Putting Compressor Failures into Perspective for the PHA

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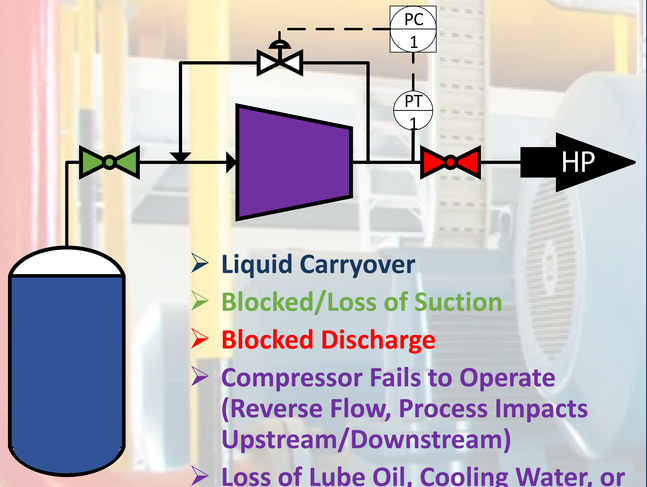
TYPES OF COMPRESSOR HAZARDS



- Liquid Carryover
- Blocked/Loss of Suction
- Blocked Discharge
- Compressor Fails to Operate (Reverse Flow, Process Impacts Upstream/Downstream)
- Loss of Lube Oil, Cooling Water, or Other Compressor Auxiliaries

COMPRESSOR DESIGN CONSIDERATIONS

CENTRIFUGAL VS. RECIPROCATING COMPRESSORS

- Loss of containment in centrifugal compressors usually results from a failure of the mechanical seals.
- Loss of containment in reciprocating compressors usually results from packing and internal component failure (damage to rings and rider bands, packing, and wiper failure).
- Liquid impact can be more severe for reciprocating compressors as the piston rods are less tolerant to liquid ingress.
- Centrifugal compressors often contain wet (oil) or dry (gas) seals that act as a barrier for escaping process gas.
- Reciprocating compressors shall be equipped with pulsation dampers and shock absorbing supports to minimize vibration and pulsation.
- Compressor housing requires proper toxic gas detection, instrumentation, and ventilation.
- Multistage compressors with varying discharge pressures and interstage equipment.

HAZARD = DESIGN + PROCESS CONDITIONS

BLOCKED DISCHARGE CONSIDERATIONS

- Reciprocating compressors can reach higher discharge pressures than centrifugal compressors.
- Downstream equipment and discharge piping pressure limits.
- Potentially larger release inventory compared to blocked suction case.
- Overheating
  - Impact on compressor or process materials (vapor pressure, decomposition, etc.)
- Typical safeguards:
  - Pressure relief valve
  - High vibration trip
  - High discharge pressure and/or temperature alarm/trip
  - Anti-surge protection system

LOSS OF SUCTION CONSIDERATIONS

- Loss of suction to reciprocating compressors may be limited to a localized release.
- Surge in centrifugal compressors leads to mechanical damage, seal failure and loss of containment.
- Process flow into upstream vessel typically continues.
- Equipment elevations
- Typical safeguards:
  - Low suction pressure alarm/trip
  - Anti-surge protection system
  - High discharge temperature alarm/trip

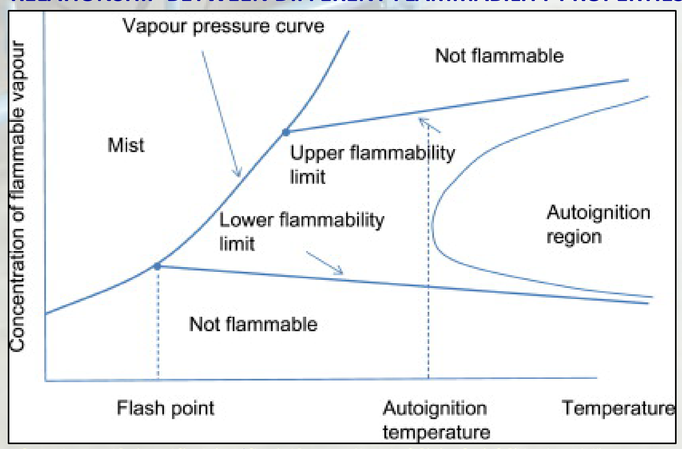
LIQUID CARRYOVER CONSIDERATIONS

- Liquid impact can be catastrophic for reciprocating compressors.
- Typical safeguards:
  - High level alarm/trip on upstream vessel
  - High vibration trip

REVERSE FLOW CONSIDERATIONS

- Material can reverse flow through the open compressor spillback line.
- Potential overpressure of interstage exchangers or KO vessels for multistage compressors.
- Typical safeguards:
  - Critical check valves
  - Emergency Isolation Valves (EIV)
  - Pressure relief valve

RELATIONSHIP BETWEEN DIFFERENT FLAMMABILITY PROPERTIES



Source: Integrated Design and Simulation of Chemical Processes, Alexandre C. Dimian, Costin S. Bildea, Anton A. Kiss, https://doi.org/10.1016/B978-0-444-62700-1.00016-4

PROCESS CONDITIONS SIGNIFICANTLY AFFECT TYPE AND MAGNITUDE OF HAZARD

- PRESSURE
- TEMPERATURE (AUTOIGNITION)
- COMPOSITION (H2S, AMINE, ETC.)

TIPS FOR MANAGING THE PHA

- Get SME/Rotating personnel involved with PHA (during prep phase or during team sessions)
- Send a "Request-for-Information" (RFI) to Rotating Equipment SME (with briefing on "probable worst-case consequence" to the compressor itself)
  - Provide SME with process parameters – Pressure, Temperature, Composition
  - Basics – Reciprocating vs. Centrifugal, Min. Flow Spillback, etc.
  - Severity and Timing Expectations – Safety/Environmental and Financial consequences are most important
- Compressor failure mechanisms and timing are more complicated than other PHA topics and involve input from multiple "disciplines"
- Compressor damage and release potential is often over-predicted by the PHA Team
- There is NO EXACT UNIVERSAL answer to compressor hazards
- Decision-making must be focused on adequacy of existing safeguards
  - All compressors and operating conditions are unique
  - PHA Team must focus on the "probable worst-case consequences"
  - Information such as release rate calculations or dispersion modeling may not be necessary during a PHA
  - Conveying to the PHA Team what drives risk is most important
- When in-doubt, err on the conservative side, but ensure risks stay "in-perspective"