Management of Change

A key to safety—not just process safety

By Mark D. Hansen and Gerald W. Gammel

ON NOV. 25, 1998, a fire at the Equilon Enterprises oil refinery delayed coking unit in Anacortes, WA, caused six fatalities. A loss of electric power and steam supply approximately 37 hours before the fire had resulted in abnormal process conditions (CSB, 2001).

The investigation revealed that personnel had expected a tarry mass to drain from the drum. [A drum is a tower or vessel in which materials are processed, heated or stored. Coke drums can be very large (e.g., 120 ft tall with a 29 ft diameter) and typically stand several stories high.] The supervisor had directed that the drum be opened with a minimum number of people present. In response to concerns that the limited flow of steam might not sufficiently strip all the toxic compounds from the tar inside the vessel, workers removing the bolts on the drum heads were required to wear self-contained breathing apparatuses. The top head was unbolted and lifted from the drum. The bottom head was also unbolted and held in place by a hydraulic dolly. The operator then activated a release mechanism to lower the dolly.

Witnesses reported hearing a whooshing sound and seeing a white cloud of vapor emanate from the bottom of the drum. The hot petroleum vapor burst into flames. The process supervisor, an operator and the four contract personnel assisting were caught in the fire and died (CSB, 2001). After the incident, Equilon relocated the controls for the hydraulic dolly to allow workers to position themselves farther from a drum when opening it (CSB).

Lessons Learned

Why examine this accident? Because it illustrates the need for management of change (MOC). MOC is critical to process safety—and it is a concept that if well implemented could likely prevent incidents in many other industries as well. Many industries would benefit from establishing policies to manage deviations from normal operations. Systematic methods for managing change are sometimes applied to physical alterations, such as those that occur when an interlock is bypassed, new equipment is added or a replacement is "not in kind."

For an MOC system to function effectively, field personnel must know how to recognize which deviations are significant enough to trigger further review. Thus, operating procedures must include well-defined limits for process variables for all common tasks. Once on-site personnel are trained on MOC policy and are knowledgeable about normal limits for process variables, they can make informed judgments regarding when to apply the MOC system.

Once a deviation is identified that triggers the MOC system, management must gather the right people and resources to review the situation. A multidisciplinary team may be required to thoroughly identify potential hazards, develop protective measures and propose a course of action.

The Equilon incident could have been avoided had the change been managed by a team experienced in hands-on operations, safety procedures and engineering calculations. Written procedures for cooling and emptying partially filled drums, as recommended by an investigation team in 1996, may also have reduced the likelihood of this incident.

The Potential for Severe Injuries

Manuele (2003), referring to Petersen (1998), notes that "studies in recent years suggest that severe injuries are fairly predictable in certain situations. Some of these situations involve:

- unusual, nonroutine work;
- nonproduction activities;
- sources of high energy;
- certain construction situations."

These are just a starting point. A long list could be made that would more extensively specify the areas where severity is predictable. Manuele (2003) continues:

> Data, not yet published and provided by Franklin Mirer, director of the Health and Safety Department at the International Union-UAW, is in concert with Petersen's

Abstract: *Management of change (MOC) is critical to process safety—and it is a concept that if well implemented could likely prevent incidents in many other industries as well. Many industries would benefit from establishing policies to manage deviations from normal operations. This article defines key change concepts and examines several key elements of an effective MOC process.*

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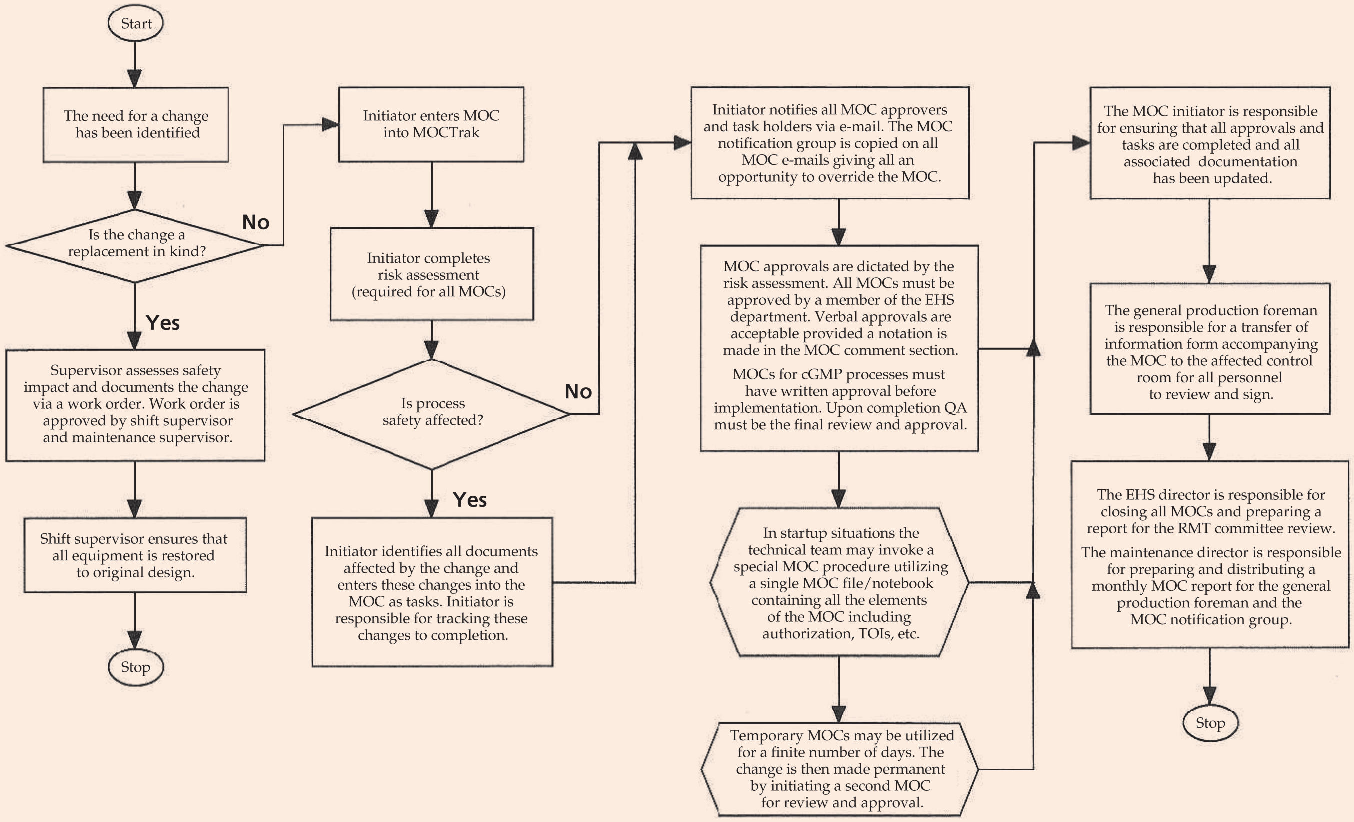
Figure 1

Management of Change



observations. The data indicate that severe injury accidents occur disproportionately in unusual and nonroutine work, in nonproduction activities and where high sources of energy are present. During the 18 years prior to Jan. 1, 2002, the data show that skilled trades people—who represent about 20% of the UAW work population of about 700,000—make up 40 to 50% of the fatalities. These individuals include maintenance personnel, millwrights, electricians, steamfitters and tinsmiths; they rarely engage in repetitive and routine work, nor do they engage in production work. Total hours worked by the UAW population over this period is in the billions, which represents a sound statistical base; these data have significance.

The potential for severe injuries to occur during nonroutine activities is being recognized by some in industry. According to Manuele (2003), the safety director of one chemical company reported that when the system is running, the risks are lower; when the system must be opened for maintenance or equipment fails or a chemical release occurs, severity potential is greatly increased. A safety director for a heavy electrical equipment manufacturer says that severe injuries in his company rarely occur during routine production operations.

Management of Change Defined

OSHA has made three things about process safety management (PSM) clear: Write what you do, do what you write and, if no written records were made, it never happened. The agency defines management of change in its PSM standard—29 CFR 1910.119 (OSHA, 1992). The standard requires that an employer 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. In addition, the standard requires that the procedures shall ensure that the following considerations are addressed prior to any change:

1) the technical basis for the proposed change;
2) impact of change on safety and health;
3) modifications to operating procedures;
4) necessary time period for the change;
5) authorization requirements for the proposed change.

Under the standard, employees involved in operating a process, and maintenance and contract employees whose job tasks will be affected by a change in the process are to be informed of, and trained in, the change prior to start-up of the process or affected part of the process. The standard also states that "if a change covered by this paragraph results in a change in the process safety information required by paragraph (d) of this section, such information shall be updated accordingly." It further states, "If a change covered by this paragraph results in a change in the operating procedures or practices required by paragraph (f) of this section, such procedures or practices shall be updated accordingly."

Center for Chemical Process Safety (CCPS, 1989) offers this guidance regarding MOC:

> In any operation, situations will arise that were not foreseen when the operating procedures were developed. At such times, person-

nel may want to conduct operations in a way that differs from, or contradicts, the process technology or the standard operating procedures. To ensure that these deviations from normal practice do not create unacceptable risks, it is important to have a variance procedure, or to have incorporated the same means of control into other management systems. The variance procedure will require review of the planned deviation and acceptance of the risks it poses. The variance procedure should require the explanation of the deviation planned; the reasons it is necessary; the safety, health and environmental considerations; control measures to be taken; and duration of the variance. Variances should require the approval by a suitable level of management, based on the process risks involved.

Effective MOC Programs

As noted, an effective MOC process can help prevent accidents. Numerous investigations have identified weaknesses in the MOC process as a root cause of process safety incidents (CSB, 2001). CSB has also stressed the need for non-PSM companies to adopt a systematic MOC process.

Following the completion of initial process hazard analyses (PHAs), a systematic MOC methodology (Figure 1) serves as the principal PSM system to ensure that risk levels associated with process modifications are addressed properly. This ensures that changes do not bypass or otherwise render the safety controls useless.

Non-PSM companies (e.g., automobile parts, consumer products) that have various manufacturing processes could benefit from an MOC program to ensure that changes to the process do not render safety controls and safety critical controls ineffective. Such a program would also reduce equipment failure as a result of factors such as incompatible materials and technologies, and ensure that operating procedures are updated for equipment operators. In the author's experience, some non-PSM companies document lessons learned, yet because they lack an effective management system, the controls are typically lacking.

PSM companies that continue to incorporate MOC best practices and systems in their processes are able to achieve continuous PHA revalidation, which offers measurable cost reductions and safety benefits (CCPS, 2000). Where non-PSM facilities are not required to perform PHAs, clearly these analyses provide the basis for engineering design for safety. Failing that, an MOC program provides a control mechanism to pro-

Examples of Temporary Changes Requiring an MOC

- Changes in materials of construction
- Change in raw materials or feedstocks
- Replacement equipment, machinery and piping that differ from the original design specifications
- Addition or removal of process equipment or piping such as adding block valves or flowmeters
- Changes in physical layout that may affect employee escape paths
- Change in product recipe or the introduction of new products
- Temporary electrical equipment or connections
- Removal or decommissioning of equipment, alarms and safety systems
- New projects that involve tie-ins of equipment modifications of units already operating
- Projects to increase throughput or accommodate different feedstocks or products including differing catalysts
- Equipment changes including the installation of new equipment and modifications of equipment already in use
- An alternative supply of process materials, catalysts or reactants, possibly through temporary drums or tanks in the plant
- Changes resulting from process hazard analyses, safety reviews before start-ups, and accident or incident investigation recommendations
- Modification of the process or equipment that causes changes in the relief requirements including capacity, trip points or venting routes
- Changes in the process or mechanical design
- Change in process chemicals or chemistry
- Introduction of new or different process additives (e.g., corrosive control agents, antifoulants, antifoam agents)
- Major equipment replacement by a manufacturer that did not make the original equipment
- Change in equipment design
- Temporary piping connections or hoses
- Change in piping and equipment specifications
- Change in operating or maintenance procedures
- Change in process control or conditions including changing control ranges of temperature and pressure instruments to exceed defined standard operating limits
- Change in equipment service or maintenance routine (e.g., the introduction of reliability centered maintenance such as pumps)
- Change in metallurgy of a piping system
- Change in electrical service
- Adding or removing insulation on a major scale
- Installation or changes in structural members supporting covered processes
- Changing the method or controls scheme of an instrument loop
- Changing or bypassing ("jumping") alarms, permissive switches or trips
- Change in warehousing procedures, indexing and storage conditions
- Change in operating discipline such as a computer programming change

Note. *From "Documentation—The Key to MOC," by M.M.R. Eastman and J.R. Sawers, 1998,* Chemical Processing.

Examples of Changes to Facilities & Processes Requiring an MOC

- Structural changes to a unit or facility including changes in access roads, manways, ladders or stairs
- Changes to pressure-relief devices such as adjusting valve settings or relieving capacity
- Any replacement of equipment or components, piping, instruments or electrical components that is not an in-kind replacement
- Nonroutine changes to instrumentation, control loops or computer programs such as changing the range of transmitters or control-valve failure positions
- Any change in safety alarm settings, interlocks, process or equipment trips, or in the testing or calibration frequency or standards of those devices
- All temporary facilities and connections including pipe clamps, temporary pipe, hoses, temporary utility connections and temporary electrical equipment or connections
- Changes to fire protection, emergency response or other safety systems

Note. *From "Documentation—The Key to MOC," by M.M.R. Eastman and J.R. Sawers, 1998,* Chemical Processing.

vide a disciplined engineering process to manage the documentation and system operations.

Documentation Is Key

According to Eastman and Sawers (1998), "Document control and training are critical to the MOC process." All affected personnel must be informed by memo, through formal training or by other appropriate methods. Inform purchasing departments and stores to ensure new or replacement parts are ordered and that no costly mishaps occur through less-than-up-to-date inventory control.

A good approach for this effort is to have the person requesting the change complete a request for change to policies or procedures. This would normally be the employee responsible for job documentation, the draftsperson or the project engineer who owns a particular document. The request is then sent to the area superintendent who will approve it and verify that the training required for MOC is scheduled and conducted; affected documents have been updated; and appropriate operations, maintenance, purchasing, stores and other personnel have been notified of the changes.

Affected documents may include operations job documents, such as job analyses, training plans (basic and job-specific), standard operating procedures and skill demonstrations. General-purpose reference documents might include standard operating conditions and limits (SOCLs), pressure-relief devices, lubrication manuals and others. Similarly, maintenance craft documents, such as job analyses, training plans (basic and craft-specific), standard maintenance procedures and skill demonstrations are included, as are general-purpose reference documents, such as technical data sheets, spare parts lists, manufacturers' manuals and corresponding documents for contractors. In most cases, site policy manuals, reference documents and software—including safety, process safety management, environmental (with the risk management plan), employee, purchasing, warehouse, MSDS, quality, maintenance scheduling, training scheduling, turnaround and other project management software—should also be included.

Many PSM companies reshape their MOC programs based on past experiences and current best practices. In addition, the author knows of some refineries that adhere to PSM requirements even for process units not regulated by that standard. Clearly, while many may struggle to address issues that affect overall program objectives and effectiveness, they benefit from the disciplined approach to change.

It's All in the Details

While implementing MOC is, in principle, a positive control process, companies often overlook the details. As a result, the process has some inherent pitfalls (CCPS, 1989; 1992; 1994; 1995; 1996). The same is true (or worse) for PSM companies that have no disciplined approach to managing change. Factors that are often overlooked include the following:

- **Inadequate definition of a change:** What is replacement in kind?
- **Resolution of temporary changes:** Do we want to extend the duration of the change, return the process to original condition or make the change permanent?
- **Managing emergency changes:** How do we ensure that all requirements of normal changes are satisfied?
- **Procedural changes:** Do we require a prestart-up safety review?
- **Tracking/closure of action items:** How do we verify that action items have been completed and meet the intent of the recommendation?
- **Communication of the change:** How do we achieve this and maintain adequate documentation?
- **Prestart-up safety review:** How do we decide when one is needed?
- **Updating process safety information (PSI):** How do we manage updating to ensure MOC action items are closed out in a timely manner?
- **PHA interface:** How do we revalidate an existing PHA for each MOC?

MOC Implementation Issues

Let's take a closer look at each of the overlooked factors.

Inadequate Definition of a Change

A common shortfall of many MOC programs is an inadequate and inconsistent methodology in identifying changes that should be captured by the MOC process (CCPS, 1989, 1995). According to CCPS (2000), in general, all process and changes except replacements in kind should be associated with an MOC, although some latitude can be exercised regarding the specific methodologies and the level of reviews required.

Care should be taken to ensure that even seemingly minor issues, such as personnel changes in key positions or changing set points of instruments, are captured to ensure that requisite safety and reliability levels are maintained. As noted, MOC should be initiated when a process is altered or when the mechanical

Figure 3

MOC Form

MANAGEMENT OF CHANGE (for a non PSM-covered company)

Management of Change Form

Facility: ____________________________

Date of change: ____________________
Duration:
Permanent from ____________________

Temporary from ____________________

to ____________________

Type of change:
☐ Operational
☐ Facility
☐ Emergency
☐ AFE

Emergency changes must be submitted to local management within in 24 hours of initiating changes

Change affects:
☐ Process chemicals ☐ Operating
☐ Equipment ☐ Procedures
☐ Other: ______________________________________

Description and purpose of change (attached report, sketch, P&IDs, AFE, etc.)

Does this change create a possibility for a catastrophic release different than those identified? Explain.

LIST SH&E or regulatory reviews that require follow-up review and/or evaluation

Approvals to begin change/approve emergency change

Operator ______________________ **(signature)**
Date __________________
Foreman ______________________ **(signature)**
Date __________________

Documentation Impacted

Required	Completion date	Completed by
Procedures		
Process hazard analysis		
Inspection / testing		
Electrical class		
Training		
Communications		
PSSR/RSSR		
Mechanical integrity		
Emer proc		
Operating proc		
Other		

Reason for change

Does this change reduce the margin of safety for this process, as described in the process safety information?

Any comments or suggestions that you would like to include?

Notification of employees affected by change

Employee(s) assigned to Follow-up/review updates ________________

Completion date ________________

Affected employees notified of change ________________

design is modified. It may also result from changes in feedstocks, catalysts, product specifications, by-products or waste, design inventories, instrumentation and control systems, or materials of construction (CCPS, 1994). Non-PSM companies experience many of the same issues. The key difference is that they do not store the large quantities of highly flammable liquids that trigger the PSM and MOC requirements.

Technology is another type of change that should be tracked. Such changes occur when equipment is

Written MOC Process

Following is an example of how a management of change process would be written as part of an overall management system.

1.1 The health, safety, security, environmental, technical and other impacts of temporary and permanent changes are formally assessed, managed, documented and approved.

1.2 Changes in legal and regulatory requirements, technical codes, and knowledge of health and environmental effects, are tracked and appropriate changes implemented.

1.3 Effects of change on the workforce/organization, including training requirements, are assessed and managed.

1.4 The impact on product quality of changes in manufacturing processes is assessed, associated hazards are evaluated and risks are controlled.

1.5 The original scope and duration of temporary changes are not exceeded without review and approval.

altered or new equipment, such as process equipment piping, electrical or control system alarms, instrumentation and control schemes, are added. Changes in technology also occur when the process is modified or the relief requirements are changed, including modifications in relief points, capacity or other corrective actions. These changes can result in increased throughput, operation at higher temperatures or pressures, increased size of equipment, or the addition of equipment that might contribute to higher capacity relief requirements. Installation or removal of bypass connections around equipment that is normally in service is a change in technology under MOC requirements (Eastman & Sawers, 1998).

Changes in facilities are also changes in technology as defined in 29 CFR 1910.119. A change in a facility would not necessarily appear on a process and instrumentation diagram (P&ID). These changes can occur in equipment configuration; materials of construction; installation of temporary facilities; temporarily bypassing or disabling equipment, including electrical jumpers; and operating a control valve with the handjack engaged.

Changes in technology also include any new administrative controls, document controls and training. In addition, projects to increase plant throughput or accommodate different feedstocks or products are also considered under this definition.

Significant changes in operating conditions also constitute changes in technology. These can include alterations to pressures, temperatures, flow rates, equipment operating speeds or process conditions outside the engineering maximum-minimum limits set in the SOCLs or manufacturer's specifications.

Changes in process chemicals are also construed as changes in technology. Examples include introduction of new process additives, new process materials, and new catalysts or reactants in covered processes such as corrosion control agents, antifoulants and antifoam agents.

What is exempt? Certain routine changes do not require MOC procedures under the OSHA standard. One example is a change of set point within the administrative limits of an SOCL. Administrative limits demarcate the range where control room operators are allowed to make changes (OSHA, 1992).

Changes of the engineering MOC limits are considered management of change items, which include replacement of equipment that is replacement in kind or changes made to allow for the safe shutdown of a process unit in an emergency. That type of change needs to stay in accordance with emergency procedures and protocols, and is documented in appropriate log books, returning the process to its original state as soon as practical (OSHA, 1992).

An ideal MOC policy should allow for variances to handle special cases or circumstances. Preventive maintenance and related inspections and tests including repairs are also exempt, as are recalibration of instruments; in-kind or equivalent replacement of insulation, instrumentation or equipment; cleaning of exchangers, piping or other equipment; bypassing interlocks, trips and alarms; trips bypassed during normal operations to blowdown transmitters; trips bypassed for weekly checks; and nuisance alarms bypassed when equipment is down for maintenance.

For non-PSM companies, technology is often a huge driver. Companies are market-driven and must respond quickly to market conditions. As a result, details of system parameters may be missed, creating the potential for an incident. As the number of changes grows, corporate memory can evaporate. When software is added to the mix, being able to remember what changes took place 1 month ago, much less 1 year ago, is challenging—and is often made more so by frequent personnel changes.

Temporary Changes

Documentation, closure and communication of temporary changes are often cited as major quality issues in MOC programs (CCPS, 1989; 1995). Examples of temporary changes requiring an MOC are discussed in the sidebar on p. 43. Common issues include the following:

- authorized period expires without removing or making the change permanent;
- change is made permanent, but is not reflected in the P&IDs and other process safety information;
- change is improperly or incompletely removed.

Non-PSM companies experience similar temporary changes, such as the interim use of a hose in place of failed piping to allow the process to be brought to a safe stopping point to make the necessary repairs. Another example of a temporary change is the need to accept a raw material from an unapproved supplier because the normal supplier has experienced a business interruption and cannot provide the material.

Emergency Changes

Due to their nature, emergency changes are often extended special privileges in the MOC process (CCPS, 1992; 1995). These privileges allow personnel to perform emergency field changes and modifications using a less-rigorous process than normal changes. However, these field changes often are not brought into the mainstream MOC process even after the emergency situation has been addressed. Consequently, a change that may be temporary often inadvertently becomes permanent (Ozog & Stickles, 2003). As one of Murphy's laws states, "Nothing is more permanent than that which is marked temporary and nothing is more temporary than that which is marked permanent."

Non-PSM companies also experience emergency changes. If not incorporated into the system, the documentation does not follow and the information and knowledge are not captured.

Procedural Changes

Although 29 CFR 1910.119 specifically mentions "modifications to operating procedures" as falling under MOC requirements, many companies do not review procedural changes through an MOC process (CCPS, 1992; 1994). Confusion typically stems from the wording of the prestart-up safety review (PSSR) element, which for example states, "A PSSR is not required if there is no change in the PSI" (Ozog & Stickles, 2003). Since procedures are not included in the definition of PSI, companies often think that a PSSR is not required for a change that only affects procedures. However, this reasoning clearly does not exempt procedural changes from being managed via the MOC process (Ozog & Stickles).

Non-PSM companies also experience procedural changes—perhaps even more often than PSM-companies. The question is whether the documented procedures are changed and maintained or whether the company relies on key personnel to pass on knowledge rather than document and update it when things changes.

Tracking/Closeout of Action Items

PSM audits often cite companies for lacking an efficient mechanism for tracking and closing out assigned action items (CCPS, 1992; 1994). A typical MOC will involve multiple departments and personnel, each with an assigned responsibility. Often, a single individual may have hundreds of assigned action items related to MOCs, PHAs, audits and similar activities. Under such circumstances, it may be that MOC items remain active simply because the assigned individuals have not documented the closeout stage (Ozog & Stickles, 2003). Over time, with no tracking system, the facility accumulates a large MOC backlog—or worse, loses track of open MOCs. According to some sources, it is not uncommon for a medium-sized processing facility to have more than 1,000 open MOCs because of an inefficient tracking mechanism (Ozog & Stickles).

Even with a documented process, it is a challenge to keep current. In the author's experience conducing PSM-related audits and inspections, lack of follow-up and closure with corrective actions and action items is a problem.

MOC-Initiated Training

An MOC process often indicates the need for additional training (CCPS, 1994). The following issues are common concerns:

- lack of documentation regarding the training date and participants;
- commencing operations covered by the MOC process before conducting the required training.

How often does training ensue after big changes occur in the system, especially for non-PSM companies? Without a disciplined approach to change, especially in a marketplace where speed is of the essence, training often takes a backseat.

Prestart-Up Safety Review

Although the PSM standard does not require a PSSR for every MOC item (such as those that do not entail any PSI changes), it is not uncommon to encounter situations where there is no record of a PSSR even though it is required (CCPS, 1992; 1994; 1995). Often, this may be due to a lack of adequate documentation or a formal approval process prior to start-up. While this is required for PSM companies, even an informal process would prove wise for a non-PSM company seeking to ensure that change is managed.

Updating PSI

Updating relevant PSI is the litmus test of an effective and systematic MOC process (CCPS, 1992; 1994; 1995). Most companies attach redlined copies of the relevant PSI (such as procedures, P&IDs, loop diagrams) to the respective MOC forms that serve as guidelines to update the master/controlled copies. However, a random field audit of completed MOCs in an operating facility may reveal that the PSI in many cases has not been updated and is not reflective of the field conditions (Ozog & Stickles, 2003). This can lead to the conclusion that many companies are struggling to identify procedures and work processes which ensure that an MOC program captures PSI updates in their entirety.

PHA Issues

An MOC for a major modification and/or change involving inherently hazardous materials requires a formal PHA using an accepted methodology such as hazard and operability analysis (HAZOP) or fault-tree analysis (CCPS, 1992; 1994; 1995). The sidebar on p. 44 identifies changes to processes and facilities requiring an MOC.

However, many MOC programs do not provide clear guidance on when a PHA may be beneficial or required. Consequently, there may be a tendency to bypass a PHA in the interest of cost/schedule even though one may be required.

Another inherent inefficiency occurs when a PHA associated with a particular MOC item is conducted without integrating the information with the then-current PHA documentation (Ozog & Stickles, 2003). By not doing so, the operating facility is ignoring the revalidation aspect of the overall PHA. This will likely result in a longer, more costly PHA revalidation effort at the next 5-year cycle because at that time the operating facility will need to review and incorporate all MOCs into the PHA, thereby incurring redundant cost and schedule demands. Non-PSM companies experience many of the same changes and would do well to follow some kind of procedure to manage them. The example checklist presented in Figure 3 (p. 45) could serve as a starting point.

Administering MOC

Adminstering the MOC process can be accomplished using a low-tech, paper-driven process

MOC: A Risk Reduction Tool for Every SH&E Toolkit

By Vickie L. Chapman

Management of Change (MOC) is the universally adaptable analysis process that emerged from OSHA's Process Safety Management standard (29 CFR 1910.119 in 1992) and EPA's Risk Management Program (40 CFR 68.75 in 1994). MOC is a proactive process for reducing the risk of an incident associated with changes to machinery, equipment, processes and other activities.

Under an MOC structure, any changes made to a process—whether it is a new product/process or a not-in-kind replacement or upgrade to existing equipment and/or process—must undergo multistage reviews. What results is a systematic, comprehensive review that is designed to reduce or eliminate opportunities for failures such as permit misses, bad design installation, incomplete/inadequate rollout of the change, or equipment failure up to and including loss of property or life.

Making Changes: Three Examples

Process X uses a 300-gallon per minute (gpm) centrifugal pump to move a chemical from tank Z into the process reactor. The pump fails. The site has another 300 gpm pump in storage. Fairly simple—install the pump and move on because the substitution in this case is a replacement-in-kind (300 gpm = 300 gpm).

Imagine the same situation, but this time, the only substitute pump available is rated 200 gpm—and it will take 1 week for a new 300 gpm model to arrive. Because of the difference in pumping capacity, the installation of the 200 gpm pump, even temporarily, cannot be considered a replacement in kind. Additional consideration is needed regarding the risk involved with such a substitution. How will it affect the process? Will it starve the process downstream in the reactor and cause an upset or runaway reaction? Upstream, will it cause tank Z to overpressurize or overflow?

Now consider a more difficult scenario. The engineering and technology department has been asked to invent and install a state-of-the-art combination vertical extrusion furnace flame tempering machine. Nothing else in industry is available against which to benchmark this machine. How much cooling water will it use? What type of waste will it generate? What permits are required? How many operators will be needed and at what skill level? How does the site imagine all possible scenarios and items needed for this new apparatus?

MOC Structure

An MOC program provides a structured manner by which to address the concerns that would arise in these scenarios. The program revolves around three key components: 1) a written program detailing the step-by-step elements—from purpose to auditing effectiveness; 2) MOC generation form that acts as the router document, ensuring inclusion of all relevant parties to the change process; and 3) a checklist that articulates matters for consideration involving the change.

Written Program

The written program outlines the scope of the program in detail. Sections include: purpose; definition of change/modification as it relates to MOC; responsibility; MOC process details; installation phase; temporary/expedited MOCs; document retention; training requirements; annual program auditing; personnel and organizational changes; MOC forms (and the order of their use).

MOC Generation Form

The MOC generation form generally has three parts: Part 1 requires the change initiator (e.g., engineer, operations manager) to document relevant descriptive information about the change. This includes details such as the place and the process where the change is located; the originator; the type of installation (temporary or permanent); equipment name; MOC title and tracking number; affected documents; and a narrative section where the originator details the reason for the MOC.

Part 2 of the form is a section for col-

requiring signatures and reviews by various parties or it can also be accomplished by using MOC software. According to Eastman and Sawers (1998), MOC software should "monitor the creation, notification, distribution, tracking and reporting of approvals and tasks that must be completed for the change item." It should also track not-in-kind equipment changes, procedure changes and changes to documents not in the document management system, such as check requests and travel vouchers. A preferred software package should include a function that allows managers and workers to be notified via e-mail regarding the need to approve or take other actions.

Integrating With Management Systems

Occupational safety and health management systems are evolving and becoming more prevalent (Manuele, 2006). ANSI/AIHA Z10-2005 states:

> Quality, environmental and occupational health and safety management systems are used by many organizations in the U.S. and around the world. Quality and environmental systems are frequently in conformance to international voluntary consensus standards, or they share many basic concepts and principles with them. . . . Many organizations operate their own occupational health and safety management systems, while others use systems that conform to available guidelines. . . . There is widespread agreement that the use of management systems can improve organizational performance, including performance in the occupational health and safety arena.
>
> OSHA's Voluntary Protection Programs rely on management system principles and has reported success in improving occupational health and safety performance among participating companies. In addition, the American Chemistry Council reports success in improving environmental performance of participating organizations. The major professional health and safety organizations are also on record in support of management systems as effective tools for improving health and safety performance, as well as for contributing to the overall success of the business. Finally, the fact that many organizations in the U.S. and abroad are implementing management systems in occupational health and safety is evidence that these systems add value to their businesses.

Management systems require an MOC process because it is good business to manage change properly (Manuele, 2006). The sidebar on p. 46 is an example of how such an element would be written for a management system.

lecting signatures of those who attend the design package review meeting. Parties that should be active in this meeting include: operating technicians, maintenance, quality, SH&E, engineering, technology and others.

Part 3 of the form is section for collecting signatures of those involved in a final walk-through inspection of the changes made. This inspection should ensure that the equipment is in a condition to be safely started and operated. At a minimum, final signatures should include the MOC originator, operating technician and the department manager.

MOC Checklist

The third document is the MOC checklist (see p. 50). It helps those involved recognize all possible items to be considered concerning the change. Subelements of the checklist include operations, health (industrial hygiene), training, process controls, maintenance, process analysis, environmental, engineering and safety. Each subelement contains bullet points to be considered regarding the change. As projects are completed, the checklist should be improved to make it more robust and comprehensive.

The MOC Process in Practice

Identifying the need for a change is the first step. The MOC initiator generally is the management leader tasked with making the change happen. The initiator completes Part 1 of the MOC generation form and creates a package of materials that explain the change project. The initiator then schedules a design review meeting with all applicable team members (e.g., maintenance, SH&E, technology, operations leaders, technicians) and provides each with a copy of the MOC project package.

At the meeting, participants ask questions and review relevant project drawings and documents. Participants also collectively work through the MOC checklist in order to openly discuss, consider and capture any tasks related to making the proposed change. The checklist may be in a paper checkbox form, but an electronic spreadsheet expedites the process and helps the team easily provide descriptive action details, identify action owners and list target completion dates.

After the meeting, personnel sign off on the MOC generation form to acknowledge their participation in the review process. Team members then work to address and complete assigned action items. Once these are completed, the initiator is notified.

Once all action items are completed and the change is in place, the initiator schedules the final walkdown inspection. The team assesses the completed change to ensure that all items are in place and that the equipment and/or process is ready to be placed into service. All parties participating in this inspection sign off on the MOC generation form. Copies of completed MOC forms and the project package should be filed in the initiator's office, as well as in the SH&E and engineering department offices. These records will be used when auditing the program's effectiveness and robustness.

The duration of the MOC review process varies depending on the breadth, width and depth of the change—which can range from a small change (e.g., pump, blower, valve changeout, on-site equipment move) to the introduction of expensive process equipment. The MOC program should differentiate flexibility for small process changes (e.g., a process temperature increase from 300 to 400 ºF), conducted under controlled conditions (e.g., research and development experimentation). Lastly, the program should address a temporary/expedited MOC strategy for emergency situations.

The MOC process is not a matter of conducting a review simply as a regulatory requirement. The real payoff from this process is reduced risk and fewer incidents. The MOC process takes time to work through, but it is time well spent. ■

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Conclusion

The overall quality and effectiveness of MOC programs in the process industries can be improved. Most gaps in existing MOC programs fall into three categories: lack of well-defined workflow, documentation and information management capabilities (CCPS, 1996). Implementation of software systems can help companies better define workflow requirements and be both more efficient and effective in instituting MOC programs that drive measurable cost and safety benefits to the facility.

Many lessons learned within the process industries could benefit non-PSM-covered companies. Just because companies do not meet the chemical thresholds does not mean they do not have similar implementation problems. In fact, these problems could be worse because the data are not collected to identify them. Non-PSM-covered companies are as prone (and perhaps more) to have poorly defined workflow, inadequate documentation and poor information management capabilities.

It has been said that there are three states of intelligence: Knowing what you know; knowing what you don't know and not knowing what you don't know. From an MOC standpoint, not knowing what you don't know can have devastating and perhaps catastrophic results. ■

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MOC Sample Checklist

❏ All ❏ N/A Operations

- ❏ Y ❏ N/A Technician review
- ❏ Y ❏ N/A Manpower (+/-)
- ❏ Y ❏ N/A Startup services
- ❏ Y ❏ N/A Painting
- ❏ Y ❏ N/A Labeling (pipes and valves, etc., for purpose and content)
- ❏ Y ❏ N/A Accessibility (e.g., need a ladder?)
- ❏ Y ❏ N/A Success (keep running) or failure (shutdown) criteria

❏ All ❏ N/A Training

- ❏ Y ❏ N/A MPIs changed (job instructions)
- ❏ Y ❏ N/A Emergency procedures
- ❏ Y ❏ N/A Training materials (new/existing)
- ❏ Y ❏ N/A Training time
- ❏ Y ❏ N/A Maintenance inclusion
- ❏ Y ❏ N/A Operations inclusions
- ❏ Y ❏ N/A Other training overlap (cranes, PPE)

❏ All ❏ N/A Maintenance

- ❏ Y ❏ N/A Maintenance accessibility
- ❏ Y ❏ N/A Equipment compatibility
- ❏ Y ❏ N/A Drawings/prints/documentation
- ❏ Y ❏ N/A Isolation
- ❏ Y ❏ N/A Procedures
- ❏ Y ❏ N/A PM program and equipment and tools
- ❏ Y ❏ N/A Spare parts
- ❏ Y ❏ N/A Critical equipment
- ❏ Y ❏ N/A Excavating and trenching
- ❏ Y ❏ N/A Hot work
- ❏ Y ❏ N/A Mechanical integrity
- ❏ Y ❏ N/A Inspection and testing criteria

❏ All ❏ N/A Process controls

- ❏ Y ❏ N/A Critical instrument involved?
- ❏ Y ❏ N/A Calibrations
- ❏ Y ❏ N/A Input/output additions or deletions
- ❏ Y ❏ N/A Sequence program change?
- ❏ Y ❏ N/A Instrument change? (range, type, etc.)
- ❏ Y ❏ N/A New/modified interlocks?
- ❏ Y ❏ N/A Variable changes (timers, recipes, alarms?)
- ❏ Y ❏ N/A Determine control feasibility
- ❏ Y ❏ N/A New/modified control strategy
- ❏ Y ❏ N/A Statistical process control
- ❏ Y ❏ N/A PM program

❏ All ❏ N/A Process analysis

- ❏ Y ❏ N/A System layout
- ❏ Y ❏ N/A Corrosive/erosive
- ❏ Y ❏ N/A Pressure (relief/containment)
- ❏ Y ❏ N/A MEPT (maximum expected pressure and temp)
- ❏ Y ❏ N/A Reactivity
- ❏ Y ❏ N/A Utilities (Any demand changes?)
- ❏ Y ❏ N/A Backup power required?
- ❏ Y ❏ N/A Process stability?
- ❏ Y ❏ N/A Block flow diagram
- ❏ Y ❏ N/A Fail-safe conditions (equipment/valves)
- ❏ Y ❏ N/A Equipment tagging

❏ All ❏ N/A Engineering

- ❏ Y ❏ N/A Codes/standards referenced?
- ❏ Y ❏ N/A Civil/structural (building changes)
- ❏ Y ❏ N/A Stress
- ❏ Y ❏ N/A Material compatibility understood
- ❏ Y ❏ N/A Insulation
- ❏ Y ❏ N/A Best practices
- ❏ Y ❏ N/A Electrical class
- ❏ Y ❏ N/A Pipe/equipment supports
- ❏ Y ❏ N/A Inerting supports
- ❏ Y ❏ N/A Regulation forms (U1, etc.)
- ❏ Y ❏ N/A Standards (new codes/specs)
- ❏ Y ❏ N/A Process flow diagram
- ❏ Y ❏ N/A Baseline integrity inspection
- ❏ Y ❏ N/A Piping and instrumentation diagram
- ❏ Y ❏ N/A Electrical line diagram
- ❏ Y ❏ N/A Material balance
- ❏ Y ❏ N/A Energy balance
- ❏ Y ❏ N/A FMEA

❏ All ❏ N/A Safety

- ❏ Y ❏ N/A Fire protection (sprinkler, extinguisher)
- ❏ Y ❏ N/A Explosivity/inerting
- ❏ Y ❏ N/A FM compliance (insurance underwriter)
- ❏ Y ❏ N/A Compressed gases and storage
- ❏ Y ❏ N/A Carseal
- ❏ Y ❏ N/A Hot/cold surfaces/insulation
- ❏ Y ❏ N/A Grounding/bonding/earthing
- ❏ Y ❏ N/A Energy isolation points and LOTO
- ❏ Y ❏ N/A Eyewash/safety shower
- ❏ Y ❏ N/A Laser light
- ❏ Y ❏ N/A Job safety analysis
- ❏ Y ❏ N/A Personal protective equipment
- ❏ Y ❏ N/A Contractor safety and health review
- ❏ Y ❏ N/A Hazard analysis
- ❏ Y ❏ N/A Occupancy changes
- ❏ Y ❏ N/A Potable water
- ❏ Y ❏ N/A Means of egress
- ❏ Y ❏ N/A Confined spaces
- ❏ Y ❏ N/A Walking/working surfaces
- ❏ Y ❏ N/A Machine guarding
- ❏ Y ❏ N/A Hazardous materials
- ❏ Y ❏ N/A Safety labeling/warning (signs, pipes, color coding)
- ❏ Y ❏ N/A Fall protection
- ❏ Y ❏ N/A Hot work (welding, cutting, brazing)
- ❏ Y ❏ N/A Hand and power tools
- ❏ Y ❏ N/A Emergency equipment (SCAT pack, stop buttons, etc.)

❏ All ❏ N/A Health (IH)

- ❏ Y ❏ N/A Noise (85 dB)
- ❏ Y ❏ N/A Fumes/ventilation
- ❏ Y ❏ N/A Ergonomics and positioning of people
- ❏ Y ❏ N/A Material introduction/compatibility
- ❏ Y ❏ N/A HazCom-MSDS and labeling
- ❏ Y ❏ N/A Toxicity
- ❏ Y ❏ N/A Working environment (hot, cold)
- ❏ Y ❏ N/A Laboratory safety
- ❏ Y ❏ N/A PPE assessment

❏ All ❏ N/A Environmental

- ❏ Y ❏ N/A Operating permits: air/water/waste (new/modified)
- ❏ Y ❏ N/A Emission controls
- ❏ Y ❏ N/A Waste minimization
- ❏ Y ❏ N/A Waste type/quantity
- ❏ Y ❏ N/A Waste characteristics (any change)
- ❏ Y ❏ N/A Emission point change
- ❏ Y ❏ N/A Water demand change
- ❏ Y ❏ N/A Tank change usage
- ❏ Y ❏ N/A SARA 311, 312, 313
- ❏ Y ❏ N/A Containment/spill prevention
- ❏ Y ❏ N/A SPCC change?
- ❏ Y ❏ N/A Change in fugitive emission points (LDAR)
- ❏ Y ❏ N/A RMP change
- ❏ Y ❏ N/A HVAC systems (CFCs, ozone depleting)
- ❏ Y ❏ N/A Waste water impact reviewed
- ❏ Y ❏ N/A Chemical control/restricted chemicals
- ❏ Y ❏ N/A Review storm water permit