TotalTemp Technologies, Inc.

Thermal Platform with High Vacuum Pump System

Operators Manual

Model VmSD49-N

Rev. 1n 06/2021

Introduction

Thank you for purchasing a Thermal Vacuum Platform and Controller from TotalTemp Technologies. This product was designed to provide years of efficient trouble free operation. Please read and understand this manual plus the controller manual for safe and best use of this product.

Safety

Safety Symbols:

The following symbol on equipment indicates the existence of a hazard that is explained in more detail in the manual.

The following symbol on the equipment indicates there is danger of electric shock it the indicated panel is removed while the product is connected to power.

The following symbol indicates the possible presence of danger caused by hot surfaces.

General Warnings:

This device employs line voltage connected components and caution should always be used to avoid electrical hazards.

 Due to the extreme temperatures that these systems are capable of, always exercise caution in the vicinity of the platform. Burns from either extreme hot or cold conditions may result. As a rule, hands off should be the policy for the thermal platform surface.

Important Warnings:

1) Read and be familiar with the operating manual for the vacuum pump system. The pump is an expensive component and easily susceptible to damage or personal hazard. Never allow particles, dust, dirt moisture or oil to enter the cylindrical chamber. Cleanliness is very important. Even so much as the oil left from a fingerprint can hamper the ability to draw a good vacuum.
2) The glass bell jar is obviously heavy and fragile. Do not force the glass jar under any circumstances. Do not use if the bell jar becomes scratched or chipped. A strong metal screen over the bell jar is a good idea if the system is to be used in an environment where the bell jar is at risk of being hit or broken.
3) The system is designed for cooling only under vacuum conditions. When operating at cold temperatures under atmospheric pressure, condensation or frost on the surface of the platform and underside plumbing will occur. There is a clear risk of water droplets entering and damaging the vacuum pump system at some point if this is allowed to happen. It is recommended to bring the platform up to a warm temperature before returning the chamber to atmospheric pressure to prevent condensation or frosting. Also be aware that longer may be required before the plumbing that is not in direct contact with the plate & heaters to warm up. Of course, always avoid moisture near electrical power connections. Do not operate the product or controller with the safety cover panels removed. The protective covers reduce the risks of exposure to electrical and thermal hazard, as well as protecting the internal components from damage.

4) These systems employ expendable compressed liquid refrigerants. Extreme caution should always be observed when handling these cryogenic fluids. The extremely cold temperatures and high pressures of the refrigerants must be respected. Leather or other temperature resistant gloves and face shield are recommended to be used when connecting and disconnecting hose fittings. Additionally, if portable tanks are being used, the tanks are typically very heavy. Tip over and other mishandling accidents must be avoided. With the less stable geometry of Liquid CO_2 thanks in particular, always strap top heavy tanks to a wall or other immovable fixture to prevent accidental tip over of tanks. As a rule, keep tanks secured and always keep valve covers on high pressure tanks when they are not in use. Face shield and insulating gloves are recommended when handling cryogenic fluid connections.

See lists of troubleshooting and precautions for achieving vacuum in the Getting Started section and the Detailed Vacuum system operators manual from Leybold. Some admonitions are repeated but are important information.

Warning! Tank shut off hazard:

Misuse could result in burst hose, damaged equipment or safety hazard. After using the equipment, some people will elect to shut off the coolant source at the tank or point of supply. If this is done, be aware that if the system has been recently used, cryogenic liquid in the hose will expand dramatically as it warms up in the hose. If the hand valve is closed at the supply and the control solenoid is closed at the thermal platform, excessive pressure will build up in the hose. Liquid Nitrogen hoses such as P/N 29-30019-06 sold by TotalTemp have a built in pressure relief valve near the tank that will automatically vent if the pressure gets too high. Still it is a good idea to vent the hose before shutting off the hand valve at the tank. The pressure relief for the hose is higher than the Maximum Operating

Pressure Differential of the valve. Any hazard of closing a tank valve or opening a fitting which has liquid Nitrogen in it is far less if the system has not been used recently in the cooling mode. In any event, gas pressure in the hose still requires the user's attention to safety. In order to prevent this hazard, the user, as a rule should either leave valve at supply open or vent remaining coolant in the hose. Alternatively, after closing tank valve, set the controller to operate at a cold temperature until the pressure in the hose is relieved or carefully open the connection at an end of the hose until pressure is relieved. Although vacuum jacketed L-N_2 hoses purchased from TotalTemp have a pressure relief safety built into the hose to prevent rupture, it is still recommended to not rely on the overpressure safety valve every time system is shut off. Leaving the tank hand valve on when the solenoid valve is not activated is generally not considered risky when the system is unattended. It is also recommended that any L-N_2 hoses acquired from somewhere other than TotalTemp be fitted with pressure relief valves.

When connecting and disconnecting hose fittings containing cryogenic fluids, it is recommended that the user wear face shield and gloves to reduce the chance of injury from high pressure gas discharge or contact with cryogenic temperature liquids or gasses.

Hazard due to moisture in cooling system:

Moisture and other contamination is the primary cause of valve failure. When disconnecting a coolant delivery hose, it is highly recommended to place a cap on the open end of the hose. If the system has been recently used in the cooling mode, temperatures inside the hose below the dew point will result in moisture or frost accumulation inside the hose. When the system is put back into use, this water or ice could contaminate the coolant valve(s) resulting in erratic operation or run away cooling. An open hose is also an invitation to particles, dirt, insects and other things that might contaminate the cooling solenoid.

Asphyxiation and excessive or harmful gas hazard:

Cryogenic gases released by the thermal platforms are not toxic or chemically hazardous. Although it is important to avoid face or skin contact with the exhaust gas due to the possible extreme temperatures and pressures, there also is a possible hazard due to the displacement of breathable Oxygen with the exhaust from the platform. CO_2 can often be detected by the gassy smell that is characteristic of carbonated beverages such as beer or colas. Nitrogen is not detectable by human senses as our breathable air is already around 80% Nitrogen. The thermal platform should only be used in an area that has normal ventilation. It is recommended that the exhaust be vented to outside the work area if there is any question about the ventilation or there are multiple systems operating in a room. If there is ever a question of the concentration of exhaust gas in the room, TotalTemp recommends an Oxygen monitoring system be in place in the room where the exhaust is being vented. These can be in the form of a hand held alarm, a wall mounted instrument or a sensor that can be monitored by the Synergy Nano temperature controller. Consult factory for options and pricing.
Be aware that there is often little time between the first signs of dizziness and unconsciousness.

Also – there is potential for harmful gases emitting from the material(s) in the DUT (Device Under Test). It is imperative that the user be aware of the temperature limitations of the material(s) used in the DUT. NEVER heat any explosive or flammable materials on the platform surface. Further, moisture oils and contamination as seemingly minimal as finger prints can dramatically slow down or

overwhelm the vacuum pumps ability to remove air from the vacuum chamber.

Built in out-of-range safety controls:

The controllers employed by TotalTemp have several built in watchdog features.

1) Setpoints above and below the allowable limits of product operation have been blocked at the factory. Do not attempt to defeat these limits.
2) The controllers will go into an alarm/shutdown condition if the temperatures measured goes beyond preset limits
3) Open or shorted sensor or erratic readings will put the controller into a shut down mode.

All standard TotalTemp thermal platform systems have a fixed bimetal thermostat that latches power off for heating and cooling circuits in the event that temperatures exceed 205°C. On the rear electrical interface panel of the standard plate chassis, there are two LED indicator lights. The green LED light indicates power to the safety thermal switch and should always be on during normal operation. The red LED light indicates the thermal safety switch has tripped do to an over-temperature condition. It is only safe to use the system if the green light is on and the red light is off

1- Failsafe Working, Normal operation, Green LED ON

Temperature limits set in the controller are intended to prevent operation at temperatures above 200C. Therefore, under normal operation the red LED should never come on. Device under test heat, platform system component failure or other possible issues could cause the red LED to come on. Should the red LED come on, turn the system off immediately. Before using the system again, make sure the temperature of the platform is back in normal operating range (< 185 deg C), then turn power back on again. Cycling power resets the bimetal failsafe thermostat latch. If the green light comes on and the red is off, the safety switch has reset itself and normal operation may be reestablished. If the red light continues to come on, the system needs to cool down or is in need of service. Consult factory.

Controllers may also be equipped with an independent redundant failsafe system, a high and low limit setting may be easily entered from the front panel to protect from unintended cooling and heating beyond user set limits. This controller uses its own sensor in the platform and provides an enhanced level of safety. Consult factory for options and pricing.

The optional redundant coolant valve feature is an additional safety option. The redundant valve is plumbed in series with the main control valve(s) and it is energized whenever the system is powered on. The redundant valve does not cycle the way that the control valve cycles, thus does not accumulate the wear and tear of pulsing operation. The redundant valve will be ready to close when the signal from the independent redundant failsafe indicates an out of range condition. This improved level of safety will stop single failure mode run away conditions. Be aware that the severe oil or moisture contamination that causes the primary valve to fail could also potentially cause the redundant valve to fail. Consult factor for options and pricing.
The redundant valve option only applies generally only for L-N_2 systems, due to the extreme cold temperatures that can be achieved with L-N_2. Redundant valves are generally not used in L-CO_2 because the risk of runaway is less likely and less severe. Additionally, the extra valve plumbing in L-CO_2 systems can actually increase the chance of valve malfunction due to dry ice formation in the second valve orifice.

Equipment Ratings

The Lybold Vacuum pump has a power switch and detachable power cord that is accessible by reaching around to the lower right hand side of the vacuum pump. The vacuum pump has universal power input, it can be 120v. 60 Hz. or 230v 60 Hz at 120v, the amperage is rated at 20A.

Thermal Platform Power Supply:

Check the Voltage and Amperage ratings on your product label near the power connector of your platform and on the rear of the controller. Do not exceed the rated voltage and amperage as indicated when connecting to your power source. The controller, with heating and cooling platform can operate only at 120v. in the 50/60Hz range. Maximum amperage for the platform is 7A.

The correct Environmental Conditions for proper operation of the Thermal Platform System are as follows:

- Indoor use only, unless specified differently on the product label
- Altitude up to 2,000 M maximum
- Ambient temperature range no lower than 10°C and no higher than 40°C

- Maximum relative humidity of 80% for temperatures up to 31°C
- Pollution index of degree 2 or better
- Mains power supply voltage fluctuations shall not exceed ± 10% of the nominal voltage as indicated on the product label
- Transient overvoltage's according to overvoltage category II

System Description

Theory:

The system is designed for testing of electronic or other items at specific combinations of temperatures and high vacuum as required for a variety of purposes and is a common requirement for products to be deployed in space.
Thermal platforms provide a rapid and convenient method to perform this testing/conditioning.
Especially for items with a flat thermally conductive surface and conditions such as a vacuum where convection can not be used. The thermal platform will provide very efficient, fast thermal vacuum testing. Remember that better clamping force = better heat transfer.
Heating is provided by symmetrically distributed resistance heaters and cooling is provided by vaporizing an expendable cryogenic fluid in a sealed internal channel. As the fluid vaporizes, heat is removed from the platform and absorbed by the coolant.
Often these systems prove to be more cost effective and convenient than larger chambers or systems employing closed cycle refrigeration systems. Savings come in the form of faster cooling ramp times, lower initial cost, lower ongoing maintenance costs, improved reliability, lower electricity consumption, no environmentally hazardous gasses**, Smaller footprint using less valuable lab space.

** Note on Environmental hazard of CO_2 gas: Commercial CO_2 gas is not toxic and not considered an environmental hazard as it consists of CO_2 previously captured from the environment for this use. It is not being made, it is simply being captured as a liquid and re released to its original gaseous state.

Primary System Contents:

Platform with coolant filter installed externally
Controller
Power cord
Exhaust tubing

Vacuum pump system with rolling cart-
Includes provision for measuring vacuum level and manually venting the vacuum for ending the testing.

Accessories:

Optional redundant coolant valve
Optional redundant failsafe controller
Coolant delivery hose
Hold down accessories
Coolant conversion options

DUT sensing probes
Controller options
Adapter plates

Specifications:

SD14 - Surface area 3-3/4" x 3-3/4", 14 square inches or 90 square centimeters.

SD49 – Surface area 6-1/2" x 7-1/2", 48.75 square inches or 314 square centimeters.

SD144 – Surface area 12" x 12", 144 square inches or 929 square centimeters.

Supplies required:

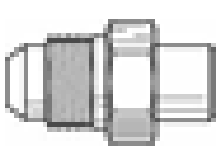
Coolant - TotalTemp platforms are designed for one of four coolant configurations as noted on equipment.

1) Standard configuration, high pressure L-N_2. 75-125 psi.
2) Special low pressure L-N_2 for applications where high pressure L-N_2 cannot be obtained. 15-35 psi.
3) High pressure L-CO_2 800-950 psi.
4) Low pressure L-CO_2 300 psi.

Consult factory if your available coolant does not match what the thermal platform you have is designed for. Read the ID tag on product to determine proper coolant.

Coolant inlet fitting:
The coolant inlet on all products is a ¼" male SAE flare fitting

Coolant filter:
Directly behind the inlet fitting is a particulate filter to protect the valve and injection tubes from damage due to particulate contamination.
The filter parts are assembled per the artwork below.
The inlet nipple may be purchased separately as a wear item and the four pieces of the filter assembly must be purchased as a complete filter.


Inlet, ¼" SAE flare to pipe fitting (standard)


Filter body


Filter media


Filter outlet to valve


Retaining nut

Coolant Exhaust connection

A section of Silicone hose is provided as an exhaust and accessory to prevent the exhaust gas from exiting directly to the work area for noise and safety reasons. For light duty operation, in a normally vented room, the exhaust from a few units may be allowed to terminate into the room air.
Used coolant exits as a gas from the 5/8" (SD49 5/16") hose nipple at the left rear corner of the unit.
Use caution when installing and removing exhaust hose to hose nipple. Exhaust port is not designed to be structural and does not support twisting or excessive mechanical force.
It is recommended to hook the exhaust up to a vent from going outside of the local room. See Safety precautions.

Power:

Standard configuration SD14, SD49 and SD144 thermal platform in North America is 15A/120v.
Models intended for Europe and Asia are 230v models, designed for 7A unless otherwise specified. ***Always confirm proper configuration before connecting power to controller and controller to platform.***
The umbilical cable on TotalTemp Controllers are designed to be plugged into only the standard TotalTemp SD14, SD49 or SD144 Platforms, unless otherwise specified for a custom configured TotalTemp Thermal Platform.
Controller systems can operate on either 120, 208-240vac. 50/60 Hz.
Platforms must be operated on specified voltage. Platform power connectors are keyed to disallow mating systems intended for alternate voltages however always note that the voltage applied is in accordance with *platform* product labeling.
Other power configurations are possible on special order basis.

Assembly:

The thermal platform system consists of five parts. Be aware of the following when installing:

1) The coolant source – Ensure proper pressure range before connecting coolant
   Inlet fitting is ¼" SAE flare fitting
2) The coolant exhaust – Provide proper venting to reduce noise and possibility of asphyxiation
   Exhaust fitting is a 5/16" for SD49 or 5/8" for SD98 – SD144, male barbed hose nipple
3) The power source – Verify proper voltage and amperage capacity before applying power.
   Be aware of Voltage and current rating on Platform
4) The controller – Note power switch is off when applying power, be familiar with proper use.
   Make sure switch on rear always stays ON. Controllers are universal 120-240 v. Standard models are 15A. max. Note white dot on platform connectors indicates top.
5) The platform – Verify unintended items do not contact surface, hands off and caution must be the rule.

For testing and programming purposes the controller can easily be powered up without the platform. Otherwise it is recommended to have all above system parts connected per this document before

connecting the power source.

Before Operating platform:

Verify that the voltage of the electrical supply matches the product ID tag for the product and it has adequate capacity to supply the required current for the system heaters.
Temperature controllers are typically of universal voltage. Standard model controllers are designed for 15A maximum load. Platforms with heaters and coolant solenoids have specific voltage ratings which must be observed. The Leybold Turbolab 350 operates on it's own power cord and can be operated on 120v. 20 A. or 230v ~ 10 A. Recommended to have the heating and vacuum system on separate circuits to prevent accidentally exceeding capacity of typical 15 or 20 A. 120v circuits.

Verify that the system power cord is plugged into a properly grounded receptacle.

Verify that the power cord plug in position at the receptacle is not blocked by any equipment for easy access to disconnect.

Verify that the controller umbilical is properly connected and secured to the platform.

Verify that the correct coolant and pressure is connected to the coolant valve box before attempting to use the cooling function.

Although the coolant valve(s) are designed to withstand continuous operation under all conditions, understand that it is far more stressful on the coolant solenoid to run the system in the cooling mode when there is no coolant supplied to the system.

Make sure that any items that might be burned by heat or damaged from extreme cold are removed from the surface of the thermal platform prior to use.

Hands off is a good rule for operation of the platform.

Note on anodized surfaces:

Black anodize on standard atmospheric platforms is not used on vacuum rated systems. Anodize on atmospheric platforms is both cosmetic and functional to protect the surface from corrosion and abrasion. Be aware that the flat aluminum surface is critical for heat transfer and must not be damaged. No plating or nickel plating are possible options on Vacuum platforms is used in lieu of the anodized surface. No maintenance beyond cleanliness, protecting from scratches and dings is required for bare aluminum or Nickel plated surfaces.

Note on threaded holes in platform surface:

All TotalTemp platforms come standard with 10-32 threaded holes in the surface as a convenience to the user for mounting their DUT, or for mounting an adapter plate, or for using DUT clamp sets. The quantity and locations of these holes can vary based on the model. Additional threaded holes can be purchased at time of ordering, in specific patterns if the customer chooses. If the end user wishes to

drill their own additional threaded holes after receiving the equipment, ***always consult the factory first***. There is the possibility of damage to the system if drilling too deep. Maximum depth for any hole on the platform surface is 0.250" (6.35mm) to the drill point.

Operation

Please read the controller operation manual for a good understanding of proper use of the controller.

Platform System Shut down:

Normal shut down.
The main power switch/breaker on the front of the controller may be used to apply and remove power from the system.

Failsafe shutdown.
TotalTemp thermal platforms all have safety out-of-range limits built into the controllers. The platform has an internal, fixed high temperature limit switch that will shut the system down if the temperature of the platform exceeds 175°C (+15-0°).
When this temperature limit is exceeded, power will be removed from the heating and cooling circuits of the system. Normal operation may be restored when the temperature comes back into the operating range by turning power off, then back on.
NOTE: The built in failsafe shutdown system is designed for proper operation only. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.
Optionally, platform controllers also have an independent redundant high / low limit temperature safety. Typically the Watlow 1/32 DIN, EZ Zone PM limit controller. When so equipped, the system will also typically be equipped with an optional series redundant coolant shut down valve. This redundant valve is not cycled to maintain temperature, therefore it will not accumulate the wear and tear that the control solenoid does and will be ready to protect the system and device under test should the main control valve experience a failure that might otherwise result in an uncontrolled cooling condition.

Maintenance:

There is no required maintenance for the thermal platform other than inspecting the coolant filter and the periodic rebuild of the coolant solenoid valve. The valve is typically good for 10 million cycles. Factory cycle rate is 1-2 cycles per second when maintaining a cold temperature. The valve normally does not cycle when heating or going to a temperature. Doing the calculations, a typical valve life is found to be many years. If you experience erratic valve operation, inspect and troubleshoot the system before continuing to use the system to eliminate latent or pending valve problems and reduce the chances of accidental run away cooling.
Periodically inspect the hoses, power cord, and umbilical to plate and associated connectors. Remove product from service if a hose or electrical connection appears damaged or worn.
Check to confirm access panels are always in place during use to prevent safety hazards and to prevent damage due to buildup of condensation or frost inside unit.
Do not use any abrasive cleaners on the thermal platform surface. A soft nonabrasive damp cloth with mild dishwashing detergent is all that is needed.

Troubleshooting:

After reading the operation manual, if problem persists or a clear solution is not provided, please consult the factory for resolution of the problem. Offices are open 8-5 Pacific time, weekdays.

Storage:

Make sure system is dry before closing into any packaging. It is recommended to put a cap over the coolant inlet and exhaust connections to prevent foreign objects from lodging in the plumbing, especially the inlet.
When packing, be careful to prevent stress from being applied to the electrical or plumbing connections. You may want to remove any coolant filter from the product so that it is not damaged in shipping. The bell jar and the cable to the sensor on the ion gage vacuum measuring device in the back right area should be secured as well.

Special storage considerations for the thermal platform and controller:
Store in a dry environment. Normal safe packing procedures should be followed if the unit is to be shipped. Controllers must be stored in a non condensing environment,

Service:

TotalTemp Technologies, Inc
3630 Hancock St. A
San Diego, CA 92110
www.TotalTempTech.com Support@TotalTempTech.con
(888) 712-2228 x1

Parts: *Contact the factory for any needs involving maintenance or accessory parts.*

Appendix:

Materials compatible for vacuum use - From Wikipedia

Metals

- Austenitic stainless steels are the most common choice for high vacuum and ultra-high vacuum systems. Not all alloys are suitable; e.g. the free-machining 303 steel contains sulfur, which tends to outgas. Alloys with good weldability under argon arc welding are usually chosen.
    - **304 stainless steel** is a common choice of a stainless steel.
    - **304L stainless steel**, a low-carbon variant of 304 steel, is used for ultra-high vacuum systems.
    - **316L stainless steel** a low-carbon and low-magnetic stainless steel, used in accelerator technologies.
    - **347 stainless steel** does not accept high polish.
    - **321 stainless steel** is chosen when low magnetic permeability is needed.
- Mild steel can be used for moderate vacuums above 1×10^{-6} torrs (1.3×10^{-7} kPa). Outgassing can be lowered with suitable (e.g. nickel) plating. It has high permeability to hydrogen and tendency to rust. For use it should be thoroughly degassed in vacuum.
- Aluminium and aluminium alloys are another class of frequently used materials. They are well-machinable and have low outgassing, unless the alloys contain higher proportions of zinc. The parts must not be anodized, as the oxide layer traps (and then outgasses) water vapor. Anodizing also makes the surface non-conducting, so that its surface will charge up in electrostatic systems. The best treatment is Alochroming, which seals the surface, makes it hard and conductive. Its outgassing rate is considerably less than non-treated aluminium. Aluminium and its alloys have low strength at high temperatures, distort when being welded, and the copper-containing ones are poorly weldable. Aluminium wire rings can be used as cheap gaskets in demountable seals. Aluminium has high thermal conductivity, good corrosion resistance, and low solubility of hydrogen. Loss of strength at high temperatures limits its use in bakeable applications, but aluminium is advantageous for large-size systems due to its lower weight and lower cost than stainless steel. Use of aluminium is limited by difficulties in its welding and brazing. It can be used for x-ray windows.[1]
- Aluminium bronze is a material that looks and machines similar to brass. It is not susceptible to galling, which makes it suitable for sliding fits against stainless steel.
- Nickel is widely used in vacuum technology, e.g. as mechanical parts in vacuum tubes. It is relatively low-cost, can be spot welded, can be easily machined, has high melting point and is resistant to many corrosive fluids and atmospheres. Its potential drawback is its ferromagnetism, which restricts applications that would be influenced by magnetic fields.[1]
- Nickel alloys, e.g. cupronickel[2]
- Beryllium is used primarily for x-ray windows.
- Oxygen-free copper is widely used. It is easily machined and has good corrosion resistance. It is unsuitable for bakeable vacuum envelopes due to its tendency to oxidize and create scales. Copper rings are used in demountable seals. Normal copper is unsuitable for high vacuum as it is difficult to outgas completely. Copper is insensitive to hydrogen and impermeable to hydrogen and helium, has low sensitivity to water vapor, but is attacked by mercury. Its strength falls sharply above 200 °C (392 °F). Its vapor pressure becomes significant at above 500 °C (932 °F).[1]

- Brass is suitable for some applications. It has good corrosion resistance. Its zinc content may cause problems; zinc outgassing can be reduced by nickel-plating.
- Indium wire is used as a gasket in demountable seals.
- Gold wire is used as a gasket in demountable seals for ultra-high vacuum, as well as an alternative to lead-tin solder for making electrical connections.
- Platinum is a highly chemically inert material with high cost and low outgassing.
- Zirconium is corrosion-resistant. It has low production of secondary electrons, so it is used as a coating of areas where reducing their production is important. It is used for neutron windows. It is costly and scarce, its uses are therefore limited. Zirconium and zirconium hydride are used for gettering.
- Tungsten is often used in high temperature applications as well as for filaments in electron/ion optics. It becomes brittle from work hardening when mechanically deformed, or subjected to very high temperatures.
- Molybdenum and tantalum are useful for high temperature applications.[2]
- Titanium and niobium are good materials.
- Solders are sometimes unavoidable for soft-soldered joints. Tin-lead solders (Sn50Pb50, Sn60Pb40, Sn63Pb37) can be conditionally used when the apparatus is not to be baked and operating temperatures aren't elevated (lead tends to outgas). A better choice for vacuum systems is the tin-silver eutectic, Sn95Ag5; its melting point of 230 °C (446 °F) allows bakeout up to 200 °C (392 °F). A similar 95-5 alloy, Sn95Sb5, is unsuitable as antimony has similar vapor pressure as lead. Take care to remove flux residues.
- Brazing alloys are used for joining materials by brazing. Care has to be taken while choosing the alloys, as some elements tend to outgas. Cadmium and zinc are the worst common offenders. Silver, a common component of brazing alloys, can be problematic at higher temperatures and lower pressures. A silver-copper eutectic, named e.g. Cusil, is recommended. A superior alternative is a copper-silver-tin alloy called Cusiltin. Copper-silver-phosphorus alloys, e.g. Sil-Fos, are also suitable.[2]

Plastics

- Some fluoropolymers, e.g. polyvinylidene fluoride, are suitable for use in vacuum. They have low outgassing and are tolerant to higher temperatures.
    - Polytetrafluoroethylene (PTFE or Teflon) is commonly used inside of vacuum systems. It is self-lubricating, a good electrical insulator, tolerant to fairly high temperatures, and has low out-gassing. It is not suitable for barrier between vacuum and atmosphere, as it is somewhat permeable for gases. Ceramics is a superior choice, however.[2]
- Polyethylene is usable but requires thorough out-gassing. Nalgene can be used as a cheaper alternative for Bell jars.
- Vespel polyimide is very expensive, but machines well, has good electrical insulator properties and is compatible with ultra-high vacuum.
- PVC, despite its high outgassing rate, can be used in limited applications for rough vacuum lines.
- Nylon is self-lubricating but has high outgassing rate and high affinity to water.
- Acrylics have high outgassing rate and high affinity to water.
- Polycarbonates and polystyrene are good electrical insulators with moderate outgassing.

- PEEK (PolyEtherEtherKetone) has relatively low out-gassing values (0.31% TML, 0.00% CVCM, 0.06% WVR).
- Kapton is a type of polyimide film, has very low outgassing. Kapton is discouraged if a ceramic alternative can be used.[2]
- Some elastomers have sufficient vacuum properties to be employed in vacuum o-rings:
    - NBRs, (Nitrile rubber), commonly used for demountable vacuum seals (bakeable only up to 100 °C).
    - FKMs (FPMs), (Viton) is used for demountable vacuum seals. It is better for lower pressures than nitrile rubber and chemically much more inert. It is bakeable to 200 °C.
    - FFKMs (FFPMs) very low out-gassing similar to Teflon and withstands baking temperatures up to 300 °C, while chemically one of the most inert sealing elastomers.

Glasses and ceramics

- Borosilicate glass is often used for smaller assemblies and for viewports. It can be machined and joined well. Glasses can be joined with metals.
- Porcelain and alumina ceramics, when fully vitrified and therefore non-porous, are excellent insulators usable up to 1500 °C. Some ceramics can be machined. Ceramics can be joined with metals.
- Macor is a machinable ceramic that is an excellent alternative to alumina, as the firing process of alumina can change the dimensions and tolerances.

Lubricants

Lubrication of moving parts is a problem for vacuum. Many lubricants have unacceptable outgassing rates,[3] others (e.g. graphite) lose lubricating properties.

- Vacuum greases are greases with low outgassing.
    - Ramsay grease is an old composition of paraffin wax, vaseline and natural rubber, usable up to about 25 °C, for low vacuums to about 1 Pa.
    - Krytox is a fluorether-based vacuum grease, useful from -75 to over 350 °C, not flammable even in liquid oxygen, and highly resistant to ionizing radiation.
    - Polyphenyl ether greases
    - Torrlube, a brand encompassing a range of lubricating oils based on perfluoropolyethers.[4]
- Dry lubricants, can be incorporated in plastics as fillers, as a component of sintered metals, or deposited on metal, ceramic and plastic surfaces.
    - Molybdenum disulfide is a dry lubricant usable in vacuum.
    - Tungsten disulfide is another dry lubricant usable in vacuum. It can be used at higher temperatures than MoS_2. Tungsten disulfide used to be significantly more expensive, but rise of prices of molybdenum disulfide brought them to a comparable range.[5] Usable from -188 to +1316 °C in vacuum, from -273 to +650 °C in normal atmosphere.[6]
    - Hexagonal boron nitride is a graphite-like dry lubricant used in space vehicles.

Adhesives

- Torr-Seal, or its generic equivalent Hysol-1C (USA brand name) or Loctite 9492 (EU brand name), is an epoxy with resin and hardener for use in vacuum environments. It will begin to degrade at high temperatures but otherwise is very stable with very little outgassing. Other vacuum-rated epoxies are also available. For mounting or joining thin metal foils, grids, or other small pieces that are not expected to undergo stress, silver or gold paste may be used as an adhesive. After fixing the material(s) with silver paste, the piece must be baked (to > 200 C) in air for > 24 hours to remove volatiles prior to insertion into vacuum.

End