

COUPP-0.1 Bubble Chamber
What-if analysis

v0.1 4 Dec 2012 M. Hai

WHAT IF	CONSEQUENCE/HAZARD	CONCLUSION/RECOMMENDATION
The pressure vessel or bubble chamber develops a leak?	<p>The pump can provide up to 6.6gph (.11gpm) of mineral oil to the system until the reservoir runs dry. Thereafter the vessel will begin to empty of mineral oil. The system will be unable to pressurize the vessel, and the mineral oil will leak into the water bath. The system will be unable to keep up with a larger leak, and decompression of the system will occur sooner.</p> <p>If the bubble chamber leaks, C3F8 will leak into either the water or the pressure system. In the former case, it will boil off and evaporate. In the latter, it may remain liquid in the pressure system piping and introduce gas bubbles. In both cases, either mineral oil or water will be observed filling the bubble chamber.</p>	<p>This condition will result in no liquid spillage. The leak will likely originate from one of the threaded fittings or from the O-ring seal on the pressure vessel. These components are off-the-shelf parts and can be replaced.</p> <p>Monitoring of the reservoir level should reveal any slow leaks in the pressure system. Connecting the reservoir to the pressure system to temporarily relieve working fluid losses requires immediate actuation of manual valves.</p>
There is a loss of house compressed air?	<p>Compressed air is used to refill the reservoirs for compression. Losing building air will prevent the system from compressing after an expansion event. If the system is expanded after the loss of compressed air, compression may not be possible.</p>	<p>If the pressure regulator is for whatever reason unable to provide the requested pressure, expansions should be disabled until house air is available again. AC-001 will provide a safe source of pressure if the expansion valve is kept closed.</p>
There is a loss of electrical power?	<p>The water bath will power off. There will be no control system. EV-002 is normally open, and EV-003 is normally closed, so the pressure chamber will compress upon power failure.</p>	<p>Absent electrical power, the system is in a safe configuration at no risk of mechanical damage. Upon return of power, the system can resume operation as normal.</p>
The pressure system needs to be emptied while the bubble chamber is full?	<p>Upon removal of pressure, the bubble chamber will expand. At room temperature, assuming the water bath has been drained, the bubble chamber's contents will boil to the C3F8 vapor pressure of >110psi. This will cause the bellows to meet the hard stops and the system will be safe. However, it will not be possible to return the bellows to the neutral position to refill the hydraulic system.</p>	<p>To depressurize the hydraulic system, C3F8 should be removed from the bubble chamber. Though the pressure vessel will not be breached, the hydraulic system will be impossible to refill. C3F8 should be removed before the hydraulic system is depressurized to retain pressure control within the chamber for C3F8 removal.</p>
The operator commits an error?	<p>If the chamber is decompressed to a very low pressure and the C3F8 begins to boil without compression to suppress it, the bellows can become overextended. If the operator chooses to open valves to either the hydraulic system or the inner chamber, a dangerous situation can be created when pressurized fluid is forcefully expelled. Otherwise, the system should tend to remain in a safe configuration that will not damage the vessel.</p>	<p>Clearly label valves that should not be opened unless system is safe to vent. Implement warning and automatic repressurization features in software to prevent inadvertent damage to the bellows.</p>

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The DAQ fails?	The system is considered passively safe unless the high-pressure accumulator loses a significant amount of pressure. Under total DAQ failure, the chamber should compress to a safe state. If a compression is for some reason not triggered upon C3F8 bubbles but the DAQ continues to control the valves, the C3F8 may boil and the bellows will fail. This has happened with the COUPP-4kg chamber and damaged the bellows.	Failure of the DAQ can lead to bellows overextension and take the device out of commission. This requires a very particular kind of failure; however, it is not impossible. This will not lead to an unsafe condition.