Auto-Refrigeration / Brittle Fracture

Prevention and Process Safety Mitigation

The olefins and hydrocarbons processing industries have experienced a number of brittle fracture failures caused by exposure to low temperatures due to auto-refrigeration. Auto-refrigeration is a process where an unintentional and/or uncontrolled phase change of a hydrocarbon from a liquid state to a vapor occurs resulting in a very rapid reduction in the temperature of the local equipment or piping. This phenomenon can result in a catastrophic 'break-before-leak' scenario …brittle fracture. Where auto-refrigeration potentially could occur, it is important to evaluate the process unit's material of construction for all vessels and piping systems to ensure their fitness for service under the auto-refrigeration excursion. Some common process units where auto-refrigeration has occurred include Olefin Plants, Gas Processing, Refineries, Polymer Units and Ammonia Units.

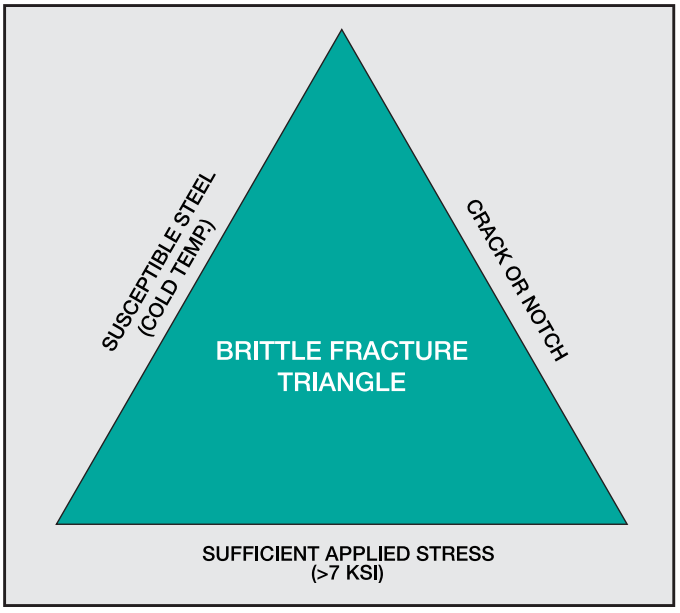
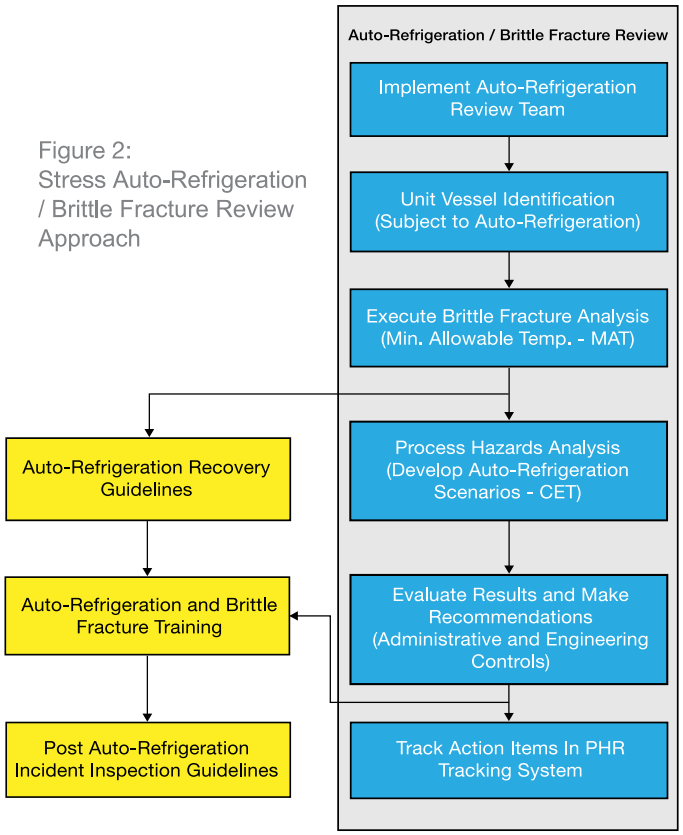


Figure 1: Brittle Fracture Triangle illustrates how "closing" of the triangle can potentially result in brittle fracture

Figure 2:
Stress Auto-Refrigeration / Brittle Fracture Review Approach



Brittle fracture occurs when a vessel or piping is chilled due to auto-refrigeration and excursion or post excursion stresses are sufficient to drive fracture at existing flaws. This behavior is often described by the brittle fracture triangle where closure of the triangle indicates the potential for brittle fracture (see Figure 1).

Auto-refrigeration is unique in that potential scenarios must be pro-actively identified and mitigated. By their very nature these transient events occur under uncontrolled non-normal operating states (upset, startup, shutdown, etc.). To that end Stress Engineering Services has

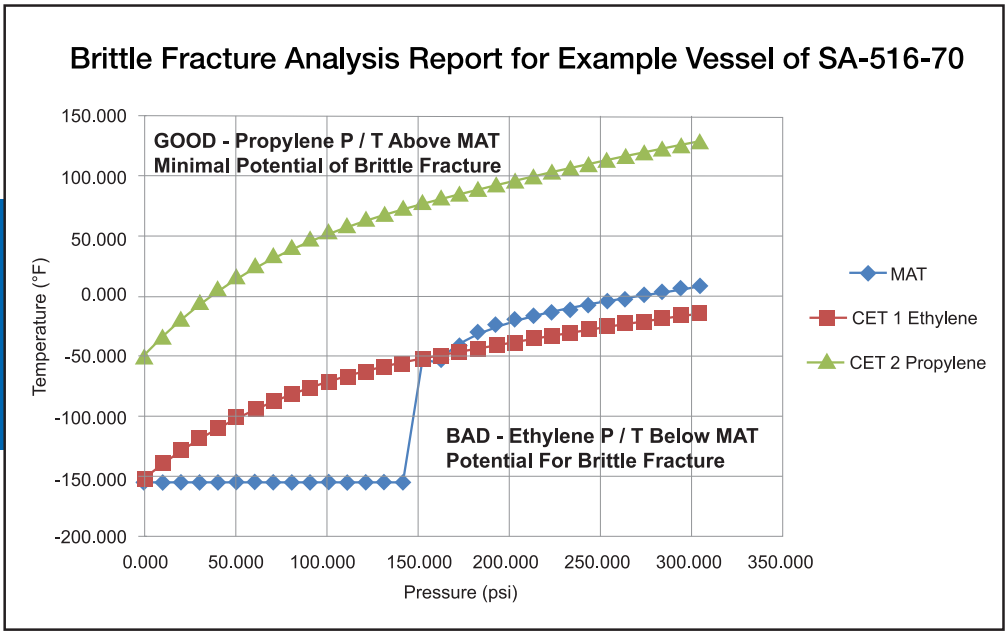
developed a practical approach using process hazards analysis and API 579 / ASME FFS-1 methodologies to assess vessels and piping. Our experienced staff has evaluated 1,000s of vessels and piping systems using this approach. This approach is outlined in Figure 2. It is important to note that Operations training on auto-refrigeration avoidance is a critical component to an effective brittle fracture prevention program. We also have well developed and informative training available to assist clients in accomplishing this key activity.

Figure 3: Brittle Fracture during pressure testing

Coupled with our experience, we can apply unique process hazards evaluation methods that can be used to identify and evaluate potential auto-refrigeration and brittle fracture process hazards. We routinely use methods outlined in Part 3 of API-579 / ASME FFS-1 to develop a minimum allowable temperature (MAT) curve. The MAT curve defines the lowest temperature allowed at a specific pressure to ensure the vessel material remains ductile. Once the MAT curve is defined, process hazards scenarios are developed using the dynamic and sequence driven methodologies to compare to the equipment MAT curve.

USA OSHA National Emphasis Program (NEP) requires utilizing API 579/ASME FFS-1 as a basis for establishing and documenting fitness-for-service and minimum allowable temperature on vessels and piping. With significant experience and expertise in the evaluation and remediation of auto-refrigeration related problems; We want to be your partner in insuring the safe and efficient operation of your chemical, refining or polymer manufacturing plant.

Figure 4: Illustrates a brittle fracture analysis result where the low temperatures caused by an auto-refrigeration event could lead to brittle fracture.



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