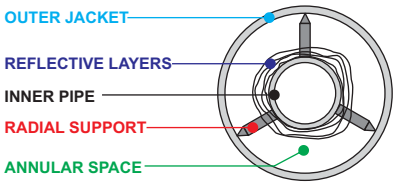
Cryogenic Insulated Piping: Static Vacuum or Dynamic Vacuum?
That is the Question

That is a question we are asked frequently. Which one is better: Static (Sealed) Vacuum Jacketed Piping or Dynamic Vacuum Jacketed Piping? In order to answer the question, let's look at both technologies first. Then we will compare their respective pros and cons more closely. The answer to the question cannot be completed without some field experience gathered over two decades.
Please keep in mind that BeaconMedaes, Part of the Atlas Copco Group, is not a manufacturer of vacuum jacketed piping but a reseller. We have no vested interest in promoting one technology versus the other. We have simply determined that one technology is more suitable for the customer we serve: the laboratory market.

About Heat Transfer

Due to their very low boiling points, cryogenic liquids are easy to evaporate. In a cryogenic vacuum jacketed pipe, the heat transfer between the inner pipe and the outer shell can occur in three (3) different ways: by conduction, by convection and/or by radiation.

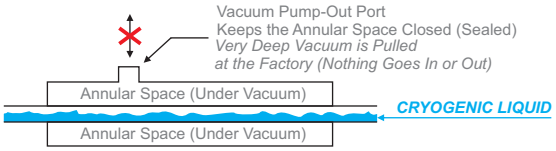


CONDUCTION - Conduction is the heat transfer between the outer shell and the inner pipe due to the physical contact of the radial supports between the two conduits. In order to minimize this thermal conductivity, it is of paramount importance to select the proper material for the radial support as well as having the least amount of surface in contact between the supports and the outer shell.

RADIATION - Think of radiation like how the sun heats up the face of our planet. We all feel "cooler" when we are under the shade of an umbrella. The reflective multiple layers of aluminum foil and micro fiberglass paper limit the radiation between the outer jacket and the inner pipe.

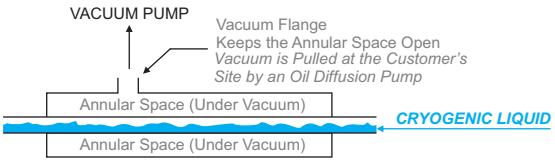
CONVECTION - Convection is movement of molecules left in the annular space that bounce between the inner pipe and the outer shell. causing the heat exchange between the two. Convection in the annular space can be minimized in two ways: by a very deep vacuum and the use of gas traps. Deep vacuum means less molecules inside the annular space (hence less heat exchange). The gas traps are essentially chemicals that are "intercepting" molecules inside the annular space.

Static (Sealed) Vacuum



As you can see above, the vacuum is pumped in the annular space at the factory where the piping is made. The vacuum pump-out device prevents any molecules to go in or out of the annular space.

Dynamic Vacuum



A dynamic vacuum jacketed piping implies that a vacuum pump is used to evacuate and holds the insulation (the annular space) at the end user's site.

NOTE - The cutout views above illustrate the differences between the way the vacuum is maintained inside both types of insulated pipes. The annular space is normally populated with thermal expansion bellows, gas traps, female bayonet fittings and multiple layers of aluminum foil and micro fiberglass paper.

Evaluation Criteria

	STATIC VACUUM	DYNAMIC VACUUM	COMMENTS
VACUUM LEVEL	1 X 10^{-8} torr	1 X 10^{-6} torr	Vacuum pumps used at manufacturing facilites are way more efficient than the ones used at end user's sites
APPLICATION OF HEAT DURING EVACUATION	Yes	No	Applying heat is very important to evacuate stubborn molecules
UTILITY REQUIRED TO MAINTAIN VACUUM	None	Yes - **Electricity** for the vacuum pump **floor space** is also required for the vacuum pump	The cost to own a dynamic vacuum pipe is significant due to the power required to keep the pump running.
CHEMICAL GETTERS (aka Gas Traps)	Yes	Usually **no gas traps** or otherwise the gas traps gets saturated very rapidly	As shown above, the gas traps are essential to minimize heat transfer
INSTALLATION TIME	Very simple with bayonet-style	On top of the VJ piping itself, the installer has to install the vacuum pump and related hardware	Vacuum dynamic piping installation requires more hardware and more time to install over static vacuum piping installations.
MAINTENANCE REQUIREMENTS	None	Yes - Routine oil level checks, fill ups and replacements. like any mechanical devices, all vacuum pumps require maintenance over time	Static vacuum does NOT require a vacuum pump. Therefore, no maintenance is required and no oil mist in the air.

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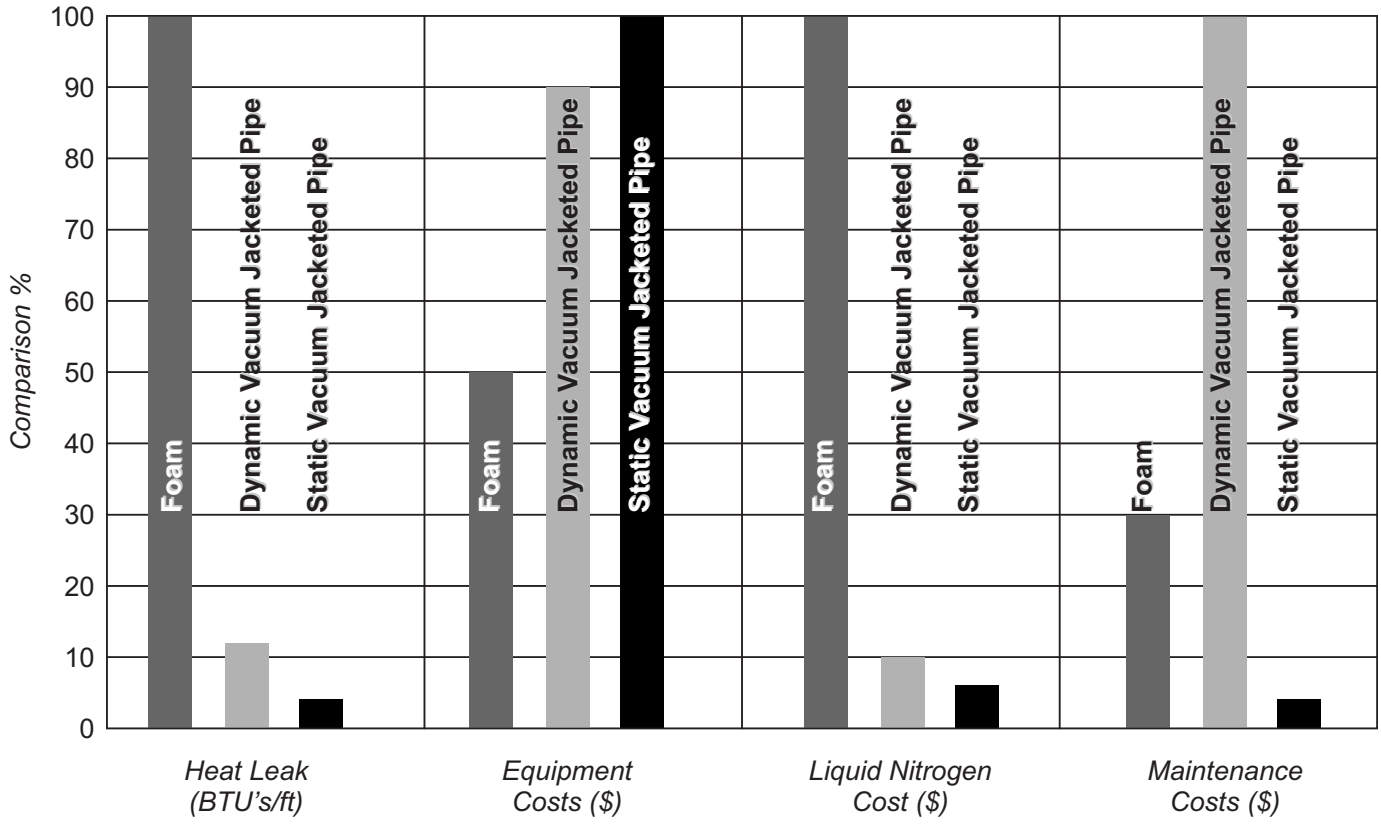
Cost Comparison (Foam Insulated, Dynamic Vacuum, Static Vacuum)



Conclusion

It appears very clear that static vacuum jacketed piping is a better choice over dynamic vacuum jacketed piping. Static vacuum type vacuum jacketed pipes have been sold around the world for several decades now. Static vacuum is a proven technology. It is technically sound and the cost to own is by far the lowest of any other type of insulated pipes for cryogenic applications including dynamic vacuum jacketed pipes.

In fact, most if not all manufacturers of vacuum jacketed piping offer static vacuum jacketed pipes and very few (most probably only one) offer dynamic vacuum jacketed pipes. The static vacuum technology is not only used for piping, but it is also widely used for other type of cryogenic applications such as cryogenic freezers and cryogenic tanks like the ones you see holding large amounts of liquid oxygen at hospitals.

In our opinion, the lower cost to purchase of a dynamic vacuum jacketed piping versus a static vacuum jacketed piping is rapidly offset by its total lower cost of ownership.

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