



aiigma

All India Industrial Gases Manufacturers' Association

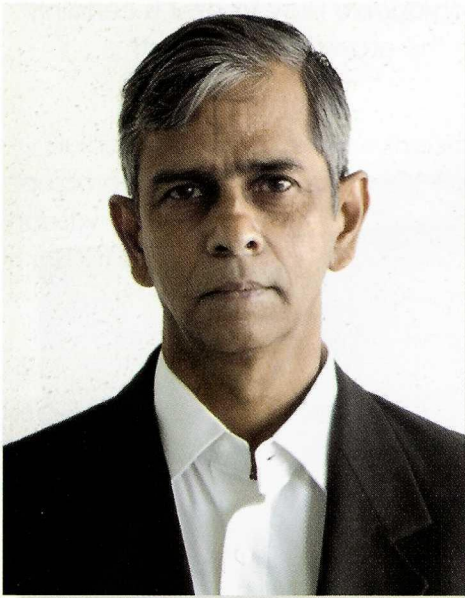
GAS NEWS
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DELEGATE MANUAL

ADVANCED CRYOGENIC INSULATION

Shankar Ghosh, Shell-N-Tube Pvt. Ltd.



ADVANTAGES OF SUPER INSULATION

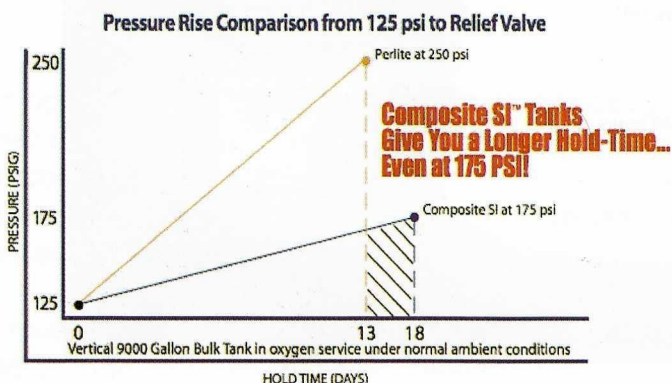
Golden Rule of Cryogenic Liquid

- ⇒ Lower the pressure - Lower the temperature
- ⇒ $-196^{\circ}\text{C} = 1 \text{ atm pressure}$

The Traditional Perlite Insulation allows more heat into the liquid, thereby driving the pressure up faster

- ⇒ Liquid nitrogen stored at 8 bar (g) gets pressurized to 17 bar (g) in just 13 days in perlite insulated tank
- ⇒ Liquid nitrogen stored at 8 bar (g) gets pressurized to 10 bar (g) in 18 days in Super Insulated tank

SUPER INSULATION VS PERLITE INSULATION



SUPER INSULATED CRYOGENIC TANKS

Advantages of Multilayer Insulation over Puff or Perlite insulation:

- Smaller Footprint
- Lower Tare Weight
- Less daily Evaporation
 - ⇒ Lower product losses
 - ⇒ Longer hold times
- Lower life cycle maintenance costs.

MULTILAYER INSULATION

- Used for vessels which require a high level of thermal isolation.
- Vessels are enclosed in an outer vessel with a separating space that is vacuum evacuated to the 10^{-4} torr range at ambient condition.
- Convective heat transfer virtually eliminated.
- Small conductive heat path from outer to inner.
- Selecting materials with low thermal conductivity properties further enhances thermal isolation.



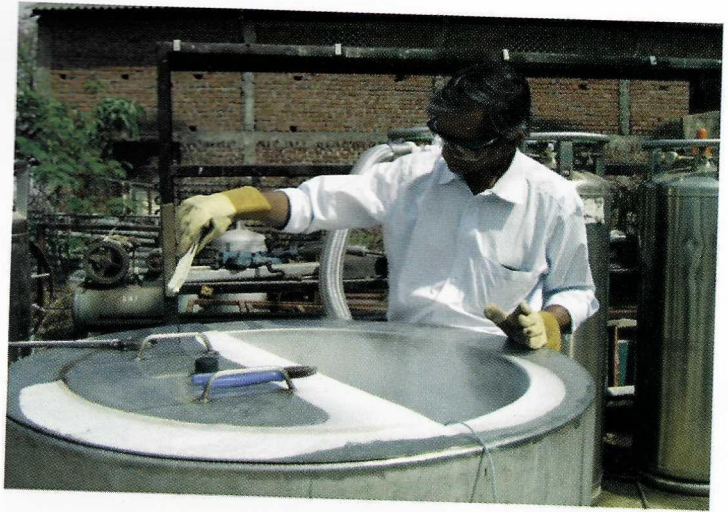
MULTILAYER INSULATED HEX

MULTILAYER INSULATION PROPERTIES



SUPER INSULATED VALVE BOX FOR IPR

VARIABLES IN MULTILAYER PERFORMANCE



MULTILAYER INSULATED CRYO-BIO FREEZERS

Variables associated with the performance of the vacuum level in a MLI system:

- Layer Density
- Warm boundary temperature.
- Number of reflective layers.
- Spacer material between reflecters.
- Interstitial gas pressure.
- Interstitial gas content

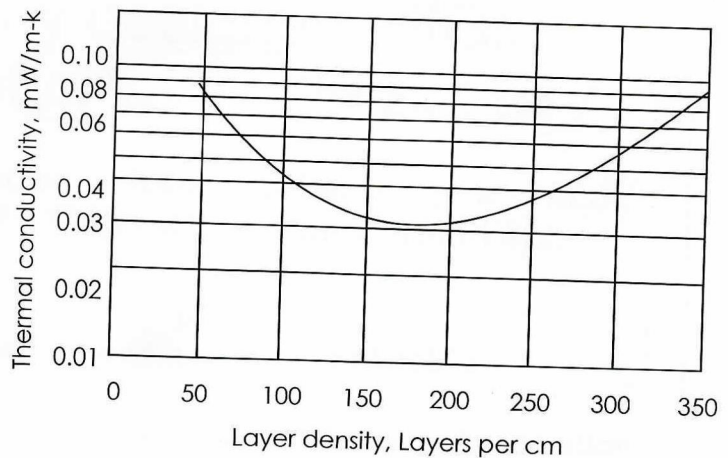
MULTILAYER INSULATION PERFORMANCE

- Thermal performance of MLI is a function of layer density – number of alternating layers per thickness
 - ⇒ Radiation heat transfer inversely proportional to number of reflective layers
 - ⇒ Conduction heat transfer directly proportional to thickness of spacer material used.
- Typically 1 inch of MLI, approx 20 alternating layers of reflective and spacer material is used for liquid nitrogen.

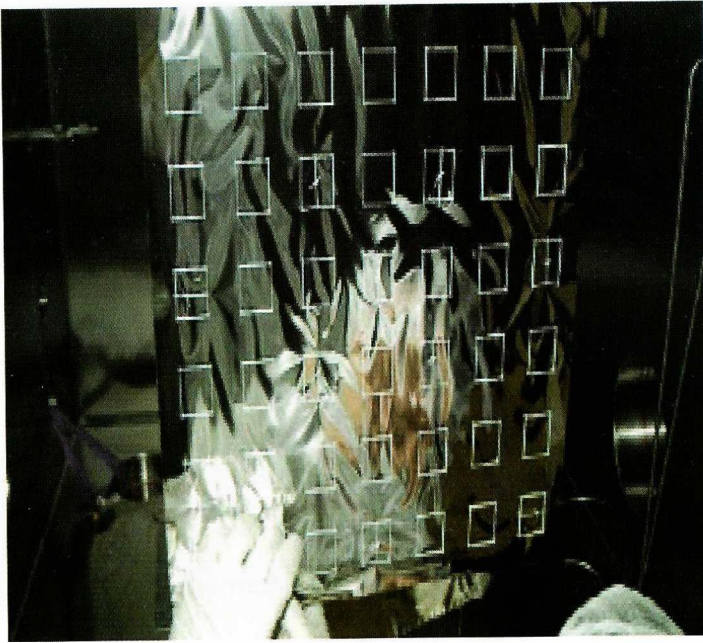


MULTILAYER INSULATED RECTANGLE CRYOSTAT

MLI is designed to work under high vacuum, i.e. pressure below about 1×10^{-4} torr. Lengthy pumping time along with heating and purging is required to obtain the required vacuum. Chemical getting materials that absorbs out gassed molecules is also required to maintain vacuum over extended periods.



INTEGRATED MULTILAYER INSULATION



IMLI SHEETS FOR NASA

- Difficult to maintain desired value of gap distance between radiative film using spacer blankets in conventional MLI
- Integrated Multilayer Insulation (IMLI) is being developed as an improved alternative.
- Micro Moulded Discrete Matrix separate the reflective layers in IMLI
- Micro Moulded Discrete Matrix is an array of highly engineered small lightweight polymer frames attached to and placed between the reflective layers.
- Micro Moulded refers to the smallness of the frames and the fabrication process which forms precise small features.

- Discrete refers to the nature of the matrix as consisting separate frames in contradiction to unitary frame of a MLI blanket.
- Matrix spacer designed to reduce heat conduction to minimum levels.
- Radiation sheets reduce radiation
- Entire insulation system is near the radiation limit.
- Possible to optimize the distance and the concomitant dimensions of the frames while minimizing the contact area the associated conductive heat transfer.
- Studies indicate IMLI to have a thermal conductivity approx 60% of conventional MLI.
- 0.139 W/m^2 for a 40 layer blanket has been achieved with IMLI

LAYERED COMPOSITE INSULATION

- New requirements for thermal insulation include robust multilayer (MLI) systems that work for a range of environments from high vacuum to no vacuum.
- Spacecraft that must contain cryogenics for lunar service (high vacuum) and ground launch operations (no vacuum) are planned.
- Future cryogenic spacecraft for the soft vacuum environment of Mars are also envisioned.
- Layered Composite Insulation (LCI) has been developed by the Cryogenics Test Laboratory at NASA Kennedy Space Centre.
- LCI thermal performance under cryogenic conditions is shown to be six times better than MLI at soft vacuum conditions and similar to MLI at high vacuum.