

## EVALUATION OF VALVES EXTERNAL TO TGO VESSEL

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The safety valves external to the TGO Vessel have the following features:

- The High Pressure Penetration Fitting made from round stock of Monel with drilled penetrations for the gas flow is welded into the wall of the TGO Vessel
- The portion of the High Pressure Penetration Fitting which could be exposed to a high pressure chlorine release internal to the TGO Vessel has no corners to promote stress cracking and/or corrosion
- The Fail-Safe Valve is welded to the end of the high pressure penetration fitting external to the wall of the TGO Vessel
- The only non-welded connections under chlorine gas pressure are:
  - The one end of connector at the outlet of the Fail-Safe Valve
  - The other end of connector at the inlet of the Manual Shut-Off Valve
  - The outlet of Manual Shut-Off Valve which attaches to inlet of vacuum regulator
- Fail-Safe Valve is normally closed
- Loss of nitrogen supply or electrical supply to Fail-Safe Valve causes Valve to close
- Leakage at any non-welded connections will cause Fail-Safe Valve to close
- Flow stopped by Manual Shut-Off Valve if Fail-Safe Valve fails to close
- Break in vacuum line causes vacuum regulator to close
- Maximum loss from non-welded connections is 0.00899 lb of chlorine gas.

### Calculations for Chlorine Gas Loss:

A break is considered which maximizes the amount of chlorine gas released. Thus, assume:

- The break occurs at the non-welded connection to the vacuum regulator
- The chlorine gas on the outlet of the vacuum regulator is drawn safely away by the vacuum in the vacuum line

Note that the amount of chlorine that passed through the Fail-Safe Valve before the Fail-Safe Valve is closed is not part of the amount of chlorine that remains between the outlet of the Fail-Safe Valve and the break at the vacuum regulator. This overestimates the amount of chlorine released and is a conservative assumption.

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

$$(15 \text{ lb/hr}) (2 \text{ sec}) (1 \text{ hr}/3600 \text{ sec}) = 0.00833 \text{ lb of chlorine}$$

From the outlet of the Fail-Safe Valve to the vacuum line is:

2 inch connector	2 in
Manual Shut-Off Valve	3 in
Heater/evaporator tube	10 in
Vacuum regulator	<u>2 in</u>
<b>Total Length</b>	<b>17 in</b>

Consider the passage through all these items as 0.25 in id.

The vapor density at 70°F and 100 psi is 0.7335 ft<sup>3</sup>/lb or 1.36 lb/ft<sup>3</sup>

The amount of chlorine vapor in this 17 in length of 0.25 in id is

$$(3.14/4) (0.25 \text{ in}/12 \text{ in}/1 \text{ ft})^2 (17 \text{ in}/12 \text{ in} / 1 \text{ ft}) = 0.000483 \text{ ft}^3$$

Then the amount of chlorine gas is:

$$(0.000483 \text{ ft}^3) (1.36 \text{ lb/ft}^3) = 0.000656 \text{ lb}$$

The total amount of chlorine gas released is:

During the 2 sec flow before Fail-Safe Valve is closed	=	0.008330 lb
From Fail-Safe Valve to leak when Fail-Safe Valve closed	=	<u>0.000656 lb</u>
<b>Total chlorine released</b>	=	<b>0.008986 lb</b>