Hazards Assessment & Fracture Control Plan for Critical Components

Autorefrigeration Challenge

Introduction

"Autorefrigeration" occurs whenever a gas or low-boiling-point liquid is depressurized. In thermodynamics, it is known as the "Joule-Thomson Effect". Autorefrigeration can cool down processequipmenttoverylowtemperatureswhichcanreducethestructuralintegrityofvesselsor piping. Fires andexplosionsarearealhazardwhenflammableliquids areinvolved. Indeed, in a number of plants the depressurization of hydrocarbon process streams has resulted in very low temperaturesandembrittlementofcarbonandalloysteelprocessequipment.

Aptech EngineeringServices, Inc. (APTECH) hasdevelopedmethods toanalyzeandpredictthe hazards associated with autorefrigeration. We successfully employed these methods to analyze known orsuspectedautorefrigerationevents in severaltypes of chemical processingplants. Our analysis methods provide a powerful tool for pinpointing the process areas that are subject to autorefrigeration hazards, and for preventing and mitigating such hazards. We have conducted seminarstoshareourexperiencesonthisproblemandtodemonstratehowhazardscanbereduced oreliminated.Wehaveprovidedthermal-hydraulicandstressanalysesofcomponents,andhave consultedonprudentreturn-to-serviceofcomponentsthathavebeencooledtolowtemperatures.

We canprovidearealisticdefinitionoftheautorefrigerationproblemfor eachpotentiallyaffected unitorcomponent,andwecansuggestpracticalapproachesforitsresolution.Forexample,some plants have replaced some components andmaterials, while othershave reduced the sources of autorefrigeration.

Wegenerallydefinetheissuesasfollows:

- Unanticipated flow transients, with autorefrigeration, can compromisethedesign basis for equipment. This can lead to damage, lost production,andpossibly severe and hazardous conditionsfortheplantanditspersonnel.
- The seriousness of the problem varies widely for different units/components. APTECH's analysis determines whether the hazard is minor, appreciable, or severe. This provides a rationalbasisforprioritizingfixes.
- "Humanfactors"areimportantcontributors to therootcause ofmanydamaging eventsin the processing industry. We provide techniques for upgrading operating and emergency proceduresandimprovingmonitoringinstrumentation.Wealsoproviderelatedtrainingand requalificaiton of personnel. These techniques singly or in combination can produce large gainsinsystemsafetyandinplantproduction.

General Approach, Objectives, & Benefits

APTECH recommends a "top-down" approach, tailored to corporate needs for prudent assets management and protection, and applicable to all processing facilities. Perspective is provided by an independent evaluation, usually done in conjunction with an in-house peer review by company specialists.

As a first-step to assist a client in meeting its corporate safety and productivity objectives, we perform a pilot phase during which we determine specific needs and evaluate the potential risks. Recommended objectives of this scoping study include:

- Establish a corporate approach and policy to address the autorefrigeration hazard.
- Develop procedural guidance for hazardous operations (HAZOPs) assessment teams to help them recognize potential autorefrigeration targets. Procedures include criteria for identifying susceptible components, parts, and materials.
- Quantify priorities to establish the relative risk of the autorefrigeration hazard on a component-by-component basis, using simple screening for most equipment and more detailed analysis, as required, for more complicated situations or more costly remedies.
- Develop lifecycle management strategies for identified susceptible equipment, components, or materials.

We have found that this approach, combined with computational tools and our recent industrial experience, can assure integrity of plant components to a much higher degree than in the past.

The major benefits of utilizing APTECH's approach include the following:

- Assure component integrity during upset condition by using APTECH's enhancements to your HAZOPs assessment procedures.
- Gives management the data they need to control the risks associated with the potential hazards and environmental risks of autorefrigeration. The ranking of vulnerabilities provides a rational basis for prioritizing needed plant improvements.
- Identifies key elements of "human factor" issues and improvements in the decision process for maintenance, repair, and replacement. These provide gains in safety comparable to changes in hardware and control systems, at relatively modest costs.

APTECH's product is consulting engineering experience in responsible and cost-effective management of the autorefrigreation hazard. APTECH is able to provide this service because we have the broad range of expertise required, including:

- System risk analysis

- Processengineering
- Thermal-hydraulics
- Structuralanalysis
- Metallurgy
- Stressanalysis
- Fracturemechanics
- Failureanalysis/prevention

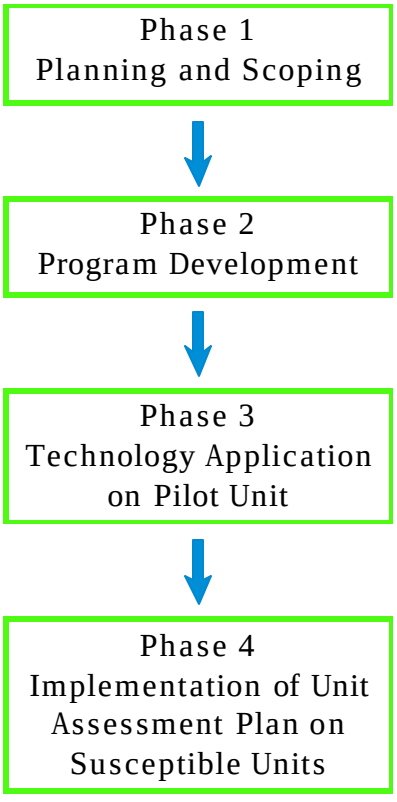
This expertise, combined with our considerable accumulated experience in working on the autorefrigerationhazard,ensuresthatyouwillobtainacomprehensiveandstate-of-the-artassessment and remedy guide for potential autorefrigeration hazards in your plant. Your company will realize immediate benefits of reduced risks to personnel, plant production rates, and physical plant by mitigatingorentirelyeliminatingtheautorefrigerationhazard.

Typical APTECH Multi-Phase Approach

Phase1-Planning

Inthisphase,wereviewthecorporateinformationandcomplete an audit to identify candidate critical components and to collect sufficient information to permit customizing of an assessment plan.Theusualstepsare:

- Gather data, including interviews with maintenance, operations, process engineering personnel, and process controlpersonnel.
- Research past autorefrigeration events (known or suspected) and the kinds of process upset conditions leadingtoevents.
- Identify potential human error and operating practices issues.
- Identify critical components, systems, or subsystems, at riskandthereasonforbeingatrisk.
- Reviewdetaileddesignandmaterialsspecificationsforthe candidatecriticalcomponents.
- Review operating and maintenance history of candidate criticalcomponents.



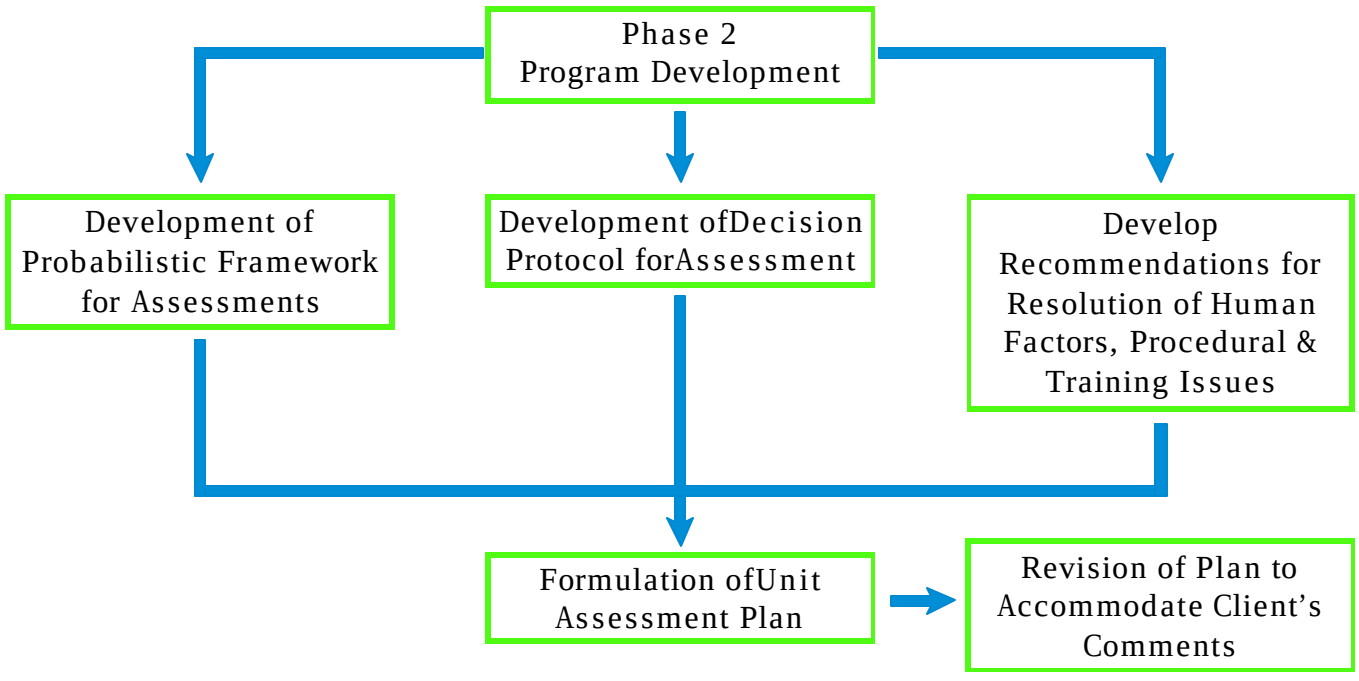
Phase2-ProgramDevelopment

Several candidate critical components and potential off-normal operating conditions are chosenfor detailed analysis. Where susceptibility is found, we develop one or more options forcost-effective remediesanddocumentthebasisfortheexpectedimprovement(s).Basedonlessonslearned,theplan isupdatedtobeapplicable(withsomequalification)tootherunits.

Operatingproceduresarereviewedfornormaloperations,recoveryfromoff-normalconditions,and recognizing and responding to serious emergency conditions. We note and suggest remedies for ambiguities or confusing aspects known to promote errors. We review training procedures and recommendchangeswhereneeded.

We will develop a localized probabilistic framework for prioritization of critical components. This provides inputs to ongoing HAZOPs reviews or refines existing documented fault trees. APTECH evaluates several sequences ofevents that are knownbyexperiencetohavethehighestpotentialto occur. Available faulttrees will be studied, or developed, starting with known or suspected initiator events involved in autorefrigeration. The evaluation includes a rough quantification of those sequences judged most likely to happen. Rough probability rankings for known types of initiating eventsaredevelopedandprobablerootcausesofinitiatingeventsareidentified.

Weidentify and rank optionsforpreventionand/ormitigationof the sequencesthat havethelargest apparentrisk.Thisgenerallyincludessomehardwareorcontrolchanges.Comparableaddedgainsin risk mitigation can generally be obtained from “human factors” reviews. These include reviews of procedures,training,personnelqualificationsforsensitiveoperations,and/orimprovedergonomicsof readouts and process mimics. Better component identification systems also reduce error rates and improveemergencyresponses.



Weestablish“bounding”thermal-hydraulicparametersandmaterialstressesusingsimplecalculations taking into consideration such factors as equipment histories and mechanical, thermal, and cyclic loads.Thesecalculationsprovideabasisforrankingvulnerabilities.

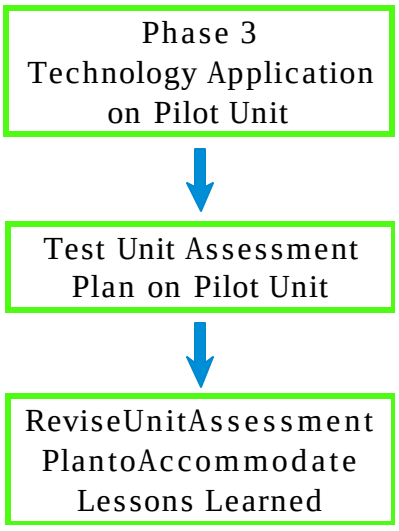
Theresulting“UnitAssessmentPlan”considers:

- Probabilityofautorefrigeration
- Magnitudeofanticipatedstresses
- Materialpropertiesandvariationofthesepropertie s
- Consequencesoffailure
- Likelihoodofmaterialdegradation
- Likelihoodofmanufacturingdefects
- Itemsmostsensitivetohumanfactors

Phase 3 - Pilot Phase

This phase tests the unit assessment plan on a specific process unit or component. This includes developing a critical component list and evaluating high priority components. APTECH ranks the alternatives for minimizing the risk of catastrophic failures during autorefrigeration events. These alternativesinclude,butarenotlimitedto,thefollowing:

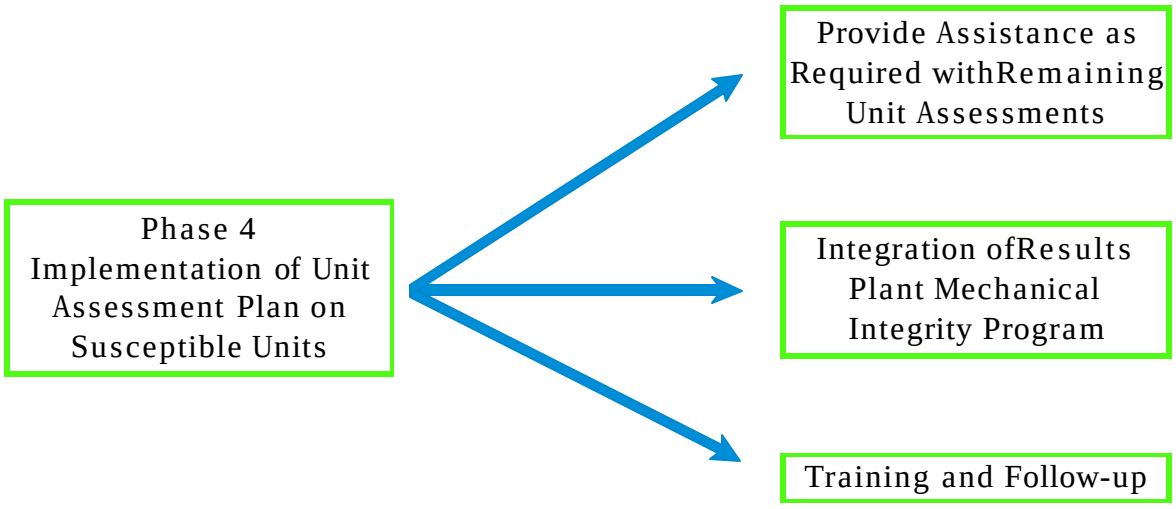
- Run/repair/modify/replacedecisions
- Constraintsandmodificationsforfutureoperation
- Condition assessment, including material and prooftesting
- Additionalon-lineinstrumentation
- Monitoringandfutureinspection
- Specialitemsforpersonneltraining



Phase4-ImplementationofAssessmentPlan

APTECH conducts component, unit, system, or plant assessments; including planning, engineering analysis, inspection, and disposition of problems. The mechanical integrity assurancerequirementsofsubparagraph(j)ofOSHARule1910.119isconsidered,including:

- Writtenproceduresandprogramstomaintainon-goingintegrity
- Writtenproceduresandprogramstomanagechanges
- Traininginprocedurestoassurethatemployeescanperformjobtasksinasafemanner
- Conduct and trend inspections, tests, and maintenance records to recognized and generallyacceptedgoodengineeringpractices
- Inspection and test frequencies are established based on risk level and condition assessments
- Safeandtimelydetectionandcorrectionofdeficiencies
- Qualityassuranceofmaintenancematerials,spareparts,andequipmentforsuitability



Phase5-Follow-up

APTECH conducts a periodic audit of inspection, maintenance, and test records and assists withcontinuedimplementationofotherfacetsofthemechanicalintegrityprogramrequiredby OSHARule1910.119,subparagraph(j).