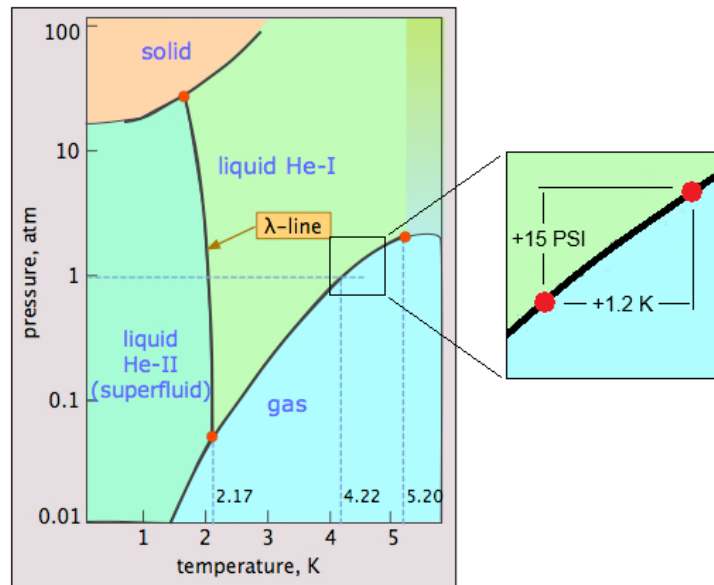


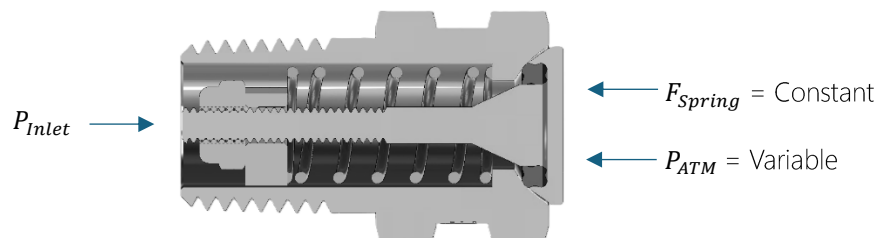
What is The Purpose of an Absolute Pressure Relief Valve (APRV)?

The simple answer is **EXTREME COLD**. APRV's are almost always used for cryogenic liquid helium vessels whose primary purpose is to supply a process with an extremely cold fluid. At ambient pressure, liquid helium exists at 4.2 Kelvin, a temperature where atoms have nearly stopped moving altogether. This is a requirement for systems that utilize superconducting wire like MRI machines. In cryogenics, pressure and temperature are closely related because the liquid and gas like to stabilize on the vapor curve. When the pressure rises, the liquid temperature rises, and vice versa. In order to conserve the extreme cold in your liquid helium vessel, it is important to maintain the pressure as low as possible. A pressure rise of 15 PSI results in a 1.2 K increase in liquid temperature. This may not seem like a lot but that's almost a 30% rise when operating so close to absolute zero.



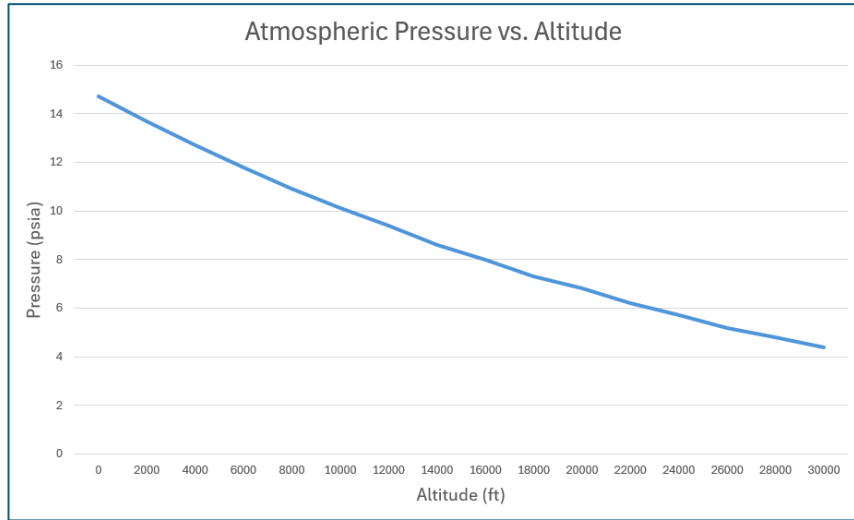
Keeping the pressure low in a vessel is easy to do but that gets tricky when you try to transport the vessel through the air.

Typical direct spring acting relief valves are set at gauge pressure. Gauge pressure technically means “with respect to ambient conditions.” It’s a differential pressure versus ambient conditions. A 1 PSIG relief valve will open 1 PSI higher than whatever the ambient pressure conditions are. This is because the ambient pressure is exerting pressure force on the outlet side of the poppet. Below is a force diagram of a standard relief valve and the sum of pressures acting on its sealing surface. Both Pressure components “P” act on the same sealing Area to net a force.



The force from P_{inlet} is counteracted by the sum of F_{spring} and P_{ATM} . Because of this force balance, if a standard relief valve is used in an environment where atmospheric pressure fluctuates, the absolute pressure set point (P_{inlet} in absolute terms) will change the same amount as the change in atmospheric pressure.

When a pressurized vessel needs to be transported by air, the changing ambient conditions need to be accounted for because atmospheric pressure (P_{ATM}) decreases with altitude.



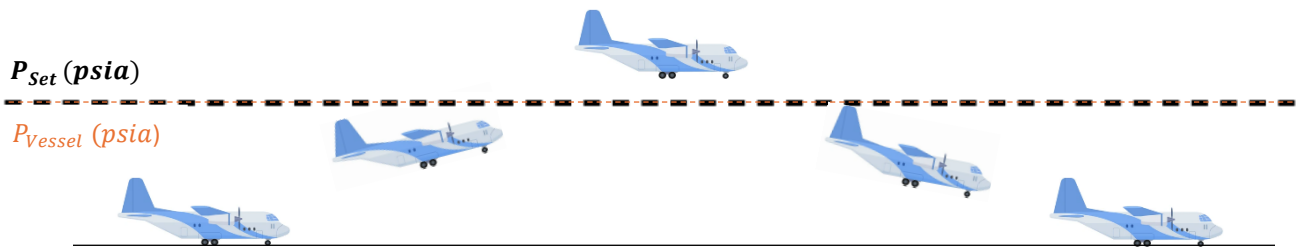
Let's look closer at the case of the 1 PSIG standard relief valve on a cryogenic vessel. As you may know, cryogenic vessels have a natural evaporation rate, or NER, that constantly builds pressure in the vessel. Even though cryogenic vessels are very well insulated, a small amount of heat is always entering the vessel and boiling off cryogen which results in pressure rise. A relief valve venting to atmosphere is the preferred way to handle this small boil-off rate. When a 1 PSIG valve is installed on our vessel and loaded on an airplane, the vessel will be stable at a pressure of about 1 PSIG or 15.7 PSIA (orange dotted line). However, when the plane gets up to altitude, ambient conditions would be ~4 PSIA at 30,000 feet. Since we have a standard relief valve on the vessel, the relief valve is still set at 1 PSIG but this is just 5-6 PSIA. During the ascent, the relief valve will have relieved helium to reduce the vessel pressure by more than 10 PSI. On the descent from altitude, NER won't build fast enough to recoup this pressure. When the plane lands, the vessel will now be under a considerable vacuum relative to ambient pressure!



This presents a few big problems for the user. First, they wasted a lot of very expensive helium by venting the vessel down 10 PSI. And that is not just the gas in the head space. The liquid itself would have been rapidly boiling that entire time to get the liquid contents back to equilibrium on the vapor curve. A 25-50% loss of vessel contents is not out of the question. The customer now needs to recharge their vessel with liquid helium on-site to deliver the full vessel. Second, the vessel as delivered is now under vacuum. Even if delivering the full contents was not required, they can't even attach to their process before building the pressure back up. This is not easy to do because opening a valve would allow ambient air into their liquid helium vessel. Beyond mixing air with helium, this would instantly create water ice formation in the vessel as any humidity from the air instantly condenses and freezes. Any components on the vessel leaking because they aren't rated for internal vacuum conditions could cause the same problem. As you can see, keeping helium extremely cold at low pressure during air transport is not easy to do.

For many years, industry leaders in the MRI business have dealt with this problem. Some just used 15 PSIG relief valves for transport to ensure that vessel pressure never dropped below sea level ambient pressure conditions. This led to air transport vessels always being delivered HOT which necessitated a specialized cool-down process and machine recalibration on-site.

Generant came out with the APRV Series in 2014 to provide the cryogenics industry with a unique and cost-effective solution for liquid helium transport. The APRV is a pressure relief valve that is unaffected by changes in ambient pressure conditions. This is achieved using special precision internal components that compensate for ambient pressure fluctuations. When installed on the helium vessel we discussed earlier, the vessel remains at 15.7 PSIA throughout the entire trip. During the trip, the valve setpoint (in gauge terms) fluctuated substantially. Sometimes it was at 1 PSIG, sometimes it was at 10 PSIG. The pressure compensation is automatic and extremely reliable.



By specifying an APRV, you are ensuring that the extreme cold required for the customer application is conserved without loss of helium, the need for expensive cooldown processes, or machine recalibration onsite. Below is a table demonstrating how Standard Relief Valves and APRV Series Relief Valves perform through changing ambient conditions in typical air transport.

Altitude		Atmospheric Pressure (psia)	Std. Relief Set Pressure (psia)	Std. Relief Set Pressure (psig)	APRV Set Pressure (psia)	APRV Set Pressure (psig)
(ft)	(m)					
0	0	14.7	15.7	1.0	15.7	1.0
5,000	1,524	12.2	13.2	1.0	15.7	3.5
10,000	3,048	10.1	11.1	1.0	15.7	5.6
15,000	4,572	8.3	9.3	1.0	15.7	7.4
20,000	6,096	6.8	7.8	1.0	15.7	9.0
25,000	7,620	5.5	6.5	1.0	15.7	10.3
30,000	9,144	4.4	5.4	1.0	15.7	11.3

APRV Series is offered in a Vent to Atmosphere or Inline configuration. It has a high flow capacity, excellent reseal characteristics, and is qualified for extreme low temperature applications. The Fluorosilicone seal used in the device was selected specifically for the application. It provides a leak-free seal at low temperatures, handles extreme low temperatures without failing, and is helium compatible.

If you have any questions about the APRV Series or other products that Generant provides to the cryogenic and industrial gas industry, please reach out to our Customer Service team at 973-838-6500 or visit www.generant.com.