

COUPP-0.1 FMEA

Type	Tag	Service	Description	Failure or Error Mode	Hazard or Effect	Hazard Class	Remarks
Manual valves							
MV	003	Mineral oil	Expansion regulation needle valve	Fails open	Expansion rate cannot be modified	Safe	Rate of expansion cannot be modified.
MV	003	Mineral oil	Expansion regulation needle valve	Fails closed	Chamber cannot be expanded	Safe	Expansion of chamber by normal means is unachievable.
MV	004	Mineral oil	Fill line high-pressure valve	Fails open	High- and low-pressure systems cannot be refilled independently	Safe	High-pressure region extends to MV-016. High- and low-pressure lines cannot be refilled independently.
MV	004	Mineral oil	Fill line high-pressure valve	Fails closed	High-pressure line cannot be refilled	Safe	High-pressure system cannot be directly refilled. No mineral oil will leak out. System could be refilled by filling low-pressure line, bleeding out old fluid / air, and running pump.
MV	005	Mineral oil	Mineral oil vacuum pump-down port	Fails open	System cannot be degassed	Safe	MV-005 is closed off from the operational pressure system by MV-004, MV-006, and MV-016. No risk of forceful fluid expulsion.
MV	005	Mineral oil	Mineral oil vacuum pump-down port	Fails closed	System cannot be degassed	Safe	If the system is already filled and degassed, operation can continue as normal until the next fill becomes necessary.
MV	006	Mineral oil	Fill line low-pressure valve	Fails open	High- and low-pressure systems cannot be refilled independently	Safe	Low-pressure region extends to MV-016. High- and low-pressure lines cannot be refilled independently.
MV	006	Mineral oil	Fill line low-pressure valve	Fails closed	Low-pressure line cannot be refilled	Safe	Low-pressure lines cannot be directly refilled. No mineral oil will leak out. System can be refilled by filling high-pressure line, bleeding out old fluid / air, and running pump.
MV	010	C3F8	C3F8 vacuum pump-down port	Fails open	Mineral oil leaks out		System cannot be pressurized. If system is pressurized above atmospheric upon failure, mineral oil will be forcefully expelled. If pressurization is attempted after failure, it will be unsuccessful and expel more mineral oil.
MV	010	C3F8	C3F8 vacuum pump-down port	Fails closed	C3F8 cannot be degassed	Safe	Vacuum pump cannot be connected. System cannot be degassed.
MV	011	C3F8	Bubble chamber fill valve	Fails open	C3F8 leaks or boils out		Bubble chamber cannot be pressurized. If system is pressurized above atmospheric upon failure, C3F8 will be forcefully expelled. If pressurization is attempted after failure, it will be unsuccessful and expel more C3F8.
MV	011	C3F8	Bubble chamber fill valve	Fails closed	Bubble chamber cannot be filled directly	Safe	Bubble chamber cannot be filled.
MV	012	C3F8	Bubble chamber bleed valve	Fails open	C3F8 leaks or boils out, system cannot be bled		Bubble chamber cannot be pressurized. If system is pressurized above atmospheric upon failure, C3F8 will be forcefully expelled. If pressurization is attempted after failure, it will not be successful and will expel more C3F8.
MV	012	C3F8	Bubble chamber bleed valve	Fails closed	System cannot be bled	Safe	Air bubbles may collect near top of pressure chamber.
MV	014	Mineral oil	Mineral oil fill valve	Fails open	System cannot be degassed, mineral oil may leak out	Safe	MV-014 is closed off from the operational pressure system by MV-004, MV-006, and MV-016. No risk of forceful fluid expulsion.
MV	014	Mineral oil	Mineral oil fill valve	Fails closed	System cannot be filled	Safe	If the system is already filled and degassed, operation can continue as normal until the next fill becomes necessary.
MV	016	Mineral oil	Fill line isolation valve	Fails open	Small quantity of mineral oil leaks out	Safe	Mineral oil between MV-004, MV-006 and fill point may leak out of system.
MV	016	Mineral oil	Fill line isolation valve	Fails closed	Mineral oil system cannot be refilled	Safe	MV-016 is isolated from the operational pressure system.

Pressure regulators

PR	001	air	Accumulator pressurizing regulator	Incorrect pressure – high	Low-pressure accumulator pressure too low	Safe	Low-pressure accumulator may drop to atmospheric pressure. Expansion will be faster and less controlled.
PR	001	air	Accumulator pressurizing regulator	Incorrect pressure – low	Low-pressure accumulator pressure too high	Safe	Regulator can supply up to 100psi. Accumulator is rated for 3500psi. No risk of failure. Bubble chamber expansion would be slow and limited to regulator pressure.
PR	002	air	Pressure gauge/regulator on building air line	Incorrect reading - low	Supplied air pressure too low	Safe	May be impossible to pressurize bubble chamber to desired level.

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Type	Tag	Service	Description	Failure or Error Mode	Hazard or Effect	Hazard Class	Remarks
PR	002	air	Pressure gauge/regulator on building air line	Incorrect reading - high	Supplied air pressure too high	Safe	Pressure regulator will supply appropriate pressure for system.

Pressure transmitters

PT	002	Mineral oil	High-pressure manifold transducer	Incorrect pressure – high	High-pressure line pressure too low	Safe	Chamber compression could be impossible. C3F8 could boil. Could generate false bubble sightings.
PT	002	Mineral oil	High-pressure manifold transducer	Incorrect pressure – low	High-pressure line pressure too high	Safe	Chamber could be overcompressed, affecting operation. Quartz rated for 1160psi, pump can provide 150psi – no safety risk.
PT	003	Mineral oil	Low-pressure manifold transducer	Incorrect pressure – high	Low-pressure line pressure too low	Safe	Low-pressure accumulator may drop to atmospheric pressure. Expansion will be faster and less controlled.
PT	003	Mineral oil	Low-pressure manifold transducer	Incorrect pressure – low	Low-pressure line pressure too high	Safe	Regulator can supply up to 100psi. Accumulator is rated for 3500psi. Bubble chamber expansion would be slow and limited to regulator pressure.
PT	004	Mineral oil	Bubble chamber pressure transducer	Incorrect reading – high	Chamber pressure too low	Safe	C3F8 could boil. Could generate false bubble sightings.
PT	004	Mineral oil	Bubble chamber pressure transducer	Incorrect reading – low	Chamber pressure too high	Safe	Chamber could be overcompressed, affecting operation. Quartz rated for 1160psi, pump can provide 150psi.
PT	005	Mineral oil	Transient pressure vessel transducer	Incorrect pressure – high	System pressure too low	Safe	Chamber compression could be impossible. C3F8 could boil. Could generate false bubble sightings. Failure to raise pressure to appropriate level should be detected by steady-state transducer.
PT	005	Mineral oil	Transient pressure vessel transducer	Incorrect pressure – low	System pressure too high	Safe	Chamber could be overcompressed, affecting operation. Quartz rated for 1160psi, pump can provide 150psi – no safety risk. Failure to raise pressure to appropriate level should be detected by steady-state transducer.
PT	006	Mineral oil	Steady-state pressure vessel transducer	Incorrect pressure – high	System pressure too low	Safe	Chamber could fail to compress to desired pressure. C3F8 could boil. Could generate false bubble sightings.
PT	006	Mineral oil	Steady-state pressure vessel transducer	Incorrect pressure – low	System pressure too high	Safe	Chamber could be overcompressed, affecting operation. Quartz rated for 1160psi, pump can provide 150psi – no safety risk.

Pumps

PU	001	Mineral oil	Accumulator rebalancing pump	Fails on	High-pressure accumulator pressurized above design	Safe	Accumulator is rated for 3500psi, pump is rated for 150 psi. Pump will fail before accumulator. After pump fails, chamber cannot be compressed after expansion.
PU	001	Mineral oil	Accumulator rebalancing pump	Fails off or cannot provide pressure	High-pressure accumulator cannot be compressed	Safe	Compression may not be possible after expansion. C3F8 could boil. Could generate false bubble sightings.
PU	001	Mineral oil	Accumulator rebalancing pump	Slow leak	Accumulators gradually equalize in pressure	Safe	Running pump will repressurize high-pressure accumulator. Fast compress could fail if pressure is not monitored and adjusted as necessary.

Solenoid valves

EV	001	Mineral oil	Fast compress valve	Fails open	Chamber cannot be expanded	Safe	Pressure chamber is permanently connected to high-pressure accumulator. After expansion, pump compresses against pressure chamber and entire high-pressure system rather than accumulator alone.
EV	001	Mineral oil	Fast compress valve	Fails closed	Fast compress capability lost	Safe	Chamber can still be compressed with slow-compress valve.
EV	002	Mineral oil	Slow compress valve	Fails open	Chamber cannot be expanded	Safe	Pressure chamber is permanently connected to high-pressure accumulator. After expansion, pump compresses against pressure chamber and entire high-pressure system rather than accumulator alone.
EV	002	Mineral oil	Slow compress valve	Fails closed	Slow compress capability lost	Safe	Chamber can still be compressed with fast-compress valve.
EV	003	Mineral oil	Expansion valve	Fails open	Chamber cannot be compressed	Safe	Chamber compression could be impossible. C3F8 in bubble chamber evaporates. Could generate false bubble sightings.
EV	003	Mineral oil	Expansion valve	Fails closed	Chamber cannot be expanded	Safe	No means of connecting chamber to low-pressure system.