UNIT-3rd

Compressors, Blowers, Vacuum pumps and their performance characteristics

Blowers and compressors these are actually air handling devices or machinery which one will come across in many plants and industries. So the working fluid in blowers and compressors is air or gas see this fluid handling devices are very similar in they are out say principle or in philosophy in comparison with electrical machines

Compressor:

A compressor is a machine which reduces the volume of gas or liquid by creating a high pressure. We can also say that a compressor simply compresses a substance which is usually gas.A compressor is the most important and often the costliest component (typically 30 to 40 percent of total cost) of any vapour compression refrigeration system (VCRS). The function of a compressor in a VCRS is to continuously draw the refrigerant vapour from the evaporator, so that a low pressure and low temperature can be maintained in the evaporator at which the refrigerant can boil extracting heat from the refrigerated space. The compressor then has to raise the pressure of the refrigerant to a level at which it can condense by rejecting heat to the cooling medium in the condenser.

Blowers: Blower is a machine to move air at a moderate pressure. Or simply, blowers are used for blowing air/gas.

The basic difference between the above three devices is the way they move or transmit air/gas and induce system pressure. Compressors, Fans & Blowers are defined by ASME (American Society of Mechanical Engineers) as the ratio of the discharge pressure over the suction pressure. Fans have the specific ratio up to 1.11, blowers from 1.11 to 1.20 and compressors have more than 1.20.

Blowers can achieve much higher pressures than fans, as high as 1.20 kg/cm2 . They are also used to produce negative pressures for industrial vacuum systems. Major types are: centrifugal blower and positive-displacement blower. Centrifugal blowers look more like centrifugal pumps than fans. The impeller is typically gear-driven and rotates as fast as 15,000 rpm. In multi-stage blowers, air is accelerated as it passes through each impeller. In single-stage blower, air does not take many turns, and hence it is more efficient. Centrifugal blowers typically operate against pressures of 0.35 to 0.70 kg/cm2 , but can achieve higher pressures. One characteristic is that airflow tends to drop drastically as system pressure increases, which can be a disadvantage in material conveying systems that depend on a steady air volume. Because of this, they are most often used in applications that are not prone to clogging. Positive-displacement blowers have rotors, which "trap" air and push it through housing. Positive-displacement blowers provide a constant volume of air even if the system pressure varies. They are especially suitable for applications prone to clogging, since they can produce enough pressure - typically up to 1.25 kg/cm2 - to blow clogged materials free. They turn much slower than centrifugal blowers (e.g. 3,600 rpm), and are often belt driven to facilitate speed .

Vacuum pumps

A compressor that takes suction at a pressure below atmospheric and discharges against atmospheric pressure is called a vacuum pump. Any type of blower or compressor, reciprocating, rotary or centrifugal can be adapted to vacuum practice by modifying the design to accept very low density gas at the suction and attain the large compression ratios necessary As the absolute pressure at suction decreases, the volumetric efficiency drops and approaches zero at the lowest absolute pressure attainable by pump. Usually the mechanical efficiency is also lower than for compressors. The required displacement increases rapidly as the suction pressure falls, so large machine is needed to move much gas. The compression ratio used in vacuum pumps is much higher thane. in compressors, ranging up to 100 or more, with a correspondingly high adiabatic discharge temperature. Actually however , the compression is nearly isothermal because of the low mass flow rate and the effective heat transfer from the relatively large area of exposed metal.

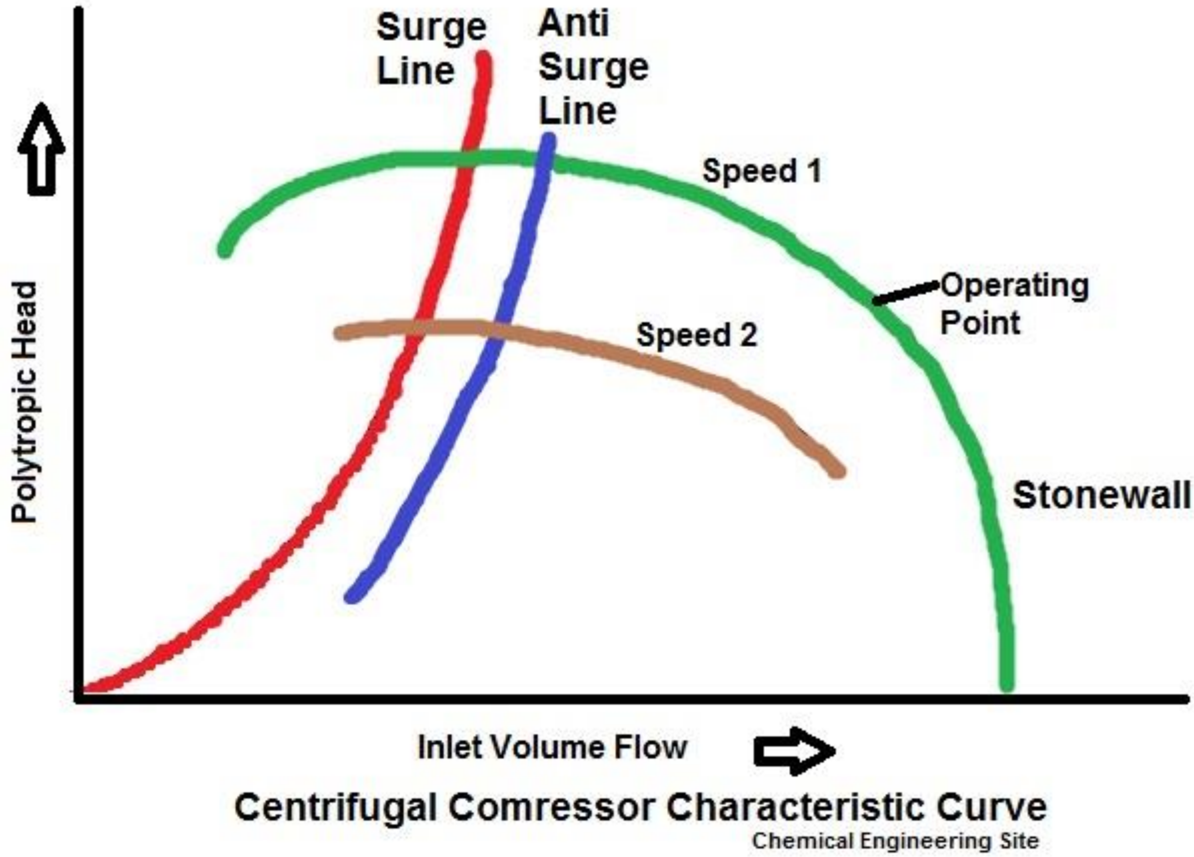
Characteristic curve of compressors

Performance of reciprocating compressors For a given evaporator and condenser pressures, the important performance parameters of a refrigerant compressor are: a) The mass flow rate (m) of the compressor for a given displacement rate b) Power consumption of the compressor (Wc) c) Temperature of the refrigerant at compressor exit, Td, and d) Performance under part load conditions.

Centrifugal Compressor Performance characteristic curve is the curve between Polytropic Head and Inlet Volume Flow. In a characteristic curve the terms like Compressor Surge line, Anti surge line, Choke or Stone wall point are the important phenomenon to be understood.

When the inlet flow to the centrifugal compressor decreases beyond a limit an unwanted and unstable cyclic phenomenon occurs called Surge. When the compressor loses its ability to develop the pressure head due to low inlet flow, the reversal of gas flow from discharge to suction takes place. Again the compressor tries to develop the head and this cycle is repeated till the desired head is achieved. This cycle develops roaring noise and causes severe damage to compressor and even foundations. Centrifugal compressor surge line is the limit for the inlet flow below which it should not be operated.

The reasons for compressor surge might be plant trips, Power failure or Utility failure, Compressor Suction Heat exchanger leaks, Suction filter choke, Intercooler leaks, Compressor Discharge Valve closure, Molecular Weight changes due to process upsets etc.



The most common way of creating a **vacuum** is to pump the gas out of a vessel that is initially at atmospheric pressure. ... The backing pump is used to extract residual gases from the main pump to keep it at low enough pressure to operate. The pressure of the backing pump is called the backing pressure.

Vacuum pressure is limited by the following three factors.

1. Carrier gas: Depends on analytical parameters.
2. Gas desorption from the surface of the chamber and parts: Decreases slowly. It takes much time for this contribution to decrease.

3. Limitation from pump performance. Usually, pressure less than 10-3 to 10-4 Pa is required near the rod and the detector

Piping Piping falls within Chapter VIII of the ASME Pressure Piping Code, "Piping for Category M Fluid Service." Category M Fluid Service is defined as "fluid service in which the potential for personnel exposure is judged to be significant and in which a single exposure to a small quantity of a toxic fluid, caused by leakage, can produce serious irreversible harm to persons on breathing or bodily contact, even when prompt restorative measures are taken."

Piping systems should meet the requirements for both Category M Fluid Service and for "severe cyclic conditions." Piping systems should be subjected to a flexibility analysis and, if found to be too rigid, flexibility should be added. Severe vibration pulsations should be eliminated. Expansion bellows, flexible connections, and glass equipment should be avoided. Pipelines should be designed with the minimum number of joints, fittings, and valves. Joints should be flanged or butt-welded. Threaded joints should not be used.

Methods of developing Vacuum and their limitations

A perfect vacuum is a region of space which is free of all matter. How perfect a real vacuum is can be quantified in terms of the absolute pressure inside a chamber. The lower the pressure, the "better" or "higher" the vacuum.

The most common way of creating a vacuum is to pump the gas out of a vessel that is initially at atmospheric pressure. There are many different ways of pumping on a vessel, but all of them have a limiting pressure below which they are ineffective. The lowest possible pressure achievable by a particular pump is called the ultimate pressure of the pump. Some pumps also have a limiting pressure (< 1 atm) above which they are ineffective. The use of those pumps must be preceded by another pump, called a "forepump" or a "roughing pump", which brings the pressure in the vessel within their working range. Usually pumps which require a forepump require a backing pump as well. The backing pump is used to extract residual gases from the main pump to keep it at low enough pressure to operate. The pressure of the backing pump is called the backing pressure. Different pumps will evacuate a given vessel in different amounts of time. The time required for a pump to achieve its ultimate pressure depends ot only on the kind of pump, but also on the volume of the vessel to be evacuated and the size of the conduit or tubing which connects the pump to the vessel. The pump down speed, S, of a complete vacuum system (pump + conduit + vessel) is defined by:

$$S = Q/ P \qquad (1)$$

where Q is the throughput, or the volume of gas leaving the system in a unit of time, and

P is the pressure of the system.

To define the speed of a pump we could then write:

$$S_p = Q_p/ P_p \qquad (2)$$

In practice the speed of the pump can be determined by pumping on a blank. A blank is a flat piece of metal which covers the intake of the pump. After measuring the pump with a blank it is sensible to connect tubing to the pump and watch its effect on the pump speed. A wide tube might not restrict gas flow or pump speed while a narrow tube might. It is useful to introduce the conductance, F, of a tube which is the gas throughput of the tube divided by the difference in pressure of the two ends of the tube. This is written as:

$$F = Q/ (P_1 - P_2) \qquad (3)$$

where P_1 and P_2 are the pressures at the two ends of the tubing.

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Material handling under Vacuum

In order to be able to handle materials with the aid of vacuum technology, the material to be handled must have an airtight surface. For example, concrete, metal or paper. Contrary to what is commonly believed, the surface doesn't need to be perfectly flat, smooth or free of bumps. Materials of a great variety of shapes and designs can be handled using vacuum technology. Think of objects with a flat side, but also circular objects such as pipes and architecturally designed objects. Aerolift selects the most suitable suction pads for every situation.

Inert gas systems

Inert gas is the gas which contains insufficient oxygen (normally less then 8 %) to suppress combustion of flammable hydrocarbon gases.

Inert gas system spreads the inert gas over the oil cargo hydrocarbon mixture which increases the lower explosion limit LEL (lower concentration at which the vapors can be ignited), simultaneously decreasing the Higher explosion limit HEL (Higher concentration at which vapor explodes). When the concentration reaches around 10 %, an atmosphere is created inside tank in which hydrocarbon vapors cannot burn. The concentration of inert gas is kept around 5% as a safety limit.

The following components are used in a typical inert gas system in oil tankers:

1. **Exhaust gases source:** inert gas source is taken from exhaust uptakes of boiler or main engine as contains flue gases in it.

2. **Inert gas isolating valve:** It serve as the supply valve from uptake to the rest of the system isolating both the systems when not in use.

3. **Scrubbing tower:** Flue gas enters the scrub tower from bottom and passes through a series of water spray and baffle plates to cool, clean and moist the gases. The SO_2 level decreases up to 90% and gas becomes clear of soot.

4. **Demister:** Normally made of polypropylene, it is used to absorb moisture and water from the treated flue gas.

5. **Gas Blower:** Normally two types of fan blowers are used, a steam driven turbine blower for I.G operation and an electrically driven blower for topping up purpose.

6. **I.G pressure regulating valve:** The pressure within the tanks varies with the property of oil and atmospheric condition. To control this variation and to avoid overheating of blower fan, a pressure regulator valve is attached after blower discharge which re-circulates the excess gas back to scrubbing tower.

7.**Mechanical non return valve:** It is an additional non return mechanical device inline with deck seal.

8. **Deck isolating valve:** The engine room system can be isolated fully with the deck system with the help of this valve.

9. **Pressure Vacuum (PV) breaker:** The PV breaker helps in controlling the over or under pressurization of cargo tanks. The PV breaker vent is fitted with flame trap to avoid fire to ignite when loading or discharging operation is going on when in port.

10. **Cargo tank isolating valves:** A vessel has numbers of cargo holds and each hold is provided with an isolating valve. The valve controls the flow of inert gas to hold and is operated only by a responsible officer in the vessel.

11. Mast riser: Mast riser is used to maintain a positive pressure of inert gas at the time of loading of cargo and during the loading time it is kept open to avoid pressurization of cargo tank.

12. Safety and alarm system: The Inert gas plant is provided with various safety features to safeguard the tank and its own machinery.

LUBRICATION

Expander bearings are usually high-speed, and they should have full film lubrication. This is best assured by using force-feed lubrication at a pressure of the order of 689.5 kPa (100 lbf/in2) or more. There is no special objection to using pressures as high as 6.895 MPa (1000 lbf/in2) or higher, if for some reason it is desirable to do so. Usually, a journal bearing and a thrust bearing are combined in one assembly, and oil is injected so as to feed both of them. The rate of flow usually is adjusted so as to carry the heat away with a temperature rise of the order of 11 to 17° C (20 to 30° F).The smallest expanders usually use oil with a viscosity at 38° C (100° F) of 60 to 100 SSU, and large machines up to 500 SSU. If the oil is kept in a totally enclosed system in contact with hydrocarbon or another partly soluble gas, which would dissolve and reduce the viscosity of the oil, then a compensating higher viscosity should be used so that the working viscosity after ultimate equilibrium with such gasis suitable for the bearings.

The lubrication system, for reliability reasons, usually has an operating and a standby pump and dual switchable filters. If there is a cooling- water scaling problem, coolers may also be switchable.

Air Filters The types of equipment previously described are intended primarily for the collection of process dusts, whereas air filters comprise a variety of filtration devices designed for the collection of particulate matter at low concentrations, usually atmospheric dust. The difference in the two categories of equipment is not in the principles of operation but in the adaptations required to deal with the different different quantities of dust. Process-dust concentrations may run as high as several hundred grams per cubic meter (or grains per cubic foot) but usually do not exceed 45 g/m3 (20 gr/ft3). Atmospheric-dust concentrations that may be expected in various types of locations are and are generally below 12 mg/m3 (5 gr/1000 ft3). The most frequent application of air filters is in cleaning atmospheric air for building ventilation, which usually requires only moderately high collection-efficiency levels. However, a variety of industrial operations developed mostly since the 1940s require air of extreme cleanliness, sometimes for pressurizing enclosures such as clean rooms and sometimes for use in a process itself. Examples of applications include the manufacture of antibiotics and other pharmaceuticals, the production of photographic film, and the manufacture and assembly of semiconductors and other electronic devices. Air cleaning at the necessary efficiency levels is accomplished by the use of highefficiency fibrous filters that have been developed since the 1940s.

Air filters are also used to protect internal-combustion engines and gas turbines by cleaning the intake air. In some locations and applications, the atmospheric-dust concentrations encountered are much higher than those normally encountered in air-conditioning service.

High-efficiency air filters are sometimes used for emission control when particulate contaminants are low in concentration but present special hazards; cleaning of ventilation air and other gas streams exhausted from nuclear plant operations is an example.

Air-Filter Types Air filters may be broadly divided into two classes: (1) panel, or unit, filters; and (2) automatic, or continuous, filters. Panel filters are constructed in units of convenient size (commonly 20- by 20-in or 24- by 24-in face area) to facilitate installation, maintenance, and cleaning. Each unit consists of a cleanable or replaceable cell or filter pad in a substantial frame that may be bolted to the frames of similar units to form an airtight partition between the source of the dusty air and the destination of the cleaned air.

Insulation

Any surface which is hotter than its surroundings will lose heat. The heat loss depends on many factors, but the surface temperature and its size are dominant.
Putting the insulation on a hot surface will reduce the external surface temperature. By insulation, the surface will increase on objects, but the relative effect of temperature reduction will be much greater and heat loss will be reduced.

A similar situation occurs when the surface temperature is lower than its surroundings. In both cases some energy is lost. These energy losses can be reduced by laying the practical and economical insulation on surfaces whose temperatures are quite different than the surrounding one.The ability of a material to retard the flow of heat is expressed by its thermal **conductivity** (for unit thickness) or **conductance** (for a specific thickness). Low values for thermal conductivity or conductance (or high thermal resistivity or resistance value) are characteristics of thermal insulation.

Categories of Insulation Materials

INSULATION MATERIALS OR SYSTEMS MAY ALSO BE CATEGORIZED BY SERVICE TEMPERATURE RANGE.

There are varying opinions as to the classification of mechanical insulation by the service temperature range for which insulation is used. As an example, the word cryogenics means "the production of freezing cold"; however the term is used widely as a synonym for many low temperature applications. It is not well-defined at what point on the temperature scale refrigeration ends and cryogenics begins.

The National Institute of Standards and Technology in Boulder, Colorado considers the field of cryogenics as those involving temperatures below -180°C. They based their determination on the understanding that the normal boiling points of the so-called permanent gases, such as helium, hydrogen, nitrogen, oxygen and normal air, lie below -180°C while the Freon refrigerants, hydrogen sulfide and other common refrigerants have boiling points above -180°C.

Understanding that some may have a different range of service temperature by which to classify mechanical insulation, the mechanical insulation industry has generally adopted the following category definitions:

Category	Definition

Cryogenic Applications	-50°F and Below
Thermal Applications:	
Refrigeration, chill water and below ambient applications	-49°F to +75°F
Medium to high temp. applications	+76°F to +1200°F
Refractory Applications	+1200°F and Above

CELLULAR INSULATIONS are composed of small individual cells either interconnecting or

sealed from each other to form a cellular structure. Glass, plastics, and rubber may comprise the base material and a variety of foaming agents are used.

CELLULAR INSULATIONS are often further classified as either open cell (i.e. cells are interconnecting) or closed cell (cells sealed from each other). Generally, materials that have greater than 90% closed cell content are considered to be closed cell materials.

FIBROUS INSULATIONS are composed of small diameter fibers that finely divide the air space. The fibers may be organic or inorganic and they are normally (but not always) held together by a binder. Typical inorganic fibers include glass, rock wool, slag wool, and alumina silica.

Fibrous insulations are further classified as either wool or textile-based insulations. Textile-based insulations are composed of woven and non-woven fibers and yarns. The fibers and yarns may be organic or inorganic. These materials are sometimes supplied with coatings or as composites for specific properties, e.g. weather and chemical resistance, reflectivity, etc.

FLAKE INSULATIONS are composed of small particles or flakes which finely divide the air space. These flakes may or may not be bonded together. Vermiculite, or expanded mica, is flake insulation.

GRANULAR INSULATIONS are composed of small nodules that contain voids or hollow spaces. These materials are sometimes considered open cell materials since gases can be transferred between the individual spaces. Calcium silicate and molded perlite insulations are considered granular insulation.

REFLECTIVE INSULATIONS & treatments are added to surfaces to lower the long-wave emittance thereby reducing the radiant heat transfer to or from the surface. Some reflective insulation systems consist of multiple parallel thin sheets or foil spaced to minimize convective heat transfer. Low emittance jackets and facings are often used in combination with other insulation materials.

Some Insulation Type Examples

Cellular Insulations

ELASTOMERIC

Elastomeric insulations are defined by ASTM C 534, Type I (preformed tubes) and Type II (sheets). There are three grades in the ASTM standard which are widely available.

Cryogenic Insulation

Cryogenic [-273 to -101°C (-459 to -150°F)] High Vacuum

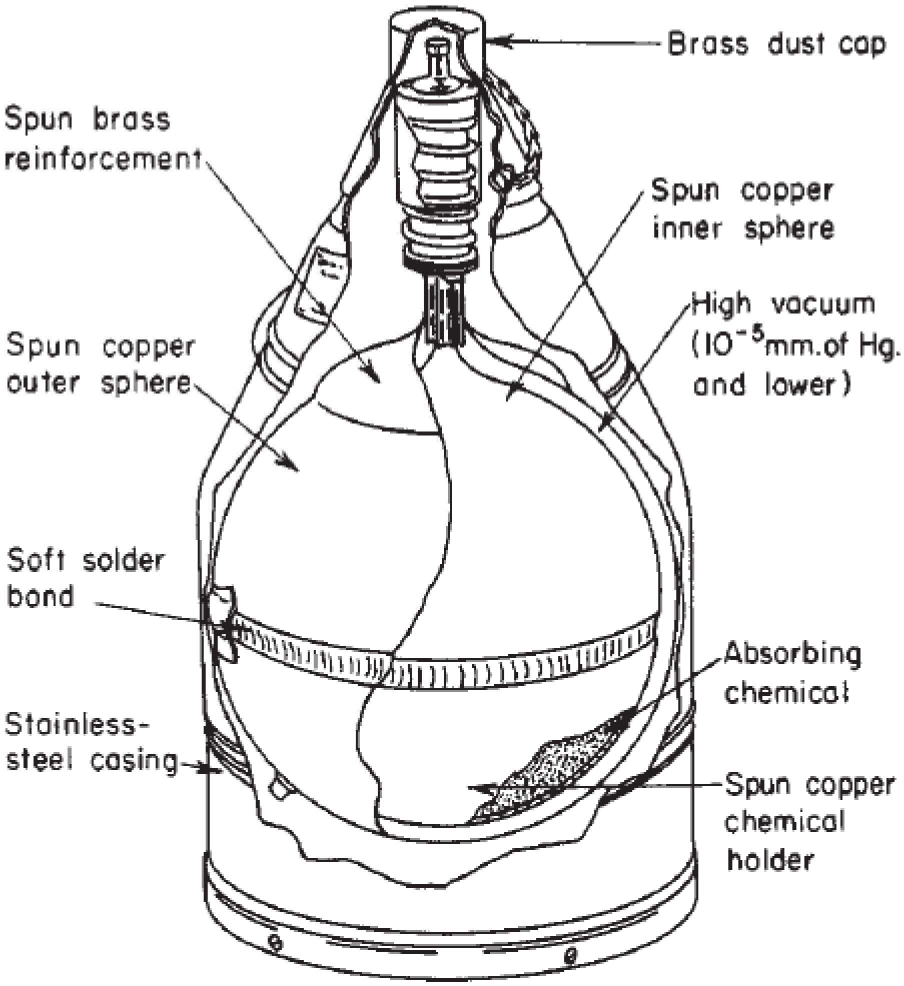
This technique is based on the Dewar flask, which is a double-walled vessel with reflective surfaces on the evacuated side to reduce radiation losses Radiation losses can be further reduced by filling the cavity with powders such as perlite or silica prior to pulling the vacuum.Expanded foam is a low density, cellular structure. A gas filled powder or a fibrous insulation reduces the gas convection due to the small size of voids.

Multilayer Multilayer systems consist of series of radiation reflective shields of low emittance separated by fillers or spacers of very low conductance and exposed to a high vacuum.

Foamed or Cellular Cellular plastics such as polyurethane and polystyrene do not hold up or perform well in the cryogenic temperature range because of permeation of the cell structure by water vapor, which in turn increases the heat-transfer rate. Cellular glass holds up better and is less permeable.

Low Temperature [-101 to -1°C (-150 to +30°F)] Cellular glass, glass fiber, polyurethane foam, and polystyrene foam are frequently used for this service range. A vapor-retarder finish with a perm rating less than 0.02 is required. In addition, it is good practice to coat all contact surfaces of the insulation with a vapor-retardant mastic to prevent moisture migration when the finish is damaged or is not properly maintained. Closed-cell insulation should not be relied on as the vapor retarder. Hairline cracks can develop, cells can break down, glass-fiber binders are absorbent, and moisture can enter at joints between all materials.

Moderate and High Temperature [over 2°C (36°F)] Cellular or fibrous materials are normally used. See Fig. 11-68 for nominal.



IG. 11-66 Dewar flask.