DEPARTMENT OF AEROSPACE ENGINEERING

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Course	:	**19AST301 - Space Propulsion**			

UNIT IV - CRYOGENIC EQUIPMENT

Cryogenic Compressor

The HC-4 MK2 Compressor is a single-stage, water-cooled, rotary compressor designed to deliver high-pressure, oil-free, helium gas to cryogenic refrigerators. An expander cable connected to the compressor supplies electrical power to the expander. Self-sealing couplings allow for easy connection to and disconnection from the rest of the closed-cycle cryogenic refrigeration system.

PRINCIPLES OF OPERATION

The compressor continuously draws low-pressure helium from the system return line. It compresses, cools and cleans the gas, then delivers it through the system supply line to the expander.

When gas leaves the compressor, it contains heat and compressor lubricant. Both must be removed. From the compressor, the hot gas with its entrained oil flows over the motor winding, where the gas loses some of its suspended oil, then out of the shell and through one circuit of

a three-circuit heat exchanger, where the gas is cooled. Next, the gas passes through the oil separator and the adsorber for oil and moisture removal. From the adsorber, the high pressure gas is piped to the expander. Through the system gas return line, low-pressure gas from the expander flows into the compressor.

A gas line containing an internal bypass valve connects the high-pressure line to the low• pressure line. The bypass valve will open to prevent overloading the motor when the system gas lines are not connected to the compressor.

Oil is separated from the gas in three stages. The first stage is by precipitation when the gas passes over the motor windings. The second-stage is the oil separator whose element collects oil mist from the gas, agglomerates it and returns the oil to the compressor. The third stage is the adsorber which removes any remaining oil the gas is carrying.

Oil collected in the separator flows back to the compressor through a capillary tube. The differential gas pressure across the system is the moving force, and the capillary size limits the amount of gas bypassed. The small amount of oil collected in the adsorber remains there and is removed only by replacing the adsorber.

Oil in the compressor housing also collects heat. The shell-wrapped heat exchanger removes heat from the compressor motor and the warm oil by direct conduction through the compressor shell. Gas pressure pushes oil through the heat exchanger's outer tubes which cool the warm oil from the compressor. This cooled oil is then reinjected into the gas return line, which returns the oil to the compressor to reabsorb heat and lubricate the compressor.

PRINCIPLES OF OPERATION

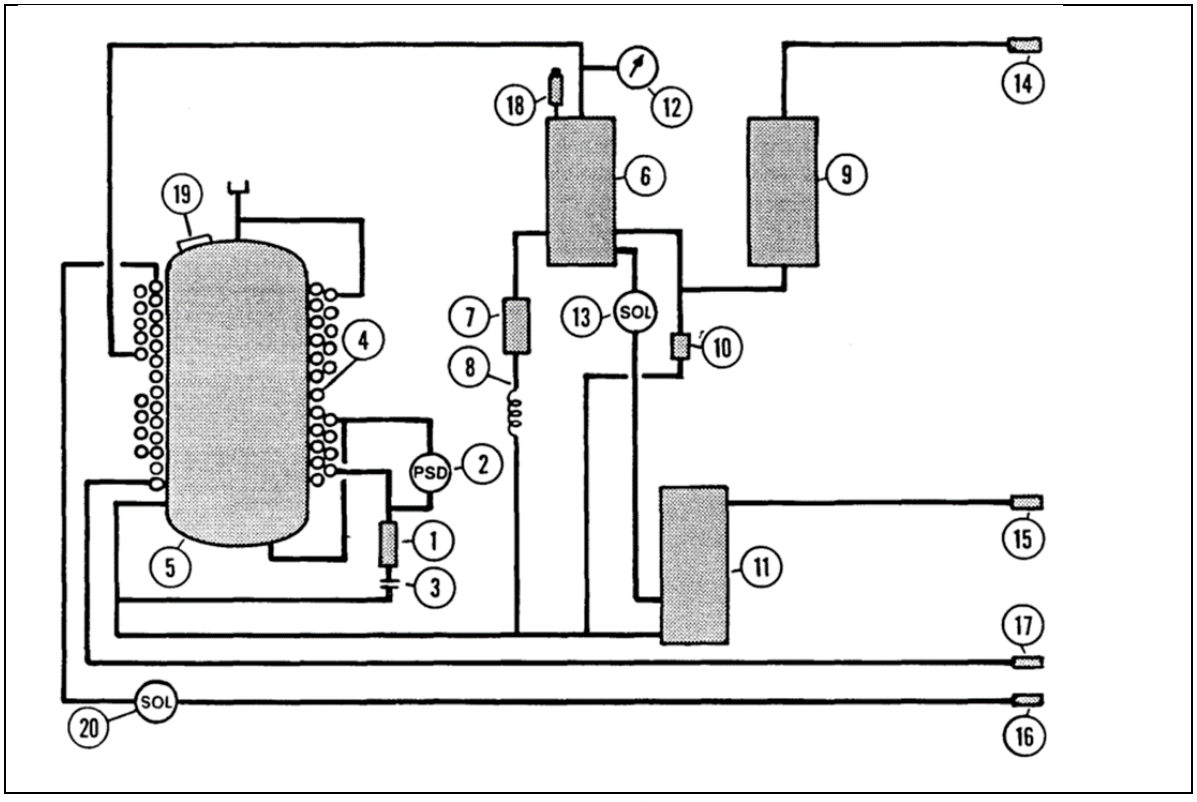


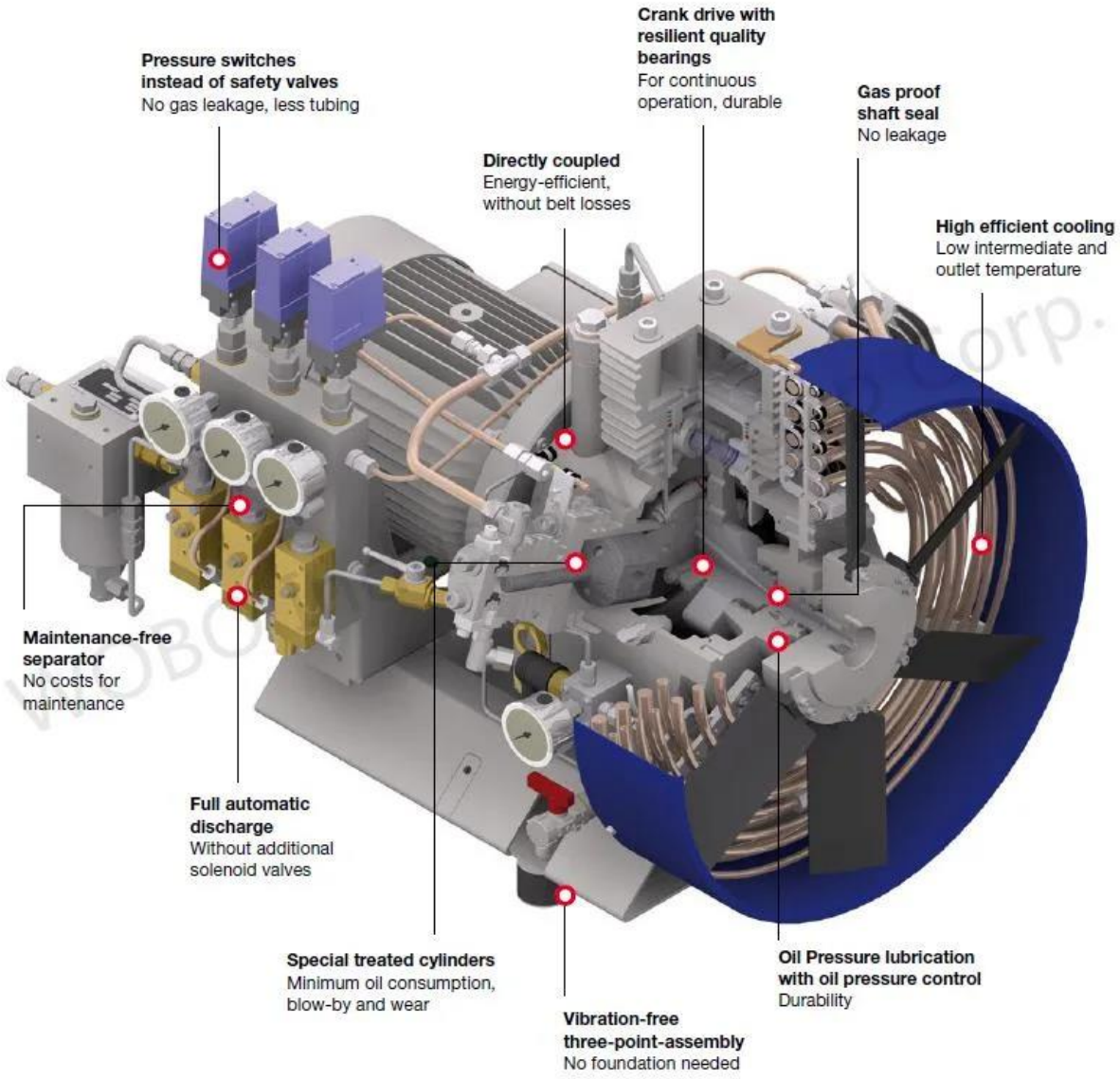
Fig 1 Compressor Flow Diagram

1. Oil Line Filter
2. Oil Differential Pressure Switch
3. Oil Injection Orifice
4. Heat Exchanger
5. Compressor
6. Oil Separator
7. Oil Capillary Filter
8. Oil Capillary
9. Adsorber
10. Internal Bypass Valve
11. Surge Bottle
12. Pressure Gauge
13. Gas Equalization Solenoid Valve
14. Gas Supply Coupling
15. Gas Return Coupling
16. Water Supply Fitting
17. Water Return Fitting
18. Pressure Relief Valve
19. Temperature Overload Switch
20. Water Solenoid Valve

DESCRIPTION

The components of the HC-4 MK2 Compressor are identified schematically in Fig. 1. Figures 2, 3 and 4 identify the parts pictorially. Features and functions of individual components are described in the following paragraphs.

Components



Gas Supply and Return Couplings -- Both are self-sealing bulkhead couplings and are the points of connection on the rear panel for the rest of the system.

Water Supply and Return Fittings -- Both fittings are compression-type bulkhead fittings mounted on the rear panel, for 3/8" tubing.

Compressor Power Cord -- Terminating with a 3-prong plug, this power cord supplies electrical power to the compressor.

Elapsed Time Meter -- The battery-operated LCD elapsed time meter shows the compressor's cumulative runining time in hours up to a total of 99,999 hours.

Power Switch -- This on/ off switch starts and stops the compressor. The switch lights to indicate that power is on to the compressor.

Pressure Gauge -- A pressure gauge indicates gas supply pressure. When the compressor is not running, the gauge shows the equalization pressure.

Expander (Displacer) Receptacle and Expander Cable -- A 28-socket receptacle mounted on the rear panel and an expander cable supply electrical power from the compressor to the expander.

Accessory Receptacle and Optional Cables -- The accessory receptacle mounted on the rear panel is a 14-socket connector for supplying auxiliary power or remote on/ off control. The remote on/ off and auxiliary power cables are available as options.

Circuit Breaker -- A panel mounted circuit breaker in the main power supply protects the compressor module from electrical overload.

Fuses -- Two 0.6 ampere fuses in the expander circuit and one 0.6 ampere fuse in the primary of the control transformer are accessible in the rear panel. Two 5 ampere fuses in the auxiliary power circuit (from the accessory receptacle) are located in the electrical chassis.

Electrical Chassis Box -- The electrical box contains electrical components and connections and distributes power to all system circuits. It is accessible by removing the top cover of the compressor.

Compressor -- The rotary, positive displacement compressor is hermetically sealed. Electrical connections to the motor are made at terminals under a protective cover on top of the housing.

The lubricant is a synthetic oil put in the compressor at the factory. Thereafter, oil is not changed or added. The oil fill fitting on the top of the compressor housing must not be opened.

Heat Exchanger -- The heat exchanger consists of three coils wrapped around the compressor. One cools helium, another cools the compressor shell and another cools oil in the oil injection circuit. This circuit cools oil that has absorbed heat from the compressor and reinjects the cooled oil, which continues to absorb heat from the compressor.

Temperature Overload Switch -- Installed under the electrical terminal box cover on top of the compressor, this switch senses compressor temperature through contact with the housing. The switch opens the control circuit at a predetermined temperature and resets automatically upon cooling.

Gas Equalization Solenoid Valve -- This solenoid valve opens when the compressor is stopped. The valve allows the helium gas pressure across the compressor to equalize, to prevent oil from being blown out of the compressor into the low-pressure gas line.

Oil **Separator** -- The bottom of the oil separator serves as a sump. A retainer plate above the sump supports fibrous material that acts as the separating agent. Entrained oil coalesces on it, forming large droplets which drain into the sump. This unit needs no servicing or replacement.

Oil Capillary -- The capillary returns oil collected in the separator sump to the low-pressure side of the compressor for recycling.

Adsorber -- The adsorber removes any oil and moisture the gas is carrying which did not drop out in the separator. This vessel contains activated charcoal for oil adsorption. The adsorber has a finite life and must be replaced every 10,000 operating hours. 4

Pressure Relief Valve -- The relief valve prevents the compressor from operating at an unsafe pressure.

Oil Filters -- There are two oil filters. One filter in the oil separator drain line protects the return oil capillary. The other filter in the oil injection circuit protects the compressor.

Oil Injection Orifice -- This orifice is installed downstream of the oil filter in the oil injection line and controls the flow rate of oil into the compresor's gas return line.

Surge Bottle -- The surge bottle located in the return gas line dampens the pressure pulsations.

Oil Differential Pressure Switch -- This switch shuts down the compressor if oil injection flow is too low or too warm for proper operation.

Internal Bypass (Relief) Valve -- The internal bypass valve opens to allow the compressor to be run when the system gas lines are disconnected, to avoid overloading the motor.

Transformer -- Some 50 Hz applications include an externally-mounted transformer on the rear panel of the compressor. See Specifications.

Water Solenoid Valve -- This normally closed solenoid valve opens when the compressor starts to allow cooling water to flow.