Propylene Refrigeration Compressor
Over-Pressure Analysis

Lummus Technology – Technical Safety Bulletin

1.0 SUMMARY

Following a failure in the propylene refrigeration system at a licensee’s ethylene plant, Lummus Technology has re-analyzed the potential for over-pressuring the propylene refrigerant compressor inter-stage outflow system. In this case, the failure of a minimum flow recycle valve caused a part of the system to reach a pressure in excess of the design value.

The following recommendations are made:

Either remove the check valve from the dedicated inter-stage outflow line, install sufficient relief capacity or install a high integrity safety instrumented system (SIS) to trip the compressor as required during the operating scenario described below.

2.0 DISCUSSION

For propylene compressor systems with a dedicated inter-stage outflow nozzle, a failure of the minimum flow valve to the fully open position may cause over-pressure. Depending on the specifics of the design, the compressor can have outflows at the third and possibly fourth stage.

Please refer to the schematic below. In this example, a failure of the minimum flow valve causes an increase in the vapor available for condensing in the ethylene fractionator reboiler. This causes the normal compressor interstage outflow to stop and attempt to reverse. If a check valve is located in the outflow line, this prevents reverse flow causing the pressure in the outflow piping and drum to rise, potentially over-pressuring the system. The potential over-pressure could reach the compressor discharge pressure.

Some plants have a pressure control “B” valve located on the affected drum overhead that may open under this scenario. The “B” valve may prevent an over-pressure from occurring. However, a “B” valve may not provide adequate over-pressure protection due to concerns about reliability. In addition, using a “B” valve for protection may not be compatible with the governing pressure vessel code and or accepted by the local regulatory authority governing your site. For example, a “B” valve is not a pressure relief device accepted by the ASME Code. The “B” valve cannot, therefore, be relied on for protection in the event of a recycle valve failure if ASME Code is governing.
Lummus Technology has received only one notice of a minimum flow valve failure in this service from our licensees’ plants.

To prevent this potential overpressure occurrence, Lummus recommends one of the following options:

- Removal of the check valve from the inter-stage outflow
- Installation of sufficient pressure relief capacity on the affected stage
- Addition of a highly reliable safety instrumented system (SIS) high-pressure trip to stop the compressor.

Check Valve Removal

The removal of the check valve may cause reverse flow potentially leading to turning gear and or seal damage following a normal shutdown, depending on the compressor design. The potential for damage will depend on the compressor design and should be evaluated with the compressor vendor.

Pressure Relief Capacity

The pressure relief capacity must be suitable for passing the flow through the failed open valve at relieving conditions. Credit may be taken for the normal outflow from the compressor falling to zero and the forward flow into fractionator reboiler or other condensing exchanger at turndown (i.e., minimum stable operating condition, typically 60 – 70% of normal).

The maximum valve capacity of the recycle valve should be based on the installed valve trim, the actual Cv based on the wide-open position with a normal upstream pressure and the downstream pressure at relieving conditions.

Required Relief Capacity = (Maximum valve capacity) – (turndown forward flow to fractionator reboiler or other condensing exchanger).

The existing safety valve (PSV) capacity should be checked since it may be sized for a fire case and would then be too small for this case.

Reliable Trip System

A highly reliable SIS trip is required to detect and stop the source of the over-pressure. A typical system might be comprised of redundant pressure sensors mounted on the affected equipment, connected to a highly reliable logic solver which signals to redundant final control elements to shutdown the compressor turbine steam supply. A suitable maintenance and testing program is essential to ensure the required reliability. Consideration should be given to the system dynamics following a minimum flow valve failure to ensure an adequate response time.
3.0 FOLLOW-UP

Lummus Technology advises that qualified licensee personnel assess individual plant risk and agree on an acceptable method for over-pressure protection for the above mentioned failure case. It should be noted that local regulatory acceptance of the use of an SIS for overpressure protection needs to be confirmed before an instrumented solution can be implemented. Lummus Technology recommends that plant management should inform the affected personnel and develop operating procedures covering the described failures until acceptable remedial action is completed. Additionally, inter-stage pressure alarm and “B” valve set points for the affected compressor systems should be reconfirmed along with “B” valve testing.

If you have further questions or require assistance regarding the above subjects please feel free to contact Steve De Haan via email at sdehaan@cbi.com or phone 973-893-2325. You may also contact the Lummus Technology Plant Performance Improvement (PPI) Group by email at lummus.ethylene.techserv@cbi.com.
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