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Application of Temperature Activated Relief Devices - Part 2

By Martin Gollin

A previous article described the situation where conventional pressure-activated relief valves may not be able to provide sufficient venting to protect a system from exceeding its maximum allowable working pressure (MAWP). In such cases, overpressure protection may be provided by system design. This article highlights some ways that this may be done.

Rupture Disc or Other Non-Reclosing Device

Although conventional pressure-activated relief systems may not provide adequate protection against overpressure resulting from some types of exothermic runaway reactions, an appropriately sized and installed non-reclosing device may be suitable (e.g., rupture discs, buckling pin devices, breaking pin/shear pin devices, etc.). These devices may be effective, as they remain open, by design, until the system has reached atmospheric pressure and VLE effects do not arise. Therefore, the venting will provide adequate cooling to lower the temperature, and hence the reaction rate, and prevent overpressure. However, the use of rupture discs has some practical drawbacks[1]. For example:

- Some styles are subject to fatigue in service.
- They require careful handling and installation to avoid mechanical damage.
- Most types require special holders.
- Care is required to install the disc correctly (i.e., right side up).
- Burst pressure is sensitive to temperature.
- Special types are required for low operating pressure margin applications.
- Performance sensitivity to deposition on the rupture disk surface is an issue in particular services (e.g., from polymeric or other materials).
- Potential failure at a pressure lower than its nominal bursting pressure, particularly in liquid service or where pulsating flow can occur, must be considered.

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Installing redundant rupture disc assemblies in parallel, and isolating them individually to inspect and replace the discs on a regular basis, could mitigate some of these issues. It may also be effective to install a nitrogen purge under the rupture disc to minimize the potential for deposition. However, many companies choose not to use rupture discs due to the problems identified above and, particularly for large continuous processes, the safety, operational, and economic consequences that would arise if a rupture disc activated unnecessarily.

Temperature-Activated Relief Valve System

A temperature-activated relief valve system can be set to open a relief valve at a given temperature and close it at a given temperature. This opening and closing is achieved by using an actuator (attached to the valve) and a control system. The use of a temperature-activated relief valve system allows control of the process variable (i.e., temperature) that directly affects the rate of reaction. The relief valve can be opened either at a specified temperature above the operating temperature, or when the rate of temperature rise meets a specified value. This enables the onset of an exothermic reaction to be detected and action taken at an earlier stage than would be possible using conventional pressure-activated relief valves. By keeping the relief valves open until the temperature of the system has reached a level where the rate of reaction is essentially zero, the system can be brought to a safe condition, while venting the least amount of material. The lower the opening set point temperature and the higher the closing set point temperature, the smaller the amount of material that is vented from the system. An additional advantage to using temperature as the basis for opening the relief valve is that the lower the temperature, the lower the reaction rate and the lower the potential for two-phase flow effects in the inlet and outlet piping. Holding the valve open may also minimize issues concerning two-phase flow through the relief valve itself. While the use of a temperature activated system can be highly effective, care must be taken in its design and installation so that the required availability is achieved. This usually requires the use of redundant components (sensors, processors and valving), plus the ability to functionally test the system on-line.

Design Process

To effectively analyze whether a control system is required to protect a system from the effects of an exothermic runaway reaction, the following steps may be required:

- Determine the potential for an exothermic runaway reaction.
- Assess the initiating events that could lead to an exotherm.
- Determine whether prolonged venting of the system would result in potentially hazardous concentrations of high boiling point material in the system or other hazardous conditions.
- Assess whether a conventional pressure-activated relief valve system is capable of providing protection against overpressure. This assessment may require developing a dynamic model.
- If a conventional pressure relief system cannot provide adequate protection, consider whether a non-reclosing device (e.g., a rupture disc) is acceptable in terms of safety and the potential for rupture during “normal” operations. If it is acceptable, then design and install such a system.
- If a non-reclosing device is unacceptable, then assess the initiating event frequencies for the various scenarios leading to an exotherm and determine what independent protection layers exist in the existing design.
- Assess whether the existing risk level is tolerable or not.
- Determine whether there are any “inherently safe” concepts that can be applied to the process to minimize or eliminate the risk associated with an exothermic runaway.
- If the current risk level is unacceptable, then assess the magnitude of the risk reduction required and examine the requirements of the ASME Code Case 2211 where applicable.
- Determine whether there is the potential for two-phase flow in any section of the system following the opening of the relief device. If there is, then utilize DIERS methods to size components. If redundant relief valves are utilized, then ensure that the relief header system and flare can handle the total flow if all relief valves open.
- Design and install a control system to provide protection against overpressure. This will involve determining the required overall system availability and the equipment redundancies and the test frequencies required to achieve this overall availability. Ensure that all components of the system are examined for their contribution

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to the overall availability and that potential "common cause" issues are reviewed. The design process should include an independent safety review.

- Define the criteria to be used for opening and closing the relief valves (e.g., temperature, dT/dt, etc.).
- Define whether any other action is to be taken by the control system (e.g., closing valves, adding quench, etc.).
- Ensure that test frequencies for equipment and systems are defined and implemented.
- Ensure that all components of the relief valve and actuator are designed to withstand the mechanical stresses imposed when the relief valve is opened for testing when there is only atmospheric pressure under the relief valve.
- Document all issues associated with the study to ensure knowledge is retained within the organization and that the basis for the system design, testing, etc. is available.
- Implement a tracking system to monitor the testing and other requirements necessary to ensure that the required system availability is maintained.

Reference

1. "*Guidelines for Pressure Relief and Effluent Handling Systems*," American Institute of Chemical Engineers, Center for Chemical Process Safety, New York, 1998, ISBN 0-8169-0476-6.

Martin Gollin has over twenty-five years of progressive technical and managerial experience in the chemical and contracting industries. Proven effectiveness in project and line management.

How to Develop NIR Property Models that Work

By Ara Barsamian

Today's blending environment could be a nightmare from the point of view of blend calculations.

- Some components are available only some of the time:
  - For marketing reasons (e.g., aromatics and butanes are more valuable for direct sales)
  - Process unit turn-arounds
  - Process unit failures
- Some components are opportunistic cargoes (e.g., reformates, toluenes, TX mixes, FCC gasolines, etc.) of poorly known properties
- Component properties vary with season
- Component properties vary with catalyst age/activity
- Component properties vary with process unit upsets
- Pre-blends properties with pooled rundown components are poorly known

Because the above situation is quite common, and most users of NIR analyzers do not properly prepare the property prediction model, most NIR analyzers are not in use primarily because the models are not robust and "act up" by providing erroneous readings.

So how do you get robust property prediction models for the NIR (or NMR or Raman) analyzer, which work no matter what crude feed diet you run, or upsets that occur at the process units, and with opportunistic purchases of blend components?

The Solution? Extreme Recipe Modeling to Cover the Property Envelope.

What that means is that you have to make HAND BLENDS for EACH GRADE of gasoline (applies equally to other fuels, such as diesel), for each seasonal grade, including transitions, and using "Extreme" recipes (e.g., one with and one without butane, or with and without MTBE, large changes in use of reformate, etc.). You can get these from the recent (one year) historical blend data. If you anticipate ethanol blends, do hand blends and include the spectra in the model.

These hand blends are done so that we don't have to wait for months to get to the right season to get samples to build the model. The hand blends are

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used to build the initial NIR property prediction models, so this work must be done before the installation, start up and commissioning of the field NIR analyzer (using a lab NIR).

So, let's take an example.

Assume we make three conventional gasolines (i.e., regular, mid-grade, premium), covering three seasonal changes (Summer, Winter, transition), and we have a total of six extreme recipes/grades. Thus, we need to make 3 x 3 x (6 x 3) = 54 hand blends.

These 54 hand blends get divided into three equal parts: one is analyzed by the refinery lab using ASTM methods and also taking the sample NIR spectra with the lab NIR, and the other two are analyzed by two independent labs using the conventional ASTM test to insure that we have two out of three matches in analysis results (we pick the results that are within one ASTM reproducibility). This assumes that all three labs are members of a recognized round-robin proficiency testing group, and that their performance is in the upper third. If the results are far off, we have to worry about the quality assurance procedures at the three independent labs!

If we frequently buy a blendstock (e.g., LCN or reformate), if its critical properties are within 3-5% of the refinery equivalent, we can get away without a hand blend; otherwise, we have to go through the additional work.

Blendstock component tanks are analyzed infrequently (e.g., once a week, if at all). Most of these component tanks are "running" tanks that are filling with rundowns at the same time that they feed the in-line blender. If you analyzed the tanks a week ago, the components measured are long gone, and you are "guessing" that the data is the same … which, for many reasons, (e.g., feed changes, unit problems, purchased feedstock, temperature variations, stratification, rain or snow, etc.) is not. If the process unit operators take a rundown sample once a shift and the results are entered in the LIMS system, you have enough data to determine if the variability will be a problem. If the numbers show that, then you might want to consider measuring the blend component properties in the piping from tanks to the in-line blender. The most suitable and economical way to measure blendstock component properties (once every 30 minutes to once an hour) is by using a multiplexed fiber optic channel NIR analyzer.

Finally, a new type of Chemometric property modeling software uses additional math tricks like cluster analysis and spectral topological analysis to increase the "robustness" of the prediction, but only if the initial model covers a reasonable property envelope.

How do you know if the model is in trouble? Use a "Delta" chart plotting the difference between NIR reading against the lab analysis when you certify a finished blend. This is not extra work; the sample comes either from the finished product tank or an automatic composite sampler.

The "Delta" chart upper and lower control limits are the ASTM reproducibility limits (providing 95% confidence limits, or not more than one outlier out of 20). If there is one outlier in 20 successive measurements, the model is OK; if there are two or more "outlier" readings in a string of 20 successive measurements, the model needs updating.

In the same manner, you need to calculate potential biases in the model, i.e., making sure you don't have roughly either successive identical delta values.

References

1. ASTM D2885 "*Standard Test Method for RON and MON Rating Using On-line Analyzers.*"

2. ASTM Dxxxx D02 Committee Workgroup draft of "*Standard Guide for Establishing and Validating the Relationship Between Analyzer and Primary Test Method Results Using Relevant ASTM Standard Practices*."

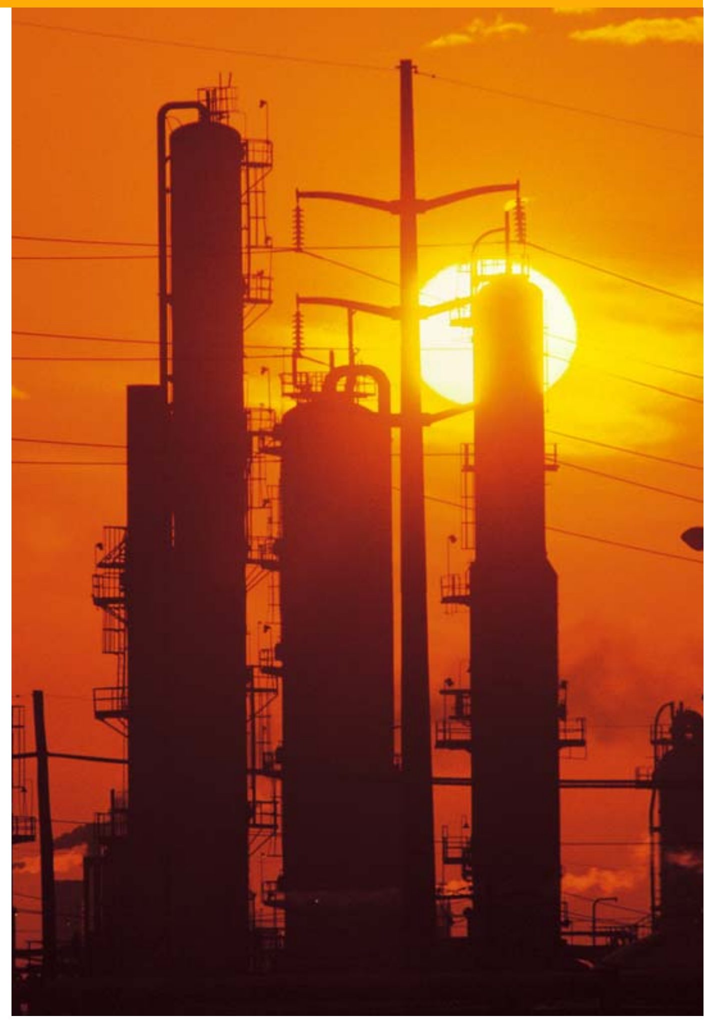
Ara Barsamian has over 31 years of experience in blending (crude, mogas, distillate, fuel oil, lubes), oil movements & storage (OM&S), crude handling logistics, refinery tank farm sizing studies, refinery supply chain management, NIR analyzers, and master plan/automation benefits studies for major process plants and hydrocarbon storage facilities.

Special Safety Considerations for Hot Tapping

By Vincent A. Carucci

The following highlights safety-related guidelines that should be included in the detailed site-specific and application-specific hot tap procedures.

- Representatives of the process and mechanical departments, inspection, and safety must agree on the methods and precautions to be taken before starting the job.
- Confirm that the personnel performing the work have been advised of and understand the required safety precautions.
- Identify foreseeable hazards and develop appropriate contingency plans.
- Obtain the required work permits.
- Review and comply with local regulatory requirements.
- The proposed hot tap location should be indelibly marked on the pipe.
- If a crane is required to support the tapping machine, shut off its motor during the cutting.
- Perform the cutting operation as soon as possible after the nozzle has been welded, inspected, and pressure tested, to ensure that the entire job is done under properly controlled conditions.
- Have a means to indicate that the nozzle and valve assembly has successfully passed inspection and testing.
- A process safety watch is typically required when hot tapping. Monitor process conditions for any variations that might be of concern.
- A mechanical fire watch is typically required when the pipe being hot tapped contains flammable material.
- Observe the surrounding area for any hydrocarbon releases.
- Notify the fire department to provide any needed standby fire equipment and personnel.
- Minimize the operating pressure to the extent possible consistent with maintaining operations.
- A plan for isolating the piping in an emergency should be available. Review warning system and emergency shutdown plan.



- Ensure that personnel have suitable personal protective equipment.
- Ensure that there is a means for personnel to escape.
- Avoid performing other hot work in the vicinity while a hot tap is being done. Restrict access by motorized vehicles, cranes, etc.
- Additional precautions are required if personnel will be working in an excavation.

Vincent Carucci, President of Carmagen Engineering, Inc. also provides mechanical engineering expertise in the areas of pressure vessels, heat exchangers, piping systems, and storage tanks to the process and power industries, insurance companies, and attorneys.

- Conducted an Asset Management System Scoping Study for a European client and developed a followup program to provide assistance.
- Providing refractory consulting assistance for Canadian and US clients in support of turnaround planning activities and resolution of “hot spot” issues.
- Providing project management planning support to a US client for modifications of their FCCU.
- Assisted a European client with troubleshooting several furnace operating problems.
- Continued to provide a US client full-time mechanical engineering assistance in performing Finite Element Analyses and general technical support.
- Providing expert witness assistance to four US-based clients.
- Assisting a US client in the development of valve purchase specifications.
- Provided crane lifting safety reviews for a Canadian client.
- Conducted a refractory presentation for FCCU applications to a US client.
- Providing machinery inspection/test witnessing assistance to several US clients.
- Provided mechanical and refractory consulting assistance to a US client in reviewing hot spots on a FCC external riser line.
- Providing marine terminal engineering expert witness support to a Far East client.
- Providing extensive process design services to a major technology developer/licensor.
- Performed process design of vacuum unit overhead system upgrade for European refinery.
- Performed scoping assessment of Vacuum and Visbreaker unit improvement and reliability program for a European refinery.
- Providing consulting support on LNG project being executed in the Far East.
- Performing pilot plant scale-up development for domestic refiner.
- Providing multi-project plot layout support for a domestic refiner.
- Facilitated energy value improvement review of major refiner’s FCCU revamp project.
- Providing continuous support of a major Middle Eastern LNG project via engineering services at the contractor and the sub-contractor’s offices in Europe and the Far East.
- Provided hydrogen plant startup consultation services to Gulf Coast refiner after Hurricane Katrina.
- Providing technology support to client regarding on-going arbitration case.
- Provided technical review of contractor’s amine unit revamp basis and proposed modifications.
- Provided consultation and recommendations to refiner regarding modification options to meet H_2S emission requirements.
- Provided catalyst loading and unit startup support to licensor for clean fuels project.
- Performing hydrotreater Cold Eyes Review and revamp screening study for licensor.
- Performing UDEX unit troubleshooting and technical support.
- Provided various HAZOP support services to European refiner.
- Provided vessel revamp modifications for a licensor’s overseas project.
- Providing extended lube hydrotreating pilot plant support services.
- Conducted two process design courses at client’s Far East refinery.
- Provided Alkylation unit troubleshooting support.
- Conducted heavy distillate analyzer consultation services.
- Continued to supply specialized, high-value added services to several novel process developments pursued by major technology companies.