1 INTRODUCTION

The current manual gives the necessary technical informations about:

- Installation
- Use
- Maintenance
- carriage
- Demolition

The knowledge of the manual is required to all the operators who will deal the above-mentioned performances.
In case of doubt or necessity of explanation, refer to :

M.T.M. s.r.l.
Via la Morra,1
12062 Cherasco (CN)

THE CURRENT MANUAL IS AN INTEGRAL PART OF THE MACHINE.
IT IS COMPULSORY TO READ IT BEFORE WORKING ON THE MACHINE

1.1 MANUAL'S RECEIVERS

The current manual has to be read by :

- Employees of the factory
- Employees on installation
- Operator
- Employees on maintenance

The manual must be kept by the staff in an appropriate place, so that it could always be available, for consultation, in the best conditions of conservation.

In case of loss or deterioration of the manual, the substitutive documentation has to be requested, mentioning the code of the current one, directly to:

M.T.M. s.r.l.
Via la Morra,1
12062 Cherasco (CN)

The user has to take care that the current book, or a copy will always be near the machine for the consultation of the operator.

1.2 MAIN CHARACTERISTICS

The gas equipment is planned to fill tanks with methane compressed to the pressure of 220 bar.
Two groups of storage tanks are used to reach this objective , one for medium pressure (200 bar) and one for high pressure (250 bar).
The working fluid is natural gas (SEE SCHEDULE COMPOSITION) ; it is untaken from the distribution web with the following project characteristics:

- ***compressor***

CODE COMPRESSOR	W90-SE01	
TYPE OF COMPRESSOR	alternative	
COMPRESSED FLUID	NATURALE GAS (CNG)	
GAS FLOW	550	Nmc/h
INLET PRESSURE	6	bar
OUTLET PRESSURE	200	bar
N° OF STAGES	3	
DISPOSITION	W	
STROKE	150	mm
CYLINDER BORE	125-70-40	mm
KIND OF STAGE	Single effect	
SPEED	985	rpm
ELECTRIC ENGINE POWER*	90	kW
INLET GAS TEMPERATURE	20	°C
OULET GAS TEMPERATURE	Ambient Temperature + 15°C	°C

- ***booster***

COMPRESSED FLUID	Methane (CNG)	
GAS FLOW	560	Nmc/h
STROKE	600	mm
DIAMETER GAS PISTON	125	mm
DIAMETER OIL PISTON	140	mm
STEM DIAMETER	70	mm
INLET PRESSURE	200	bar
OUTLET PRESSURE	250	bar
OIL FLOW	60	l/min
ELECTRIC ENGINE POWER	15	kW

- *(see enclosed document 1)*

- ***group of regulation pressure***

Natural gas, gone out from storage high pressure tanks, flows inside a pressure reductor that brings his pressure to 220 bar.
There is also a group made of: pressure sensor, pressure switch and calibrated safety valve.
This group assures the correct pressure to the gas that goes to the gas distributor.

- ***Storage tanks***

Fourteen tanks (each tank has a 90 LT capacity):

1. 10 medium pressure tanks: 200 bar
2. 4 high pressure tanks: 250 bar

Total capacity: 270 Nm3.

GAS SCHEDULE COMPOSITION (considered for this project)

COMPONENT	*VOL. %*
Methane	96.31
Ethane	1.40
Propane	0.54
Isobutane	0.20
NButane	0.11
Isopentane	0.06
Npentane	0.03
Exhano	0.03
Nitrogen	0.40
Carbon Dioxide	0.92

humidity in gas:
dew-point of the gas at the pressure 200 bar : 10°C less than the minimum ambient temperature

2 SAFETY

NOTE
To reduce the chance of personal injury and/or property damage, the instructions and special safety and caution notices provided in this manual must be fully understood and carefully observed. Understand that these safety and caution notices are not exhaustive since it would be impossible to warn of every possible consequence from failure to follow these instructions.

Speed of the machine

To insure the safe, and for a correct functioning of the compressor and of the system, adhere to the following guideline:
the speed of the crankshaft of the compressor must be not superior to 1000 rpm.

Working pressure

Maximum allowable working pressure varies in accordance with the following values:

Inlet pressure eff.	Maximum outlet pressure eff. in correspondence with the maximum inlet pressure
min 2 bar / max 7 bar	From compressor W90 : 220 bar From booster : 250 bar Towards the distributors: 220 bar

Safety valves shall be set to operate NO higher than the maximum allowable working pressure of the weakest component in the gas stream of each stage, but not less than 110% of the rated discharge pressure.
Safety valves and pressure switches are equipped with calibration certificates and with conformity certificates to the applicable european directives.
For the safety of the system and for the personal indemnity of the operators, it's important that valves would not be manumitted or modified in any way; besides periodical inspections of the correct functioning, foreseen by supervisory that are in force, have to be done.

Temperatures

The maximum temperature tolerated by the cylinders cylinders is 145 °C.
Special seals and washers are requested for temperatures superior than 125°C.

2.1 DANGER NOTICES

1. DON' T NEVER USE THE SYSTEM IN A SERVICE OTHER THEN THAT FOR WITCH IT IS SPECIFICALLY DESIGNED.

2. COMPRESSED GAS IS POTENTIALLY EXPLOSIVE. SPECIAL PRECAUTIONS MUST BE TAKEN WHEN WORKING WITH THIS EQUIPMENT. BE SURE TO STRICTLY OBSERVE ALL APPLICABLE SAFETY REGULATIONS AND PRACTICES (THOSE REQUIRED BY THE NATIONAL DIRECTIVES AND THOSE WRITTEN IN THIS MANUAL).

3. DON'T PERFORM ANY MAINTENANCE OPOERATION ON THE SYSTEM WHEN IT IS FUNCTIONING, AND/OR IN PRESSURE, AND/OR HOT.
   BEFORE EVERY OPERATION ON THE SYSTEM, BE SURE THAT ELECTRTICAL FEEDING IS CUT OFF AND THAT ACCIDENTAL STARTING IS NOT POSSIBLE .
   BE SURE THAT ALL THE SYSTEM HAS BEEN PURGED, AND THAT THERE IS NOT PRESSURE IN ANY COMPONENT.
   BE SURE THAT THE EQUIPMENT IS CUT OFF FROM THE METHANE PIPELINE, FROM STORAGE TNAKS AND THE GAS DISTRIBUTOR.

4. DON'T OPEN OR LOOSEN PIPE FITINGS THAT WORK IN PRESSURE DURING THE NORMAL FUNCTIONING OR BEFORE HAVING PURGED THE PIPES.

5. DON'T EXCEED THE MAXIMUM WORKING PRESSURE OF EVERY COMPONENT OF THE EQUIPMENT.

6. DON'T WARM THE PIPES OR OTHER COMPONENTS OF THE EQUIPMENT OVER MAXIMUM LIMITS OF WORKING TEMPERATURE.

7. REPLACE ALWAYS INTERELY DAMAGED COMPONENTS

8. THE PRESENCE OF AN EXPLOSIVE ATMOSPHERE IS ALWAYS POSSIBLE NEAR EQUIPMENT, SO IT'S FORBIDDEN APPROACHING WITH A POSSIBLE TRIGGER SOURCE, LIKE CIGARETTES, MOBILE PHONES, FLAMES, HOT OBJECTS OR POSSIBLE ELECTRICAL DISCARGE / ELECTROSTATIC SOURCES (SYNTHETIC WEARING).

WARNING
FAILURE TO OBSERVE THIS NOTICE CAN CAUSE SERIOUS MECHANICAL PROBLEMS, AND COULD RESULT IN SERIOUS INJURY OR DEATH.

WARNING
Proper service and repair procedures are important to the safety of the service technician and the safe, reliable operation of the compressor. If part replacement is necessary, the part must be replaced with one of the same part number or with an equivalent part. Do not use a replacement part of lesser quality. Accordingly, anyone who intends to use a replacement part, service procedure, or tool that is not recommended by the manufacturer, gets serious dangers, and compromises the correct functioning of the compressor and of his system.

WARNING
Before beginning any repairs on or within the compressor frame or cylinders, the following precautions must be taken:
_ refer and strictly adhere to the packager's complete instruction manual.
_ close the main suction (inlet) and discharge (outlet) block valve to isolate the compressor package.
_ cut off the electrical feeding
_ be sure that all the pressures in the compressor, in pipes, and in the heat exchangers are slow
Purge the entire system prior to start up, after extended periods of shut down and whenever any gas seal, including valve cover seals, has been broken.
Use an inert gas to purge the system, so that no explosive mixture could be compressed.
Do not reverse or install suction or discharge valves upside down or in the wrong cylinder port. Severe over pressure may result, causing damage to the equipment or personal injury.

2.2 SAFETY AND MAINTENANCE

Only qualified personel shall carry out installation, operation, maintenance and repair in accordance with the corresponding regulations for operation and safety.
The system must be maintained in safe operating condition. Inspection should be carried out on a regular basis.
Never perform any work on the compressor when it is running.
Only qualified and authorized personnel are to open the control panel and motor starter cabinet.

WARNING
Note that even if the main switch is set to the "OFF" position, the poles of the switch and the terminal's feed cables are live.

Do not touch anything, or carry out work on the control panel until the system is entirely free of power. Keep heat sources far from gas , oil and electrical components of the system
Always wear eye protection when working on compressor.
Before working on oil or gas tanks, empty and clean them either by steam jet or by purging with nitrogen.
In the event of oil, gas or coolant leak, remove the lost liquid and repair the leak.
Never use flammable solvents for the cleaning of parts. After the use of any solvent, carefully rinse and clean the parts with compressed air or clean, lint-free rags.
Keep impurities from contaminating removed parts or exposed openings by covering them with a clean rag, paper or adhesive tape.
After completing repairs, be sure no tools, loose parts or cleaning rags have been left in the compressor.
After working on the compressor, and before power is supplied to the machine and the system is pressurized, always turn the compressor over manually by using the flywheel. This ensures that the compressor is running free.
After completing any work on the compressor, be sure it is tested and accepted by the inspection authoriry concerned.
Use only the original and recommended spare parts for compressor repair; spare parts must adhere with the technical requirements specified by the constructor. This is always guaranteed for the original ones.
Do not make changes on software and on PLC.
Pipes have to be completely controlled (visual inspection and pressure test) by the operator in the prescribed times, also if emergencies haven't still emerged.
Respect all maintenance periods prescribed by the laws in force and specified in this manual.

2.3 SAFETY AND OPERATION

Do not start any operation if there is doubt on safety.
The compression equipment is to be operated in strict accordance with its specifications at all times.
Before making the compressor operative, be absolutely certain that no one is working on the compressor at the time.
If functional anomalies come, stop immediately the system. Repair immediately the damage.
All rotating power transmission products are potentially dangerous, cause of their high speed, so it's forbidden to stay in the closeness during the functioning; they must be properly guarded for the speeds and applications for which are intended.
Take care that no one can come into contact with pipe work or other heat-producing parts of the compressor system during operation.
Never store flammable materials near the compressor, e.g. oily rags.

NOTICE
The manufacturer takes no responsibility for personal injury or damage to the unit caused by the non-observance of safety precautions during handling, operation, maintenance or repair of the compressor.

3 HANDLING AND POSITINING OF THE STEEL BOX

3.1 TRANSPORT

All the compression system (excluded the air-water cooling group and gas damping and filtering group) is given to the customer mounted inside a 20" container of standard dimensions:

	Dimensioni esterne	Dimensioni interne
Length	6058	5890
Width	2438	2350
Height	2591	2385

Internal capacity : 33 m^3
Empty Weight (tare) : 2650 kg
Maximum weight : 27980 kg

To move the container use the four hook slot positioned on the four superior corners.(one for each corner).
Make the transport lift the container by using a crane and hooking wire ropes to all the corners.
The load inside the container is not uniformly distributed, so before moving it, verify it is rising with his bottom parallel to the floor; if this condition is not verified, set again the rising bands.
According to the safety rules and the technical specifications, do not lean the container, be sure that its bottom stays parallel to the floor also during the transport.
Rising container by hooking it somewhere else is not allowed.
Do not stay under the container when it is lifted.

3.2 POSITIONING

The container must be fixed at the ground in horizontal position.
It's necessary to prepare a layer made of impermeable material 200 mm thick and a cement one 250 mm thick, laying on the first one.
The cement layer must be reinforced by a double metallic web with circular section (Ø8 mm) and mesh 15x15 mm. *(see enclosure 1)*
The so determinate laying surface must have the following minimal dimension:
Length : 6458 mm + 1000 mm
Width : 2838 mm + 1000 mm
Execute in correspondence of the feet of the compressor execute four cement foundation 800x800 mm, deep1450 mm and reinforced by a metallic web.
Execute, inside each foundation, an hole Ø 200 mm of the same highness of the four cement foundations ; the holes so made will have to be filled with a catalyzed resin (FIS-V-360), so that is possible to fix the feet for the anchorage of the compressor.
For a correct positioning of the container and of the compressor, it's necessary to pay attention to make the holes respecting the distances indicated in the picture, both those between themselves, both those from the cement borders.
The compressor bed, positioned on the level ground of the container, releases his weight on the cement floor (already mentioned) by four feet, that cross the level ground, passing through four respective holes.
During the positioning it's necessary to put the four feet in correspondence of the holes Ø200 but not inside theme.

Each support foot of the compressor bed contains inside a threaded bar M30x3,5 that has to be drowned inside the resin.
Only when the resin is solidified it's possible to unscrew the feet of the bed compressor, and lean it aligned to the ground.
Once the operation of levelling is finished, tighten the metal locking rings M70 of the feet and those M30 of the threaded bar.
(see enclosure 2).

4 SYSTEM INSTALLATION

The compression station is equipped also by electrical, hydraulic and pneumatic circuit.
It's only necessary to make the connection to the electrical net and to that of CNG feeding, after having done the following controls:

- The presence of the voltage (380 V three-phase)
- The presence of the hydraulic oil in the booster circuit
- The presence of the lubrication oil
- The presence of gas in the inlet net
- The presence of cooling liquid
- Filtering / damping / drying group (if necessary)

5 DESCRIPTION OF THE COMPRESSION SYSTEM

The system in his whole is made up of :

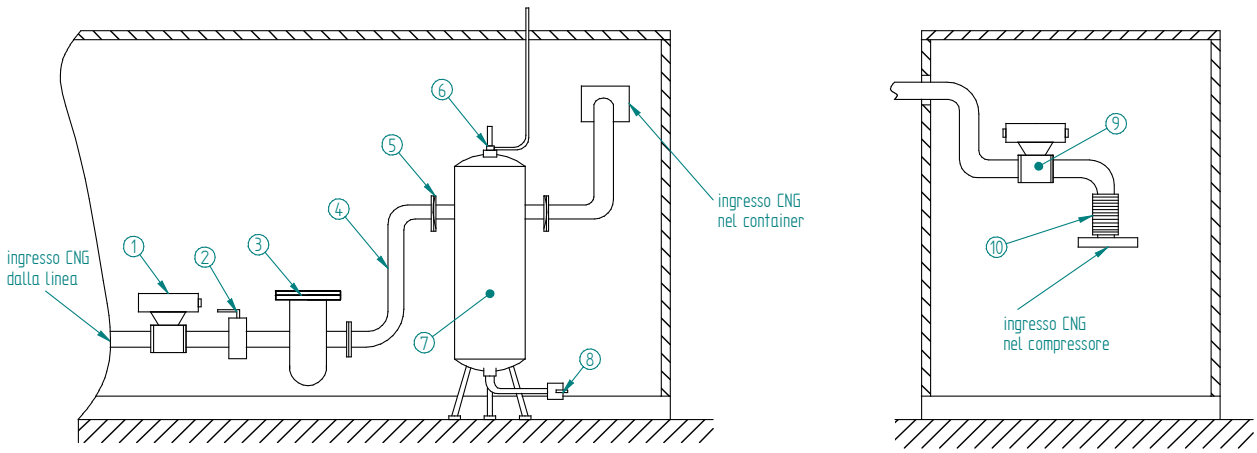
_ One part inside a 20" container that is divided in two separate rooms:

- 1° room in which there aren't pipes containing gas, and that contains the electrical panel (with plc), hydraulic power station (for box handling), and pneumatic panel with air compressor.
- 2° room containing compressor, booster, storage tanks for high and medium pressure, lubrication and cooling equipment.

Separation of the two rooms guarantees the physical isolation of the components that work in contact with CNG (and so subject of ATEX normative) from those used for measurements and that have to be easy to get from the operator.

_ One part outside the container, in which there is the connection to the distribution net.

Here gas is forced to pass through a capacity that helps to damp pressure waves, and inside a mechanical filter able to clean CNG from the impurities, before getting inside the compressor.
The damping capacity and the contingent drying group for CNG are normally optional and have to be agreed with the customer.



1. ball valve with pneumatic actuator 2" (DN 50)
2. ball valve 2" (DN 50)
3. Filter F 1 µm DN 50 and contingent drying group (*see enclosure 3)*
4. pipe 2" (DN 50)
5. junction flange
6. safety valve with connection ¾" M and 1" F (calibrated 15 bar) + connection pipe to vent
7. damping capacity – condensate recovering
8. ball valve ½" for condensate purging
9. ball valve with pneumatic actuator 2" (DN 50)
10. dilation joint 2" (DN 50)

_ Gas distributor (*see enclosure 4)*

5.1 FUNCTIONING SCHEME OF COMPRESSION SYSTEM

CNG is compressed in four stages :

- 3 stages of the compressor: pressure starts with 6 bar and gets 200 bar. Compressed CNG is in part used to fill the medium pressure storage tanks, in part sent to the fourth compression stage.
- 1 stage of the booster: pressure gets 250 bar starting from 200 bar. CNG is sent to the high pressure storage tanks.

Two feeding lines of gas get the gas distributor:

1. CNG going out from the medium pressure storage tanks pass through a condensate separator (*see enclosure 5)* and goes directly to the Gas distributor
2. CNG going out from the high pressure storage tanks, passes through a condensate separator and a pressure reducer (*see enclosure 6),* that brings pressure to 220 bar, than passes through another condensate separator and goes to the gas distributor.

SEE SCHEME 1

Along the CNG way there are pressure sensors, pressure switch, and safety valves.

Pressure sensors give to the PLC the informations about gas pressure, so PLC can use them to make a careful and organic logic of control.

The use of pressure switch allows, in case of necessity, to stop automatically the system when gas gets a threshold pressure value. This value is calibrated differently for each line of the circuit in which the manostat is located (*see enclosure 7)*.

Safety valves intervene sending CNG in a pipe connected to the vent, so to the atmosphere, when it gets too high pressures (more than the calibrated value). (*see enclosure 8)*.

5.2 FUNCTIONING SCHEME OF COMPRESSOR

W90 is an alternative compressor with the cinematic mechanism crankshaft - connecting rod – crosshead – bar - piston; it is made of three cylinders single effect (one for each compression stage).

Suction and exhaust of gas are obtained by a concentric valve with rings and plastic seal.

Suction valves can be open-locked with a pushing-valves moved by a pneumatic system that allows an idling start up of the electrical engine.

Many seals and scraper rings (to prevent the contact of lubrication oil with gas) work on the stem that moves the pistons.

Between the seals there are many holes that allow purging to the vent the eventual lost gas.

Gas liners, lubrication oil, and CNG going out from each stage are cooled by a cooling water circuit.

The compression cycle is managed by PLC thanks to the measure, made by the pressure sensor, of the pressure in the storage tanks.

Gas is taken from the damping capacity and sent inside the compressor room, using steel pipes with flanged joints.

The connecting suction to the first stage is made by an assail compensator and a ball valve with pneumatic actuator.

At the source of the valve, gas pressure in the net is measured to verify that its value is contained in the functioning limits of the compressor.

CNG gets inside the first stage passing through the central section of the concentric valve and goes out through the external section, winning the force made by the springs and by the pressure at the discharge of the valve.

The temperature of the gas at the going out of the compression stage is measured by a thermocouple positioned on the pipe near the connection.

On a metallic block are positioned a pressure gauge, a pressure sensor, a calibrated safety valve and a discharge ball valve for purging the first stage.

On the outlet of the metallic block there is a ball valve with pneumatic actuator that gets the gas before going in the heat exchanger water-CNG.
After having been cooled, gas is compressed in the second stage passing through a concentric valve similar to the one of the first stage.
At the outlet of the stage, gas temperature is measured by another thermocouple and CNG pass through another metallic block similar to that of the first stage.
Ball valve with pneumatic actuator intercepts gas before the inlet in a heat exchanger water-CNG.
After the heat exchanger gas passes in a condensate recovering equipped with ball valve for condensate purging.
CNG is compressed in the third stage and makes the same circuit descript for the second one.
At the outlet of the condensate separator of the third stage, gas in sent to the medium pressure storage tanks, passing through a metallic distributor block in which are mounted a check valve (inlet), a pressure switch, a pressure gauge, a pressure sensor (for PLC management) and a ball valve .
SEE SCHEME 2

5.3 FUNCTIONING SCHEME BOOSTER and HYDRAULIC CENTRAL

Hydraulic central is positioned in the electrical panel room and gives pressure to the oil used for booster handling, so that a fourth compression stage is made.
Booster is double effect, so makes compression in both directions (going and back) and sends CNG directly in the high pressure storage tanks; alternative movement is handled by an inversion automatic valve and pressure regulators.
CNG getting in and out of the booster passes through four not coming back- valves.
At the outlet of the booster there are: a pressure sensor (to handle booster start up and cut off), a pressure switch and a safety valve connected to vent.
SEE SCHEME 3
Oil is the means that transfers power meanwhile ensures lubrication in the hydraulic circuits.
Temperature range : from -15 to +85 °C
Recommended kinds of oil:

SHELL	TELUS46
MOBIL	DTE25
BERGOLINE	PARATER S46
AGIP	OSO46
IP	HYDRUS46
ESSO	NUTO46

5.4 FUNCTIONING SCHEME LUBRICATION SYSTEM

Compressor is equipped by a forced lubrication system; oil is compressed by an electric engine powered pump. (*see enclosure 9).*
Oil is contained inside a carter realized in the compressor bed and, before getting in the circuit, it passes through a filter and a heat exchanger (*see enclosure 10).*
Oil pressure is 5 bar. A safety pressure switch stops system in case will get under 2 bar.
Oil in pressure is sent to lubricate the compressor crankshaft, his own bearings, the connecting rods and the head cross of the three stages (as described in the scheme); good lubrication of these components is important to guarantee the correct functioning of the compressor.
Check valves (positioned close to the components) and a pressure regulator are used to maintain the correct working oil pressure.
SEE SCHEME 4

Kinds of lubrication oil

It's important to choose the most appropriated kind of oil to guarantee a correct compressor maintenance.
The most important requirements for lubrication oil are:

- Low sediment density
- Good anti-corrosive proprieties
- Emulsion of the condensate in the carter

Only high quality oils should be used, cause of the high thermic weight on compressor.
Choose the oil to use for the compressor lubrication between those illustrated in the following list:

ambient Temperature > 30 °C	**ambient Temperature < 30 °C**	**ambient Temperature < 10 °C**
Rol oil LR/100 CCW	Rol oil LR/68 CCW	Rol oil LR/32 CCW
Agip ricrea 100	Agip ricrea 68	Agip ricrea 32
Tamoil blower 100	Tamoil blower 68	Tamoil blower 32
Fina eolan AC 100	Fina eolan AC 68	Fina eolan AC 32
Shell corena H100	Shell corena H68	Shell corena H32
Shell corena 100	Shell corena 68	Shell corena 32
Excolube 100	Excolube 68	Excolube 32

5.5 COOLING CIRCUIT

It is a liquid cooling system made of:

- heat exchanger air/ cooler-liquid (*see enclosure 11)*
- Pump (*see enclosure 12)*
- heat exchanger cooler-liquid /gas (sheaf pipes and coil)
- heat exchanger cooler-liquid / lubrication oil
- heat exchanger cooler-liquid / hydraulic central oil
- wet sleeve of compressor
- Temperature and pressure sensors
- Expansion capacity

The cooler liquid is composed by water and glycol.
The process of starting up and cutting off the circuit is entirely handled by PLC, the operator has only to verify periodically the pressure in the circuit and purge it using the predisposed valves.

5.6 PNEUMATIC SYSTEM

The pneumatic system work is to put into practice the actuators that are essential for a correct and safe functioning of the machine.
Compressed air can be supplied by an external net, or moved by an electric compressor positioned inside the electric panel room.
The nominal air pressure in the circuit is 6 bar.
Air, before crossing the system and putting into practice the valves, passes through an FR (filter-regulator) group and a 40µm filter, positioned in the pneumatic panel located inside the container.
In the same panel there are also the electro - valves that handle opening and closing of the ball valves with pneumatic actuator.

It's necessary to oblige air to pass through a condensate separator, for having an optimal functioning of the system.

DESCRIPTION	CONSTRUCTOR	CODE	QUANTITY
Electro - valve 5/2 monostable	SMC	SY7120-5YO-02F	2
Electro - valve 3/2 for continuum service	SMC	VO307E-5DO-01F	2
filter regulator	SMC	AW30-F03	1
pressure gauge	SMC	0-10 G1/8 d40	1
pressure switch with extremity adapter	SMC	IS1000E-30-F03	1
condensate separator	SMC	EAMG250-F03	1
filter 40 micron	SMC	AF30-F03-7-40	1

5.6.1 BALL VALVES WITH PNEUMATIC ACTUATOR FOR START UP AND STOP COMPRESSION

The system made up of:

- Electro - valves 5/2 for putting on practice of the two ball valves with pneumatic actuator that are respectively at the inlet and the outlet of the compressor.
  Their work is to cut off from the circuit the compression stages, during the start up.
- Electro - valves 5/2 for putting on practice of the two ball valves with pneumatic actuator between the stages and the push – valves.
  Their work is allowing the functioning without compression of the compressor.
- Electro - valves 3/2 for putting on practice of the two ball valves with pneumatic actuator that allow the purging of the gas in the compressor during the stopping phase.

SEE SCHEME 5

5.6.2 BALL VALVES WITH PNEUMATIC ACTUATOR FOR THE SAFETY SYSTEM

The system is made up of an electro – valve that puts on practice the three ball valves with pneumatic actuator normally closed; these one allow the opening and closing of the gas at the inlet (connecting to the methane net) and outlet of the system (lines of high and medium pressure).
SEE SCHEME 5

5.6.3 GAS VALVES IN COMPRESSOR

The head - valves of the alternative compressor are the superior part of the cylinders.
The concentric ring – valves, that allow both suction and discharge of the gas in one only assembled component, are positioned inside the head – valves.
During the starting phase, the valves get the open position and the fluid goes in the cylinders.
Once refilling is done, compression begins: valve closes the inlet passage and the fluid, once compressed, opens the valve in outlet direction.
The handling phase of valve opening and closing happens automatically, thanks to the calibration of a series of springs and to the pressure strength of the gas contained in the pipes.

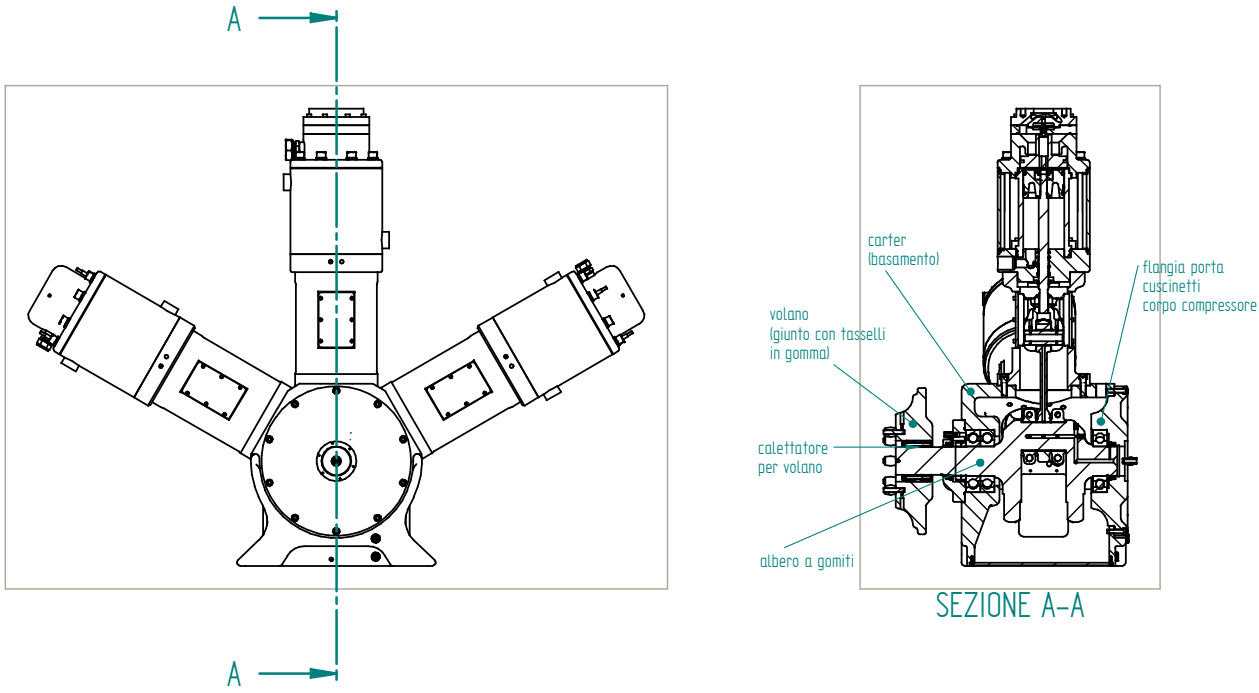
5.6.4 SAFETY VALVES

POSITION	PRESSURE CALIBRATION	CONNECTION M	CONNECTION F
damping capacity	15 bar	¾" NPT	1" NPT
outlet 1° stage	35 bar	¾" NPT	1" NPT
outlet 2° stage	90 bar	¾" NPT	1" NPT
outlet 3° stage	242 bar	¾" NPT	1" NPT
outlet booster	275 bar	¾" NPT	1" NPT
medium pressure storage tanks	242 bar	¾" NPT	1" NPT
high pressure storage tanks	275 bar	¾" NPT	1" NPT
Outlet pressure reducer	242 bar	¾" NPT	1" NPT

6 COMPONENTS ASSEMBLY

6.1 COMPRESSOR

The engine is connected to the compressor by a rubber plug joint.
The half part of the joint that is located on the compressor crankshaft is locked with a closing sleeve and it works also as flywheel.
The other half part, on the shaft of the electric engine, is fixed with a key.
The crankshaft, that keeps the three stages on moving, is located in the compressor bed with a ball bearing in one side and a couple of angular bearing in the other side (on the keep bearing flange).



6.1.1 DESCRIPTION and ASSEMBLY OF THE COMPRESOR BED

SEE EXPLODED 1:

Assembly has to be done following the operations in the same order that is possible to reed here:

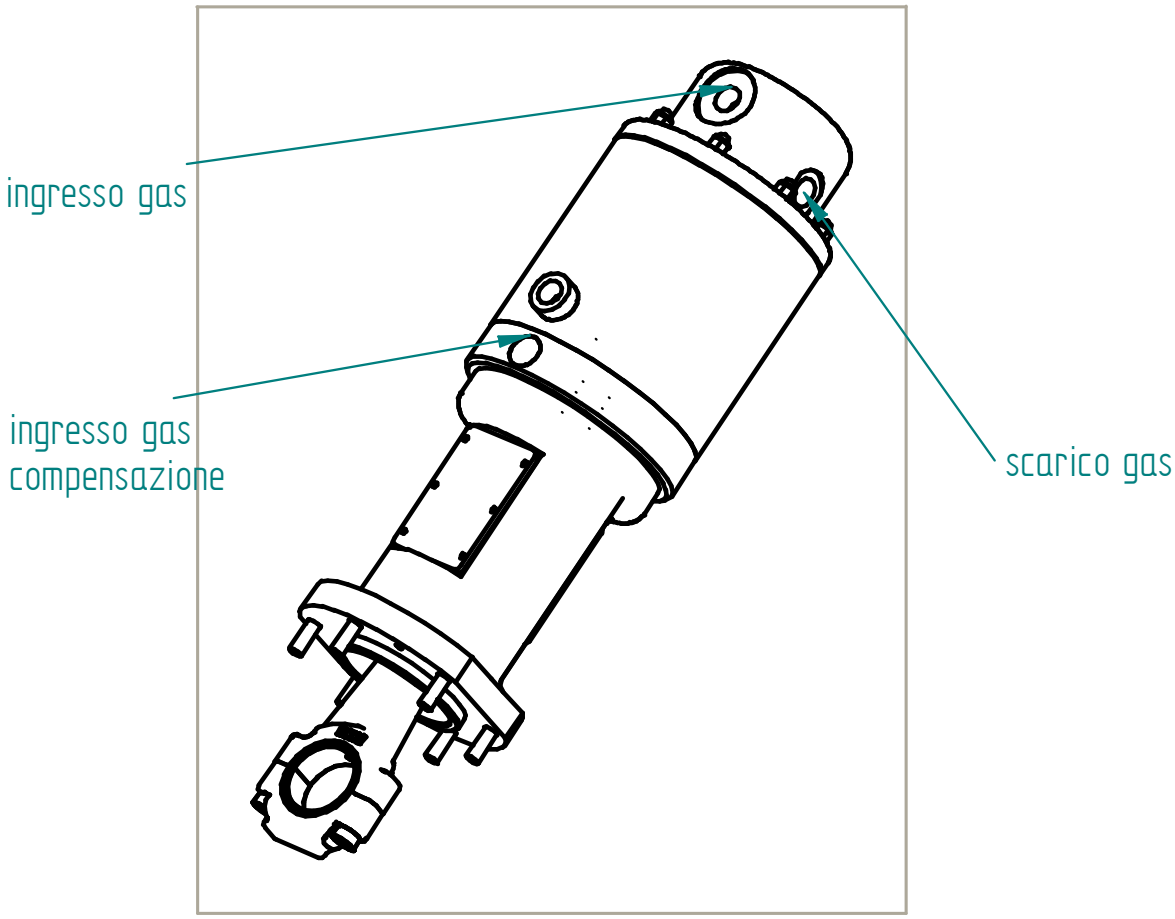
- put bearing 16 on the shaft 5
- Insert screw 15 on shaft 5
- Insert segger 17 on shaft 5
- Insert shaft inside bed compressor 1
- Insert bearing 6 on shaft 5 (“O” assembly)
- Insert ring nut 7 on shaft 5
- Insert o-ring 11, oil seal 9, and segger 8 inside the locking bearing flange 12
- Insert oil seal 18 and segger 8 inside the support bearing flange of the compressor

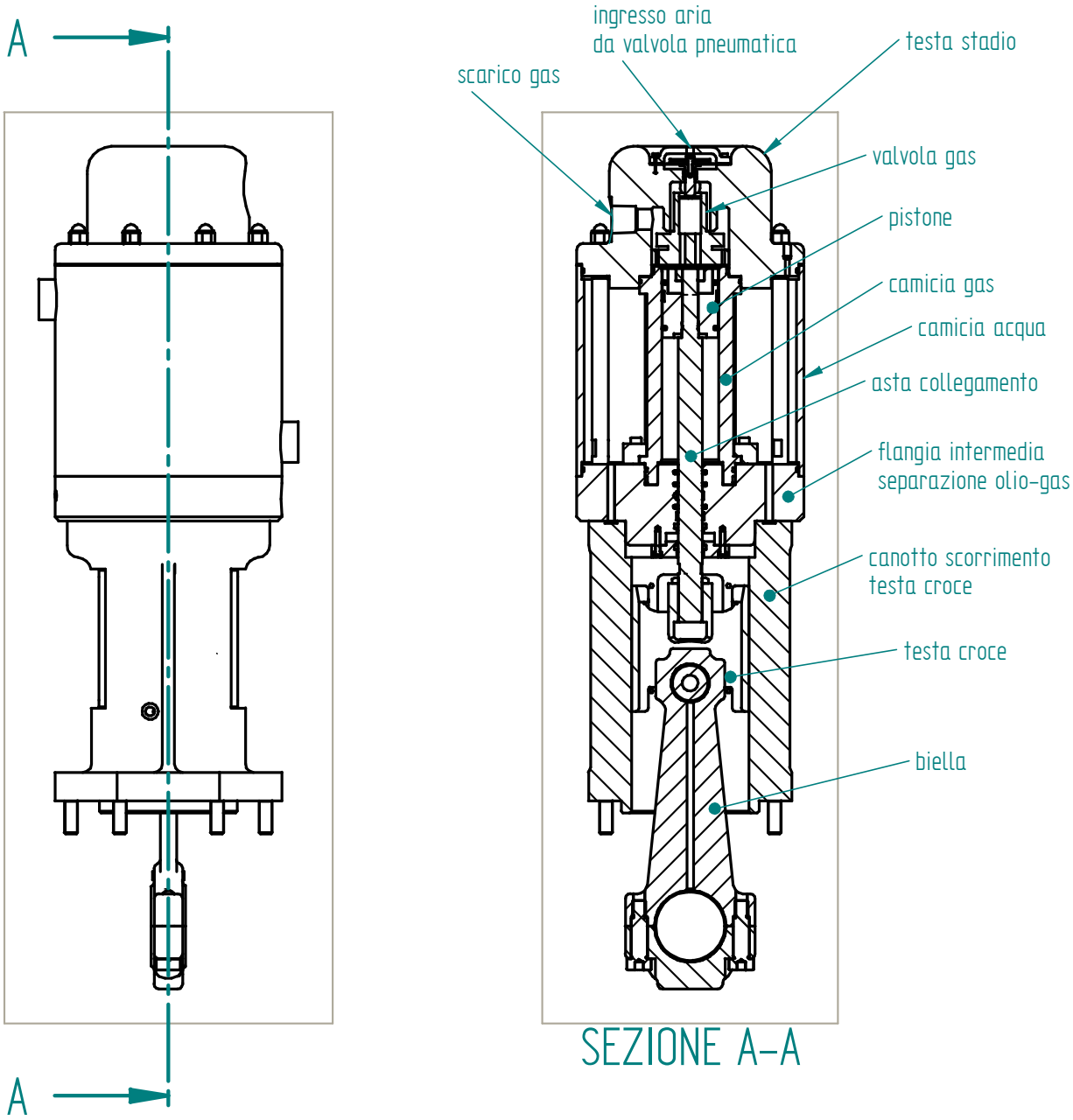
- Insert flange 12 on shaft 5 and lock it on the bed compressor using screw 13
- Insert the support bearing flange of the compressor on the bed compressor fixing it with the screws 20
- Insert segger 10 on shaft 5
- Insert bearing 22 on the two components of the connecting rod (23 e 25). Repeat the operation for all the connecting rods
- Insert bearings 26 on the small end of the connecting rod and repeat the operation for each connecting rod
- Put the crossheads on the connecting rods inserting pins 31 and locking them with screws 33
- Put the crosshead liner 27 on the respective holes on the bed compressor and lock them with screws 30
- Position the stem of the connecting rod 5 inserting it through the respective holes in the bed compressor, and making it slide with its crosshead inside the crosshead liner.
- Insert the respective inferior parts of the connecting rods and lock them to the superior using screws 24 .
  Use the lateral windows of the bed compressor for the passage of those components.
  Tightening torque 160 Nm
- Close the lateral windows of the bed compressor with the lid 3 using screws 38.
- Screw the bar 36 to the crosshead and insert the ring nut 35.

TIGHTENING TORQUES:

NUMBER OF THE COMPONENT IN THE EXPLODED	SCREW THREAD	TIGHTENING TORQUE [Nm]
Bolt (13)	M10X50	15
Bolt (20)	M12X50	85
Screw nut (24)	M16	160
Bolt (30)	M10X50	200

6.1.2 DESCRIMPTION AND ASSEMBLY OF THE SINGLE STAGE





SEE EXPLODED 2 _ 3 _4 :

Assembly has to be done following the operations in the same order that is possible to reed here: (same operations for each stage)

- Insert the gaskets 2, the guide rings 3 and the scraper ring 4 inside the intermediate flange 1.
- Put on the oil side of the flange 1 the lid-support-seal 5 and fix it with screws 6.
- Put the flange 1 on the crosshead liner fixing it with the screws 7.

- *Positioning of the gas piston:*
    1. put the washer on the bar making it slide till the beat that is made on the bar.
    2. put the guide and the E/DWR on the pistons
    3. make the piston go down on the bar making it lay on the washer.
    4. close with the ring nut and the counter-ring nut on the final screwed part of the bar, locking, in this way, the position of the piston
- Put the o-ring 9 on the gas liner 10
- Put the gas liner 10 on the intermediate flange 1 (lodging it in the respective seat) and fix using the locking dowels 11 (to lock with the bolts 12 on the flange)
- Insert the screwed bars 8 in the respective screwed seats on the flange 1
- Insert the o-ring 15 and the water liner on the flange 1
- Insert o-ring 13 e 14 on the water liner
- Insert gas valve 17 with their respective aluminium rings inside the head stage 18
- Insert the o-ring 15 on the head stage 18 and put that laying on the water liner 16
- Lock the position of the head stage with the screw nuts 20. Tightening torque 175 Nm
- *Positioning push-valves:*
    1. insert o-ring 21 in the respective seats on the head stage
    2. put, one on the other, push-valves-pan 24, membrane 23 and pushing-bar 22, and fix them using bolts 25
    3. put all the descripted group up on the head of the compression stage having care to insert the pushing bar in the apposite hole and close with the lid 26 (fix it with bolts 27) .

TIGHTENING TORQUES:

NUMBER OF THE COMPONENT IN THE EXPLODED	SCREW THREAD	TIGHTENING TORQUE [Nm]
Bolt (6)	M6X25	10
Bolt (7)	M14X80	120
Bolt (12)	M8X40	25

REGULATION OF THE DEAD ZONE ON THE GAS LINER:

The end clearance between piston and valve is 2 mm

Note
It's necessary to observe this regulation to avoid the danger of an impact between piston and valve (with consequent breaking of the system) or lowering of the compression efficiency.

For making this regulation, it's enough to screw the bar on the crosshead till right position.
Once regulated the end clearance of the piston (considering also the aluminium ring between the gas liner and the valve), it's possible to lock the bar crewing the ring nut signed as 35 in the enclosure 1.
Accessing to the bar, during the regulation, is possible thanks to the windows positioned on the crosshead liner.

6.1.3 RING - T.F.E. (seal), GUIDE RING (E-I DWR) , SCRAPER

RING - T.F.E. (seal)

Many cases of bad functioning of the mechanical components, that constitute the system, are due to the wrong assembly of the seals.
It's indispensable, in case of replacement of one of these components, before assembling the seals and the liner, to make a series of controls and cling on the following recommendations:

- Make a careful washing of all the components, so that they will result perfectly clean and free from metallic particles, scum, scratches or superficial imperfections
- Lubricate the seal and all the metallic components with will be in contact during the exercise, using the same fluid foreseen for the system or another compatible one.
  It's necessary to avoid the use of grease, much sticky oils or antioxidant fluids that leave solid films in correspondence of the rims of the seal.
  It's better not to exceed in the quantity of the lubricant because, during the first cycles of the movement, it's possible to find an emission of a small quantity of fluid, due to the adjustment of the seal in its seat when it's pushed by the pressure.
- Insert the seal acting on it in an uniform way, and avoiding the use of metallic tools with sharp corners. Don't let the seal strongly deformed for too much time.
- Verify the exact orientation of the seal respect the direction of the fluid and control the perfect assembly of the components.

It's suggested to leave them in hot water (60°C) for a few minutes, to make easier the assembly of these components on the gas cylinders, before putting them in their seats.

7 START UP and STOP OF THE COMPRESSOR

The start up of the compressor is in part handled by PLC and in part made manually by the operator.

WARNING
In case of first start up, after a long time of inactivity or after the maintenance, it's necessary to purge the gas circuit with an inert gas and test the functioning of the seals.

7.1 START UP OF THE COMPRESSION SYSTEM

Check the closure of the manual ball valves for purging.
Check the aperture of the manual ball valves in the inlet and outlet of the storage thanks, of the booster, of the reduction pressure panel and of the gas distributor.
Connect the system to the electrical feeding and give power to the electric panel, put in the ON position the general switch on the operator panel.
Press the start button.
The request to make a series of control appears on the electric panel :

- Make condensate purging
- Close purging
- Check lubrication oil level on the methane compressor
- Check lubrication oil level on the air compressor
- Check lubrication oil level on the hydraulic central
- Check cooling liquid level
- Open ball valves for gas net connection
- Be sure no one is inside the compressor room
- Be sure the accesses to the compressor room are closed

Confirm the execution of these controls pushing the button indicated by PLC.
PLC leads the opening of the three pneumatic safety valves positioned outside of the compressor room, the closing of the pneumatic valves for inlet first stage and outlet third stage and the operation of the inlet push-valves.
PLC controls the pressure of the methane coming from the distribution net and of that contained inside the storage tanks, verifying that their values are included in the established ranges.
If all the conditions are respected it begins the start up of the lubrication oil pump, and after a variable time (it depends on the temperature), begins the start up of the electric engine of the compressor.
Basing on the temperature taken by the sensors, PLC handles the start up and the stop of the cooling circuit pump and of the cooling fans located in the heat exchanger water-air.
Reached the running speed, PLC handles the opening of the ball valves in the compression circuit and the deactivating of the push-valves.
It begins the compression of the gas (CNG).

7.2 NORMAL START UP OF THE COMPRESSOR

Once the first start up has been done, the compressor is automatically started and stopped by PLC, basing on the pressure value reached in the storage tanks.
Handling of these phases is entirely led by PLC.
When pressure value is inferior of an established one, PLC leads a new start up of the compressor, while when it is superior to a threshold value, orders the stop.

7.3 NORMAL STOP OF THE COMPRESSOR

When the filling pressure of the storage tanks, imposed by PLC, is reached, compressor stops working.
Suction valve at the first stage is closed and so the compressor arrested.
Once closed the valve positioned on the outlet of the storage tanks, purging is executed with the apposite valve after the third stage that connects the outlet from compressor to the inlet damping capacity.
Lubrication and cooling circuit pumps are stopped after a variable time (it depends on the temperature of the cooling circuit) by PLC.

8 CONTROL and MAINTENANCE

8.1 CONTROL PLANT

Daily controls

- Oil level: CNG compressor, booster air compressor
- Condensate purging in CH4 circuit
- Air purging in cooling circuit
- Pressure cooling liquid in the closed circuit
- Condensate discharging in the pneumatic circuit and in the separators on the CNG line
- Check of working pressure in the inlet and outlet of the stages
- Value of the suction pressure
- Values of the medium and high pressures
- Verify the working pressure of the air compressor and of the hydraulic central

Weekly Controls

- Check the presence of eventual losses of liquid in the closed circuit
- Check the conditions of pipes and connections

Monthly controls

- Check safety valves of the closed circuit of the cooling circuit
- Check values of the pressures in the box with the pressure gauges
- Clean the gas valves on booster and on compressor

Six-monthly Controls

- If necessary change oil filters
- Clean filters on the measure unity
- Clean the inlet gas filter
- Check gas and pneumatic valves
- Clean condensate separators
- Clean the heat-exchanger oil-water on the machine
- Clean the heat exchanger air-water
- Check the good functioning of the oil pump
- Check the good functioning of the safety valves
- Check the good functioning of the minimum gas pressure switch

Yearly Controls

- Disassembly from the system and test the good functioning of the safety valves
- Check the generic functioning of the compressor, comparing red values with the projected ones of the following parameters: pressure, temperature, vibrations, losses
- Check the correct functioning of the electric panel and of the put to heart
- Verify the functioning and the calibration of all the pressure switches located in the system

OPERATION	FUNCTIONING HOURS LIMITS
Change oil filters every	50 (1° substitution) 500 (2° substitution) 2000 (following substitutions)
Change lubrication oil compressor	50 500 2000 4000
Change hydraulic oil for the feeding of the booster	4000
Change gas filters	2000
Change seals on pistons	8000
Change oil scrapers	8000
Clean valves of the compressor	2000

WARNING
The intervals of maintenance are given according to functioning standard conditions and to the utilisation of good quality of materials and filters.
All the intervals can be changed basing on the CNG composition and on the working conditions; so these must be considerate as indicative and changeable according with the constructor basing on the executed tests and on the available values obtained.

WARNING
Maintenance and functioning tests have to execute only by technical personal adequately qualified and authorized by the constructor and by the eventual national body in charge.

8.2 LUBRICATION SYSTEM OF THE COMPRESSOR

8.2.1 CONTROL OF THE LEVEL AND EXCHANGE OF THE OIL

The oil cup capacity is 12 LT.
Check every day the level of the oil, by using the two spy holes located on the frontal part of the bed compressor, before giving power to the compressor.
The level of the oil must not be under the minimum value; otherwise serious problems could happen for lubrication deficiency.
It must not exceed the maximum value otherwise excessive lubrication could cause oil drawing between the seals.
Don't forget to change oil every 4000 H o once every year at least.

Instructions:

- Discharge completely oil when it is still hot
- Check valve radiators and flexible pipes for eventual sediments

If there are sediments, proceed as following:

- Replace or clean the components in which sediments have been found
- Fill the compressor with new oil
- After 100 working hours check the contamination level of the lubrication oil; change it yet if necessary

- Fill the compressor only with same type of oil

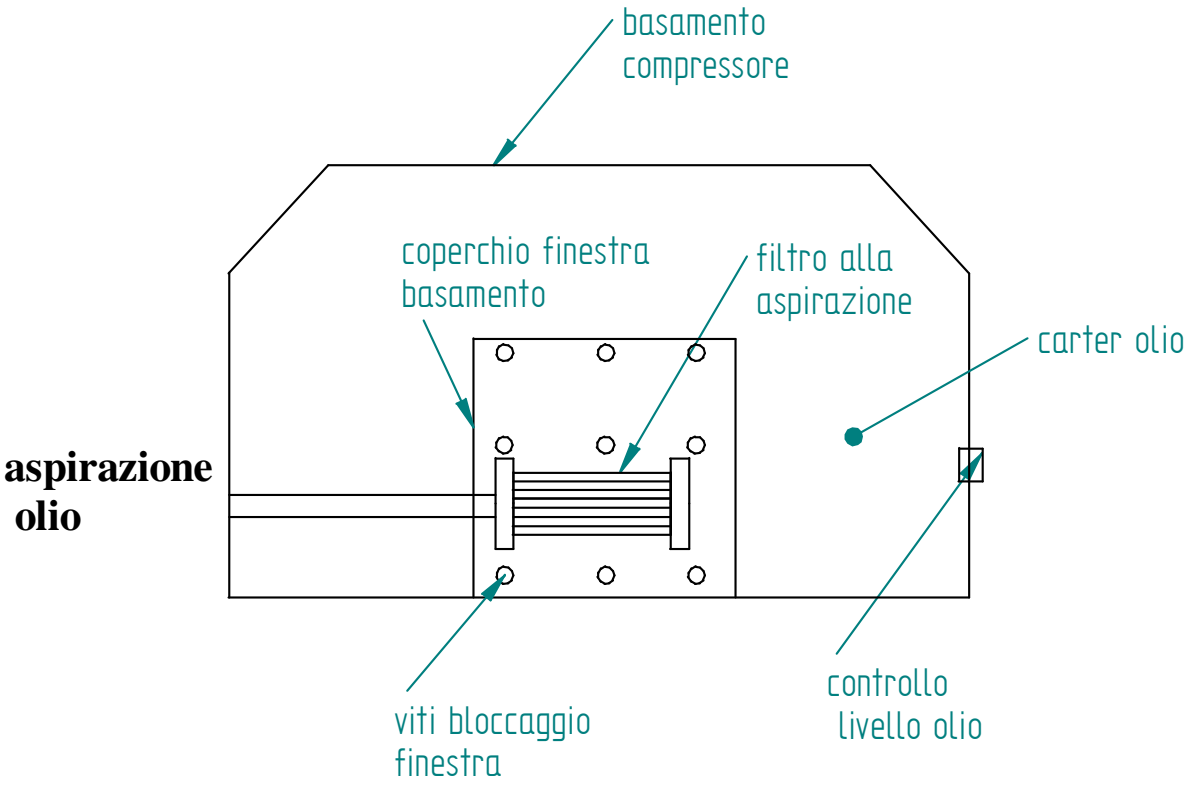
Oil exchange:

- Let the compressor get the working temperature
- Open ball valve located in the frontal side of the bed compressor and leave the oil flowing away.
- Unscrew the bolts located on one of the lateral lids that are on the bed compressor and take it away.
- Take away manually the oil that is laying on the bottom of the compressor, take away, using a cloth, the eventual remaining sediments.
- Re-close the lateral lid.
- After having closed the ball valve, unscrew the bolts of one of the lids located on one of the crosshead liners.
- Put oil through the window on the crosshead liner
- Close the lid using the bolts

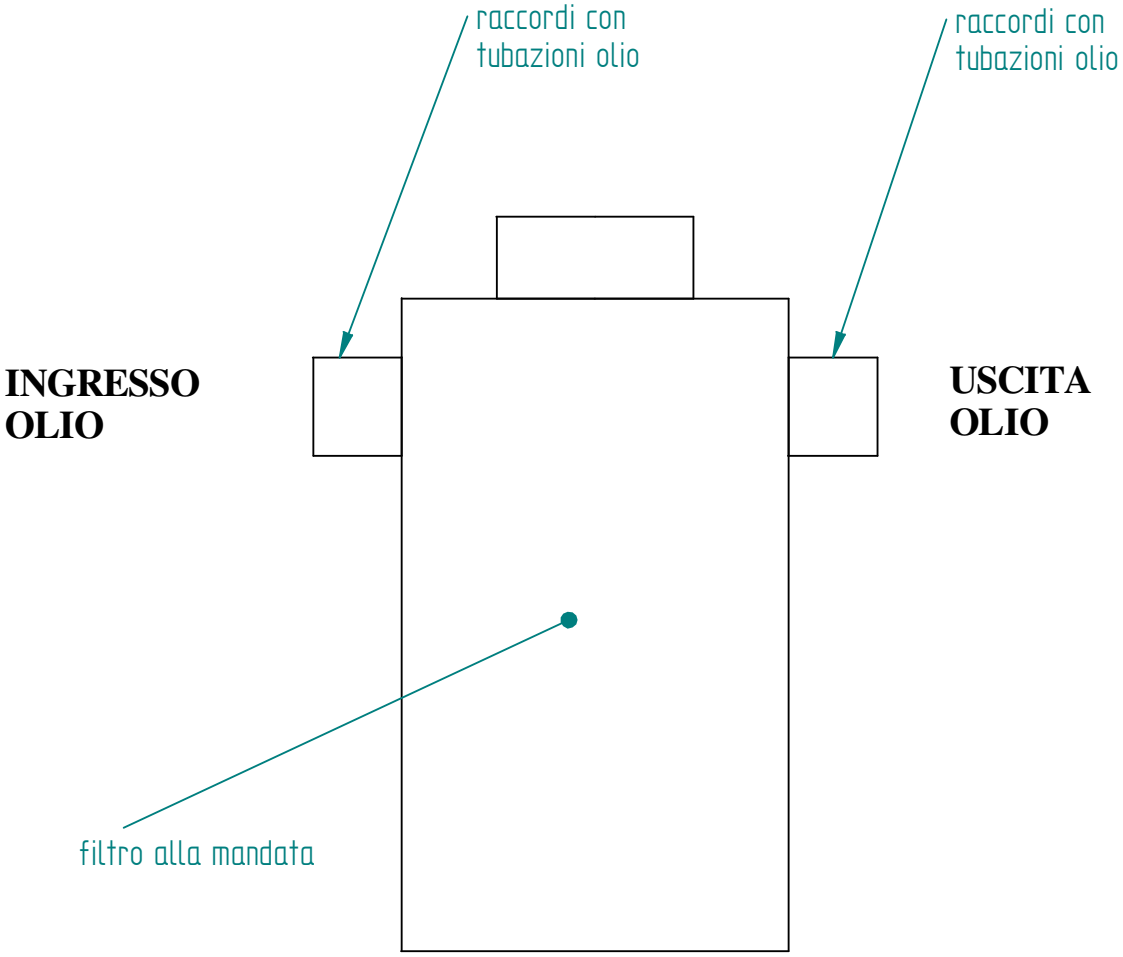
8.2.2 OIL FILTERS EXCHANGE

It's a suitable thing to change oil filters each oil- change

- *Removing suction filter*:
  Take away the oil
  Take away bolts on one lid located on the bed compressor, and the lid itself
  Exchange the filter (located inside the bed compressor).
  Close the window with the lid and its bolts

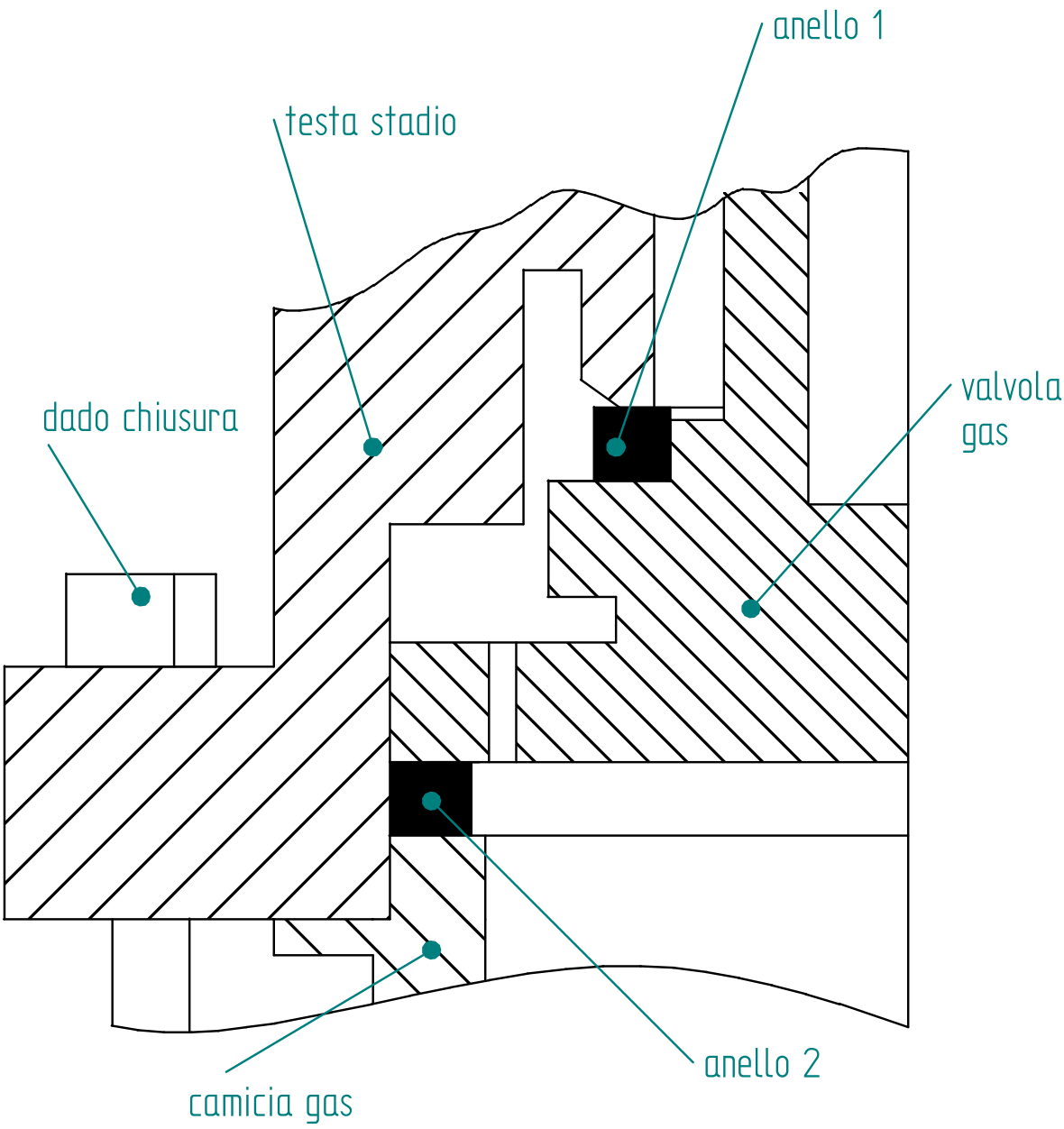


- *Removing delivery filter*:
  Take away the oil, disassemble inlet and outlet connections from the filter, exchange the filter and connect it.



Every 2000 working hours First change after 100 working hours from the start up of the compressor Second change after 500 working hours Third change after 2000 working hours

8.3 MAINTENANCE GAS VALVES OF THE COMPRESSOR



Follow the next instructions for gas valves maintenance:

- Unscrew the nuts that lock the compressor head
- Extract the aluminium ring 1
- Extract the valve
- Extract the aluminium ring 2
- If damaged, insert new aluminium rings
- Insert again the cleaned valve
- Set again the la compressor head
- Tighten the nuts with a 175 Nm Tightening torque

9 PROBLEMS – POSSIBLE DEFAULTS AND-REMEDIES

PROBLEM	DEFAULT	REMEDIES
If pressure is inferior than Pmin and compressor doesn't start working	- deficiency of electric energy	- wait the electric restoration current and make the start up again
	- burned fuses	- change the fuses
	- general switch damaged	- change the general switch and make the start up again
	- electric engine damaged	- change the electric engine
the electric engine doesn't start	- engine starter damaged	- Reset the starter or change it if it is damaged
	- pressure sensor or discharge damaged	- change the sensor
Low pressure of the lubrication oil	- oil pump doesn't give pressure to the circuit	- check the level of the oil - if dirty, change oil filter - Verify the pump functioning
Heads of the compressor are hot	- deficiency of the cooling system	- Check water circuit - discharge air on the heads
	- compressor valves are dirty or damaged	- Check gas valves - clean gas filter
Excessive increase of the pressure in single stage	- dirty inside the gas valves refrigerator filters	- Check and clean gas valves - clean gas filter - clean pipes of the cooling system
	- inter-stage valves don't function	- exchange the valves
Compressor doesn't give the correct flow	- valve disks are damaged - electric engine is damaged	- Check gas valves and exchange those damaged
	- gas loss across the safety valves; across seals and connections	- Check the correct functioning of the safety valves and exchanged the damaged ones
Anomalous pulsations in pipes that contain gas	Damage of these components: valves safety valves, gas filters	- Check the functioning of these components and exchange those damaged
Gas pressure in stages doesn't get the exact values	- gas valves dirty - Possible lowing of the suction pressure	- clean gas valves - check the pressure in the suction pipes

Anomalous vibrations of the compressor	- misalignment of the elastic joint and of the fly wheel	- line it up using a dial indicator (tolerance $^{+}_{-}$ 0.08 mm)
	- damage of the gas valves	- call the assistance
	- Damage of mechanical components inside the compressor	- call the assistance
Oil losses	- release of the connection along the circuit	- tighten the connection
	- water pipe or oil pipe damaged	- exchange damaged components
Loss of water	- release of a connection along the water circuit	- tighten the connection again
	- safety valve open	- if necessary, exchange valve or too low pressure
	- water pump damaged	- if necessary, exchange the damaged components
Booster doesn't invert the cylinder movement	- electro-pneumatic system for the inversion is dirty or damaged	- Disassembly and clean the components, assembly again. If problem persists exchange the damaged components
	- gas pressure on suction is too low	- increase the suction pressure of the compressor
	- oil pump doesn't give pressure because is damaged or oil filter is dirty	- check the pump functioning
Il booster doesn't start	- oil level too low or outlet pressure too high	- Insert oil, clean gas valves, check the storage pressure
Safety valves are open	- safety valves are dirty	- Check the storage pressure, if correct clean safety valves
	- pressure sensors and pressure switch are damaged	- change them

10 DEMOLITION AND DRAINING

All the materials composing the system are recyclable and so it is suggested to supply to the demolition and draining of its components in a differentiated way, taking care of their different nature (e.a. metals oils, plastic and rubber, copper, aluminium ecc…) and entrusting the specialized enterprises qualified on this work.

LIST OF REPLACEMENT COMPONENTS

1.	FE480005 BEARING Ø44XØ48X45
2.	FE 480003 BEARING Ø85XØ88.5X51.25
3.	CD 480003 REGULATING VALVE 3/8”
4.	GO480003 OIL SCARAPER Ø90XØ110
5.	FE480006 RADIAL BEARING Ø90XØ190X43
6.	GO480004 OIL SCARAPER Ø85Ø110
7.	FE480008 ANGULAR BEARING Ø90XØ190X43
8.	GO480001 SEAL STEM I/GR 0300
9.	GO480002 GUIDE RING I/DWR30/2
10.	PL480001 OIL SCRAPER UWR118149
11.	OR484412 OR 4412 Ø104.37X3.53 + BK
12.	OR484350 OR 4350XØ85.32X3.53 +BK
13.	OR480171 OR 171Ø68.26X3.53 +BK
14.	OR480001 OR Ø262X3.53
15.	CD480001 GAS VALVE GAS 8586
16.	OR900115 OR 115XØ11.91X2.62
17.	115-8221 MEMBRANE PUSH-VALVE (KIT)
18.	GO480003 SEAL E/GR0400
19.	GO480004 GUIDE RING E/DWR0400
20.	OR483475 OR 3475XØ120.32X2.62
21.	CD 480002 GAS VALVE 8693
22.	GO480005 SEAL E/GR0700
23.	GO480006 GUIDE RING E/DWR0700
24.	OR484625 OR 4625XØ158.34X3.53 +BK
25.	OR483650 OR 3650XØ164.77X3.53
26.	OR483600 OR 3600XØ164.77X3.53 +BK
27.	CD480005 GAS VALVE 8584/A
28.	OR483625 OR 3625 Ø158.42X2.62
29.	OR482375 OR 2375 Ø94.97X1.78
30.	GO480007 SEAL E/GR1250
31.	GO480008 GUIDE RING E/DWR125