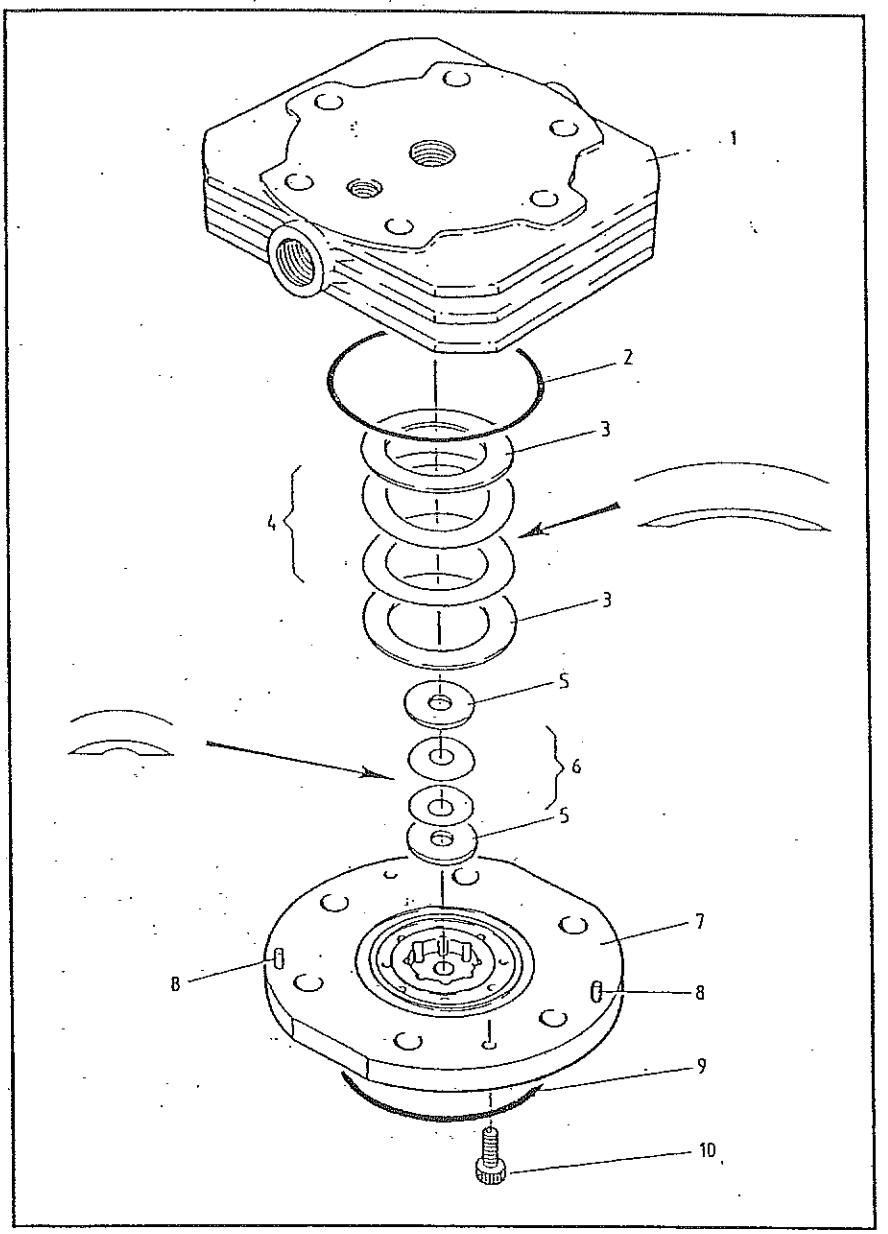


FIGURE 13-6 THIRD STAGE VALVE

13.3.2.10 FOURTH STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY

The removal and replacement procedure for this assembly is identical to that for the third stage valve.

13.3.2.11 FOURTH STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY OVERHAUL (FIGURE 13-7).

DISMANTLE

Invert the head assembly and remove cap screws (10). Separate valve base (8) from the valve seat (6) and remove "O"-ring (7), suction plate (3), spring (4), shim (5), spring (4) and plate (3).

Separate delivery valve seat (6) from the cylinder head (1) and remove "O"-ring (2), delivery plate (3), spring (4), shim (5), spring (4) and plate (3).

CLEANING AND INSPECTION

The valve components should be degreased using a suitable solvent and stiff brush. Carbon deposits may be removed by placing components in boiling water. Do not attempt to remove carbon by scraping as this may cause damage to the sealing faces.

The sealing faces of valve plate and seat should be clean and bright over the whole seat area without any evidence of uneven contact. Renew plate if cracked, indented, not flat or having a wear groove which exceeds 1/10th of the plate thickness. If the plate or seat shows severe indentation the complete valve assembly must be renewed.

Inspect the remaining components for cracks, distortion or other damage liable to impair valve operation.

TO ASSEMBLE

Place valve base (8) with pegs (9) uppermost. Fit plate (3), spring (4), shim (5), spring (4) and suction plate (3). Fit "O"-ring (7) to its groove.

Fit valve seat (6) to the base, taking care not to disturb the valve components (the offset locating pins (9) of the base prevent incorrect assembly of the seat).

Place cylinder head (1) with the valve recess uppermost and fit plate (3), spring (4), shim (5), spring (4) and delivery plate (3), to the recess. Fit "O"-ring to its groove.

Keeping base (8) and seat (6) held firmly together, fit this assembly to the cylinder head (1), taking care not to disturb the valve components. The offset locating pins ensure correct alignment of the seat and head.

Fit cap screws (10) and evenly torque to the value shown in Table 13-2. This setting is critical.

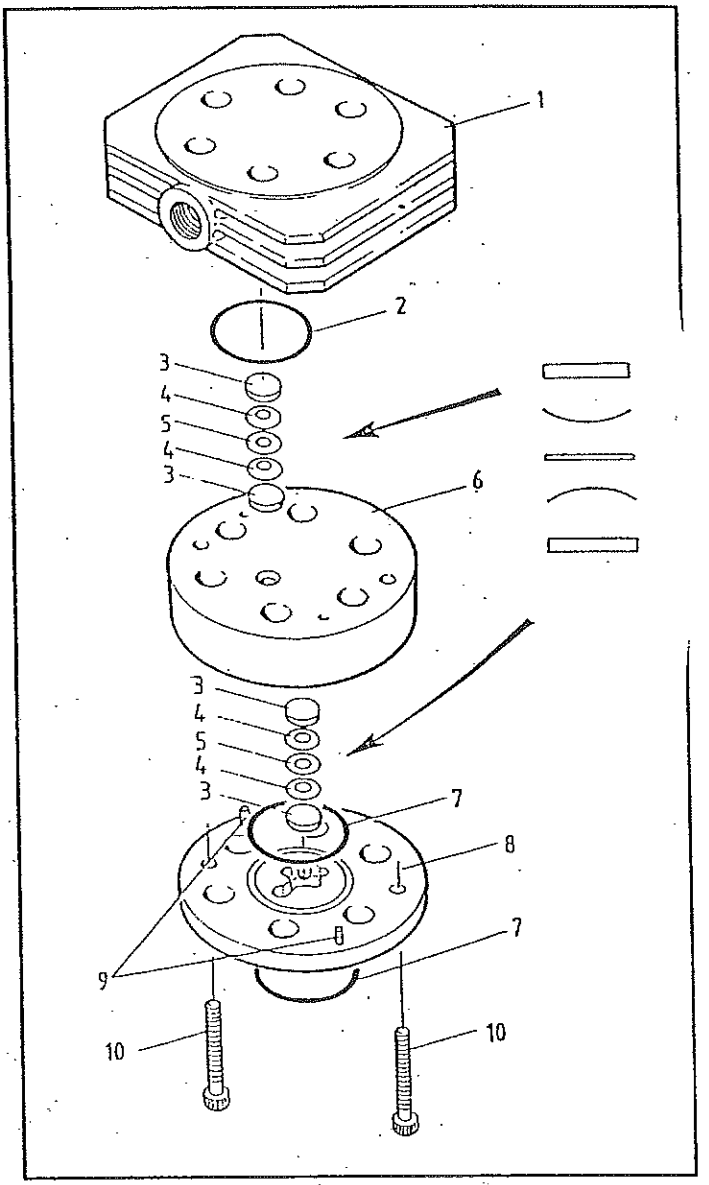


FIGURE 13-7 FOURTH STAGE VALVE

13.3.3 MODELS 5408/5409/5409H

13.3.3.1 GENERAL

Valves should have a thin carbon layer and be slightly moist with oil.

Valve removal is a simple procedure and the following guidelines should be observed.

13.3.3.2 VALVE REMOVAL (FIRST STAGE SUCTION AND DELIVERY VALVES)

TO REMOVE

Unscrew and remove the four, 10mm AF nuts securing the suction valve cover/air filter assembly, and remove from its locating studs. Similarly remove the delivery valve cover. The suction and delivery valves will now be free in the cylinder head and may be removed from their seats.

Cleaning and Inspection

Check that the airways are not obstructed or heavily coated with carbon. If de-carbonizing is necessary, blank the valve apertures to prevent loose particles entering the cylinder. Ensure all loose deposits are removed after cleaning. Inspect the valve seats for cracks or other damage liable to impair sealing efficiency.

Valve overhaul and inspection is detailed below.

TO ASSEMBLE

Position the suction and delivery valves in their respective locations within the cylinder head. The suction valve has a wider top section and a deeper seat recess in the cylinder head than the delivery valve.

Refit valve covers and securing nuts, evenly torque nuts to the value shown in Table 13-3. After tightening of the valve cover nuts, there should be a gap approximately 2 mm between the covers and cylinder head; this indicates that the valves are correctly seated.

13.3.3.3 FIRST STAGE DELIVERY VALVE OVERHAUL (FIGURE 13-8)

TO DISMANTLE

Unscrew and remove nut (16) and washer (15). Remove base plate (14), springs (13) (2 off), spacer (11) and delivery plate (12).

TO ASSEMBLE

Fit plate (12) to seat (10) engaging locating pin

(19) with the hole in plate (12) NOT with the slots. Fit spacer (11). Arrange springs (13) as shown in Figure 13-8 and place on the valve plate, engaging with the locating pin as for the plate. Centralize the plate and springs. Taking extreme care not to disturb the springs, fit guard (14), engaging locating pin with corresponding hole in the base plate. Holding the components firmly together, fit nut (16) and washer (15). Tighten nut.

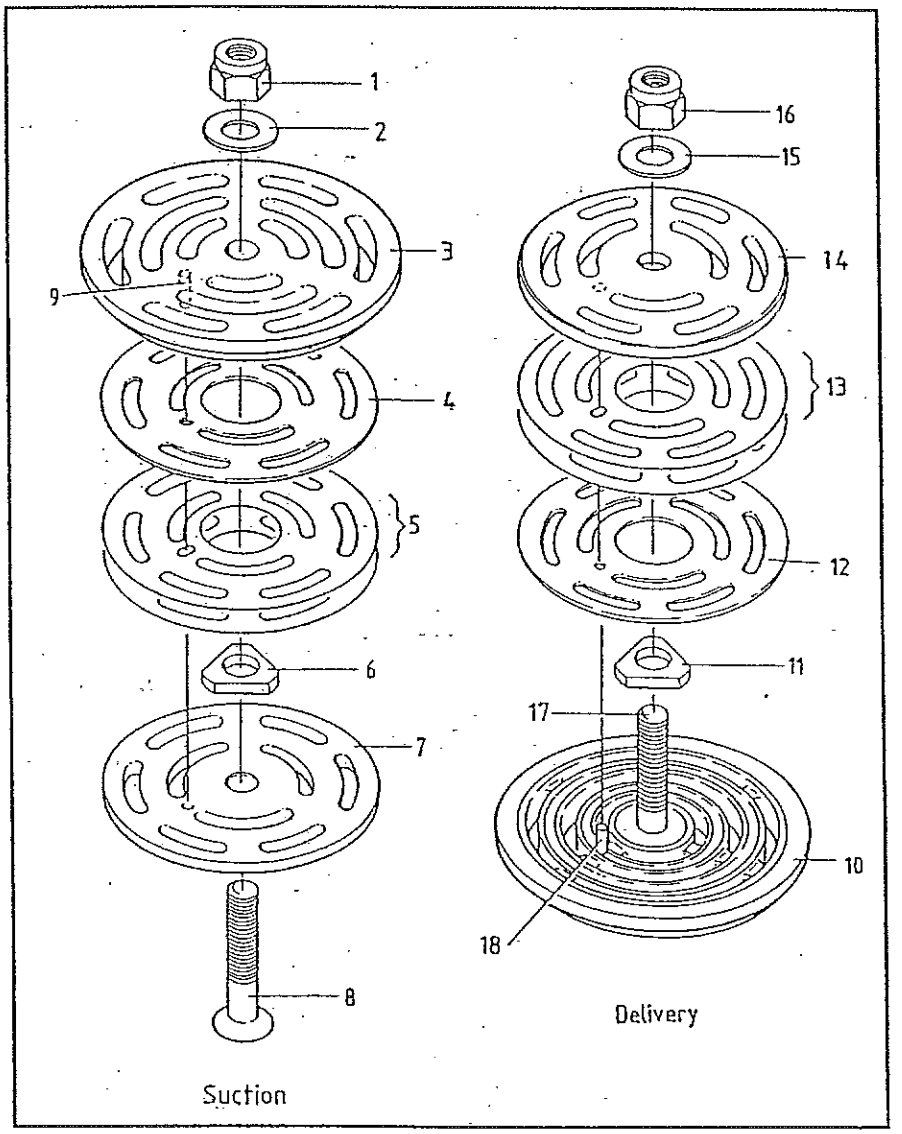


FIGURE 13-8 FIRST STAGE VALVES

13.3.3.4 FIRST STAGE SUCTION VALVE OVERHAUL (FIGURE 13-8)

TO DISMANTLE

Holding base of stud (8) with a suitable Allen key, unscrew and remove nut (1) and washer (2). Remove seat (3), valve plate (4), spacer (6), springs (5), and base plate (7) from stud.

CLEANING AND INSPECTION

The valve components should be degreased using a suitable solvent and stiff brush. Carbon deposits may be removed by placing components in boiling water. Do not attempt to remove carbon by scraping as this may cause damage to the sealing faces. The sealing faces of valve plate and seat should be clean and bright over the whole seat area without any evidence of uneven contact. Renew plate if cracked, indented, not flat or having a wear groove which exceeds 1/10th of the plate thickness. If the plate or seat shows severe indentation the complete valve assembly must be renewed.

Inspect the remaining components for cracks, distortion or other damage liable to impair valve operation.

NOTE: FOLLOW THIS PROCEDURE WITH ALL FIRST AND SECOND STAGE VALVES.

TO ASSEMBLE

Place valve seat (3) on a tubular support. (Note that this is not part of the valve assembly) with peg (9) uppermost. Fit spacer (6) and valve plate (4) engaging peg (9) with the hole in plate NOT with the slots. Arrange springs (5) as shown in Figure 13-8 place on the valve plate. Centralize plates and springs. Take extreme care not to disturb hole in the guard. Holding the valve components firmly together, pass stud (8) through the assembly, lift from the support and fit nut (1) and washer (2). Tighten nut.

13.3.3.5 SECOND STAGE SUCTION AND DELIVERY VALVES

Excepting that the second stage suction valve cover is a plain cover, the valve removal and replacement procedure is identical to that for the first stage valves.

13.3.3.6 SECOND STAGE SUCTION VALVE OVERHAUL (FIGURE 13-9)

TO DISMANTLE

Holding stud (8) with a suitably sized Allen key, unscrew and remove nut (1) and washer (2). Remove seat (3), suction plate (4), spacer (5), and springs (6) (3 off) from guard (7).

TO ASSEMBLE

Place valve seat (3) with peg (10) uppermost. Fit plate (4) and spacer (5) to the seat, engaging the hole in spacer (5) with locating pin (9). Arrange springs (6) as shown in Figure 13-9 and place on plate (4) with the angled arms pointing downward thus holding the spring centers clear of spacer 5, and aligning locating peg with the small hole in the springs. Carefully fit guard (7) engaging the locating pin with the small hole in the guard.

Keeping the assembly held firmly together, fit stud (8), and fit nut (1) and washer (2). Tighten nut.

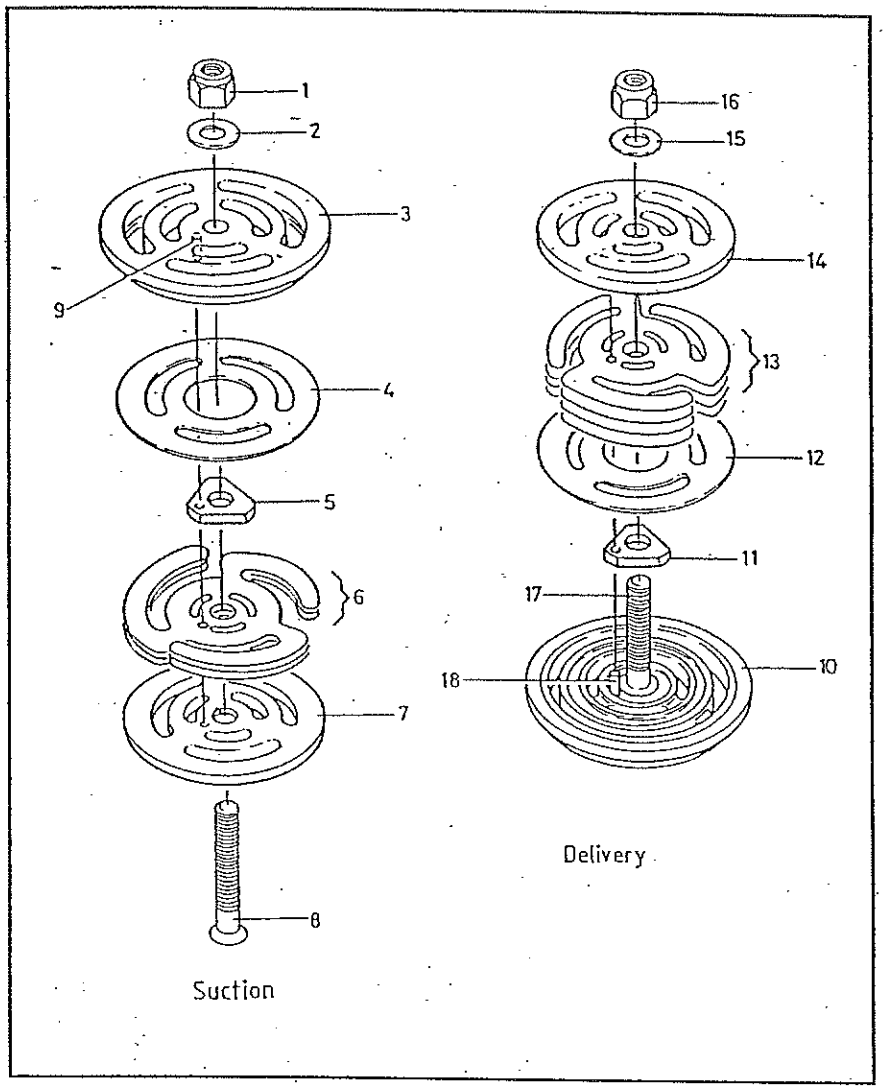


FIGURE 13-9 SECOND STAGE VALVES

NOTE: BOLTS, NUTS, SCREWS, ETC. ON THE COMPRESSOR BLOCK ARE METRIC. TORQUE VALUES FOR THE DIFFERENT SIZES OF METRIC FASTENERS ARE IN TABLE 13-3.

13.3.3.7 SECOND STAGE DELIVERY VALVE OVERHAUL (FIGURE 13-9)

TO DISMANTLE

Unscrew and remove nut (16) and washer (15). Remove guard (14), springs (13) (4 off), delivery plate (12), spacer (11) from valve seat.

TO ASSEMBLE

Fit spacer (11) to seat (10) engaging locating peg (18) with the small hole in the spacer. Place delivery plate (12) in position on the seat. Arrange springs (13) as shown in Figure 13-9, aligning the small hole in each spring with locating peg (18). Carefully fit guard (14) engaging the small hole in the guard with the locating peg. Holding the guard in position, fit washer (15) and nut (16). Tighten nut. Torque value shown in Table 13-3.

13.3.3.8 THIRD STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY

TO REMOVE

Disconnect all pipe work from the third stage cylinder head. Unscrew the six retaining nuts and remove the head from its locating studs. Remove and discard the sealing "O"-ring from the cylinder.

CLEANING AND INSPECTION

Ensure the "O"-ring groove in the cylinder is free from dirt or damage etc., and that the piston and cylinder wall are free from excessive deposits of carbon. The overhaul procedure for the cylinder head assembly is detailed below.

TO REPLACE

Ensuring that joint faces are clean, fit a new "O"-ring to the cylinder liner top and locate the head/valve assembly on the studs. Fit the six retaining nuts and evenly torque to the value shown in Table 13-3. Reconnect all pipe work.

13.3.3.9 **THIRD STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY OVERHAUL (FIGURE 13-10)**

TO DISMANTLE

Invert the assembly and remove cap screws (10) which retain base (7) to cylinder head (1). Remove suction plate (5), springs (6) (2 off) and plate (5). Remove delivery plate (3), delivery valve springs (4) (2 off) and plate (3). Remove and discard "O"-ring (2).

Cleaning and Inspection

The valve components should be degreased using a suitable solvent and stiff brush. Carbon deposits may be removed by placing components in boiling water. Do not attempt to remove carbon by scraping as this may cause damage to the sealing faces.

The sealing faces of valve plate and seat should be clean and bright over the whole seat area without any evidence of uneven contact. Renew plate if cracked, indented, not flat or having a wear groove which exceeds 1/10th of the plate thickness. If the plate or seat shows severe indentation the complete valve assembly must be renewed.

Inspect the remaining components for cracks, distortion or other damage liable to impair valve operation.

TO ASSEMBLE

Invert base (7) and fit plate (5) followed by springs (6) which should be arranged as shown in Figure 13-10. Fit suction plate (5).

Invert cylinder head (1), and fit plate (3), followed by springs (4) which should be arranged as shown in Figure 13-10. Fit delivery plate (3) and place new "O"-ring (2) into the cylinder head groove. Ensure the delivery plate (3) is centralized. With a small steel ruler, or similar thin-bladed implement, place across base (8) to retain the suction and fit to the cylinder head. Correct location of the base is assured by the offset pins (8) which engage with corresponding holes in the cylinder head.

Ensure the locating pins are correctly engaged and keeping downward pressure on the base, carefully withdraw the ruler; check the base is now in full contact with the cylinder head around its circumference and fit cap screws (10). Evenly torque the cap screws to the value shown in Table 13-3. This setting is critical. If the base does not correctly engage with the head, separate the components and repeat the assembly procedure.

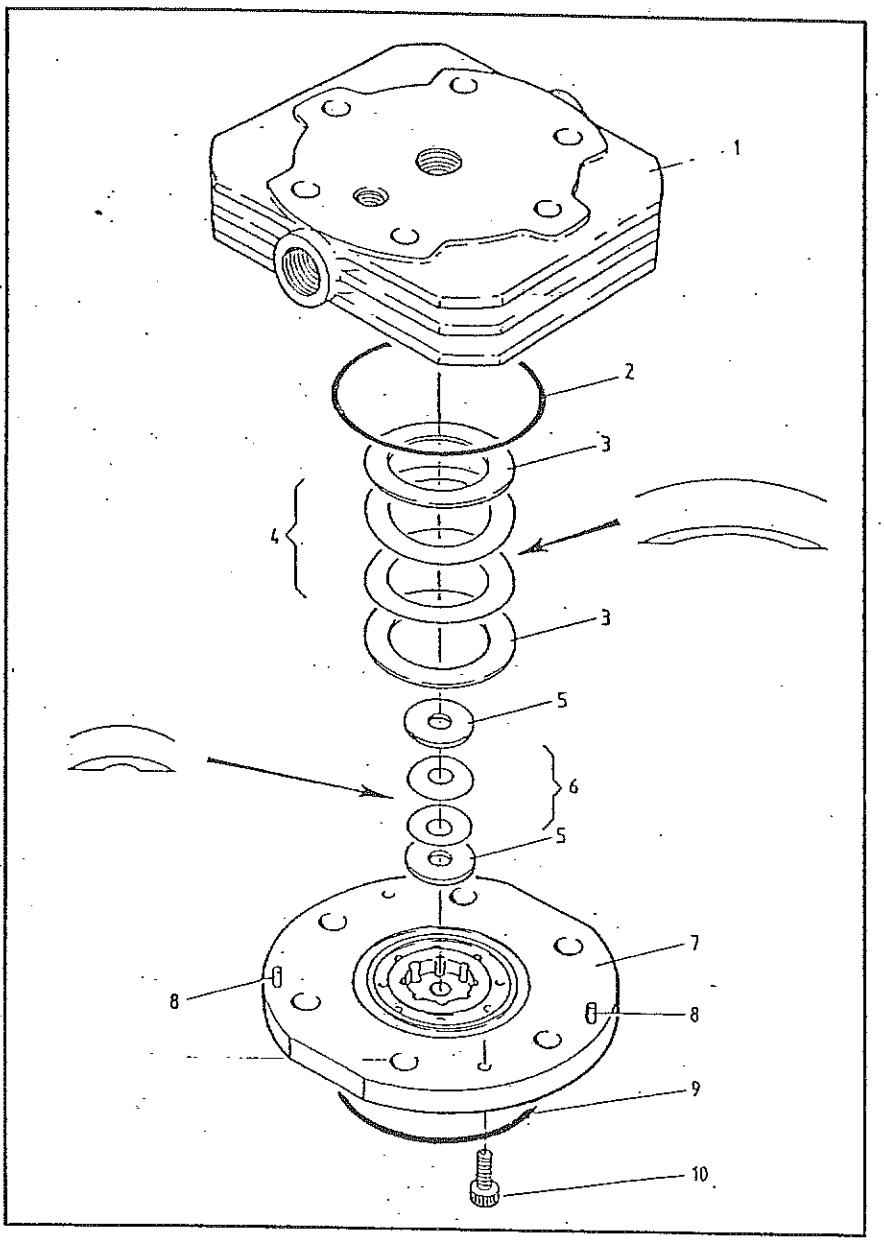


FIGURE 13-10 THIRD STAGE VALVE

13.3.3.10 FOURTH STAGE SUCTION AND DELIVERY VALVE/CYLINDER HEAD ASSEMBLY

The removal and replacement procedure for this assembly is identical to that for the third stage valve.

13.3.3.11 FOURTH STAGE SUCTION AND DELIVERY

VALVE/CYLINDER HEAD ASSEMBLY OVERHAUL (FIGURE 13-11).

DISMANTLE

Invert the head assembly and remove cap screws (10). Separate valve base (8) from the valve seat (6) and remove "O"-ring (7), suction plate (3), spring (4), shim (5), spring (4) and plate (3).

Separate delivery valve seat (6) from the cylinder head (1) and remove "O"-ring (2), delivery plate (3), spring (4), shim (5), spring (4) and plate (3).

CLEANING AND INSPECTION

The valve components should be degreased using a suitable solvent and stiff brush. Carbon deposits may be removed by placing components in boiling water. Do not attempt to remove carbon by scraping as this may cause damage to the sealing faces.

The sealing faces of valve plate and seat should be clean and bright over the whole seat area without any evidence of uneven contact. Renew plate if cracked, indented, not flat or having a wear groove which exceeds 1/10th of the plate thickness. If the plate or seat shows severe indentation the complete valve assembly must be renewed.

Inspect the remaining components for cracks, distortion or other damage liable to impair valve operation.

TO ASSEMBLE

Place valve base (8) with pegs (9) uppermost. Fit plate (3), spring (4), shim (5), spring (4) and suction plate (3). Fit "O"-ring (7) to its groove.

Fit valve seat (6) to the base, taking care not to disturb the valve components (the offset locating pins (9) of the base prevent incorrect assembly of the seat).

Place cylinder head (1) with the valve recess uppermost and fit plate (3), spring (4), shim (5), spring (4) and delivery plate (3), to the recess. Fit "O"-ring to its groove.

Keeping base (8) and seat (6) held firmly together, fit this assembly to the cylinder head (1), taking care not to disturb the valve components. The offset locating pins ensure correct alignment of the seat and head.

Fit cap screws (10) and evenly torque to the value shown in Table 13-3. This setting is critical.

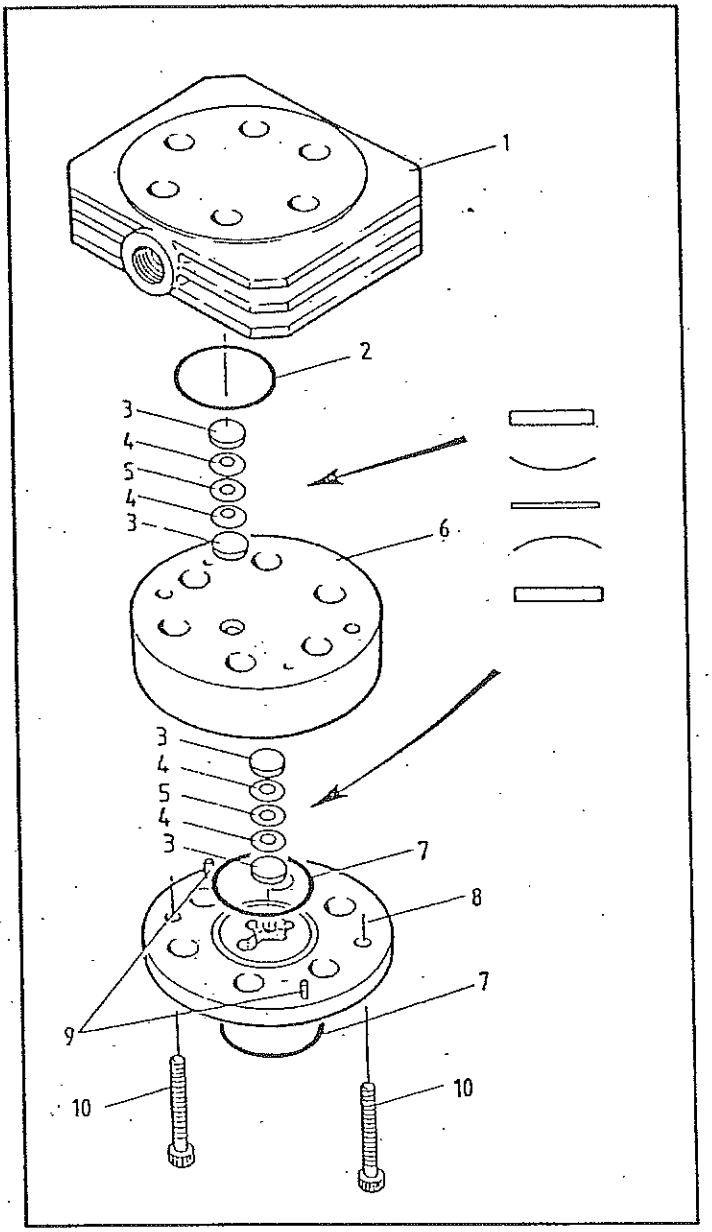


FIGURE 13-11 FOURTH STAGE VALVE

TABLE 13-1 CRITICAL TORQUE SETTINGS
MODELS 5404/5404H/54044/5405/5405E/54054

CLASS A
ALL FIGURES ± 5 PERCENT

For Non Lubricated Fasteners

ASSEMBLY OPERATION	SIZE	NEWTON-METER (nm)	lbf-ft
FIRST STAGE VALVE COVER	M8	13	10
SECOND STAGE VALVE HEAD	M8	16	12
SECOND STAGE VALVE	M8	6	5
THIRD STAGE VALVE HEAD	M8	16	12
THIRD STAGE VALVE	M8	4	3
FLYWHEEL	M8	27	20
BALANCE WEIGHT	M8	27	20

CLASS B
ALL FIGURES ± 5 PERCENT

ASSEMBLY OPERATION	SIZE	NEWTON-METER (nm)	lbf-ft
ALL OTHER FASTENERS	M6 M8 M10	11 27 54	8 20 40

TABLE 13-2 CRITICAL TORQUE SETTINGS
MODELS 5406/5406E/5406EH/5407/5407H

CLASS A
ALL FIGURES ± 5 PERCENT

For Non Lubricated Fasteners

ASSEMBLY OPERATION	SIZE	NEWTON-METER (nm)	lbf-ft
FIRST STAGE VALVE COVER	M6	5 .4	4
FIRST STAGE VALVE	M6	4	3
SECOND STAGE VALVE HEAD	M6	5.4	4
SECOND STAGE VALVE	M6	4	3
THIRD STAGE VALVE HEAD	M8	16	12
THIRD STAGE VALVE	M5	6	5
FOURTH STAGE VALVE HEAD	M8	16	12
FOURTH STAGE VALVE	M4	4	3
FLYWHEEL	M10 LH	54	40
OIL PUMP CAM	M10 LH	54	40
BALANCE WEIGHT	M8	27	20

CLASS B
ALL FIGURES ± 5 PERCENT

ASSEMBLY OPERATION	SIZE	NEWTON-METER (nm)	lbf-ft
ALL OTHER FASTENERS	M6 M8 M10	11 27 54	8 20 40

TABLE 13-3 CRITICAL TORQUE SETTINGS
MODELS 5408/5409/5409H

CLASS A
ALL FIGURES ± 5 PERCENT

For Non Lubricated Fasteners

ASSEMBLY OPERATION	SIZE	NEWTON-METER (nm)	lbf-ft
FIRST STAGE VALVE COVER	M6	5.4	4
FIRST STAGE VALVE	M8	11.0	8
SECOND STAGE VALVE HEAD	M8	5.4	4
SECOND STAGE VALVE	M6	4	3
THIRD STAGE VALVE HEAD	M8	16	12
THIRD STAGE VALVE	M8	11	8
FOURTH STAGE VALVE HEAD	M8	16	12
FOURTH STAGE VALVE	M8	11	8
FLYWHEEL	M LH	95	70
OIL PUMP CAM	M LH	95	70
BALANCE WEIGHT	M8	54	40

CLASS B
ALL FIGURES ± 5 PERCENT

ASSEMBLY OPERATION	SIZE	NEWTON-METER (nm)	lbf-ft
ALL OTHER FASTENERS	M6 M8 M10	11 27 54	8 20 40

14.0 AIR TESTING

Qualified analytical laboratories provide kits that are designed to ensure that representative air samples are obtained from the intended source. The procedure discussed in the following paragraphs is based on the sampling kit provided by a typical laboratory in the interest of providing a set of instructions that addresses a complete cycle of air sampling. Similar procedures could be prepared for use with sample capture equipment from other laboratories. The key principal involved is capturing a representative sample of ambient air being inducted into the compressor.

Figure 14.1 shows the components in each air sampling kit.

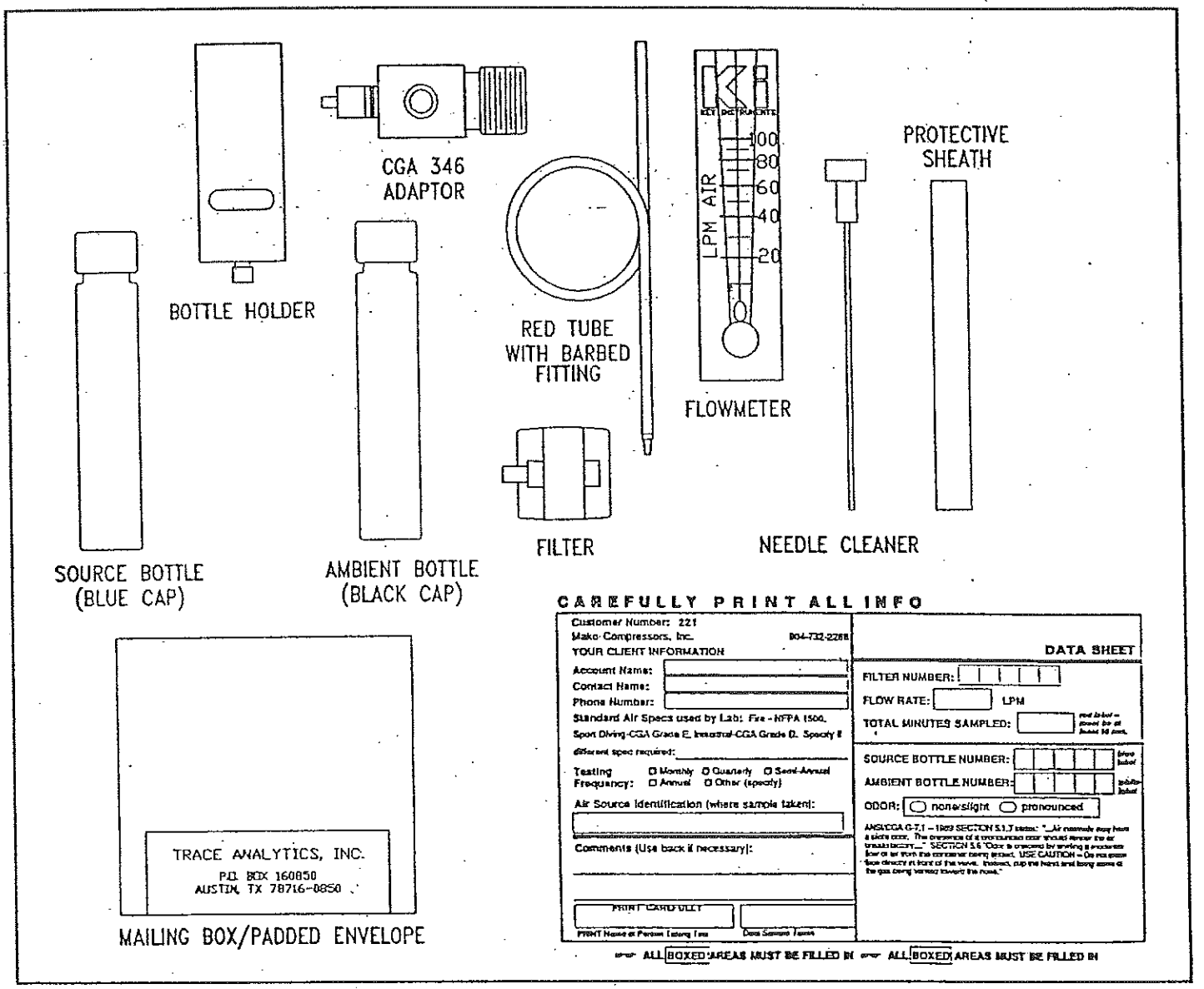


FIGURE 14-1 AIR CHECK KIT

Figure 14-2 shows the device required to : (1) convey the air to the sample from the compressor to the sample point, and (2) safely bleed the pressure from the hose assembly after the air sample is taken.

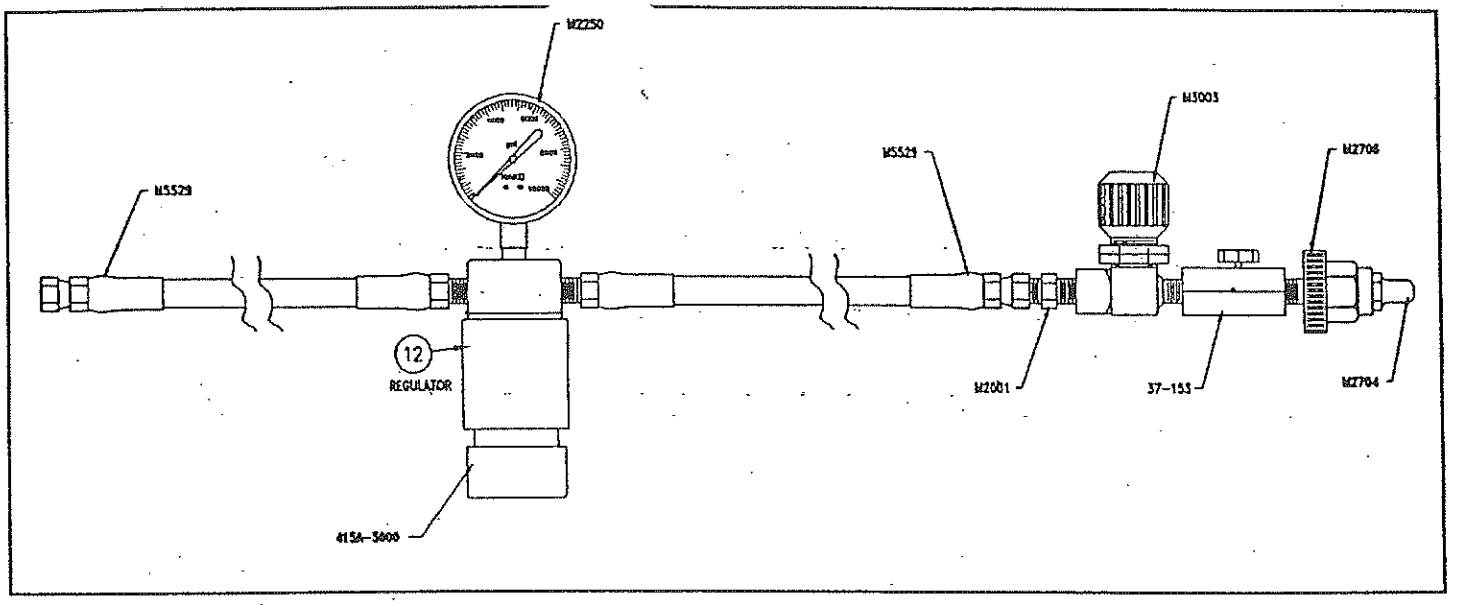


FIGURE 14-2 AIR SAMPLING DEVICE

With a laboratory sampling kit and an appropriate interface as shown in Figure 14-2, air sampling is achieved as follows:

1. Install the flexible hose on the sampling device to the PMV at point (11) Figure 14-3 and open the valve (23).

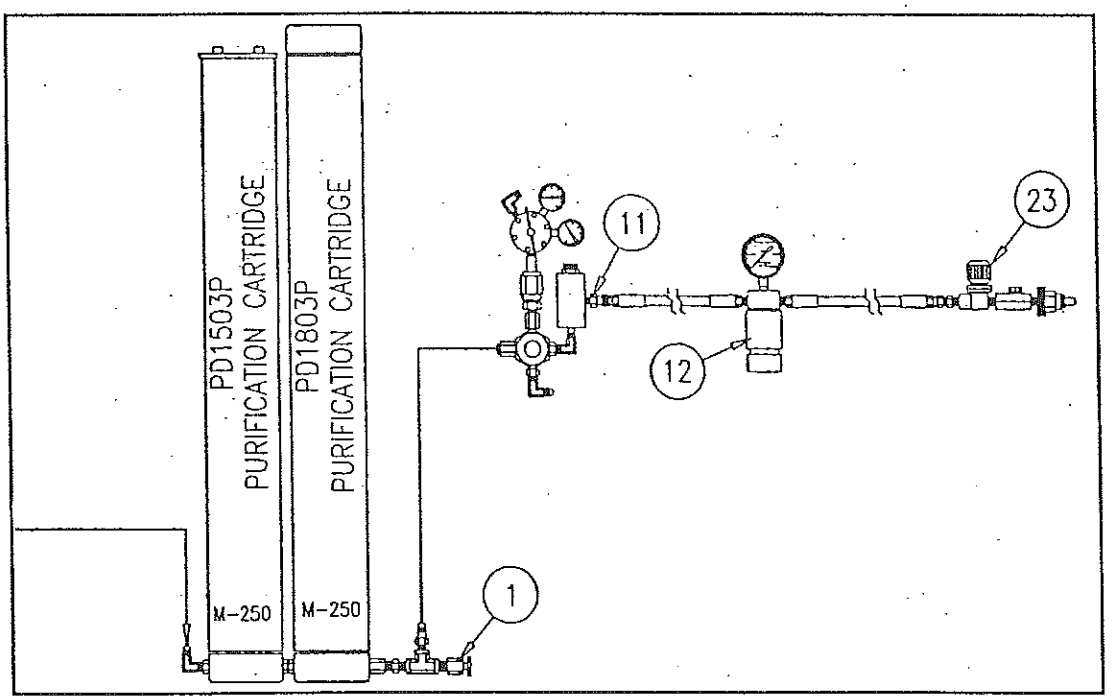


FIGURE 14-3 AIR SAMPLING DEVICE DEPLOYMENT

2. Turn on compressor and run machine for approximately 5 minutes while discharging air from the sampling device. Regulator (12) (Figure 14-3) should be set to deliver air at a pressure between 2000 and 3000 PSIG.

3. Install the brass air sample adaptor (13) on the sampling device as shown in Figure 14-4.

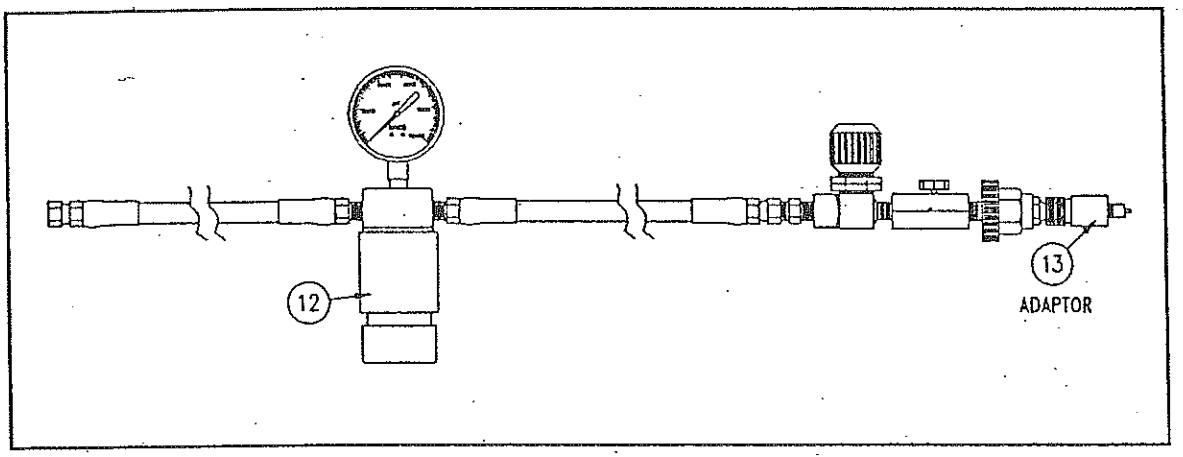


FIGURE 14-4 BRASS ADAPTOR INSTALLATION

4. Prior to each test, remove "O"-ring (14) from the bottle holder (15), carefully remove the needle cleaner (16) from the protective sheath, run the needle cleaner through each of the two holes at the bottom of the bottle holder to assure that the needle airways are not blocked (Figure 14-5).

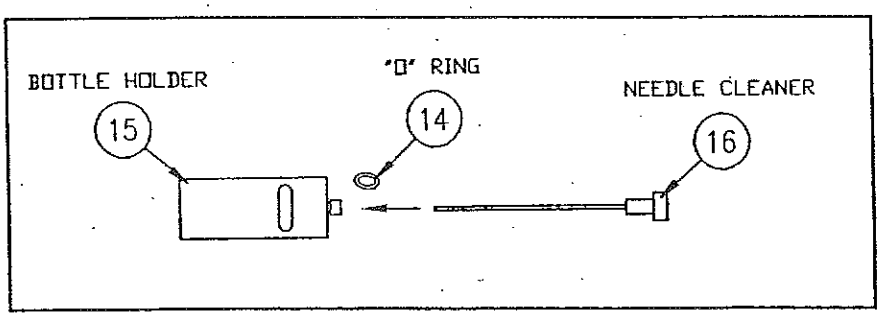


FIGURE 14-5 NEEDLE CLEANER

5. Carefully attach the aluminum bottle holder (15) to the threaded hole on top of the brass adaptor (13) taking care that you do not cross thread the fittings (Figure 14-6).

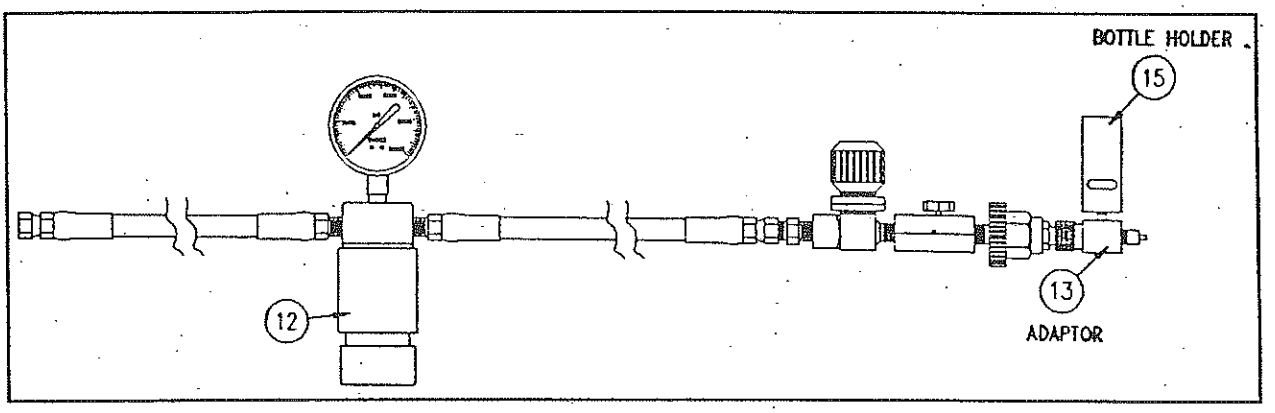


FIGURE 14-6 BOTTLE HOLDER INSTALLATION

6. Gently twist on the filter (17) to the filter fitting (male lure fitting) located on the side of the adaptor (13) (do not over-tighten) (Figure 14-7). Use the red tubing (18) with the barbed fitting attached to connect the filter to the flowmeter (19).

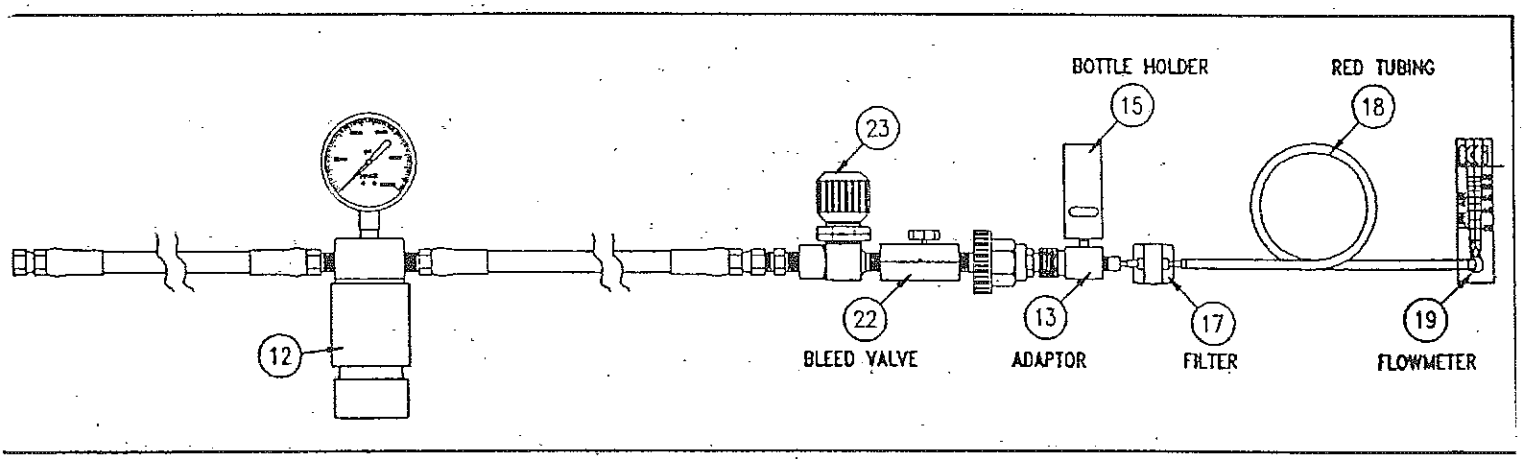


FIGURE 14-7 FLOW METER INSTALLATION

7. Insert the numbered source bottle (20) (blue capped) into the bottle holder (15) by gently pushing the bottle straight down (Figure 14-8).

CAUTION: DO NOT TWIST OR TURN BOTTLE - THIS CAN DAMAGE NEEDLES. USE THE BLUE CAPPED BOTTLE ONLY.

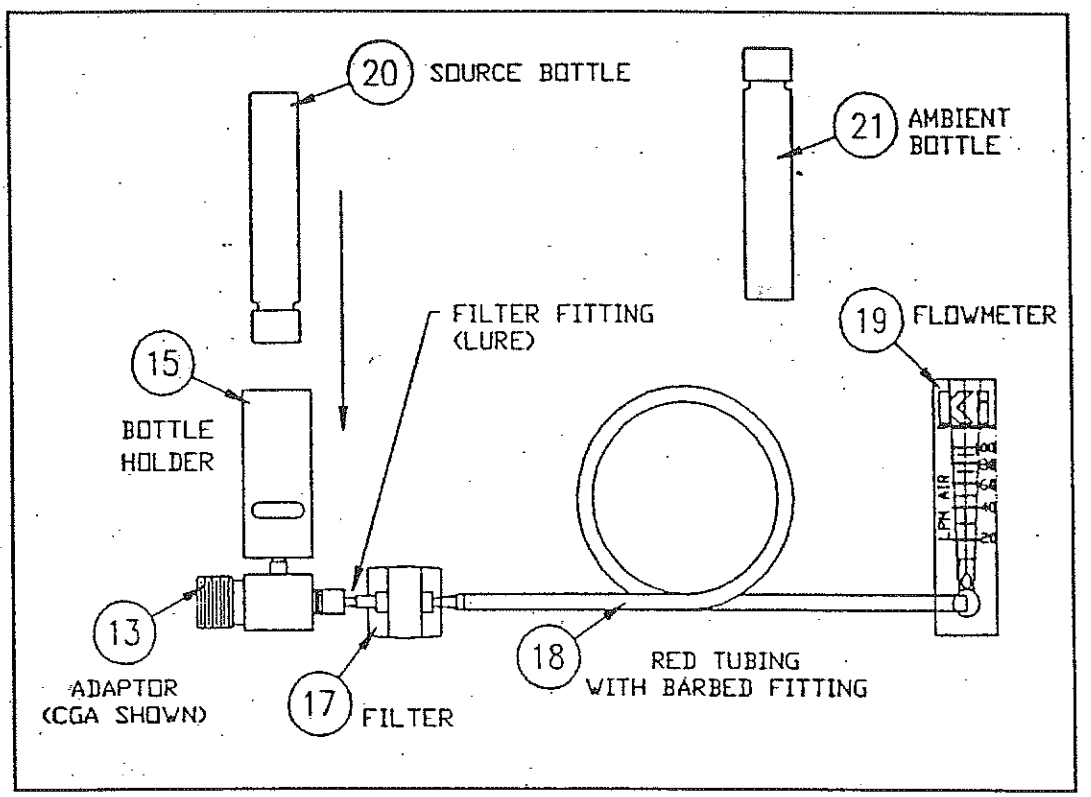


FIGURE 14-8 SOURCE BOTTLE APPLICATION

8. Open the adaptor device valve (23) (Figure 14-7) slowly to normal operating pressure. Check the flowmeter reading which must be between 20 and 100 liters per minute (LPM). Begin timing test.

CAUTION: TIMING MUST BE ACCURATE. RUN TEST FOR 10 MINUTES OR MORE.

CAUTION: FLOWMETER (19) SHOULD BE PLACED ON A LEVEL SURFACE IN THE VERTICAL POSITION AND READ AT EYE LEVEL.

Determine flow rate reading to the nearest 5 LPM mark using the middle of the ball to determine flow rate. Obtain an ambient sample at the same time as the source air test by removing the black cap from the ambient bottle (21) and placing the bottle as close to compressor inlet as possible. Recap the bottle after 10 minutes. If the red septum falls out of the cap, replace the septum inside the cap with the shiny side facing the bottle opening.

Determine flow rate reading to the nearest 5 LPM mark using the middle of the ball to determine flow rate. Obtain an ambient sample at the same time as the source air test by removing the black cap from the ambient bottle (21) and placing the bottle as close to compressor inlet as possible. Recap the bottle after 10 minutes. If the red septum falls out of the cap, replace the septum inside the cap with the shiny side facing the bottle opening.

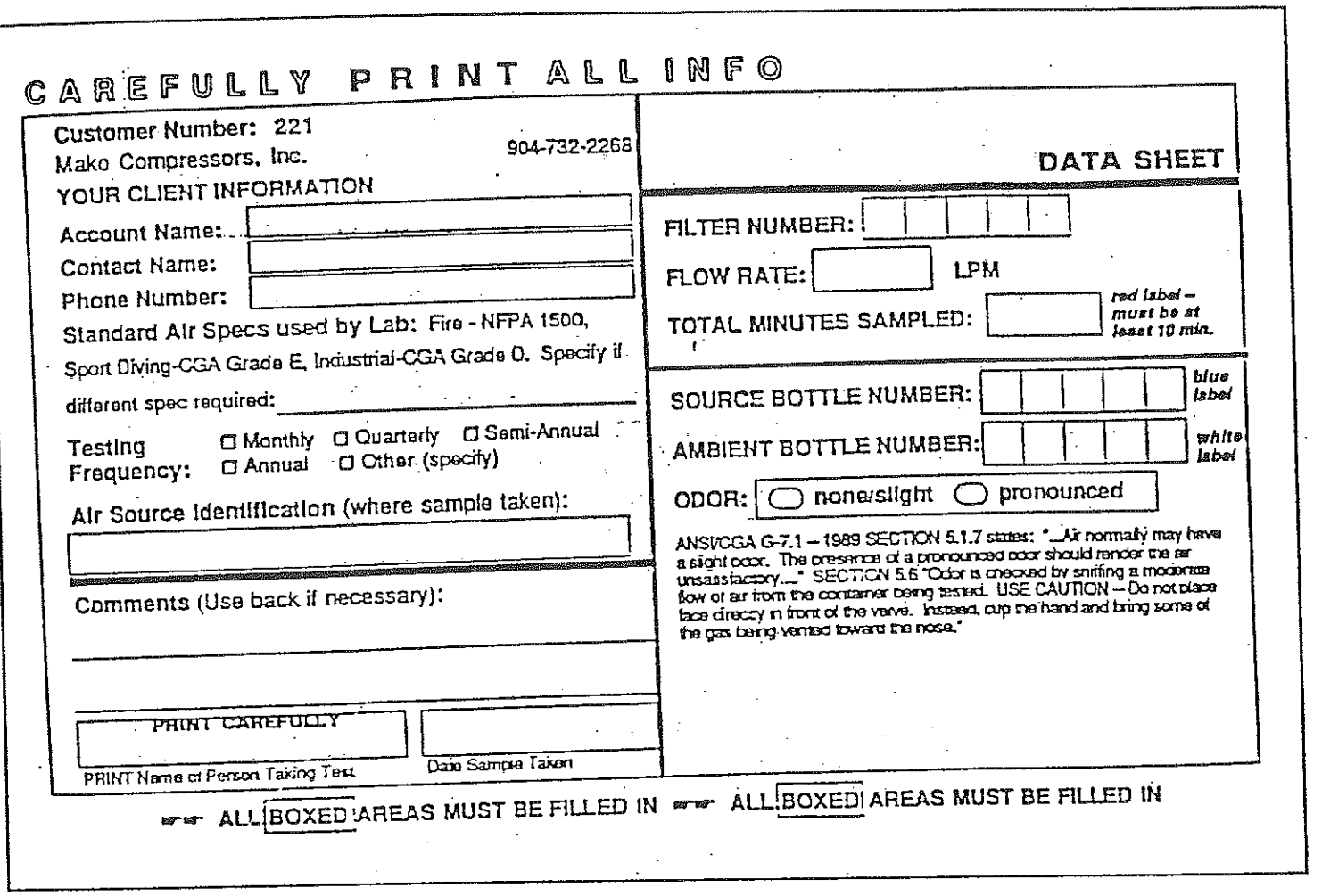
NOTE: (A) The adaptor (13) and bottle holder (15) will became cold and may ice up. This is normal. Air will be vented from both of the bottle holder side ports.

(B) The reading on the flowmeter (19) should stay steady. If flow rate drops or varies, determine an average flow rate and indicate on data sheet that a steady flow rate was not achieved.

9. After 15 minutes close valve (23) (Figure 14-7) and immediately remove the source bottle (20) from the bottle holder (15). Place a protective netting on bottles.

NOTE: IF THE COMPRESSOR REACHES ITS MAXIMUM AIR PRESSURE SETTING DURING THE TEST IT WILL SHUT OFF. THIS WILL NOT AFFECT THE TEST RESULTS AS LONG AS THE MINIMUM FLOW THROUGH THE TEST APPARATUS IS MAINTAINED.

10. Complete the data sheet with all requested information (Figure 14-9).


CAREFULLY PRINT ALL INFO

Customer Number: 221
Mako Compressors, Inc. 904-732-2268
YOUR CLIENT INFORMATION

Account Name:
Contact Name:
Phone Number:

Standard Air Specs used by Lab: Fire - NFPA 1500, Sport Diving-CGA Grade E, Industrial-CGA Grade D. Specify if different spec required:

Testing Frequency: ☐ Monthly ☐ Quarterly ☐ Semi-Annual ☐ Annual ☐ Other (specify)

Air Source Identification (where sample taken):

Comments (Use back if necessary):

PRINT CAREFULLY
PRINT Name of Person Taking Test
Date Sample Taken

DATA SHEET

FILTER NUMBER:
FLOW RATE: LPM
TOTAL MINUTES SAMPLED: red label – must be at least 10 min.

SOURCE BOTTLE NUMBER: blue label
AMBIENT BOTTLE NUMBER: white label

ODOR: ◯ none/slight ◯ pronounced

ANSI/CGA G-7.1 – 1989 SECTION 5.1.7 states: "...Air normally may have a slight odor. The presence of a pronounced odor should render the air unsatisfactory..." SECTION 5.6 "Odor is checked by sniffing a moderate flow of air from the container being tested. USE CAUTION – Do not place face directly in front of the valve. Instead, cup the hand and bring some of the gas being vented toward the nose."

☛☛ ALL BOXED AREAS MUST BE FILLED IN ☛☛ ALL BOXED AREAS MUST BE FILLED IN

FIGURE 14-9 TEST DATA SHEET

11. Return only the used filter (17), source bottle (20), ambient bottle (21) and data sheet using the return pre-addressed mailer box/padded envelope.

12. Neatly, affix first class postage or arrange for another shipping method of your choice. More than one set of samples can be sent in one return mailer, be careful not to over stuff the box. Return samples promptly.

The source and ambient bottles are analyzed for oxygen, nitrogen, carbon monoxide, carbon dioxide, and total gaseous hydrocarbons. The source bottle only is also analyzed for particles and/or condensed hydrocarbons (oil mist). Both the source bottle and the filter must be used for a complete test. An ambient sample is helpful in determining the quality of air going into your compressor. In the event of a contamination problem, you can determine if the main source of the problem was from intake air quality or from within your compressor system.

14.1 SYSTEM RESTORATION

1. Bleed pressure from the sampling device using the bleed valve (22) shown in Figure 14-7..

2. Remove sampling device.

3. Reconnect system lines at point (11) (Figure 14.3).

WARNING: MAINTAIN 1500 PSIG MINIMUM ON THE PURIFICATION SYSTEM. RUN MACHINE TO ESTABLISH THIS PRESSURE BEFORE COMPLETING TEST AND/OR MAINTENANCE WORK.

15.0 TROUBLESHOOTING

FAULT	PROBABLE CAUSE	RECOMMENDATION
Excessive stage pressure	Faulty suction or delivery valve(s)	Service valve(s) as necessary. Note: A suction valve fault gives excess pressure in the previous stage.
	Pressure gauge not accurate	Check pressure gauge against gauge of known accuracy.
	Restriction in pipeline	Existing Installation: Check setting and function of all control valves. Clean pipeline filters and service elements as necessary. New Installation: Ensure that protective plugs and blanks have been removed from ports and that all control valves are correctly set. Pipe work must be of ample size with a minimum of bends. Joint gaskets should be checked for correct positioning and size.
Excessive second stage pressure (3 stage units)	Third stage plunger failure	Remove and examine. Replace, if necessary
Excessive third stage pressure (4 stage units)	Fourth stage plunger failure	Remove and examine. Replace, if necessary
Insufficient pressure or volume	Blocked suction filter	Remove and service.
	Faulty first stage suction valve	Remove and examine.

FAULT	PROBABLE CAUSE	RECOMMENDATION
(See also: Excessive stage pressure)	Leakage in pipe system or from machine	Locate and rectify. (e.g. drain valve open.)
	Wear	If general wear is suspected, strip the machine and examine all working parts.
	Loss of drive	Check belt drive
	Premature opening of final safety valve	Renew valve
	Intake or outlet valve not closing properly	Check and clean valves. Replace main parts as necessary.
Overheating	Duty higher than recommended maximum	Reduce duty to acceptable level.
(See also: Excessive stage pressure and insufficient pressure)	Inlet temperature higher than recommended maximum	Check that pipe work/valves do not form a closed loop, i.e. feeding hot delivered air back into machine inlet.
	Insufficient supply	Check location. Maximum ambient temperature is 45^0C (113 deg. F).
	Inlet or delivery valves not closing properly	Check and clean valves. Replace worn parts as necessary.
	Cylinder fins clogged or dirty	Clean out cylinder fins
	Intercooler and aftercooler tubes dirty	Clean tubes with a brush and compressed air
	Belt drive slipping	Adjust belt drive

FAULT	PROBABLE CAUSE	RECOMMENDATION
	Air intake filter	Service air intake filter
	Wrong rotation	Reverse motor feed wiring
Second stage overheating	Possible third stage Plunger failure	Dismantle and examine third stage plunger. Replace if necessary
Third stage overheating	Possible fourth stage plunger failure	Dismantle and examine fourth stage plunger. Replace if necessary.
Excessive noise	Oil level low.	Check oil level and replenish
	Pulley loose	Tighten pulley
	Belt drive worn	Replace belts
	Vibration in machine	Insecure mounting. Tighten mounting bolts
	Pulley out of line	Inspect and adjust the alignment of the pulley
	Worn bearings	Dismantle, examine and replace, if necessary
Extended running	Machine not large enough or leaks	Check for leaks Check belt
Excessive wear	Excessive speed and/or pressure	Check accordingly
	Dirty air and/or suction pipeline	Clean filter element

FAULT	PROBABLE CAUSE	RECOMMENDATION
	Excessive side or end thrust	Pulley out of alignment - Realign
		Belt too tight or too loose - Adjust
	Excessive moisture content in air	Check drainage system and regularly check condition of crankcase oil
	Belt wear	Belt too tight or too loose - Adjust
		Oil or grease on belt. Clean or replace V-belt
Failure to start	Seizure	If machine does not rotate freely (when unloaded) this indicates a fault of a serious nature. Investigate and check for broken and damaged components before trying to restart.
	Electrical or control fault	Locate and rectify or consult an electrician
(See: Overheating)	Air leak in pipe work	Locate and rectify
	Plunger failure	Dismantle and examine. Replace if necessary

FAULT	PROBABLE CAUSE	RECOMMENDATION
	Valve failure	Dismantle and examine. Replace components if necessary
Filter cartridge disintegrated	Excessive water carry over into cartridge	Ensure that separator and filter chamber base are drained more frequently
	Cartridge left in too long	Change cartridge
Short cartridge life	Failure to drain separators or filter base	Drain frequently
	Poor compressor cooling	Enure that cooling air has free passage through belt guard. Make sure that hot cooling air is not recirculated and that coolers are clean.
Gas Moisture content too high	System damp after installation of new cartridge	Purge system with hoses open for half hour or more.
	Cartridge at end of life	Change cartridge
	Failure to drain separators and filter base	Drain frequently
	Faulty measuring instruments	Check accuracy and function of instrument
	Gas by-passing cartridge	Check cartridge installation
Oil mist level too high	Cartridge not installed in filter chamber	Clean system and fit cartridge
	Compressor fault	Service compressor

15.1 CARTRIDGE MONITOR TROUBLE SHOOTING GUIDE

FAULT	POSSIBLE CAUSE	CORRECTIVE ACTION
Compressor will not start	Compressor AC electrical system is dead.	Check and/or repair AC electrical system.
12V	Compressor 12V electrical system is dead.	Check and/or repair electrical system.
		Check red (+) and black (-) wires for proper polarity. If rewiring is required, fuse F3 on Cartridge Monitoring System Main Board may need replacing.
		Check NO1 (blue) and C1(yellow) and/or NO2 (brown) and C2 (orange) for proper connection.
Compressor starts up but immediately shuts down.	Power Harness is wired incorrectly.	Set Power-up Delay Timer for recommended delay.
	Power-up Delay Time set for zero daily.	Check NO1 (blue) and C1(yellow) and/or NO2 (brown) and C2 (orange) for proper connection.
	Power-up Delay Timer set for recommended delay.	Check and/or repair AC and 12V electrical systems.
		Replace Cartridge Monitoring System. Factory service on old unit is required.
		Replace Main Harness.

PROBLEM	PROBABLE CAUSE	CORRECTIVE ACTION
Compressor starts up and runs during the power-up delay interval, but shuts down at the start of normal operation.	Expired indicator is lit.	Replace old cartridge with fresh new cartridge.
		Replace Cartridge Sensor Module. Recalibrate Main Unit for new sensor module.
		Replace Cap Harness.
		Replace Cartridge Monitoring System. Factory service on old unit is required.
	Cart. Not Inst. indicator is lit.	Install fresh new cartridge.
		Check and/or clean dirt or moisture on infrared reflective object sensor ROS1 on Cartridge Sensor Module.
		Replace Cap Harness.
		Readjust (R47). If readjustment cannot cure problem, replace Cartridge Sensor Module.
		Replace Cartridge Monitoring System. Factory Service on old unit is required.
		Replace Main Harness.
	OK or Warning indicators are lit or neither are lit.	Check and/or repair AC and 12V electrical systems.
		Replace Cartridge Monitoring System. Factory service on old unit is required.

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Compressor shuts down during normal operation.	Expired indicator is lit.	Replace old cartridge with fresh new cartridge.
		Replace Cartridge Sensor Module. Main Unit for new sensor module.
		Replace Cap Harness.
		Replace Cartridge Monitoring System. Factory Service on old unit is required.
		Replace Main Harness.
	Cart. Not. Instr. Indicator is lit.	Check and/or clean dirt or moisture on infrared reflective object sensor ROS1 on Cartridge Sensor Module.
		Replace Cap Harness.
		Readjust (R47). If readjustment cannot cure problem, replace Cartridge Sensor Module.
		Replace Cartridge Monitoring System. Factory Service on old unit is required.
		Replace Main Harness.
	OK or Warning indicators are lit, or neither are lit.	Check and/or repair AC and 12V electrical systems.
		Replace Cartridge Monitoring System. Factory service on old unit is required.

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Cart. Not Inst. indicator blinks during power-up delay interval.	Condensate on the reflective object sensor ROS1.	None required. This is normal, provided that all condensate can be purged during delay interval. The indicator will stop blinking when the condensate is purged.
	No cartridge installed.	Install fresh cartridge.
	Cartridge Detector Override engaged.	Turn off Cartridge Detector Override dipswitch.
Cart. Not Inst. indicator blinks during normal operation.	Cartridge Detector Override engaged.	Turn off Cartridge Detector Override dipswitch.

16.0 OPTIONAL EQUIPMENT

16.1 CO MONITORING SYSTEM (OPTIONAL)

The CO monitor (Figure 16-1) continuously monitors and displays carbon monoxide levels in parts per million (ppm) in increments of 1 ppm. The CO monitor is used to detect the presence of carbon monoxide in compressed breathing air. The range of the CO monitor is 0 to 50 ppm, however, the alarm is set to activate at 10 ppm, resulting in compressor shut down when exceeded. For CGA 7.1 Grade E air the CO limit is 10 ppm.

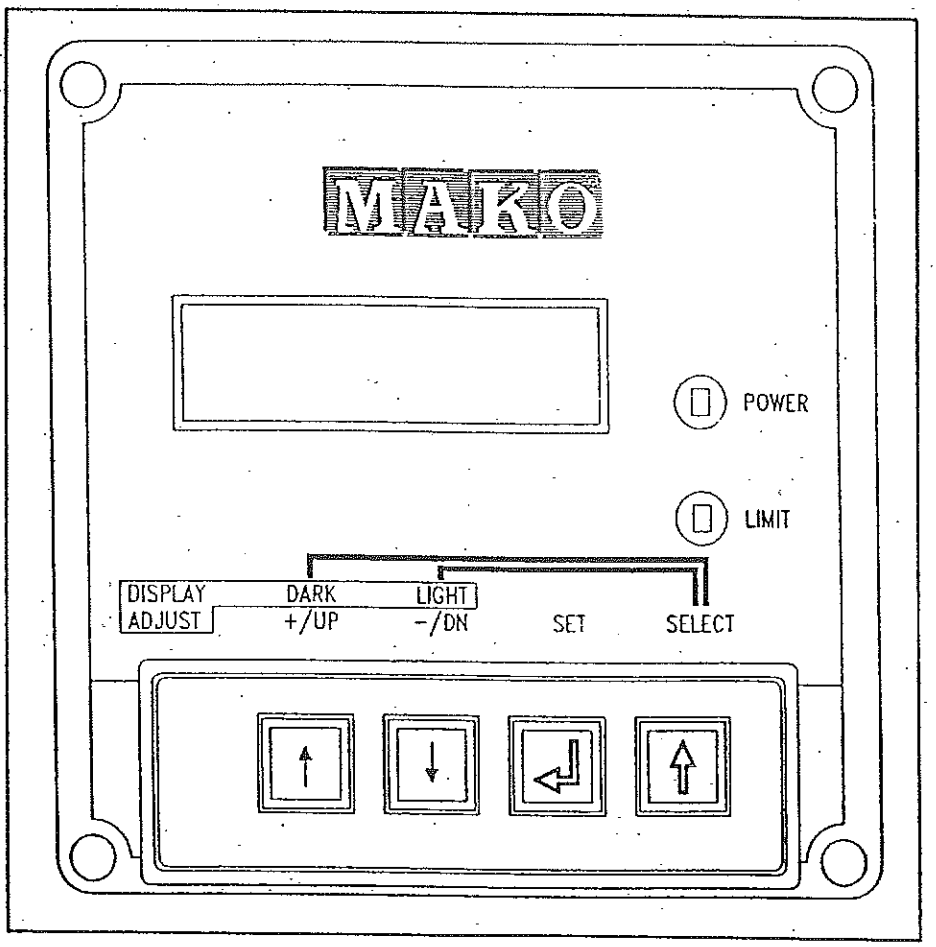


FIGURE 16-1 CO MONITOR

Continuous monitoring of the air stream from the compressor is achieved by diverting a small portion (approximately 200 cc/min) of the air through the CO monitor sensing cell. Since the CO sensing cell is a low pressure device it is necessary to regulate the pressure of this small stream from

system discharge pressure down to 5 PSIG. This pressure reduction on the sample stream is accomplished by two regulators. The first regulator (Item 1 in Figure 16-2) is connected to the discharge line from the purification system and lowers the pressure to approximately 40 PSIG. The sample air is conveyed via a small line to the selector valve (Item 2, Figure 16-2) located on the compressor control panel. The selector valve is used to choose which gas is delivered to the CO sensor cell. When the selector valve is in the sample position, air from the compressor is passed through the CO monitor. When the selector valve is on 0 ppm pure air from a canister is delivered to the sensor. When the selector valve is on 20 ppm, the sensor is exposed to a gas stream laden with 20 ppm carbon monoxide. When the selector valve is in the downward position, all flow to the CO monitor is shut off. Figure 16-2 is a schematic showing the main components in the CO monitoring system and the flow paths.

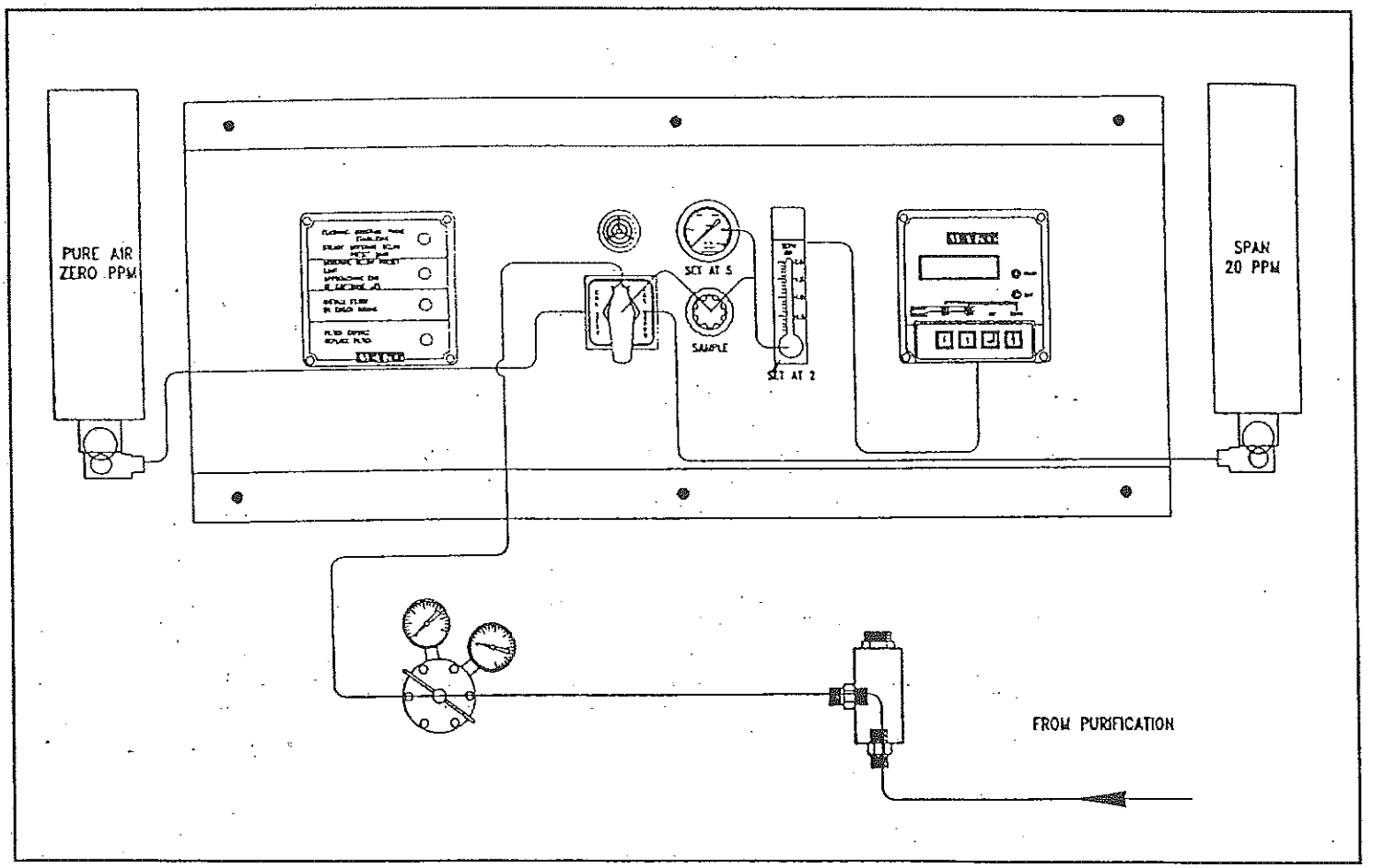


FIGURE 16-2 CO MONITOR SYSTEM

The CO monitor has the following components :

1) An electronic display unit.

2) An electronic sensor unit.

3) A canister of calibration gas with a shutoff valve containing 20 PPM CO.

4) A canister of pure air with a shutoff valve to establish a true zero point in the calibration process.

5) A 50 to 500 cc/min. flowmeter with a integral adjustment valve to set instrument throughput.

6) A regulator that reduces the test air stream to 5 PSIG for induction into the monitor.

7) A 1/8" valve plumbed in a manner that permits the selection of either span gas for calibration, the air stream from the compressor, and an OFF position. This valve should be turned to the "OFF" position when compressor is not in use. This should prevent premature deterioration of sensor cell.

Figure 16-2 shows the location of the CO monitor on the control panel. The electronic sensor is mounted behind the compressor panel. The calibration gasses and associated valving are mounted inside the compressor compartment (Figure 16-2).

During CO monitor calibration, access to the calibration gas shut off valves is easily achieved via a door on the compressor compartment.

16.1.1 CO MONITOR DISPLAY

16.1.1.1 DESCRIPTION

The front of the CO monitor panel has a two line LCD (liquid crystal display) which can display text messages, numbers, and special symbols. The LCD has a green LED (light emitting diode) backlight that facilitates viewing at low light levels. To the right of the LCD are two LED indicators. One of the indicators is green and the other is red.

The display contrast can be adjusted for improved viewing by pressing and holding the ⇑ key down while repeatedly pressing and releasing the ↑ (to darken) and ↓ (to lighten) keys. After the display contrast is satisfactory, release the ⇑ key.

16.1.1.2 DISPLAY MODES

The CO Monitor display has four modes. Cycle between the four display modes by pressing ⇑. Each time the key is pressed, the next mode in the sequence is displayed (1→2→3→4→1).

Display mode 1 reads:

CO 0 ppm
Limit @ 10

The "CO" level may not be 0, and the "Limit @" may not be 10. This is OK. The "Limit @" displays the CO concentration level at which the CO Monitor will trip.

Display mode 2 reads :

Next Calibration
In XX days

Where XX is in the range of 0 to 90 days. This value cannot be changed directly; it is calculated by the CO Monitor based on the date of the most recent calibration.

Display mode 3 reads:

Calibration
Period XX days

Where XX is in the range of 1 to 90 days. To change this value, see section 16.1.2.2.

Display mode 4 reads:

CO Temp 26°C
Interior 30°c

The temperatures may not actually match the ones in this example. The temperature unit may be in °F instead of °C. This is OK. The temperature unit may be changed by pressing ↵. The display should now read :

Set temperature
unit °X

Where X is either "C" or "F". This value can be changed by pressing the ↑ or ↓ keys. When the desired temperature unit appears on the display, press ↵ to lock in the new value. Or, to cancel the new value and use the old value, press ⇑. The display should now return to mode 4.

16.1.1.3 DISPLAY MESSAGES AND INDICATORS

During normal operating conditions, the CO Monitor will not display any messages other than the four display modes (see Section 16.1.1.1), and the green indicator will be lit (not flashing). If abnormal operating conditions occur, the CO Monitor will display a message either by itself or with display mode 1, and either the green or red indicator will flash. The various messages and their meanings are as follows:

CALIBRATE NOW
Hit ⇑ to restart

When it is time to calibrate the CO Monitor, this message will appear and the red indicator will flash as the compressor attempts to cycle on. The compressor is prevented from running until the operator presses ⇑. If the operator does not perform the calibration procedure during the ensuing compressor cycle, the compressor will again be prevented from running when it next attempts to cycle on. This acts as a reminder to the operator that calibration must be performed as soon as possible. After the operator presses ⇑ to restart the compressor, and if the display is in mode 1, the display reads:

CO 0 ppm
CALIBRATE NOW

The "CALIBRATE NOW" message and the red indicator both flash. This is another reminder to the operator that calibration must be performed at the earliest opportunity.

CHECK WIRING
Hit ⇑ to restart

This message will appear and the red indicator will flash as the compressor attempts to cycle on. The compressor is prevented from running until the operator presses ⇑. If the operator does not rectify the problem, the compressor will again be prevented from running when it next attempts to cycle on. This acts as a reminder to the operator that service must be performed as soon as possible. After the operator presses ⇑ to restart the compressor, and if the display is in mode 1, the display reads:

CHECK WIRING

The "CHECK WIRING" message and the red indicator both flash. Possible causes of this message, in order of decreasing likelihood, are as follows:

1) The CO Monitor Wiring Harness is disconnected from the Sensor Unit.

2) The CO Monitor Wiring Harness is faulty.

3) The Electronic Sensor Unit is faulty.

CAUTION: BE SURE TO TURN OFF POWER TO THE CO MONITOR BEFORE PERFORMING SERVICE.

REPLACE SENSOR
Hit ⇑ to restart

This message will appear and the red indicator will flash as the compressor attempts to cycle on. The compressor is prevented from running until the operator presses ⇑. If the operator does not rectify the problem, the compressor will again be prevented from running when it next attempts to cycle on. This acts as a reminder to the operator that service must be performed as soon as possible. After the operator presses ⇑ to restart the compressor, and if the display is in mode 1, the display reads :

CO 0 ppm
REPLACE SENSOR

The "REPLACE SENSOR" message and the red indicator both flash. This is another reminder to the operator that service must be performed at the earliest opportunity.

When the Electronic Sensor Unit temperature is below -5°C and the display is in mode 1, the display reads:

CO 0 ppm
SENSOR TOO COLD

The "SENSOR TOO COLD" message and the green indicator both flash. The CO Monitor may still be operated in this condition, but its accuracy is reduced.

CO 0 ppm
SENSOR TOO HOT

The "SENSOR TOO HOT" message and the green indicator both flash. The CO Monitor may still be operated in this condition, but its accuracy is reduced, and its lifetime may be shortened.

EXCESSIVE
CARBON MONOXIDE

This message will appear and the red indicator will flash when the CO Monitor has detected a CO concentration equal to or greater than the limit setting. To clear this condition, turn off the power to the CO Monitor by turning the compressor power switch off. Take corrective action to eliminate the source of the CO. When power is restored to the CO Monitor, the display reads:

CO 0 ppm PURGING
Limit @ 10

The "CO" level may not be 0. This is OK. "PURGING" will flash for two minutes, during which time air flow through the system will clean out the residual CO.

16.1.3 CO MONITOR MAINTENANCE

The CO Monitor does not require routine maintenance except periodic calibration checks to verify that the unit is operating properly. The recommended period between calibration checks is one month; however, government regulations may require more frequent intervals in some applications. The CO Monitor has a built-in timer that knows when the last calibration was performed, and when the next calibration is due. There is no need to mark dates on a calendar; the CO Monitor will inform the operator when calibration is needed. Section 9.1.2 provides a step by step calibration procedure. The paragraphs below address corrective maintenance issues.

16.1.3.1 FILTER SCREEN CLEANING

If the electronic display unit reads "REPLACE SENSOR" the filter screen may have become clogged. The filter screen is housed in the cylindrical aluminum protrusion on the electronic sensor unit (see Figure 16-3).

16.1.2 CO MONITOR CALIBRATION

16.1.2.1 CALIBRATION PROCEDURE

At any time during the calibration procedure, the calibration may be aborted by pressing any key other than ⇑. The previous calibration will be retained. DO NOT attempt to a abort a calibration by turning power off and then back on. This will allow the test gas to be purged from the air lines.

1) Make sure power is applied to the monitor and it is in a normal condition. The display should read :

CO 0 ppm
Limit @ 10

The "CO" level may not be at 0 depending on if the unit has been exposed to carbon monoxide or it is out of calibration. This is OK. The "Limit" should be at 10 to meet CGA 7.1 Grade E air requirements. This is the setpoint at which the compressor will shutdown due to excessive CO.

2) Press and hold in the ⇑ key. With the ⇑ key depressed, press and release the ↵ key. Now release the ⇑ key. This activates the calibration mode. The display should now read:

When last stage
over 1000, hit ⇑

If the display does not show the message above, the calibration mode is not activated. Return to the main display as shown in step one and continue with step two until entry into calibration mode is successful.

Contact your local distributor or the factory if calibration mode cannot be activated.

3) Check the final stage air pressure gauge. If it reads at least 1000 PSIG, press ⇑. If not, operate the compressor until it does, then press ⇑. The display should read:

CompAir

Turn selector to
Sample ⇑

4) Turn the gas selector valve to the SAMPLE position. Then press ⇑. The display should now read:

Adjust regulator
to 5 PSIG ⇑

5) Adjust the CO Monitor pressure regulator mounted on the panel with the yellow adjustment knob as necessary to achieve 5 PSIG. If the knob does not turn pull firmly on the yellow knob to disengage the adjustment lock. Then press ⇑. The display should now read:

Adjust flow to
200 cc/min ⇑

6) Adjust the CO Monitor flow meter, mounted on the panel, using the black adjustment know located towards the bottom of the flow meter as necessary to achieve 200 cc/min. Then press ⇑. The display should now read:

Push EMERGENCY
STOP switch ⇑

7) Push the EMERGENCY STOP button, even if compressor is not running. However, ensure final stage pressure is at least 1000 psig. Then press ⇑. DO NOT turn off the compressor power switch, as this would remove power from the CO Monitor and disrupt the calibration procedure. The display should now read:

Turn selector to
Cal Zero ⇑

8) Turn the gas selector valve to the CAL ZERO position. Then press ⇑. The display should now read:

Open valve on
zero gas tank ⇑

9) Open the shutoff valve on the zero calibration gas canister. The location of the canister varies depending on the equipment. To locate the canister trace the 1/8Â tubing from the panel mounted gas selector valve to the canister. The tubing going to the canister should have a green label marked ‰PURE AIR.Â Ensure that the canister is also labelled ‰PURE AIRÂ or ‰ZERO AIR.Â Then press ⇑. The display should now read :

Adjust regulator
if no flow ⇑

10) Adjust the CO Monitor pressure regulator as necessary to obtain 5 psi and the flow regulator to 200 cc/min. Then press ⇑. The display should now read:

Setting zero

Please wait XX

where XX counts down the seconds remaining for this step. Ensure the air pressure remains plus or minus 1 psig of set point and the air flow level remains plus or minus 50 cc/min of set point. These limits must be maintained during this 60-second countdown. Failure to maintain set limits could produce an erroneous calibration and flash "REPLACE SENSOR" or "EXCESSIVE CARBON MONOXIDE".

Note: If pressure and/or flow cannot be maintained the gas canister could be empty and needs replaced or a leak in the tubing or fittings is present. If a leakage is suspect, identify location of leak and immediately close the shutoff valve on the canister to preserve the gas.

Watch the display and wait for it to count down to 00 and the next display message:

Close valve on
Zero gas tank ⇑

11) Close the shutoff valve on the zero calibration gas canister. Then press ⇑. The display should now read:

Turn Selector to
Cal 20 ppm ⇑

12) Turn the gas selector valve to CAL 20 PPM position. Then press ⇑. The display should now read:

Open valve on
20 ppm gas tank ⇑

13) Open the shutoff valve on the 20 ppm calibration gas canister. The location of the canister varies depending on the equipment. To locate the canister trace the 1/8Â tubing from the panel mounted gas selector valve to the canister. The tubing going to the canister should have a yellow label marked ‰20 PPM CO SPAN.Â Ensure that the canister is also labelled ‰20 PPM CARBON MONOXIDE.Â Then press ⇑. The display should now read:

Adjust regulator
if no flow ⇑

14) Adjust the CO Monitor pressure regulator as necessary to obtain 5 psi and the flow regulator to 200 cc/min. Then press ⇑. The display should now read:

Setting span
Please wait XX

where XX counts down the seconds remaining for this step. Ensure the air pressure remains plus or minus 1 psig of set point and the air flow level remains plus or minus 50 cc/min of set point. These limits must be maintained during this 60-second countdown. Failure to maintain set limits could produce an erroneous calibration and flash "REPLACE SENSOR" or "EXCESSIVE CARBON MONOXIDE".

Note: If pressure and/or flow cannot be maintained the gas canister could be empty and needs replaced or a leak in the tubing or fittings is present. If a leakage is suspect, identify location of leak and immediately close the shutoff valve on the canister to preserve the gas.

Watch the display and wait for it to count down to 00 and the next display message:

Close valve
20 ppm gas tank ⇑

15) Close the shutoff valve on the 20 ppm calibration gas canister. Then press ⇑. The display should now read:

Turn selector to
Sample ⇑

16) Turn the gas selector valve to the SAMPLE position. Then press ⇑. The display should now read:

Pull EMERGENCY
STOP switch ⇑

CAUTION: Ensure all personnel are clear of compressor. Once emergency stop button is pulled compressor may start.

17) Pull the emergency stop button. Then press ⇑. The compressor may or may not start, depending on the final stage air pressure, which should be at least 1000 psi to proceed with calibration. It is OK if compressor starts. The display should now read:

When last stage
over 1000, hit ⇑

Note: Last stage is the same as final stage.

18) Let the compressor operate until this condition is met. Then press ⇑. The display should now read:

Adjust regulator
to 5 PSIG ⇑

19) If the gas pressure is low, adjust the CO Monitor pressure as necessary to obtain 5 psi and the flow regulator to 200 cc/min. Then press ⇑. The display should now read:

Calibration
complete, hit ⇑

NOTE: Although the display shows ‰CALIBRATION COMPLETEÂ the calibration gas must be purged from the system. Failure to complete the purging step may cause sensor failure.

CompAir

IMPORTANT: IF A MISTAKE WAS MADE DURING THIS CALIBRATION PROCEDURE, IT IS NECESSARY TO ABORT THIS CALIBRATION. THIS MAY BE DONE BY ALLOWING SAMPLE AIR TO FLOW FOR AT LEAST ONE MINUTE, THEN PRESSING ANY OTHER KEY OTHER THAN ⇑. IF AN IMPROPER CALIBRATION IS NOT ABORTED, THE CO MONITOR MAY JUDGE THAT THE SENSOR NEEDS REPLACEMENT, AND FLASH "REPLACE SENSOR" ON THE DISPLAY. THIS STEP IS THE LAST CHANCE TO ABORT THIS CALIBRATION.

20) If no mistakes were made during this calibration procedure, press ⇑. The display should now read:

CO 0 ppm PURGING
Limit @ 10

The "CO" level may not be 0. This is OK. "PURGING" will flash for two minutes, during which time air flow through the system will clean out the residual 20 ppm calibration gas. The purging cycle is complete once ‰PURGINGÂ stops flashing and disappears and a rotating line appears. Once the purging cycle is complete the compressor may be shut down, if desired, and the selector switch turned to the OFF position by rotating it counter clockwise, which avoids passage through the 20ppm calibration position. This will prevent any residual 20ppm calibration gas in the lines from being re-introduced to the sensor. The next calibration day counter will automatically set itself to the next calibration session, which is the number of days from now specified in the Calibration Period setting. This concludes the CO Monitor calibration procedure.

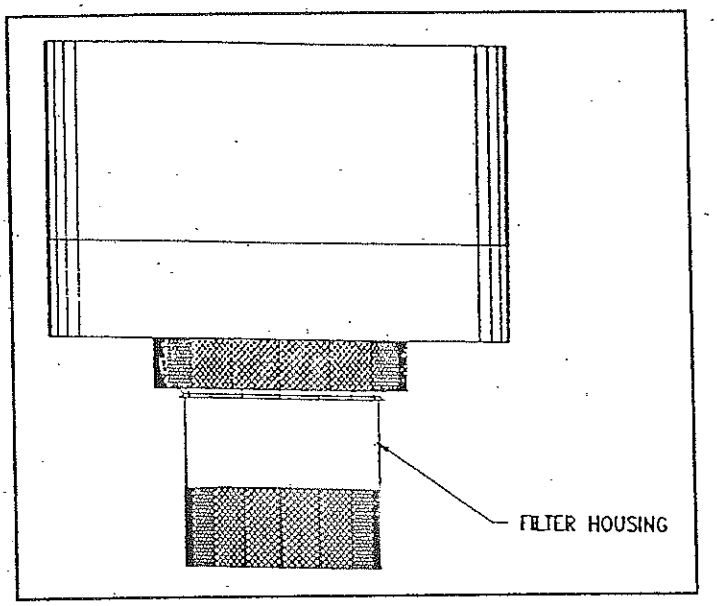


FIGURE 16-3 CO MONITOR FILTER HOUSING

This filter housing has two parts, an adaptor that mates with the sensor cell, and a threaded plug that holds the filter element in place. Figure 16-4 shows an exploded view of the several parts required to convey the sample stream to the sensor cell, hold the filter screen in place, and permit filter screen removal for cleaning.

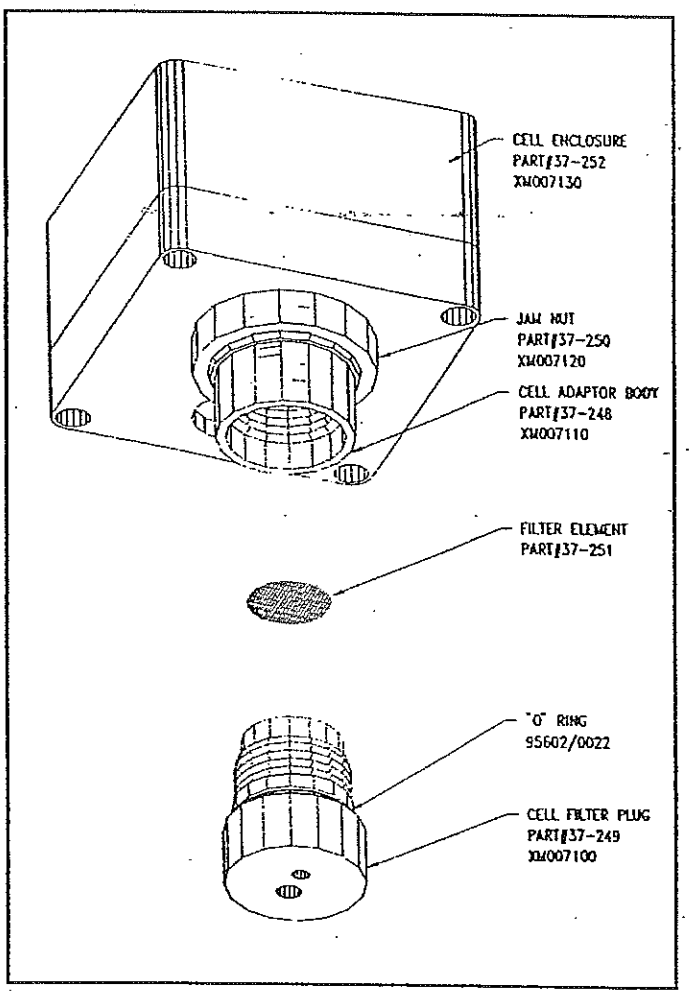


FIGURE 16-4 CO MONITOR FILTER HOUSING PARTS

Removing and cleaning the filter screen is accomplished as follows:

1) Remove the sample tubing from the hose barb, item (8) Figure 16-4.

2) Unscrew item (6), Figure 16-4. The filter element will fall out of the housing.

CAUTION: DO NOT LOOSEN THE KNURLED NUT.

3) Wash the filter screen in a soap and water solution.

4) Thoroughly rinse and dry the filter screen.

CAUTION: NEVER USE A SOLVENT OF ANY TYPE TO CLEAN THE FILTER SCREEN. IF SOAP AND WATER WILL NOT CLEAN THE SCREEN, REPLACE IT WITH A NEW ONE.

5) Reassemble the filter housing and proceed to calibrate the CO monitor.

16.1.3.2 SENSOR REPLACEMENT

If after cleaning or replacement of the filter and subsequent recalibration; the electronic display unit still reads "REPLACE SENSOR", the CO sensor has probably reached the end of its useful life (approximately 24 months).

1) Turn off the power to the CO Monitor with compressor switch.

2) Disconnect the sensor cable, from the electronic sensor unit.

3) Remove sample tubing from the hose barb.

4) Remove the two screws that attach the electronic sensor unit to the mounting bracket.

5) Install a new electronic sensor unit by reassembly. Turn on power to the CO monitor with the compressor power switch.

6) Calibrate the CO monitor.

16.1.3.3 ALARM AND SHUTDOWN ADJUSTMENT

The alarm and compressor shutdown setting is factory preset to 10 ppm CO. If there is a need to set new limits the following procedure should be followed:

If the display is not already in mode 1, press ⇑ to cycle through the display modes until it is. Display mode 1 reads:

CO 0 ppm
Limit @ 10

The "CO" level may not be 0, and the "Limit @" may not be 10. This is OK. The "Limit @" displays the CO concentration level at which the CO Monitor will trip. This may be changed by pressing ↵. The display should now read:

Set CO Limit
XX ppm

where XX is in the range of 1 to 50. This value may be changed by pressing the ↑ or ↓ keys. Pressing and holding these keys for more than 2 seconds will cause rapid counting, up or down. When the desired trip level appears on the display, press ↵ to lock in the new value. Or, to cancel the new value and use the old value, press ⇑. In either case, the display should return to mode 1.

16.1.4 CO MONITOR POWER SUPPLY

The CO Monitor is powered from the 12 volt DC control system power supply. The power wires enter the electronic display unit via a 16-pin connector and mating wiring harness. The wiring harness colors are as follows:

RED	+12 VDC
BLACK	GROUND
BLUE	SHUT DOWN CIRCUIT
YELLOW	COMMON
WHITE	ALARM
BROWN	HOUR METER CONNECTION

16.1.5 ALARM AND COMPRESSOR SHUTDOWN

The audible alarm horn sounding high CO is located on the control panel. When the CO concentration reaches 10 ppm, the alarm circuit closes, powers the external horn, and the machine shuts down.

16.1.6 CO MONITOR CALIBRATION GASES

The compressor system is delivered with fresh cylinders of calibration gas. The quantity of the gas in each cylinder should be enough for 13 to 15 calibration cycles. When these gases are expended, replacement supplies are ordered using the following information:

ITEM	P/N	DESCRIPTION
1	M4884-1	20 ppm CO (1 cylinder) Replacement cylinder
2	006-7800	Zero grade (pure) air (1 cylinder) Replacement cylinder

16.2 CARTRIDGE MONITORING SYSTEM (CMS)

The Mako Cartridge Monitoring System (Part No. M9900-2) is an electronic device that is designed to:

a) Continuously measure the relative humidity of the high pressure air leaving the purification system of the breathing air compressor where air dryness is an important parameter that must be strictly controlled.

b) Notify the operator that the drying agent is nearly saturated and that compressor shutdown is imminent.

c) Shut down the compressor unit until the drying agent has been replaced when the moisture content of the product air stream has reached a predetermined limit.

d) Indicate the absence of a purification cartridge and prevent compressor operation until a cartridge has been installed.

Physically the cartridge monitoring system can be separated into four components as follows:

(1) A small circuit board with a sensing element that is located in the air stream (see Figure 16-5).

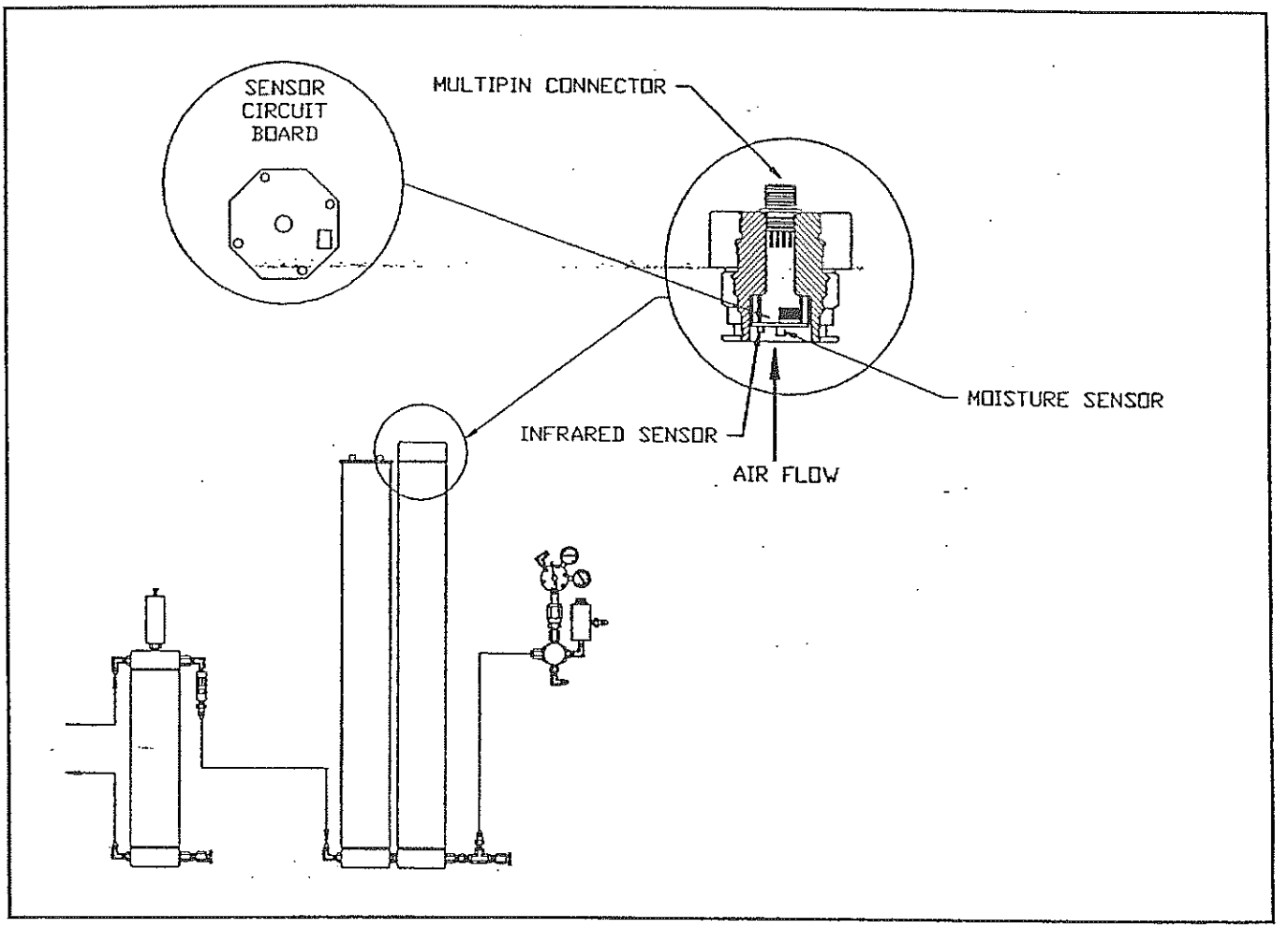


FIGURE 16-5 CMS MOISTURE SENSOR LOCATION

The circuit board is screw mounted in the top plug cavity on four posts. The moisture sensor projects downward from the circuit board into the air stream issuing from the final purification cartridge.

(2) A multipin connector that conveys the sensor power and electronic signals through the high pressure boundary of the purification system (see Figure 16-5).

(3) A multiconductor cable.

(4) An electronics box containing a circuit board that incorporates all of the system's electronic functions. The electronics box is placed on the compressor control panel or a wall mount panel.

Four light emitting diodes (LED's) are provided in the CMS electronics box to display status information (see Figure 16-8).

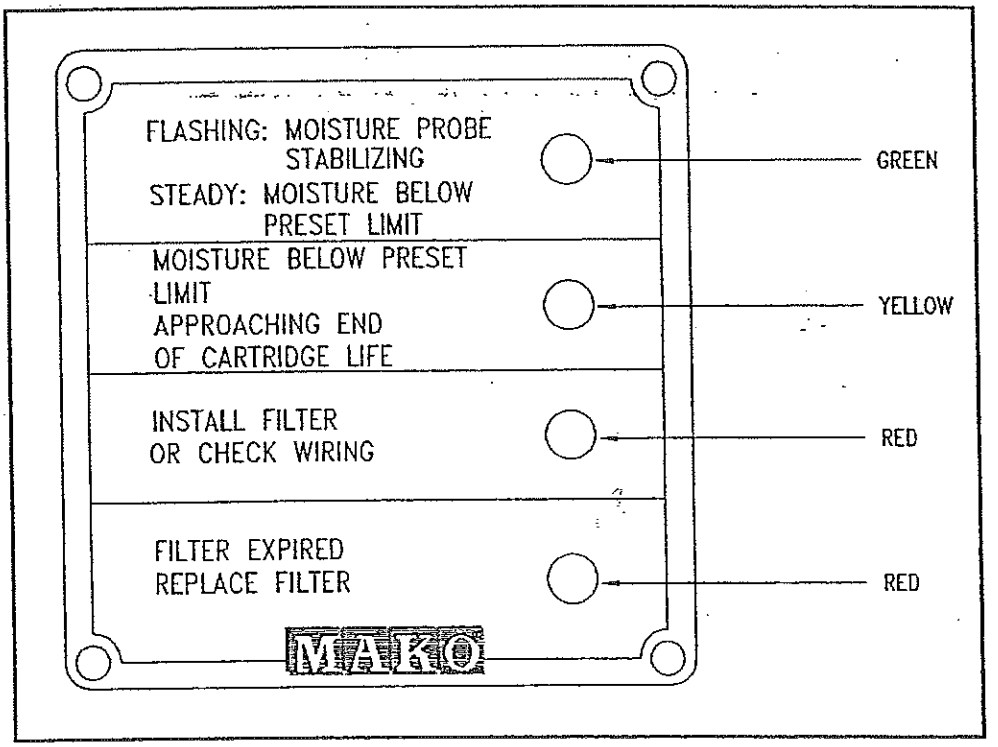


FIGURE 16-6 CMS STATUS LIGHTS

Green Light - A timing device within the control unit is activated upon start-up to allow the moisture sensor to stabilize. This timed cycle can be set between 1 and 31 minutes. The factory setting for the stabilization time period is 7 minutes. During the stabilization cycle, the cartridge "OK" green light will flash. Once the stabilization period is completed, the applicable status light for the moisture level will illuminate. If the moisture content of the sensed air stream is within preset limits, the flashing green light will quit flashing and assume a steady state illuminated condition.

Yellow Light - This light will illuminate when the moisture level in the air stream approaches the pre-set limit. End of cartridge life warning (yellow light) will be actuated at 90 percent of the conditioned sensor output

voltage required to shut the machine down. The actual clock time that will elapse between the actuation of the yellow light and machine shut down will depend upon moisture limits and flow. The target warning period is one hour. During this period the moisture content of the air is within acceptable levels but the operator should schedule timely purification cartridge maintenance to preclude unexpected air supply interruption.

Red Light (3rd Light From Top) - If a purification cartridge is <u>not</u> installed in the purification chamber, the infrared cartridge detection sensor (see Figure 16-5) will <u>not</u> send a return signal to the control unit. This will result in the illumination of the "install filter" red warning light and the compressor will not start.

Red Light (Bottom) - This light will illuminate when the moisture level in the air stream exceeds the pre-set limit. The compressor unit shuts down under this condition. At this point the operator must replace the filter cartridges.

16.1.1 CMS STABILIZATION PERIOD ADJUSTMENT

The stabilization period adjustment component is actually a bank of switches that have two positions, namely, On or Off. Figure 16-6 is an enlarged view of the switch face.

<u>NOTE:</u> **THE DIP SWITCH IS SHOWN AS IT APPEARS WHENSTANDING IN FRONT OF THE COMPRESSOR.**

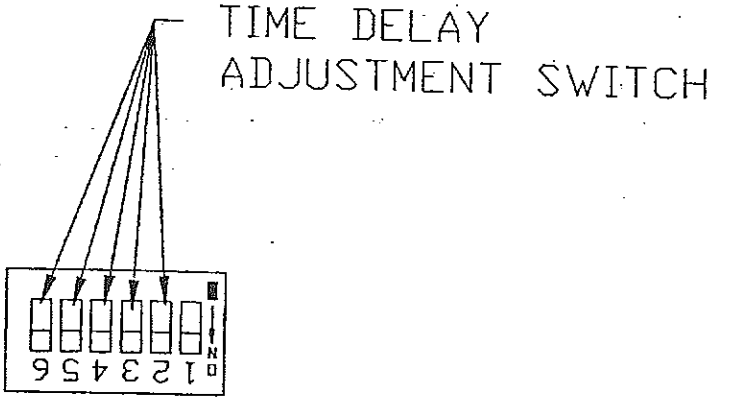


FIGURE 16-6 STABILIATION PERIOD ADJUSTMENT SWITCHES

16.1.2 CARTRIDGE MONITORING SYSTEM MAINTENANCE

The Cartridge Monitoring System requires little or no maintenance. If a problem occurs, please refer to the troubleshooting guide.

16.3 SHUTDOWN AUDIBLE ALARM OPTION

There are two shutdown audible alarm options. One option provides an audible indication when the following malfunctions occur:

* Low oil pressure
* High compressor discharge air temperature

If a maintenance time is included on the machine it will be wired to trigger the audible alarm also.

The other option provides an audible indication when the compressor is shutdown by:

* High moisture
* High carbon monoxide - if the option is implemented

The only externally noticeable evidence that these options have been implemented is the alarm horn located on the compressor panel. The alarm is silenced by shutting machine power off.

16.4 MAINTENANCE TIMER OPTION (see Figure 16-7)

The purpose of a maintenance time is to automatically shut the compressor down when preset time limits are reached. These limits are coordinated with maintenance functions such as purification cartridge replacement to ensure the timeliness of required service, hence, improving machine reliability and longevity. The maintenance timer is installed in the compressor panel when the option is ordered.

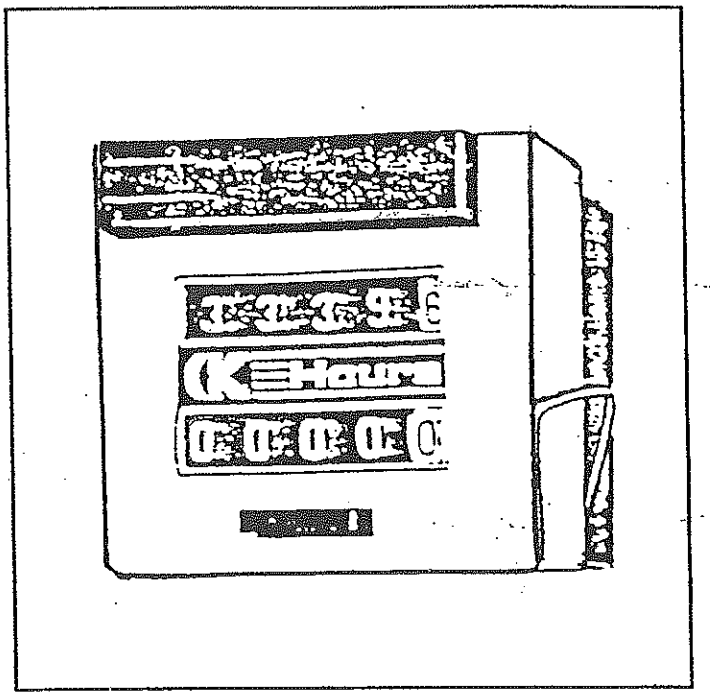


FIGURE 16-7 MAINTENANCE TIMER

16.5 MOTOR OVERLOAD LIGHT OPTION

When this option is implemented, an additional status light is added to the compressor control panel. This light illuminates when the compressor has been shut down because too much current was demanded by the motor and the overload protection mechanism in the motor starter opened. the electrical schematic shows how the light is wired. A relay (CR-3) must be added to implement this option.

17.0 COMPRESSOR PERFORMANCE SPECIFICATIONS

TABLE 17-1 BELT DRIVE, HIGH PRESSURE AIRCOOLED COMPRESSOR

UNIT DESIGNATION - A BELT DRIVEN, HIGH PRESSURE AIRCOOLED COMPRESSOR.	
TECHNICAL DATA	
5404, 5404H, 54044	THREE STAGE - SINGLE ACTING - "W" CONFIGURATION
5405, 5405E, 54054	THREE STAGE - SINGLE ACTING - "W" CONFIGURATION
5406, 5406E, 5406EH	FOUR STAGE - SINGLE ACTING - "V" CONFIGURATION
5407, 5407H	FOUR STAGE - SINGLE ACTING - "V" CONFIGURATION
5408	FOUR STAGE - SINGLE ACTING - V" CONFIGURATION
5409, 5409H, 5409I, 540921A, 54092BA	FOUR STAGE - SINGLE ACTING - "V" CONFIGURATION
COOLING	FAN ACTIVATED
DIRECTION OF ROTATION AS VIEWED FROM DRIVE END	COUNTER CLOCKWISE
TYPE OF VALVES	MULTI-PORTED REED VALVE & FLAT PLATE
INTAKE SILENCER/AIR FILTER	DRY
PERMISSIBLE INCLINATION OF COMPRESSOR FRONT TO REAR SIDE	10 DEGREES
PERMISSIBLE INCLINATION OF COMPRESSOR LEFT OR RIGHT SIDE	20 DEGREES
AMBIENT AND AIR INLET TEMPERATURE	MINIMUM 14 °F -10 °C MAXIMUM 114 °F 45 °C
MAXIMUM ACCEPTABLE VIBRATION LEVEL IN ANY DIRECTION ON THE VALVES	40 MM/S
LUBRICANTS	
MAKO SYNTHETIC OILS	SEE LUBRICATING OILS CHART
ASSEMBLY GREASE	SILICONE

TABLE 17-2 STAGE PRESSURES PSIG

MACHINE TYPE	DELIVERY	1ST STAGE	2ND STAGE	3RD STAGE
5404, 5404H, 54044	1000	48 TO 53	300 TO 360	
	2000	53 TO 58	410 TO 460	
	3000	54 TO 61	470 TO 530	
	4000	58 TO 64	540 TO 600	
	5000	50 TO 67	630 TO 700	
	6000	103 TO 119	945 TO 1050	(5404H ONLY)
5405, 54054	1000	74 TO 82	430 TO 510	
	2000	79 TO 87	500 TO 580	
	3000	83 TO 92	570 TO 650	
	4000	85 TO 94	640 TO 720	
	5000	88 TO 97	710 TO 790	
5405E	1000	73 TO 81	480 TO 530	
	2000	76 TO 84	550 TO 605	
	3000	79 TO 87	620 TO 680	
	4000	82 TO 90	680 TO 750	
	5000	86 TO 95	780 TO 860	
5406	1000	36 TO 40	155 TO 180	550 TO 650
	2000	37 TO 41	170 TO 194	701 TO 801
	3000	38 TO 42	190 TO 215	819 TO 920
	4000	39 TO 44	205 TO 231	909 TO 1009
	5000	44 TO 46	215 TO 239	999 TO 1110
5406E	1000	41 TO 44	189 TO 209	640 TO 735
	2000	41 TO 44	193 TO 215	724 TO 824
	3000	41 TO 44	199 TO 219	817 TO 917
	4000	42 TO 46	205 TO 226	912 TO 1007
	5000	42 TO 46	213 TO 234	986 TO 1086
5406EH	1000	41 TO 44	189 TO 209	640 TO 735
	2000	41 TO 44	193 TO 215	724 TO 824
	3000	41 TO 44	199 TO 219	817 TO 917
	4000	42 TO 46	205 TO 226	912 TO 1007
	5000	42 TO 46	213 TO 234	986 TO 1086
	6000	42 TO 46	220 TO 250	1090 TO 1190
5407	1000	57 TO 62	239 TO 273	743 TO 854
	2000	57 TO 62	247 TO 276	857 TO 975
	3000	58 TO 64	252 TO 284	962 TO 1085
	4000	59 TO 65	260 TO 290	1060 TO 1185
	5000	59 TO 67	265 TO 296	1150 TO 1271
5407H	1000	57 TO 62	239 TO 273	743 TO 854
	2000	57 TO 62	247 TO 276	857 TO 975
	3000	58 TO 64	252 TO 284	962 TO 1085
	4000	59 TO 65	260 TO 290	1060 TO 1185
	5000	59 TO 67	265 TO 296	1150 TO 1271
	6000	59 TO 67	270 TO 300	1210 TO 1330

STAGE PRESSURES PSIG (CON'T)

MACHINE TYPE	DELIVERY	1ST STAGE	2ND STAGE	3RD STAGE
5408	1000	25 TO 29	160 TO 180	600 TO 690
	2000	26 TO 30	165 TO 185	700 TO 790
	3000	26 TO 30	170 TO 190	790 TO 890
	4000	26 TO 30	175 TO 195	840 TO 950
	5000	27 TO 31	185 TO 210	885 TO 995
5409	1000	35 TO 39	205 TO 230	72O TO 820
	2000	36 TO 40	215 TO 240	800 TO 880
	3000	36 TO 40	220 TO 245	870 TO 970
	4000	36 TO 40	225 TO 250	935 TO 1040
	5000	36 TO 40	220 TO 250	1000 TO 1120
5409H 54092BA	1000	39 TO 44	230 TO 250	770 TO 850
	2000	39 TO 44	235 TO 260	900 TO 1000
	3000	40 TO 45	250 TO 264	995 TO 1100
	4000	40 TO 45	250 TO 270	1100 TO 1220
	5000	40 TO 45	250 TO 275	1140 TO 1260
	6000	40 TO 45	257 TO 283	1195 TO 1320
5409I 540921A	1000	35 TO 39	205 TO 230	72O TO 820
	2000	36 TO 40	215 TO 240	800 TO 880
	3000	36 TO 40	220 TO 245	870 TO 970
	4000	36 TO 40	225 TO 250	935 TO 1040
	5000	36 TO 40	230 TO 250	1000 TO 1120

TABLE 17-3 COMPRESSOR PERFORMANCE DATA

BLOCK TYPE	5404	54044	5405	54054	5405E	5406	5406E	5406E H	5407	5407H	5408	5409	5409H 54092 BA	5409I 54092 1A
OIL PRESSURE	SPLSH	SPLSH	SPLSH	SPLSH	SPLSH	1000	1000	1000	1000	1000	1000	1000	20	45
MAX INLET PRESSURE (PSIG)	1	1	.4	.4	.4	6	6	5	.5	.5	.5	.5	.4	.4
CHARGING RATE - FT3/M CHARGING RATE M3/HR	5.8 9.9	5.8 9.9	8.7 14.7	8.7 14.7	11.2 19.0	11.0 18.7	13.1 22.3	14.0 23.8	18.7 31.8	20.7 35.2	25.7 43.7	30.6 52.0	33.2 56.4	30.6 52.0
1ST STAGE PISTON DISPLACEMENT - FT3/M DISPLACEMENT - M3/HR	7.1 12.0	7.1 12.0	11.2 19.0	11.2 19.0	15.5 26.3	15.0 25.5	17.5 29.8	17.5 29.8	23.3 39.6	19.7 33.5	30.3 51.5	36.4 61.9	36.4 61.9	36.4 61.9
VOLUME - FREE AIR DELIVERED @2180 PSI - FT3/M DELIVERED @2180 PSI - M3/HR DELIVERED @5000 PSI - FT3/M DELIVERED @5000 PSI - M3/HR DELIVERED @6000 PSI - FT3/M DELIVERED @6000 PSI - M3/HR	4.8 8.2 4.3 7.3 N/A N/A	4.8 8.2 4.3 7.3 N/A N/A	7.0 11.9 6.5 11.0 N/A N/A	7.0 11.9 6.5 11.0 N/A N/A	9.5 16.1 8.8 15.0 N/A N/A	10.0 17.0 8.9 15.2 N/A N/A	11.4 19.4 10.7 18.2 N/A N/A	11.4 19.47 10.7 18.2 10.5 17.8	15.8 26.8 150 25.5 N/A N/A	15.8 26.8 15.0 25.5 12.1 20.5	21.8 37.1 21.0 35.7 N/A N/A	25.8 43.8 25.0 42.5 N/A N/A	24.8 41.1 24.0 40.8 24.6 41.8	25.8 43.8 25.0 42.5 N/A N/A
COMPRESSOR POWER @2180 PSI-HP COMPRESSOR POWER @2180 PSI-KW COMPRESSOR POWER @5000 PSI-HP COMPRESSOR POWER @5000 PSI-KW COMPRESSOR POWER @6000 PSI-HP COMPRESSOR POWER @6000 PSI-KW	4.2 3.1 4.8 3.6 N/A N/A	4.2 3.1 4.8 3.6 N/A N/A	5.0 3.7 5.8 4.3 N/A N/A	4.9 3.7 5.6 4.2 N/A N/A	8.4 6.3 9.5 7.1 N/A N/A	8.0 6.0 8.9 6.6 N/A N/A	8.7 6.5 9.8 7.3 N/A N/A	8.7 6.5 9.8 7.3 10.0 7.5	11.7 8.7 13.4 10.0 N/A N/A	11.7 8.7 13.4 10.0 11.0 8.2	16.9 12.6 19.2 14.3 N/A N/A	20.0 14.9 23.0 17.2 N/A N/A	20.0 14.9 23.0 17.2 24.1 18.0	20.0 14.9 23.0 17.2 N/A N/A
COMPREESSOR NOISE LEVEL AT ONE METER - dB/(A)	82	82	83	83	89	84	85	85	87	85	85	87	87	87
COOLING AIR FLOW RATE (APPROX) - FT3/M (APPROX) - M3/HR	1500 2500	1500 2500	1500 2500	1500 2500	2000 3400	2000 3400	3000 5000	3000 6000	4000 7000	4000 7000	4000 7000	5000 8500	5000 8500	5000 8500
SAFETY VALVE SETTINGS - PSIG 1ST STAGE 2ND STAGE 3RD STAGE FINAL STAGE	85 783	85 783	120 1000 SUPPLY	120 1000 PLUS	120 1000 10%...	50 300 1400	50 300 1400	67 303 1380	85 385 1400	85 385 1400	50 240 1400	50 300 1400	50 300 1512	60 300 1400 .....
COMPRESSOR HEAT REJECTION TO ATMOSPHERE - BTU/M TO ATMOSPHERE - KW	206 3.6	206 3.6	250 4.5	250 4.5	390 7.1	380 6.6	420 7.3	430 7.5	570 10.0	470 8.2	825 14.3	100 17.2	1050 18.0	1035 18.2

COMPRESSOR PERFORMANCE DATA

BLOCK TYPE	5404	54044	5405	54054	5405E	5406	5406E	5406EH	5407	5407H	5408	5409	5409H/ 54092BA	5409I/ 540921A
SUMP CAPACITY - QUARTS	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	7.0
SUMP CAPACITY -LITERS	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.9	1.9	1.9	7.4
DIMENSIONS:														
1ST STG CYLINDER BORE - INS	2.76	2.76	3.46	3.46	2.75	3.14	3.14	3.15	3.62	3.62	4.12	4.53	4.53	4.53
1ST STG CYLINDER BORE - MM	70	70	88	88	70	80	80	80	92	92	105	115	115	115
2ND STG CYLINDER BORE - INS	1.42	1.42	1.42	1.42	1.42	1.96	1.96	1.96	1.96	1.96	2.95	2.95	2.95	2.95
2ND STG CYLINDER BORE - MM	36	36	36	36	36	50	50	50	50	50	75	75	75	75
3RD STG CYLINDER BORE - INS	.55	.55	.55	.55	.55	.86	.86	.86	.86	.86	1.10	1.10	1.10	1.10
3RD STG CYLINDER BORE - MM	14	14	14	14	14	22	22	22	22	22	28	28	28	28
4TH STG CYLINDER BORE - INS	N/A	N/A	N/A	N/A	N/A	.43	.43	.43	.43	.43	.55	.55	.55	.55
4TH STG CYLINDER BORE - MM	N/A	N/A	N./A	N/A	N/A	11	11	11	11	11	14	14	14	14
STROKE - INS	1.57	1.57	1.57	.1.57	1.57	1.88	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
STROKE - MM	40	40	40	40	40	48	56	56	56	56	56	56	56	56
FINAL DELIVERY O/D PIPE														
CONNECTION - INS	.312	.312	.312	.312	.312	.312	.312	.312	.312	.312	.312	.312	.312	.312
CONNECTION - MM	8	8	8	8	8	8	8	8	8	8	8	8	8	8
1ST STAGE SUCTIION CONNECTION - RP	1	1	1	1	1	1	1	1	1	1	2	2	2	2
COMPRESSOR BARE HGHT - INS	20	20	20	20	20	25	27	27	25	27	27	27	27	27
COMPRESSOR BARE HGHT - MM	505	505	505	505	505	636	685	685	636	685	697	697	697	697
COMPRESSOR BARE WDTH - INS	21	21	21	21	21	24	22	22	24	22	28	28	28	28
COMPRESSOR BARE WDTH - MM	530	530	530	530	530	608	559	559	608	559	714	714	714	714
COMPRESSOR BARE LNTH - INS	14	14	14	14	15	16	19	19	16	19	20	20	20	20
COMPRESSOR BARE LNTH - MM	361	361	361	361	370	401	483	483	401	483	515	515	515	515
COMPRESSOR BARE WGHT - LBS	79	79	86	86	88	150	159	159	170	174	240	249	249	284
COMPRESSOR BARE WGHT - KGF	36	36	39	39	40	68	72	72	77	79	109	113	113	129
COMPRESSOR SPEED - RPM	1300	1300	1300	1300	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
MEAN PISTON SPEED - FT/S	5.7	5.7	5.7	5.7	7.9	11.0	11.0	11.0	11.0	9.2	11.0	11.0	11.0	11.0
MEAN PISTON SPEED - M/S	1.7	1.7	1.7	1.7	2.4	3.4	3.4	3.4	3.4	2.8	3.4	3.4	3.4	3.4
FINAL STAGE PISTON TYPE	FLOATIN G	CAPTIV E	FLOATIN G	CAPTIV E	CAPTIV E	CAPTIV E	CAPTIV E	CAPTIV E	CAPTIV E	CAPTIV E	CAPTIV E	CAPTIV E	CAPTIV E	CAPTIV E

NOTE: IT IS EXTEMELY DIFFICULT TO ACCURATELY DETERMINE COMPRESSOR AIR TEMPERATURES BY MEASURING SURFACE METAL TEMPERATURES BECAUSE FAN AIR FLOW COOLS THE SURFACE. HOWEVER, AS A GENERAL GUIDE, NO METAL SURFACE TEMPERATURE SHOULD EXCEED 338 DEGREES F (160 DEGREES C).

MACHINES HAVE A TAPPING FOR A THERMOCOUPLE PROVIDED IN THE FINAL DELIVERY IN ORDER TO MONITOR AIR TEMPERATURE ACCURATELY. THIS TEMPERATURE SHOULD NOT EXCEED 446 DEGREES F (230 DEGREES C).

RECOMMENDED LUBRICATING OILS
AIRCOOLED COMPRESSORS

MODEL	CAPACITY QTS.	AMBIENT OPERATING TEMPERATURES (DEGREES F)	RECOMMENDED OIL
5204/5205	1.5	32 to 140	MAKO "S" SYNTHETIC
5207	1	32 to 131	MAKO "S" SYNTHETIC
5207	1	14 to 59	MAKO "W" SYNTHETIC
5209	1.5	32 to 131	MAKO "S" SYNTHETIC
5209	1.5	14 to 59	MAKO "W" SYNTHETIC
5211/5213	1.5	32 to 131	MAKO "S" SYNTHETIC
5211/5213	1.5	14 to 59	MAKO "W" SYNTHETIC
5307/5309	1.5	32 to 113	MAKO "S" SYNTHETIC (1)*
5307/5309	1.5	14 to 59	MAKO "W" SYNTHETIC (2)*
5404/5405	1.5	32 to 113	MAKO "S" SYNTHETIC (1)*
5404/5405	1.5	14 to 59	MAKO "W" SYNTHETIC
5405E	1.5	32 to 113	MAKO "S" SYNTHETIC (1)*
5405E	1.5	14 to 59	MAKO "W" SYNTHETIC
5406/5406E	1.5	32 to 113	MAKO "S" SYNTHETIC (1)*
5406/5406E	1.5	14 to 59	MAKO "W" SYNTHETIC (2)*
5406EH	1.5	32 to 113	MAKO "S" SYNTHETIC (1)*
5406EH	1.5	14 to 59	MAKO "W" SYNTHETIC (2)*
5407/5407H	1.5	32 to 113	MAKO "S" SYNTHETIC (1)*
5407/5407H	1.5	14 to 59	MAKO "W" SYNTHETIC (2)*
5408	2	32 to 113	MAKO "S" SYNTHETIC (1)*
5408	2	14 to 59	MAKO "W" SYNTHETIC (2)*
5409/5409H	2	32 to 113	MAKO "S" SYNTHETIC (1)*
5409/5409H	2	14 to 59	MAKO "W" SYNTHETIC (2)*
5409IND	7	32 to 113	MAKO "S" SYNTHETIC (1)*
5409IND	7	14 to 59	MAKO "W" SYNTHETIC (2)*

*(1) IF COMPRESSOR IS FITTED WITH A SUMP HEATER, THE OIL CAN BE USED DOWN TO 14 DEGREES F.

*(2) THIS OIL CAN BE USED AT 14 TO 77 DEGREES (F) IF THE OPERATING HOURS ARE LESS THAN 200 HOURS PER YEAR.

NOTE: FOR GAS APPLICATIONS CONTACT COMPAIR MAKO.
FOR DRY HELIUM APPLICATIONS USE MAKO "H" TYPE SYNTHETIC OIL
FOR DRY NITROGEN APPLICATIONS USE MAKO "N" TYPE SYNTHETIC OIL

INSERT AS PAGE 17 - 6

OIL PRESSURE REGULATION SETTINGS FOR AIRCOOLED COMPRESSORS

SERIAL NUMBER	WORKING PRESSURE	OIL PRESSURE SWITCH SETTING	OIL PRESSURE REGULATOR SETTING
54044XXX	2000-5000	SPLASH	N/A
54054XXX	2000-5000	SPLASH	N/A
5406E	2000	400*	600*
5406E	3000-5000	600*	800*
5406EH	2000-6000	800*	1000
5407	2000	400*	600*
5407	3000-5000	600*	800*
5407H	2000-6000	800*	1000
5409I/540921A	2000-5000	LOW PRESSURE	N/A
5409H/54092BA	2000-6000	LOW PRESSURE	N/A

COMPRESSORS ALREADY OUT IN THE FIELD MAY BE ADJUSTED TO THE ABOVE SPECIFICATIONS IF HIGHER THAN NORMAL OIL CONSUMPTION IS NOTED.

INSERT AS PAGE 17 -7

Rev. 0: 10/03/96

Effective Date: 10/03/96

SP-002

MAKO COMPRESSORS INC.

OCALA, FLORIDA

SEPARATOR AND PURIFICATION CHAMBER

HYDROSTATIC TEST PROCEDURE

APPROVED BY: MANAGER OF ENGINEERING

Samuel M. Baggett

DATE: 10/03/96

Table of Contents

Section

Separator and Purification Hydrostatic Test Procedure

1.0 Purpose

To prescribe the methodology and acceptance criteria for inservice hydrostatic testing of Mako separator and purification chambers. The goal is to ensure safe operation of Mako high Pressure air purification systems.

2.0 References

2.1 Implementing References

2.1.1 Compressed Gas Association,
Inc. Pamphlet C-i
Sixth Edition (1975)
1725 Jefferson Davis Highway
Arlington, Virginia 22202

2.2 Developmental References

2.2.2 Arrowhead Industrial Sevices, Inc.
Test Report, Sept 13, 1996

3.0 Personal Indoctrination

3.1 Definitions

3.1.1 Separator- A device for removing moisture and carry over oil from the compressor discharge air stream.

3.1.2 Moisture- That portion of the water content of an air stream that can be removed by coalescence or mechanically via centrifugal force.

3.1.3 Oil Carryover- Compressor lubricating oil entrained in the discharge air stream.

3.1.4 Purification- Removal of contaminants from an air stream to make said air stream acceptable for breathing.

3.2 Responsibilities

3.2.1 CompAir Mako
To provide accurate instruction and acceptance criteria for inservice hydrostatic testing.

3.2.2 Distributor
To ensure that each owner receives a copy of these inservice hydrostatic testing procedures with each machine.

3.2.3 Owner

The owner shall remove the affected high pressure cylinder(s) from his machine(s) and forward them to a qualified test laboratory for hydrostatic testing on a schedule that is commensurate with the number of hours of machine operation and the recommendations of this procedure.

CAUTION: IN SOME ENVIRONMENTS, INTAKE AIR MAY CONTAIN CONTAMINENTS THAT FORM CHEMICAL AGENTS WITH CONDENSED MOISTURE THAT ARE HARMFUL TO CYLINDER PRESSURE BOUNDARY MATERIALS. IF THERE IS ANY REASON TO SUSPECT THE FORMATION OF HARMFUL AGENTS THE TEST FREQUENCY SHOULD BE INCREASED.

3.2.4 Testing Laboratory

The testing laboratory shall observe the stipulations of this test procedure unless permission to deviate is granted in writing from Mako. It is expected that the testing laboratory will have calibrated equipment suited to the Mako products, trained technicians, and an appropriate record system. Said testing lab shall use methods recommended by CGA Pamphlet C-1 wherever the instructions of this procedure do not prevail.

3.2.5 Acceptance Criteria Technical Basis

Mako manufactures four basic chambers (Figure 1) used in high pressure air processing as follows:

a. Small Separator - A 3.954 inch diameter X 14 3/8" long thick walled 7075T6 aluminum cylinder made from solid bar stock. The upper end of the cylinder is closed by a threaded plug made from 2024T351 aluminum.

b. Large Separator - A 3.954 inch diameter X 16" long thick walled 7075T6 aluminum cylinder made from solid bar stock. The upper end of the cylinder is closed by a threaded plug made from 2024T351 aluminum.

c. Small (Short) Purification Chamber - A 3.954 inch diameter X 14-3/8" long 7075T6 aluminum tube having a raw wall thickness of .5625 inch. The upper and lower ends of the cylinder are closed by threaded plugs made from 2024T351 aluminum.

d. Large (Tall) Purification Chamber - A 3.954 inch diameter X 31-3/8 inch long 7075T6 aluminum tube having a raw wall thickness of .5625 inch. The upper and lower ends of the cylinder are closed by threaded plugs made from 2024T351 aluminum.

The small separator is manufactured with two slight variations, namely, the number of ports in the blind end of the cylinder. The small purification chamber is assembled with various bottom and top plugs depending upon the application. Different plugs provide different porting configurations, which result in slight variations of internal volume. In a like manner the large (tall) purification chamber is assembled with various bottom and top plugs depending upon the application.

Mako has designed each cylinder so that material stress levels are in the elastic range under maximum working pressure and during hydrostatic testing up to 1.5 times the maximum working pressure. This means that there should be no permanent change of cylinder volume from metal plastic flow after a test where the internal pressure reaches to 9000 psig (1.5 X Max Working Pressure). Hydrostatic tests, however, are subject to measurement error, environmental changes, operator error, test equipment variations, and other factors that could affect the volume change measurements. One factor that is particularly difficult to define is the behavior of "O" Rings (elastomers) under the broad range of test pressures. Therefore, Mako has established a volumetric change criteria, based on <u>expected</u> laboratory test instrument precision and accuracy. By <u>expected</u> we mean the test quality rendered by a qualified lab. If a test on a particular cylinder is not conclusive, i.e., results show that the permanent volume change after test pressurization is slightly above the stated criteria or there is any reason to suspect the test accuracy, Mako recommends the preparation of a volume change vs pressure curve for the particular cylinder to determine if the material of construction is still seeing stress levels in the elastic range. To this end the test procedure has an optional set of instructions that generate the necessary data.

4.0 Instructions

4.1 Large and Small Separator

4.1.1 Owner

1. Remove cylinder from machine.
2. Remove top plug.
3. Remove sintered element and related components leaving the bare cylinder and top plug.
4. Remove existing "O" rings.
5. Clean cylinder inside and out using clean dry rags and Dawn dish washing soap.
6. Inspect chamber and plug for damage.
7. Install new "O" ring and back up ring.

NOTE: Be sure to install the back up ring in the proper orientation.

8. Install plug in chamber and tape openings with masking tape.
9. Carefully package the cylinder for shipment to the test lab.
10. Include a spare "O" ring and back up ring for the convenience of the test lab in case the installed "O" ring gets damaged.

4.1.2. Test Lab

1. Remove top plug and inspect cylinder and plug for physical damage. Notify Owner if the vessel has been compromised sufficiently to warrant immediate rejection.
2. Install interface fittings.

NOTE: Design pressure for this cylinder is 6000 psig. Maximum hydrostatic pressure impressed upon this vessel is 9000 psig. Owner may specify a lower test pressure if his working pressure is less than 6000 psig, however, the test pressure should be at least 1.5 times the working pressure.

3. Install cylinder in Test Stand.

   Note: Only the Water Jacket Method as described in CGA Pamphlet C-1 is considered sufficiently accurate for this vessel.

4. Pressurize cylinder to design pressure (6000 psig) and inspect for leakage in the "O" rings and adaptor fittings.
5. Pressurize the cylinder to the prescribed test pressure or to the default value of 9000 psig.
6. Record the volumetric expansion (in CC's).
7. Depressurize the cylinder and record the permanent displacement (in CC's).
8. Calculate the percent of permanent displacement.

$$\frac{\text{Permanent Expansion (cc's)}}{\text{Total Expansion (cc's) (at 9000 psig)}} \times 100$$

9. Compare % permanent displacement with the acceptance criteria. Reject cylinder if % permanent expansion exceeds 10%.
10. Record test results - stamp test date on cylinder bottom.
11. Dry cylinder with air or clean rags to remove traces of moisture.
12. Remove top plug and inspect vessel for damage.
13. Install top plug and package for shipment. Include test report with package.

Alternative Test Procedure (Optional)

1. Prepare cylinder for test if not already accomplished in accordance with above instructions.
2. Pressurize cylinder to 6000 psig, record displacement, and inspect for leakage in the "O" rings and adaptor fittings.
3. Depressurize cylinder and record permanent displacement.
4. Pressurize cylinder to 6500 psig and record displacement.
5. Depressurize cylinder and record permanent displacement.
6. Repeat pressurization and depressurization steps at 500 psig intervals until reaching 9000 psig.

7. Plot displacement readings vs pressure over the range of 6000 to 9000 psig and fit straight line. See example in Figure 2.
8. Observe displacement trends. Plastic deformation will cause a departure from the straight line.

WARNING: EVIDENCE OF PLASTIC DEFORMATION INDICATES A THINNING OF THE VESSEL WALL, HENCE, STRESS LEVELS ABOVE THE ELASTIC LIMIT. ANY VESSEL EXHIBITING THESE CHARACTERISTICS MUST BE REJECTED.

9. Provide vessel owner with the result of the elasticity test.

4.2 Small and Large Purification Chamber

4.2.1 Owner

1. Remove Cylinder from machine.
2. Remove top plug.
3. Remove filter cartridge.
4. Remove bottom plug.
5. Remove existing "O" rings from plugs.
6. Clean cylinder inside and out using clean dry rags and Dawn dish washing soap.
7. Inspect chamber and plugs for damage.
8. Install new "O" rings and back up ring.

NOTE: Be sure to install the back up ring in the correct orientation.

9. Install plugs in chamber and tape openings with masking tape.
10. Carefully package the cylinder for shipment to the test lab.
11. Include a spare "O" ring and back up ring for the convenience of the test lab in case the installed "O" ring gets damaged.

4.2.2 Test Lab

1. Remove top and bottom plug and inspect cylinder and plug for physical damage. Notify owner if the vessel has been compromised sufficiently to warrant immediate rejection.

2. Install interface fittings.
   NOTE: Design pressure for this cylinder is 6000 psig. Maximum hydrostatic pressure impressed upon this vessel is 9000 psig. Owner may specify a lower test pressure if his working pressure is less than 6000 psig; however, the test pressure should be at least 1.5 times the working pressure.
3. Install cylinder in test stand.

   NOTE: Only the Water Jacket method as described in CGA Pamphlet C-1 is considered sufficiently accurate for this vessel.

4. Pressurize cylinder to design pressure (6000 psig) and inspect for leakage in the "O" rings and adaptor fittings.
5. Pressurize the cylinder to the prescibed test pressure or to the default value of 9000 psig.
6. Record the volumetric expansion (in CC's).
7. Depressurize the cylinder and record the permanent displacement (in CC's).
8. Calculate the percent of permanent displacement.

$$\frac{\text{Permanent Expansion (cc's)}}{\text{Total Expansion (cc's) (at 9000psig)}} \times 100$$

9. Compare % permanent displacement with the acceptance criteria. Reject cylinder if % permanent expansion exceeds 10%.
10. Record test results - stamp test date on cylinder bottom.
11. Dry cylinder with air or clean rags to remove traces of moisture.
12. Remove plugs and inspect vessel for damage.
13. Install plugs and package for shipment. Include test report with package.

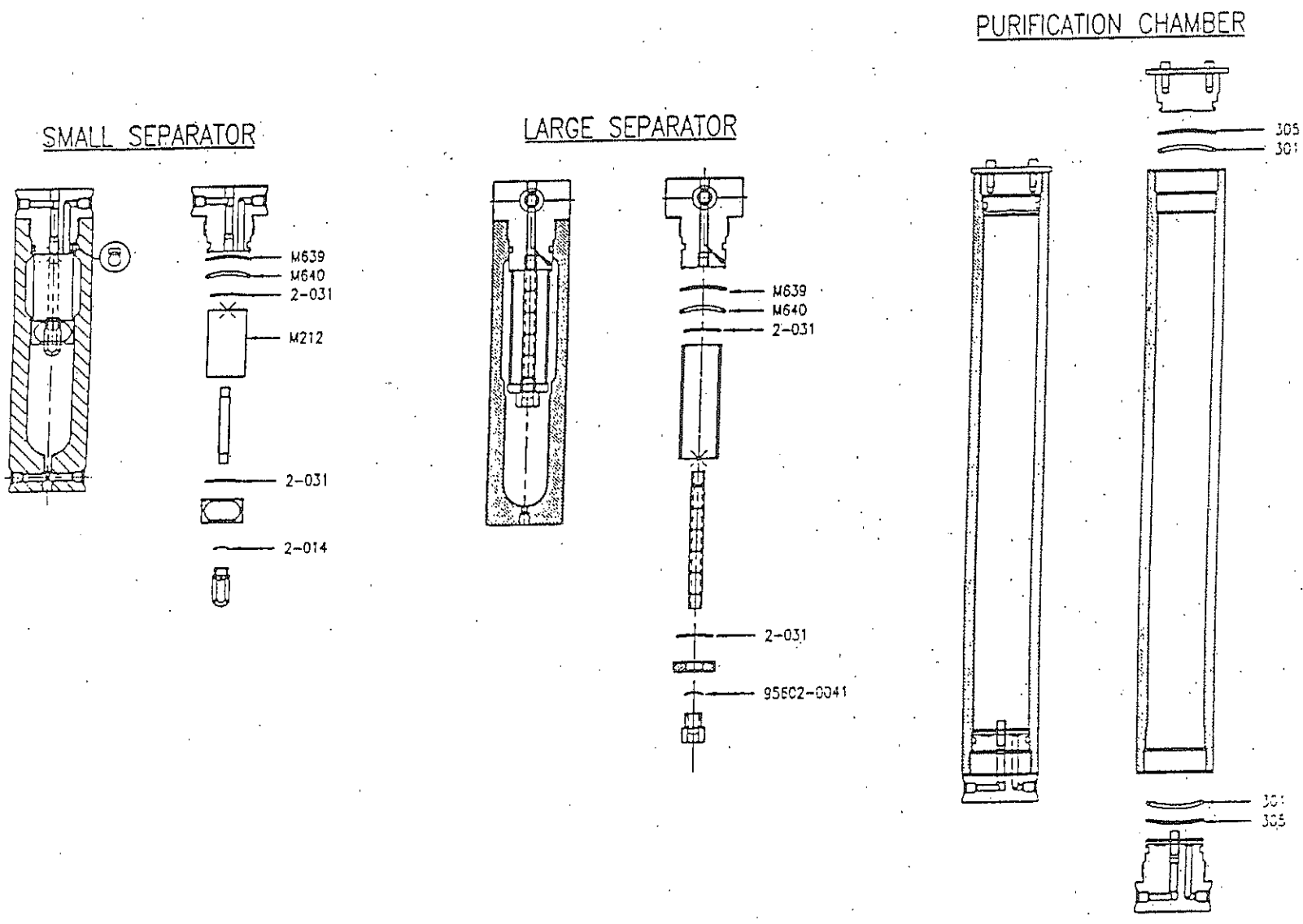
Alternative Test Procedure (Optional)

1. Prepare cylinder for test if not already accomplished in accordance with paragraph 4.2.2.
2. Pressurize cylinder to 6000 psig, record displacement, and inspect for leakage in the "O" rings and adaptor fittings.
3. Depressurize cylinder and record permanent displacement.
4. Pressurize cylinder to 6500 psig and record displacement.
5. Depressurize cylinder and record permanent displacement.
6. Repeat pressurization and depressurization steps at 500 psig intervals until reaching 9000 psig.
7. Plot displacement readings vs pressure over the range of 6000 to 9000 psig and fit straight line. See Figure 2.
8. Observe displacement trends. Plastic deformation will cause a departure from the straight line.

WARNING: EVIDENCE OF PLASTIC DEFORMATION INDICATE A THINNING OF THE VESSEL WALL, HENCE, STRESS LEVELS ABOVE THE ELASTIC LIMIT. ANY VESSEL EXHIBITING THESE CHARACTERISTICS MUST BE REJECTED.

9. Provide vessel owner with the result of the elasticity test.

FIGURE 1: CHAMBER CONFIGURATIONS



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SEPARATOR AND PURIFICATION CHAMBER
HYDROSTATIC TEST RESULTS