INTEGRITY STUDY OF TOTAL CONTAINMENT VESSEL

Area Of Concern:

Any leak or release of chlorine that occurs within the Total Containment Vessel, provided by TGO Technologies, is contained with the high pressure vessel portion of the system and the system will operate as designed. Any leak or release of chlorine gas from the vacuum line downstream of the vacuum regulator will loose the vacuum condition and cause the vacuum regulator to close stopping the flow of chlorine gas to the vacuum line. The maximum release of chlorine gas will be the amount of chlorine gas that is the length of the vacuum line to the chlorine injector and not drawn into the water solution by the suction of the injector. At both ends of the Total Containment Vessel the system can be considered to be fail-safe.

There can be a question of the integrity of the portion of the system from the location that the outlet line with chlorine gas penetrates the wall of the pressure vessel to the location where the vacuum line leaves the outlet side of the pressure regulator. This study evaluates the magnitude and effect of a leak or release in this portion of the system of the Total Containment Vessel.

Discussion:

The chlorine supply line from the outlet gas valve of the one ton container is attached to a high pressure penetration fitting through the wall of the high pressure vessel portion of the system. This fitting is attached to the valve body of the Fail-Safe Valve System. The outlet of this valve is attached to a flex supply line which is attached to the inlet of the heater and evaporator tube of the vacuum regulator. The outlet of the vacuum regulator is attached to the vacuum line. The entire portion of the chlorine gas feed system external to the high pressure vessel portion of the system of the Total Containment Vessel is contained within a metal Protective Housing.

The metal wall of the Protective Housing has high pressure penetration fittings for the electrical line for the Fail-Safe Valve, the heater on the evaporator tube and the vacuum regulator as well as the chlorine sensor of the Fail-Safe Valve System. The outlet of the vacuum regulator has a metal tube connected to a high pressure penetration fitting through the wall of the Protective Housing. The exterior side of this fitting has a fitting for the attachment of the vacuum line to the chlorine gas injector to the water solution.

The Fail-Safe Valve is closed shut within two (2) seconds of the chlorine sensor detecting chlorine within the Protective Housing above the set point established for the chlorine level of concern.

A leak or release from any component within the Protective Housing can have chlorine gas flow

for up to the two seconds when the Fail-Safe Valve is closed shut. The Fail-Safe Valve seals the outlet of the high pressure penetration fitting through the wall of the high pressure vessel portion of the system. The Fail-Safe Valve is normally closed so that any lose of electrical power also causes the Fail-Safe Valve to fail closed.

Once the Fail-Safe Valve is closed, there is chlorine gas in that portion of the chlorine feed line from the outlet of the Fail-Safe Valve to the location of the leak or release. The vacuum line will draw out that portion of the chlorine gas from the location of the leak or release. The maximum amount of chlorine left in the feed line will occur if the leak or break occurs at the location where the metal vacuum line attaches to the high pressure penetration fitting through the wall of the Protective Housing.

There are two sources of chlorine gas that can be released to the interior of the Protective Housing:

1) The chlorine gas that passes through the Fail-Safe Valve until the Valve is shut in two seconds

2) The chlorine gas that remains in the feed line from the outlet of the Fail-Safe Valve to the location of the leak or release, i.e. , the location where the metal vacuum line attaches to the high pressure penetration fitting through the wall of the Protective Housing.

It is to be noted that these two amounts are not independent since a portion of the flow in the two seconds through the Fail-Safe Valve is still in the feed line when the Fail-Safe Valve is closed and can be double counted. This is considered a conservative assumption to maximize the total amount of chlorine gas that can be released to the Protective Housing.

The change in pressure in the interior of the Protective Housing will be determined due to the combined effect of these two releases.

Calculations:

From the Chlorine Manual, by Chlorine Institute, Inc., on Page 10 in Section 2.8.2 the sustained release of chlorine from a one ton container of chlorine at 70˚F against 35 psi is 15 lb/hr.

The Fail-Safe Valve is closed in 2 sec from time of sensing the chlorine release. The amount of chlorine vapor that passes through the Fail-Safe Valve before it closes is

(15 lb/hr)(2 sec)(l hr/3600 sec) = 0.00833 lb of chlorine

From the high pressure penetration fitting through the wall of the high pressure vessel portion of

the system to the high pressure penetration fitting through the wall of the Protective Housing for the vacuum line is estimated at:

High pressure penetration fitting	2 in
Flex supply line	18 in
Heater/ evaporator	2 in
Metal vacuum line	4 in
Total length	36 in

Assume passage through all these items is with 0.25 in id.
The vapor density at 70˚F and 100 psi is 0.7335 ft3/lb or 1.36 lb/ft^3
The amount of chlorine vapor in this 36 in length of 0.25 in id is

$$(3.14/4)\ (0.25\ in/12\ in/1\ ft)^2\ (36\ in/12\ in\ /\ 1ft) = 0.00102\ ft^3$$

Then the amount of chlorine gas is:

$$(0.00102\ ft^3)\ (1.36\ Ib/ft^3) = 0.00139\ lb$$

Assume the break is inside the protective housing containing the Fail-Safe Valve and the vacuum regulator at the exit fitting of the vacuum line from the protective housing, the amount of chlorine released is:

During 2 sec flow before Fail-Safe Valve is closed	= 0.00833 lb
From Fail-Safe Valve to leak when Fail-Safe Valve closed	= 0.00139 lb
Total chlorine released	= 0.00972 lb

This assumes that the amount of chlorine that passed through the Fail-Safe Valve before the closed is not part of the amount of chlorine that remains between the Fail-Safe Valve and the break. The amount of chlorine released is overestimated by this assumption.

Calculations (continued) :

The protective housing has internal dimensions of a 14 in width, 24 in length and 12 in height. The volume in the housing is:

$$(14\ in)\ (24\ in)\ (12\ in) = 4{,}032\ in^3$$

The density of the released chlorine in the housing is:

$$(0.00972\ lb)\ /\ (4{,}032\ in^3) = 2.41 \times 10^{-06}\ lb/ft^3$$

The increase of internal pressure in the protective housing due to the chlorine release at the

70˚F temperature is:

Then $\triangle P = p\ R\ T$

$= (12\ in/1\ ft)\ (2.41 \times 10^{-06}\ lb/ft^3)\ (1545\ ft\text{-}lb_f/mole\text{-}^oR)(530^oR) / (71\ lb_m/mole)$

or $\triangle P = 0.334$ psi

Summary Of Results:

The protective housing will see an increase of internal pressure of 0.334 psi for the release of 0.00972 lb of chlorine gas. This small increase in internal pressure in the Protective Housing is expected to be contained within the Protective Housing.

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