MOC Impact Workflow to Ensure that Relief Systems PSI is Updated with Changes

Achilles Arnaez, P.E. and Dustin Smith, P.E.

Smith & Burgess

Process Safety Consulting

7600 W. Tidwell Rd., Ste. 600 | Houston, TX 770400
(713) 802-2647 | SmithBurgess.com

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Achilles Arnaez
Smith & Burgess, LLC.
Houston, TX
achilles.arnaez@smithburgess.com

Dustin Smith
Smith & Burgess, LLC.
Houston, TX
dustin.smith@smithburgess.com

Abstract

The Process Safety Management (PSM) Standard requires that covered facilities manage change through a Management of Change (MOC) program. A robust MOC program effectively identifies and analyzes changes. Observation has shown that many MOC processes have deficiencies in training[1], whereas the Authors have observed that other facilities with effective MOC processes employ checklists and workflows to help MOC facilitators identify when engineering expertise is needed (e.g. Preventative Maintenance updates or changes in engineering documents / Process Safety Information (PSI)). It is important to note that PSI encompasses an array of information, which in addition to process safety, is also utilized to make decisions associated with asset expansions and optimization. Updating relief systems PSI is an essential, and often overlooked, aspect of MOC. When changes affecting relief systems are not recognized, a facility will often have to undertake the costly and untimely process of periodically restudying and revising the relief system PSI. These periodic studies can lead to unexpected asset installations and/or operating parameter changes. Based on experiences at various facilities, a workflow is presented in this paper as a timely method for plant level engineers to recognize changes that can affect relief systems. Ultimately this methodology can reduce the error rate associated with MOC and ensure related relief system PSI is accurately updated.

Introduction

Many major accidents in industry are related to uncontrolled change[2]. In addition, the discovery of uncontrolled changes can cause unexpected cost and scope additions associated with asset maintenance / projects. One element of the Process Safety Management (PSM) standard, 29CFR1910.119[3], that addresses this concern is the Management of Change (MOC) process. As stated in 29CFR1910.119(l)(1),

> "The employer shall establish and implement written procedures to manage changes (except for "replacements in kind") to process chemicals, technology, equipment, and procedures; and, changes to facilities that affect a covered process."

Section (l)(4) mandates that Process Safety Information (PSI) "shall be updated accordingly" as part of the MOC process. This is also reinforced within Appendix C of the PSM standard when stating that,

> "...Complete and accurate written information concerning process chemicals, process, technology, and process equipment is essential to an effective process safety management program and to a process hazards analysis..."

Overlooked PSI remains a significant finding during internal audits performed by the Authors and as evidenced in regulatory citations (OSHA & EPA). The inaccurate information associated with the failure to update PSI continues to affect the facility through higher costs associated with making repairs or upgrades. One portion of PSI that is often overlooked is "relief system design and design basis", as referenced in section (d)(3)(i)(D). Historically, PSI updates were not considered an integral part of safely managing the asset. Another factor observed in audits is that the personnel responsible for MOC execution were not be aware how changes affected the relief system design. The individuals that implement MOC programs often do not have the time to learn the many publications and design standards which describe the nuances of relief system design. Outside of investing the tens of thousands of hours to become an expert in relief systems design, can an engineer responsible for relief systems documentation know when it needs to be updated? Can this process be streamlined and provide more accurate results?

This paper will introduce the principles that govern relief systems design and provide examples of updates, both common and uncommon, associated with MOC's. A workflow is provided to improve the timeliness and effectiveness of identifying the need for relief system PSI changes.

Relief Systems Design

Prior to analyzing a change for the effect on the relief system, the MOC reviewer needs to consider the following fundamental questions:

1. Why are relief devices installed?
2. What types of changes affect the design of a relief device and/or disposal system?

The answer to the first question is that they limit energy (pressure) via the release of fluid to a safe location. There are a multitude of answers to the second question, but on a high level, changes in the:

1. Ability to store energy
2. Rate that energy can be transferred
3. Operation or stability of the relief/disposal systems
4. Systems that affect compliance with RAGAGEP (e.g. API STD 521[4])

Note that changes in the process or process chemistry can directly or indirectly affect any of the above factors and may introduce other factors not previously considered.

Changes in the Ability to Store Energy

A change in the ability to store energy would include any change in Maximum Allowable Working Pressure or Temperature (MAWP/T). The applicability of many overpressure scenarios is determined by comparing the pressure of a source of overpressure with the lowest MAWP/T of a system. In this paper a system is defined as a set of equipment which is protected by a group of relief devices (where the number of equipment is one or greater and the number of relief devices is zero or greater). Thus, change in MAWP/T often can introduce additional installation and scenario considerations to relief systems design that were not previously identified. Audits performed by the authors have identified failures in the MOC process when the system is reviewed as individual pieces of equipment rather than holistically.

MAWP Re-rate

A common case of this change, the ability to store energy, would be the de-rating of a vessel due to corrosion. Consider the Overhead Drum (V-11) shown in Figure 1.

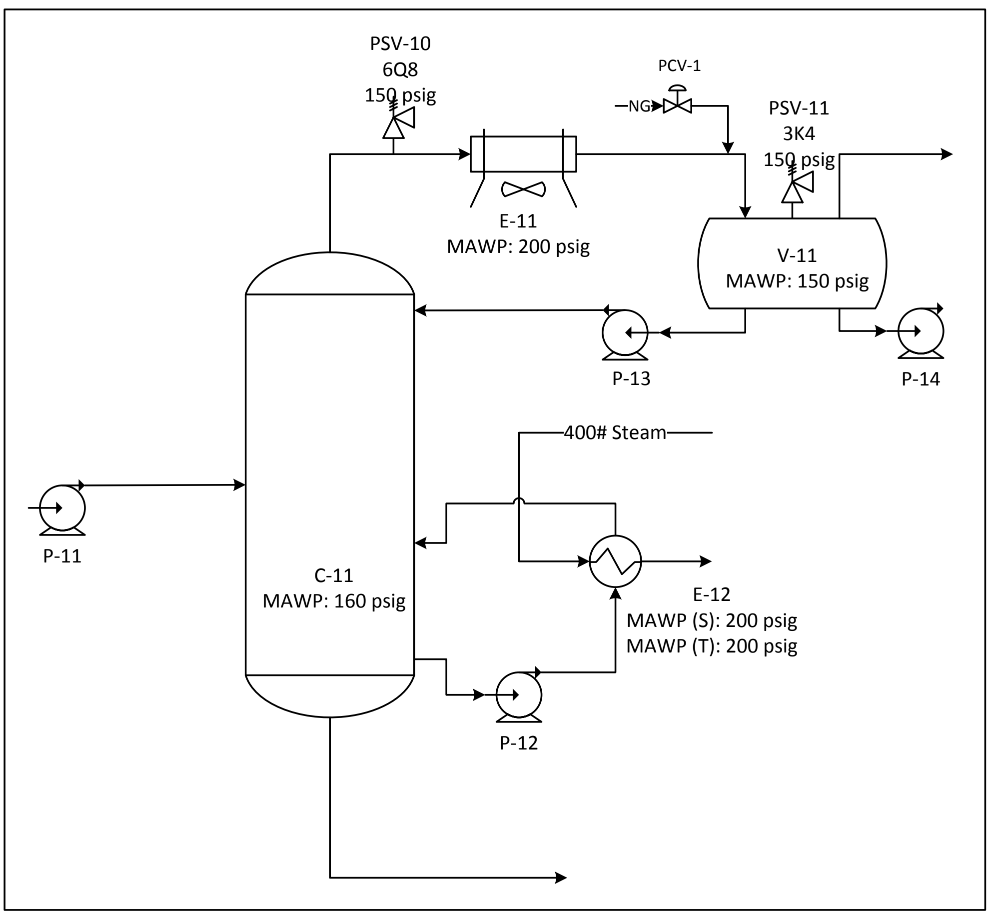

Figure 1. Effect of MAWP Re-rate of an Overhead Drum within a Column System.

Supposed that fitness-for-service analysis, based on inspection records, show that the MAWP of this Drum needs to be reduced from 150 psig to 100 psig. The individual implementing the MOC process might inspect the design basis for the pressure safety valve (PSV) on the Drum. They would see that the system is sized for external fire. To complete the MOC they would then lower the set pressure of the PSV (PSV-11) and update the calculation based on the new set pressure.

At this point with the new sizing basis, the new relief device is ordered. However, the reduction in pressure of the overhead accumulator affects the ability of the entire Column system to store energy. Initially, the relief device on the drum was only sized for fire, as the whole Column system was protected by the larger relief device (PSV-10) located on the Column (C-11). Once the Drum was de-rated, the next step is to either to (1) confirm that PSV-11 on the Overhead Drum (V-11) could protect the Column system from all potential overpressure scenarios or (2) verify and reset the Column PSV (PSV-10) to a pressure acceptable by the Code of construction of the Overhead Drum (V-11) (e.g. 52.5 psig if designed per ASME B&PVC Section VIII UG-125[5]) and reevaluate the design of the relief system. Therefore, when systems are de-rated, in addition to resizing all of the calculations for the new pressure, the system has to be analyzed for all potential sources of overpressure to ensure that the pressure rating change does not modify scenario applicability.

Another example for this system is if the pressure is controlled in the drum by PCV-1 using 125 psig natural gas. Prior to being de-rated, failure open of PCV-1 would not overpressure the system. However, after being de-rated to 50 psig, failure open of PCV-1 could overpressure the system as the supply pressure is now greater than the lowest MAWP in the system.

Changes in the Rate That Energy Can Be Transferred

A change in the rate that energy can be transferred could include one that would result in more or less fluid flow or heat transfer. Adequacy of a relief or disposal system is determined by comparing the relief rate(s) during a given scenario to the available capacity of the relief or disposal system. Some obvious examples may include replacing or upgrading pumps, control valves, or heat exchangers. Other examples may include changing operating pressures, liquid levels, or unit minimum turndown. Whereas some MOC's may result in increasing or decreasing relief rates, others may even switch the applicability of the overpressure scenario, changing relief rates to and from zero rate.

Pump Performance

Consider a change in pump performance, whether it be due to a change in pump impeller or motor speed or due to a complete replacement. In Figure 2, V-21 is protected by PSV-21 and is fed by P-21. FV-21 controls the flowrate to V-21 and has a bypass valve.

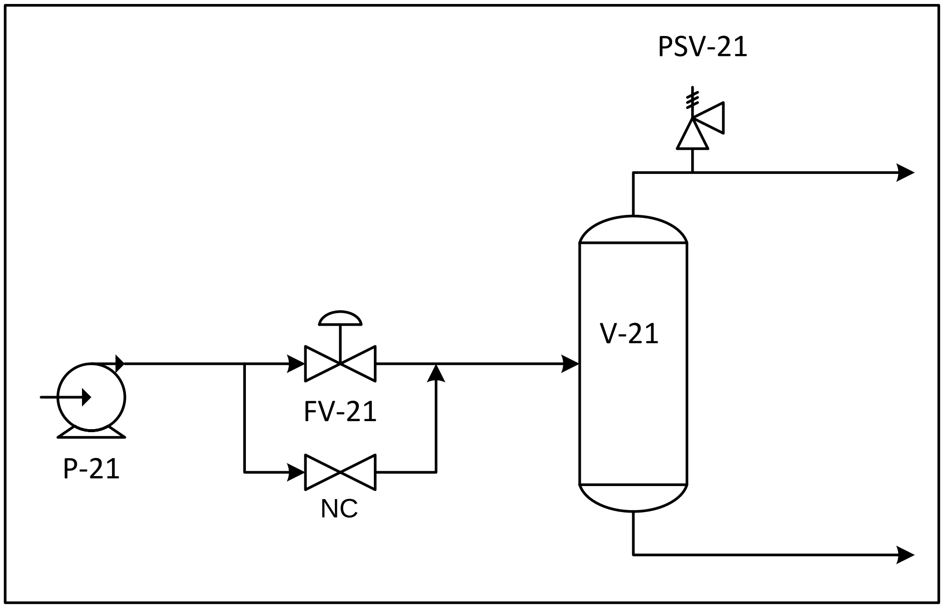

Figure 2. Effect of Pump Performance Change on Downstream System.

If the performance of P-21 is modified, maximum discharge pressure, normal discharge pressure, and flowrates would change. Maximum discharge pressure determines the applicability of the blocked outlet scenario, and, typically, normal discharge pressure determines the applicability of the control valve failure and inadvertent valve operation scenarios. Therefore, a change in P-21 performance can affect the applicability and relief rates of these three scenarios.

The above logic can be applied towards a change in compressor performance, control valve trim, or heat exchanger performance. Changing a heat exchanger bundle can also affect the required relief rate if it involves tube changes (e.g. rate of flow during tube rupture). However, the next examples feature some less obvious changes that can affect the rate that energy can be transferred or the applicability of overpressure in the event energy is transferred.

Liquid Level

Figure 3 contains two relief systems: the first consists of V-31, which is protected by PSV-31; the second consists of V-32, which is protected by PSV-32. FV-31 lets down the pressure from high pressure V-31 to low pressure V-32.

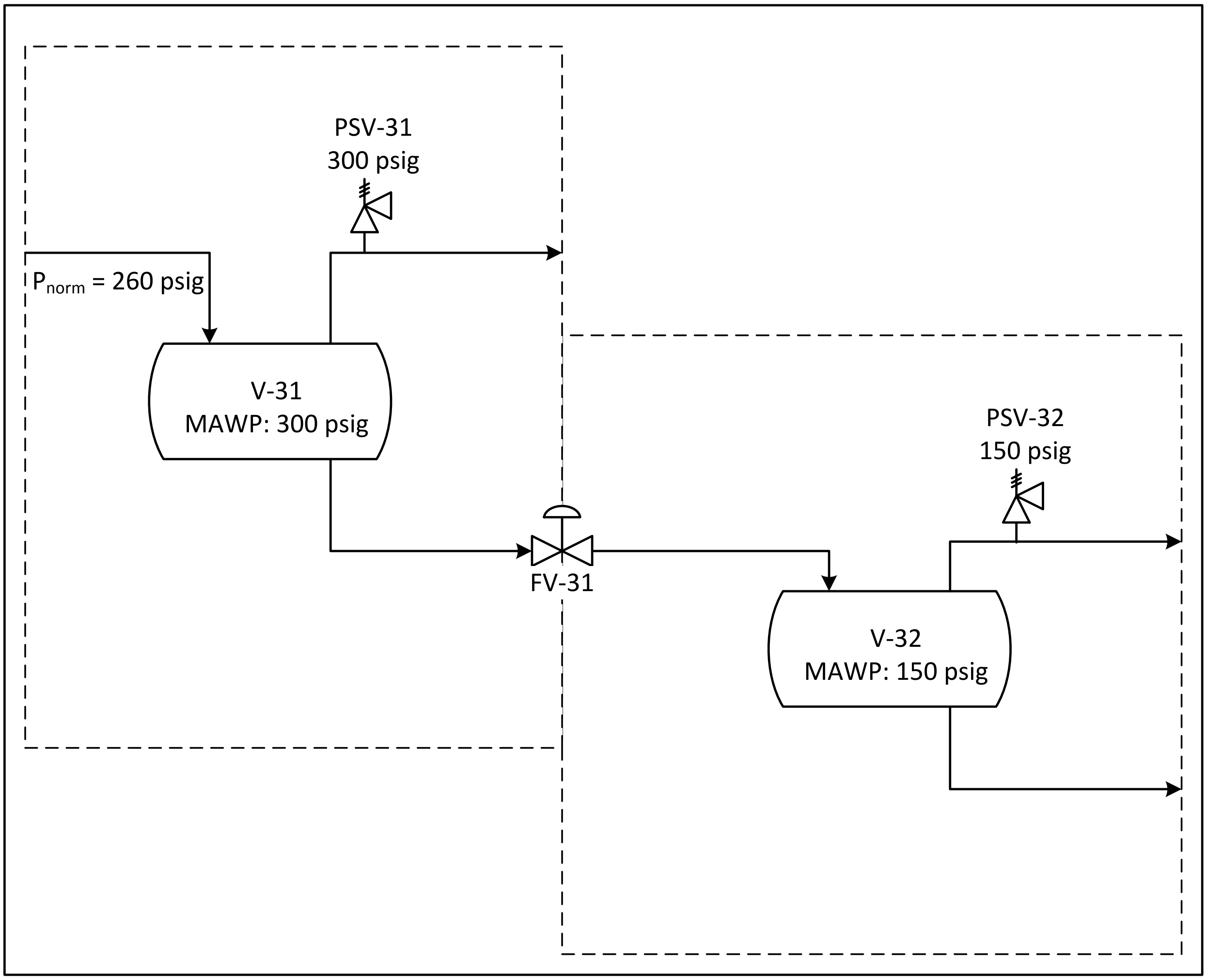

Figure 3. Effect of Liquid Level Change on Multiple Systems.

If liquid level in V-31 is increased, the required relief rate of the external fire scenario for V-31 would also increase. A secondary effect is that the gas blow-by scenario is also affected for the downstream system V-32. The initiating event of the gas blow-by scenario is failure open of FV-31. This leads to draining of liquid from V-31 into V-32. Depending on the liquid inventories in both V-31 and V-32, the subsequent relief through PSV-32 could be either (1) high pressure vapor from V-31, (2) two-phase flow, or (3) the displacement of liquid in V-32 equivalent to the volumetric rate of two-phase flow through FV-31. The factor that determines which phase (and rate) is relieved is whether V-32 will overfill during this event, which is dependent on the liquid levels in each vessel. Thus, a seemingly simple change of liquid level could result in drastically different bases of relief systems design.

Minimum Turndown

Minimum turndown is a minimum throughput operating limit at which the unit can operate stably. One may think that only increasing high limit of safe operating limits should trigger a unit-wide review of relief systems documentation to determine the impact. However, decreasing the minimum limit can also affect relief systems design. For example, within Figure 4, suppose that failure opening of FV-41 is an applicable overpressure scenario for V-41.

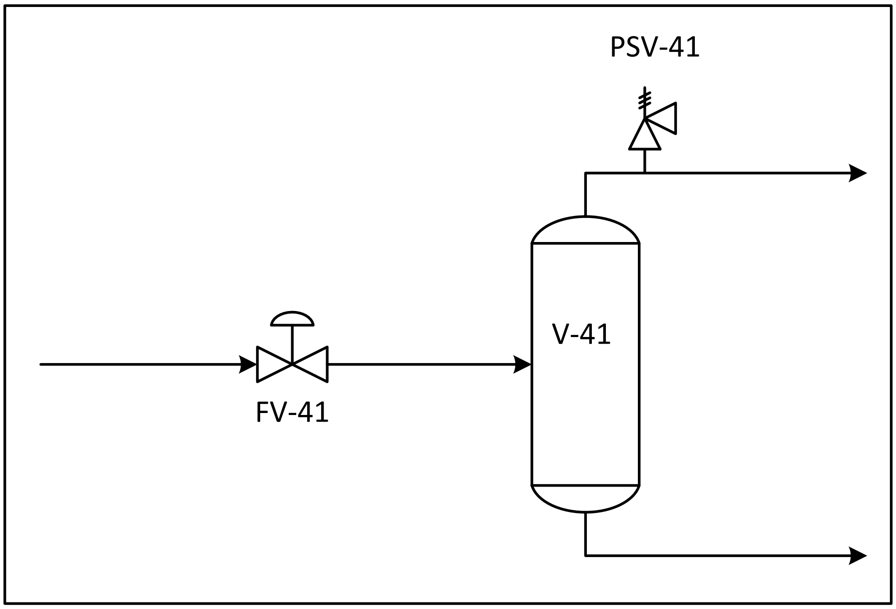

Figure 4. Effect of Minimum Turndown Change on a Vessel.

When calculating the relief rate for PSV-41, it was determined in the prior study that PSV-41 did not provide adequate capacity for the full rate of liquid through FV-41; thus, credit was taken for "minimum normal" outflow. That is, assuming that the system outlet would remain open for this case, the amount relieved through PSV-41 should only be equal to the accumulation rate, which is the incremental difference between the system outflow rate and the system inflow rate at relief conditions. This rate is typically assumed to occur during minimum turndown, when the outflow rate is at its minimum (which maximizes the required relief rate). With this assumption, PSV-41 then provides adequate relief capacity. Suppose an MOC now changes the minimum turndown for the unit, lowering the minimum operating throughput. In this case, the previously described basis requires modification which increases the required relief rate. Depending on the magnitude of the change, PSV-41 may become undersized.

Operating Pressure

Changing operating pressure can affect the relief rate of several types of overpressure scenarios. For example, a control valve failure scenario may depend on upstream operating pressure and downstream relief pressure to determine relief rate, along with control valve size, etc. Similarly, a tube rupture scenario may depend on high pressure side operating pressure and low pressure side relief pressure, along with tube size, etc. However, when evaluating the impact of these changes, one should consider the upstream and downstream systems as well as systems on the other side of exchangers.

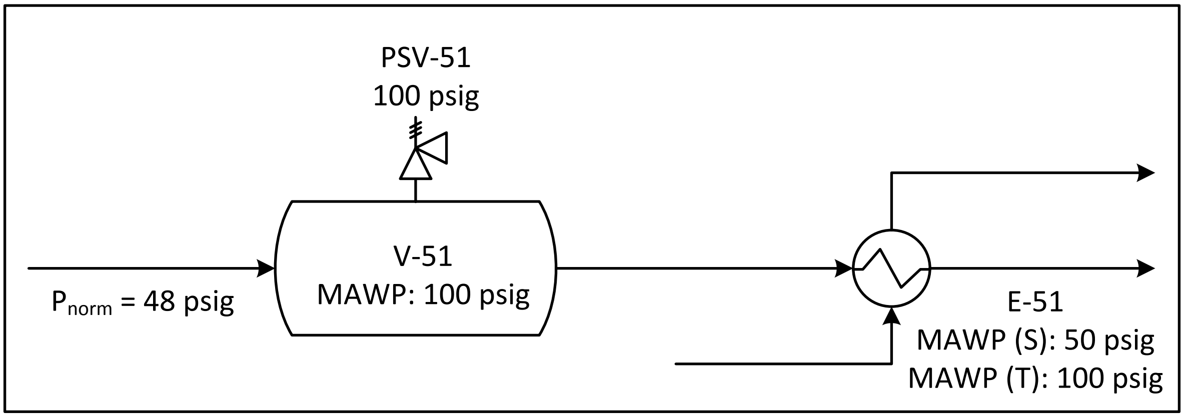

Figure 5. Effect of Operating Pressure Change on the Other Side of an Exchanger.

For example, consider Figure 5. V-51 and the tube side of E-51 are protected by PSV-51. The MOC may propose a change in the operating pressure of V-51 from 48 psig to 60 psig. A reviewer might evaluate the system and determine nothing is really affected for the immediate system. However, the shell side of E-51 is also affected by the change. Tube rupture may become a new applicable scenario for the shell side of E-51 and requires further analysis. Note that many site-specific, RAGAGEP methods exist to determine applicability of the tube rupture scenario, but some assume that tube rupture rate and applicability are determined by comparing high pressure side operating pressure against low pressure side relief pressure.

Set Pressure

Changing set pressure would change the operation or stability of relief/disposal systems, which is mentioned in the next section; however, it can also affect the applicability of scenarios for the relief system as well as for upstream and downstream systems. In Figure 6, the process line is protected by PSV-61.

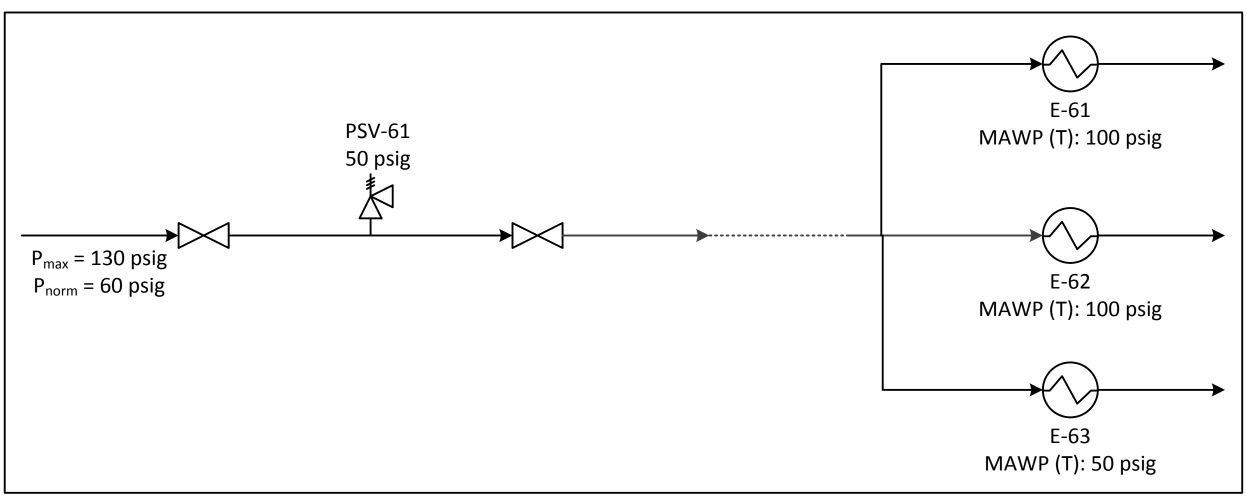

Figure 6. Effect of Set Pressure Change on Downstream Systems.

One might notice that the normal operating pressure (60 psig) of the line is greater than the relief device set pressure (50 psig). Yes, this is an example of a poorly designed system that results in a constantly relieving PSV, so the MOC was to increase the set pressure of PSV-61 to 70 psig, since the piping design pressure is around 285 psig; thus, one might think that no additional inadequacy should result. However, downstream of the process line system is a set of exchangers that were also protected by the relief valve. PSV-61 originally limited the pressure to the exchangers to 50 psig; however, since the MAWP of the tube side (50 psig) of E-63 is below the new set pressure of PSV-61, increasing PSV-61 set pressure now results in making the tube side of E-63 an unprotected equipment and also exposes it to a normal operating pressure above its MAWP.

Electrical Line-up

One type of MOC that might be overlooked is a change to electrical line-ups of equipment or the sparing of equipment. When Partial Power Failure overpressure scenarios are identified in relief systems design and flare system design, the electrical line-ups and sparing of equipment are considered. For example, consider the column system example in Figure 7.

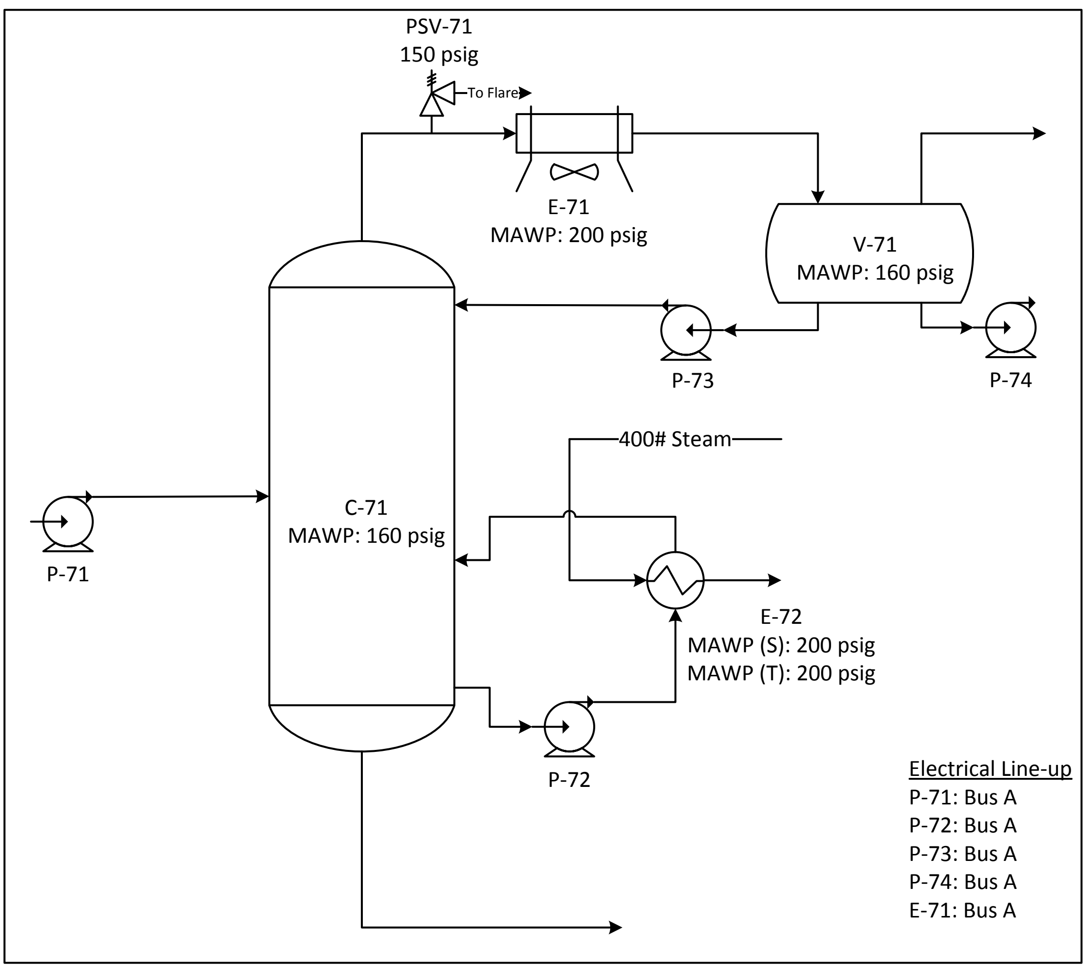

Figure 7. Effect of a Change in Electrical Line-up on a Column System and on Flare System Design.

C-71, E-71, V-71, and the shell side of E-72 are protected by PSV-71. All electrical equipment; P-71, P-72, P-73, P-74, and E-71; are shown to be electrically fed by Bus A. During the process of evaluating overpressure scenarios, the Bus A Partial Power Failure (PPF) scenario would be identified as resulting in no relief, as feed and heat input are lost, even though overhead condensing and reflux is also lost. Suppose P-72, the reboiler circulation pump, is changed to be fed by Bus B instead of Bus A. Now, during the Bus A PPF scenario, feed is lost and overhead condensing and reflux are lost; however, reboiler heat input would continue. The resulting scenario is boil-up relief. What was previously zero relief rate is then changed due to the MOC to a relief rate typically in range of several hundred pounds per hour. What impact might this change have on the flare system design?

Changes in the Operation or Stability of the Relief/Disposal Systems

MOC's might change the installation of relief systems, which include such items as relief valves, rupture disks, open vents, and relief device piping; and disposal systems, which include flares, vent stacks, header piping, flare gas recovery units, knockout drums, and seal drums. During an overpressure event, these systems must be capable of providing sufficient capacity to relieve the required loads as well as operate stably. Any change in design factors of these installations must be captured within PSI during the MOC process.

Changes in the Systems that Affect Compliance with RAGAGEP

Whereas the above three categories of changes also affect compliance, this category addresses other types of change that affect only compliance from a relief/disposal system standpoint. For example, an MOC that affects platforms on columns where personnel may perform maintenance may expose the workers to unacceptable radiation from a Flare during a Total Power Failure scenario. Nothing else changed within the flare system design, but now the flare system design has to be considered or changed as a result of the MOC.

Changes in Process or Process Chemistry

A change in process or process chemistry can be as simple as changing catalyst manufacturers with different impurities in the catalyst (not a replacement-in-kind) or changing utility line-up of a 50# steam supply to 150# steam supply or can be as complex as a complete overhaul of the process. In either event, the design of the relief system must be considered, and typically both a change in the rate that energy that can be transferred and a change in the operation or stability of a relief system is affected.

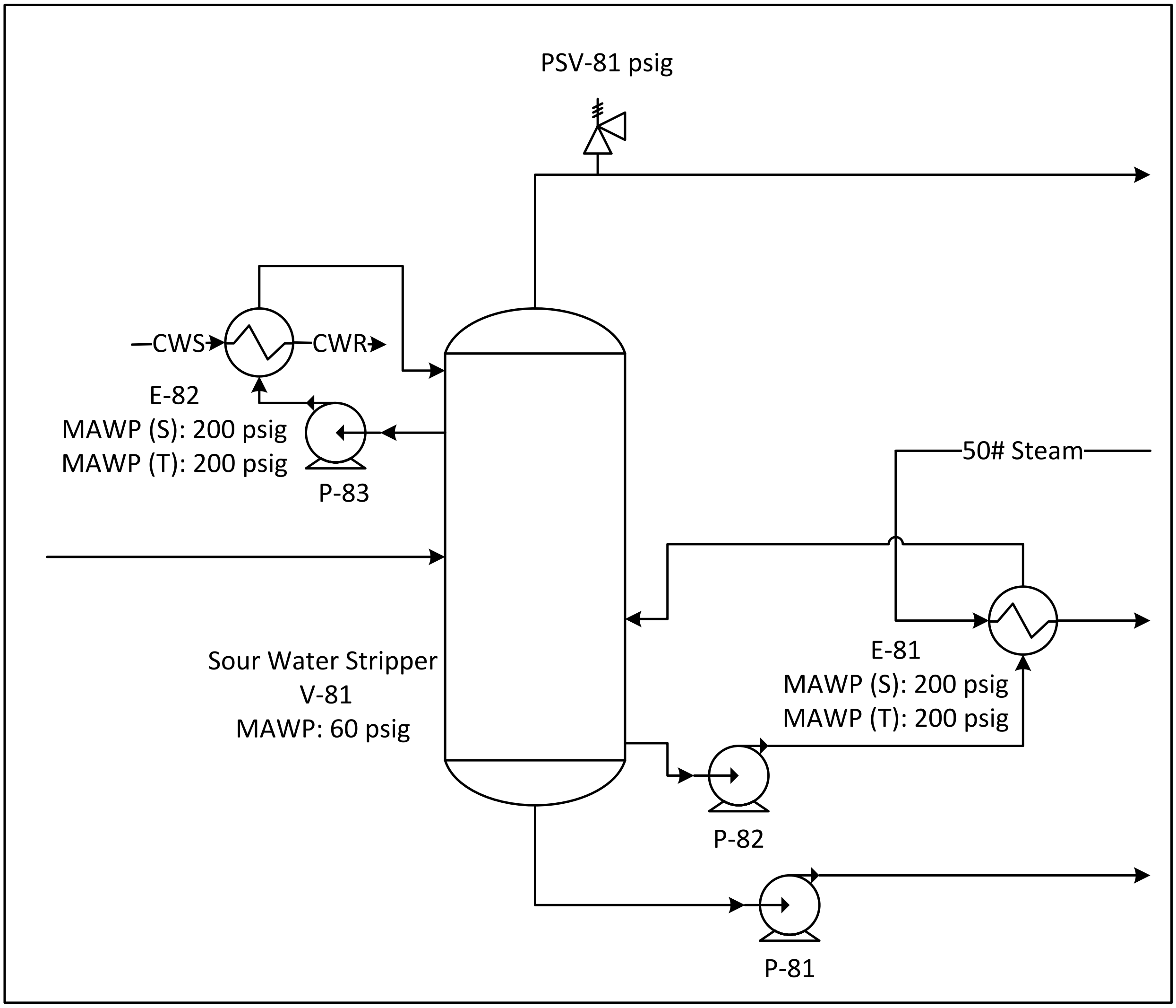

Figure 8. Effect of a Change in Utility Line-up on a Column System.

For a change in utility line-up, consider the column system in Figure 8. The system consists of the Sour Water Stripper (V-81), the shell side of E-81, and the shell side of E-82. Prior to the change, 50# steam is the reboiler steam supply, and due to insufficient temperature driving force in the reboiler at system relief pressure (60 psig + 10% allowable accumulation = 66 psig), the reboiler duty pinches to 0, and no relief is expected during a cooling failure scenario or other similar scenarios. If an MOC changes the process by changing the 50# steam supply to 150# steam supply, at system relief pressure during multiple column-type overpressure scenarios there would now be sufficient driving force to maintain a positive reboiler duty; thus, the relief device PSV-81 now needs to be evaluated for capacity and stability and the documentation updated accordingly.

Proposed Workflow and Checklist

As there are many other types of MOC's not mentioned in this paper, a workflow and checklist was developed to help MOC facilitators identify when updates need to be made to relief and disposal systems design and additional engineering expertise is needed. See Figures 9 and 10. It was compiled based on input from relief systems experts and also contains lesser-known changes that may impact relief systems design. In some of the examples mentioned earlier, not only the design of the relief system being modified but also the design of upstream and downstream systems and systems on the other side of exchangers may need to be updated. The workflow includes steps to check these commonly missed impacts. Although the workflow is meant to be used as a primary check to screen MOC impacts, auditing process steps are included to cover MOC's that are not specifically mentioned in the checklist. The first part of the workflow and the checklist is divided into two branches. The first branches focuses on MOC impacts to Equipment and Facilities, and the second branches focuses on MOC impacts to Process Chemicals, Technology, and Procedures. These branches were based on the categories of MOC's mentioned in the definition of MOC within OSHA 29CFR1910.119(l)(1).

There are several advantages to implementing a workflow and checklist method within the MOC process. First, it is an intuitive screening method that feels familiar to reviewers. Many MOC processes already employ checklists and workflows to help MOC facilitators identify when engineering expertise is needed for other aspects of PSM (e.g. Preventative Maintenance updates or changes in engineering documents / Process Safety Information (PSI)). Second, it reduces (but does not eliminate) reliance on relief systems experts. Relief systems experts are still needed for auditing and for updating relief and disposal system design and documentation as necessary; however, a facility might lack sufficient process safety personnel and resources, so a screening method helps to maximize the utilization of lesser-experienced safety personnel. Third, the methodology is systematic, which can improve the error rate of missed MOC impacts, and last, the process is efficient, that is, screening can be performed faster than without a workflow and checklist.

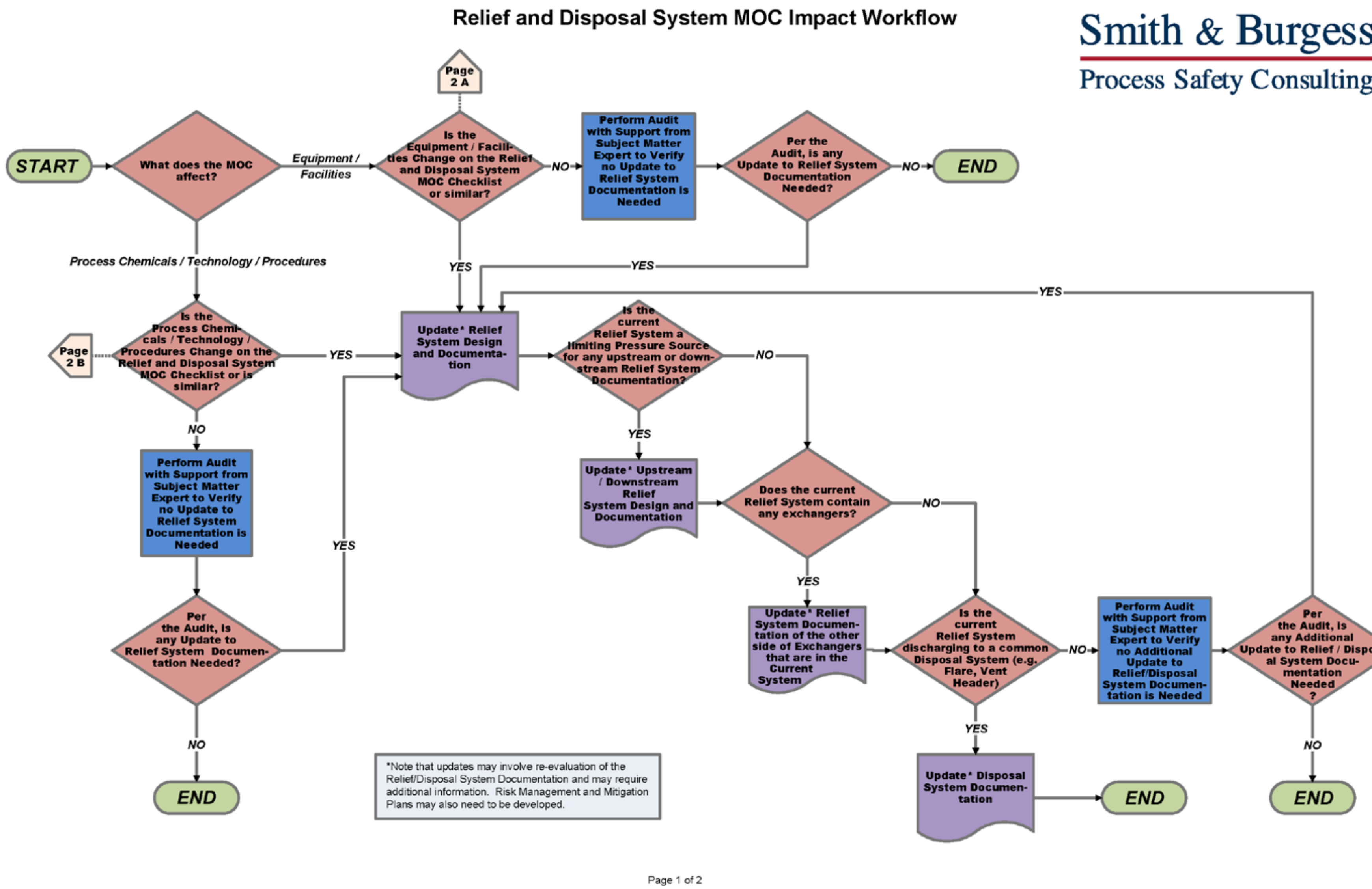

Figure 9. MOC Impact Workflow.

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Relief and Disposal System MOC Impact Checklist

Equipment/Facilities

Relief System Equipment
Addition, modification, or demolition of relief device (not including replacement in-kind)
Change in relief device capacity (orifice size, etc.)
Change in relief device discharge location
Change in relief device manufacturer or model
Change in relief device sub-type (i.e. conventional to bellows)
Change in relief device set pressure or blowdown setting
Change to relief device piping
Change in sparing of relief devices
Addition, modification, or demolition of flares, knockout drums, seal drums, and other disposal system equipment

Process Equipment
Addition, modification, repurpose, relocation, or demolition of process equipment (not including replacement in-kind)
Rerate of vessel design code
Rerate of hydrotest pressure / MAWP or change in design pressure / temperature
Change in piping connections to machinery that could affect alignment or pressure profile
Increased/Decreased heat transfer surface area of heat exchanger
Reduction/addition of fixed trays in tower
Change in tube metallurgy, tube size, or tube length
Movement of internal weir in a vessel
Removal/installation of fireproof insulation
Change of restriction orifice plate size
Change floating roof on a tank
Changes to location of equipment

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Rotating Equipment
Addition, modification, or demolition of rotating equipment (not including replacement in-kind)
Changes to machinery component design, materials or manufacturer (pumps, compressors, etc.)
Changes of performance capability of equipment
Changes of driver size (motor, turbine, engine)
Change to the pump impeller size
Change in electric or steam driver for a pump, compressor, etc.

Instrumentation
Addition, modification, or demolition of control valves, alarms, interlocks and other instrumentation
Change of control valves or bypass valves (including valve size, trim, or failure position)
Change in actuator mechanism/motive fluid (i.e. instrument air to nitrogen)
Change to safety-critical instrumentation

Utilities
Addition, modification, or demolition of electrical equipment
Changes to electrical line-ups
Change in utility line-up (i.e. switching a LP steam user to a HP steam user)
Changes to utility equipment (cooling water systems, steam systems, etc.)

Process Chemicals/Technology/Procedures

Process
Change in the unit charge rate
Change in the feed stock composition
New chemistry, or changes to chemistry of existing process
Introduce new feedstocks, catalysts, chemicals, product streams, or new process sequence
Changes to the process that could affect flows, pressures, compositions or changes involving the erosive, corrosive or toxic nature of the stream
Set point change (level, pressure, temperature, flow)
Change material in tank or increase tank throughput
Change in flare system seal gas pressure

Operation
Change to the basic mode of unit operation (including new or modified feed to the unit)
Changes to equipment operating or maintenance procedure
Change to safe operating limits or require operating outside of the approved operating envelope
Change in inventory of any vessel or exchanger
Changes to car-seal/lock valves
Change in electric or steam driver for a pump, compressor, etc.
Change in minimum turndown for the unit
Change in sparing of equipment (i.e. pumps/compressors)
Change in operation of control valve bypass valves
Change in flare line-ups or staging

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Instrumentation
Addition, modification, or demolition of control valves, alarms, interlocks and other instrumentation
Changes to instrumentation operating or maintenance procedure
Change in actuator mechanism/motive fluid (i.e. instrument air to nitrogen)

Utilities
Utility operating condition changes
Change in utility line-up (i.e. switching a LP steam user to a HP steam user or CW user to BFW user)
Addition/upgrading of firefighting equipment and/or drainage
Electrical changes (one-line information)

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Figure 10. MOC Impact Checklist.

Conclusion

Due to the safety and economic consequences associated with uncontrolled change, the importance of maintaining “complete and accurate” PSI cannot be overstated. One type of PSI, relief systems design, has often been poorly updated during the MOC process. Based on audits performed by the Authors, it was found that a reason for this deficiency is the lack of expertise of the individuals working each MOC item. Relief systems design is nuanced and often requires experts to understand the impact of a change. Often facilities have insufficient process safety personnel to work through all the changes needed which results in inaccurate PSI. To help alleviate this problem, a workflow and checklist is proposed to screen the impacts of MOC's on relief systems design that is based on the experience of relief systems experts. This maximizes the utilization of lesser-experienced process safety personnel using an intuitive, systematic, and efficient methodology.

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