

CHAPTER 11

Effectively Managing Change within the Chemical Industry

Introduction

Common sense and the OSHA Process Safety Management standard require a formal method to effectively deal with change in the chemical industry. The safety designed into the original process often occurs after a multidisciplined design team agonized for the optimum arrangement of process and layout. This process safety must not be jeopardized by modification schemes of poor quality.

Here is an overall view of Management of Change complete with beneficial insights and details. This chapter:

- offers preliminary thoughts on Management of Change (MOC)
- stresses the development of a simple MOC system
- provides pertinent OSHA MOC excerpts from the standard
- proposes principles of an effective MOC system
- defines vital MOC program terms
- presents methods to create or improve an MOC system
- proposes key steps for an MOC system for a medium or large facility
- proposes alternate key steps for an MOC system for a smaller organization
- discusses variances, exceptions and special cases of change
- includes the acid test, Auditing the Management of Change Program
- offers a comprehensive listing of effective supplemental references if additional resources seem desirable

Two appendices to this chapter offer additional details.

Preliminary Thoughts on Managing Change

Each location handling hazardous chemicals must develop, implement, and consistently use an effective formal method to confidently deal with change. Many vivid examples of flaws in managing change were described in previous chapters. Effective process safety equipment and procedures must not be jeopardized by cavalier workers or poor quality modification schemes.

No recipe or procedure can be devised that would be universally acceptable. The exact approach used to scrutinize a proposed change must be site specific and developed for that
There must be a sustained management commitment to the management of change program since this may require a change in culture within many organizations. Speaking of culture changes, Ian Sutton points out in *Process Safety Management* that a management of change system appears to contradict other current U.S. management principles, such as employee empowerment. Empowerment concepts are those in which management provides more opportunities for individuals to make decisions on their own authority. A management of change system by definition is an approval and control system with requirements to work within a firmly established bureaucracy. [1]

**Are Management of Change Systems Like Snowflakes?**

You could very easily conclude that nowadays, several years after the OSHA Process Safety Management standard, most companies have similar MOC systems. That is just not true. Most MOC systems are different at each corporation, and somewhat different at each location. Most MOC systems are like snowflakes, most are significantly different in details than the MOC system at the organization down the road.

To illustrate the point, at a three-hour meeting at McNeese State University’s OSHA Support Group in Lake Charles, four major nationally recognized chemical plants and refineries described the details of their MOC systems in November 1997. The four companies described major system differences and about five more attending companies provided information regarding their approaches. There were distinct differences in the review and authorization process philosophy.

Some organizations required only one signature for authorization and others required up to five signatures. Some organizations had a one-page first-step risk analysis and some had over 14 pages of checklists. Some systems classified the risk potential to determine the review steps. Some had a variable number of reviewers and signatures based upon the specific intention and impact of the change. When engineers discuss the details of their MOC systems at various forums across the nation, broad differences in review and authorization process philosophy can be heard.

Each chemical plant and refinery must adopt or develop a procedure tailored to fit the specific hazards, the available technical resources, the culture of the organization, and any required governmental regulations. It must be practical and workable *without undue delays*. Keep in mind that a modest MOC system that is regularly used and works is much better than an elaborate, sophisticated system with an impeccable paper trail that is occasionally winked at, bypassed, or sometimes totally ignored.

Having an inadequate system or one that is ignored is worse than having no system at all, because plant management can be lulled into thinking the employees are effectively managing change, when instead they are treading on danger. To ensure proper performance of MOC procedures, there must be periodic audits. [2]

Essential elements of an effective management of change policy would include a program in which *all employees*:

- understand the definition of change and why it is necessary to examine proposed changes
- recognize changes as they are proposed and seek independent review via established procedures
- have access to qualified resource people—available individuals or committees—that can assist in identifying all potentially-negative consequences of a proposed change
document the changes on drawings (process, electrical, instrumental, electrical area classification, and underground), revise operational procedures, change instrument testing methods, and revise training manuals, if necessary

- ensure that all recommendations offered to enhance process safety are studied and implemented in a timely manner
- believe that the company’s management firmly supports the program

A Reality Check Provided by Previous Chapters

For a chemical manufacturing facility to survive in the dynamic industry, it must be able to quickly adapt to changing conditions such as increasing production, reducing operating costs, improving employee safety, accommodating technical innovation, compensating for unavailable equipment and/or reducing pollution potentials. Chemical plants must also have a method to review temporary repairs, temporary connections, or deviations from standard operations.

Chemical plant modifications, when properly engineered and implemented, avoid actual and potential problems. Chapter 3 of this book demonstrates that a hidden practical or technical flaw in a noble effort to correct a certain problem can blemish a designer’s reputation. It can also be dangerous. Gradual changes created by unauthorized alterations, deterioration, and other symptoms of aging can compromise the integrity of containment and protective systems. The presence of these unwanted “modifications” can be minimized by proactive inspection, safety instrument system testing, and the follow-up repairs. Those mechanical integrity concepts, are covered in Chapter 10.

A hasty modification can result in an accident, as discussed in Chapter 6. To address the problems of “one-minute” modifications, chemical plant management must persistently encourage employee awareness and train their employees about the potential dangers that can be created by the quick, inexpensive substitutions. It is essential that well-maintained engineering and equipment specifications are readily available. Changes which might include improper substitutes (such as incompatible materials of construction) or improper procedures should be reviewed by a third party. However, this is sometimes easier said than done in the sometimes hectic pace of maintaining maintenance and production schedules.

Undesirable side effects may also be the result of modifications made in preparation for maintenance and/or activities in the implementation of maintenance. Some of these situations, previously discussed in Chapter 4 and Chapter 5, require more effort than the isolated projects. A system to review work orders and the preparation for maintenance requires continued diligence. Well-publicized, up-to-date mechanical and instrument specifications and written repair procedures which include lists of blinds will reduce many misunderstandings and incidents.

Keeping MOC Systems Simple

It is crucial that companies refrain from making their management of change procedures so restrictive or so bureaucratic that motivated individuals try to circumvent the procedures. Mandatory requirements for a list of multiple autographs is not necessarily (by itself) helpful. Excessively complicated paperwork schemes and procedures that are perceived as ritualistic delay tactics must be avoided. Engineers, by training, have the ability to create
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and understand unnecessarily complicated approval schemes. Sometimes a simple system with a little flexibility can serve best.

Losing Tribal Knowledge

A persistent management trend today is the one toward being “leaner and meaner” than the competition. A measurable excess in human resources is a luxury that is rarely found in today’s chemical industry in developed countries. Management must constantly be attuned to the problems of dilution of knowledge by movement of their human assets.

Trevor Kletz once said, “Organizations do not have good memories; only people have good memories.” Experienced employees can move due to promotions, changes in the organizational structure, retirements, or acceptance of other employment opportunities. When these well-trained individuals (be they auxiliary chemical process operators, lead operators, supervisors, or design engineers) are gone, all of that acquired experience evaporates. Most personnel moves result in a loss of process safety knowledge. No one should be ashamed to seek help from another employee or from a committee to establish the significance of the existing equipment, existing procedures or system control schemes before making a change.

Some Historical Approaches to Plant Changes

Many of the MOC practices developed by farsighted companies in the 1970s and 1980s are still valuable today. Several of the simple systems created by other companies to review management of change may still be beneficial, especially to smaller organizations. Appendix A to this chapter covers a historical look at some of the activities in England, Canada, and the United States that influenced the development of the U.S. OSHA Process Safety Management standard and the Management of Change element.


The OSHA Process Safety Management (PSM) standard should be reviewed to properly develop an MOC procedure. The PSM section addressing “Management of Change” is found in paragraph (l) of OSHA 1910.119 [3] and states:

(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.

(2) The procedures shall assure that the following considerations are addressed prior to any change.

(i) The technical basis for the proposed change;
(ii) Impact of change on safety and health;
(iii) Modifications to operating procedures;
(iv) Necessary time period for the change; and,
(v) Authorization requirements for the proposed change.
Effectively Managing Change within the Chemical Industry

(3) Employees involved in operating a process and maintenance and contract employees whose job tasks will be affected by a change in the process shall be informed of, and trained in, the change prior to startup of the process or affected part of the process.

(4) If a change covered by this paragraph results in a change to the process safety information required by paragraph (d) of the section shall be updated accordingly.

(5) If a change covered by this paragraph results in a change to the operating procedures or practices required by paragraph (f) of this section, such procedures or practices shall be updated accordingly.

[Note: Inclusion of the associated paragraphs (d) and (f) is beyond the intended scope of this book.]

The standard also defines "replacement in kind" as a replacement that satisfies the design specification. Appendix C to OSHA 1910.119 is entitled "Compliance Guidelines and Recommendations for Process Safety Management (Nonmandatory)." It serves as a non-mandatory guideline to assist with complying to the standard. [3]

"Managing Change." To properly manage change to process chemicals, technology, equipment and facilities, one must define what is meant by change. In this process safety management standard, change includes all modifications to equipment, procedures, raw materials and processing conditions other than "replacement in kind." These changes need to be properly managed by identifying and reviewing them prior to implementation of the change. For example, the operating procedures contain the operating parameters (pressure limits, temperature ranges, flow rates, etc.) and the importance of operating within these limits. While the operator must have the flexibility to maintain safe operation within the established parameters, any operation outside of these parameters requires review and approval by a written management of change procedure.

Management of change covers such as [sic] changes in process technology and changes to equipment and instrumentation. Changes in process technology can result from changes in production rates, raw materials, experimentation, equipment unavailability, new equipment, new product development, change in catalyst and changes in operating conditions to improve yield or quality. Equipment changes include among others change in materials of construction, equipment specifications, piping pre-arrangements, experimental equipment, computer program revisions and changes in alarms and interlocks. Employers need to establish means and methods to detect both technical changes and mechanical changes.

Temporary changes have caused a number of catastrophes over the years, and employers need to establish ways to detect temporary changes as well as those that are permanent. It is important that a time limit for temporary changes be established and monitored since, without control these changes may tend to become permanent. Temporary changes are subject to the management of change provisions. In addition, the management of change procedures are used to insure that the equipment and procedures are returned to their original or designed conditions at the end of the temporary change. Proper documentation and review of these changes is invaluable in assuring that the safety and health considerations are being incorporated into the operating procedures and the process.

Employers may wish to develop a form or clearance sheet to facilitate the processing of changes through the management of change procedures. A typical change form may include a description and the purpose of the change, the technical basis for the change, safety and health considerations, documentation of changes for the operating procedures, maintenance
procedures, inspection and testing, P&IDs, electrical classification, training and communications, pre-startup inspection, duration if a temporary change, approvals and authorization. Where the impact of change is minor and well understood, a check list reviewed by an authorized person with proper communication to others who are affected may be sufficient. However, for a more complex or significant design change, a hazard evaluation procedure with approvals by operations, maintenance, and safety departments may be appropriate. Changes in documents such as P&IDs, raw materials, operating procedures, mechanical integrity programs, electrical classifications, etc. need to be noted so that these revisions can be made permanent when the drawings and procedure manuals are updated. Copies of process changes need to be kept in an accessible location to ensure that design changes are available to operating personnel as well as to PHA team members when a PHA is being done or one is being updated.

The AIChE’s Center for Chemical Process Safety developed a “how to” type of book that addresses most of the concerns of OSHA's proposed Process Safety Management standard and all of the concerns of Management of Change. This book is useful to the front-line supervisor, the second-level supervisor, superintendent, and the manager of a facility that manufactures, handles, or stores hazardous chemicals. It is for the “on-site” organization that is developing the specific procedures of a Management of Change (MOC) program.

Plant Guidelines for Technical Management of Chemical Process Safety (1992) [4] provides contributions from many participating chemical manufacturers. There are numerous checklists, decision trees, proposed forms, apparently provided by various chemical plants who had an established MOC program. Nine very practical appendices are provided in Chapter 7, entitled “Management of Change.” One of those approaches may be very close to your needs.

The Chemical Manufacturers Association (CMA) contracted with JBF Associates, Inc., to develop A Manager’s Guide to Implementing and Improving Management of Change Systems. [2] This 100-page booklet, published in 1993, was not intended to be a cookbook, but rather a general guide to define the important features of MOC systems.

**Principles of an Effective Management of Change System That Prevents Uncontrolled Change and Satisfies OSHA**

It is easy for creative engineers to overengineer the design of a MOC system with multiple pages of forms and autograph requirements from every engineering discipline and every manager. Keep in mind that the focus is to prevent catastrophic accidents and to properly evaluate the concerns of safety and health and to accomplish this review in a timely manner.

The CMA’s Executive Summary covers these points: [2]

- An effective plan must be documented in writing, readily available, and must be relatively simple to use.
- The plan must have wide-spread acceptance and commitment.
- A new system or major changes to an existing system are best handled within a pilot area to help debug a system.
- There must be thoroughness in widespread training by providing initial education and follow-up training for newcomers to the organization.
In order to satisfy the PSM Audit element and to get the best out of an MOC System, the MOC system must be periodically audited.

Management must show continuous commitment.

A number of major chemical organizations have combined their PSM Management of Change element and their closely related PSM Pre-Startup Safety Review into the same procedure for simplicity.

Beware of the limits of managing change with a procedure. Ian Sutton introduced a term for two other types of changes that are very troublesome: “Covert Sudden” and “Covert Gradual.” These are hidden changes that are made without anyone realizing a change is in progress. [1]

A sudden covert change could be “borrowing” a hose for a temporary chemical transfer and learning by its failure that it was unsuited for the service. Or it could be the use of the wrong gasket or the wrong lubricant or some of the other changes discussed in earlier chapters. Only continuous training can help in this situation. A gradual covert change is one that equipment or safety systems corrode or otherwise deteriorate. The previous chapter on mechanical integrity addresses those type of changes. [1]

An Overall Process Description to Create or Improve a Management of Change System

Here are a few ideas on the process to get a MOC system that will work. Remember that the MOC system will only work if each level in the organization management visibly supports and continuously reinforces the policies. Note the six-step approach listed below.

The initial step in the process must be to assign and design. In most organizations MOC will affect a large multidisciplined group handling a spectrum of functions. Start by assigning a multidisciplined group to create or update the system. Evaluate the proposals that follow in this chapter. Better yet, “borrow” a procedure from a sister plant, evaluate the plan’s effectiveness in your plant, and if practical, reshape it to your plant’s needs.

There may not be an available model MOC for your situation. The OSHA standard has a number of requirements, but the procedure absolutely must be written and must emphasize identification of change and a review process. Appendix C to OSHA 1910.119, entitled, “Compliance Guidelines and Recommendations for Process Safety Management (Nonmandatory),” on pages 6414 and 6415 of the February 24, 1992 Federal Register, should be studied. If you are starting from ground zero, it may take time for the designers to reach consensus as that group attempts to design the system. Potential conflicts uncovered and resolved in the design stages save the team from troubles in the pilot effort.

The second step is to agree on an approach. This is easy to say. The plan must cover defining roles and responsibilities. Also, there must be provisions for temporary repairs or installations, emergency changes, and variance policy. Also decide if it seems best to unite the Management of Change and the Pre-startup Safety Review in the same procedure.

The third step is to sell a pilot program. Communicate the proposed plan and sell the idea so that a very limited pilot program can give the plan a true test.

Learn from the pain, and train. Incorporate any changes that might be required after piloting and train all individuals who will be affected by this activity. For optimum
acceptance, this training program must be introduced to all affected employees. Remember to train those who serve manufacturing, such as purchasing, environmental, shipping, and the like.

Install and operate. Provide a review team to listen to any concerns or problems during the shake-down phase of implementation. It is sometimes difficult to keep up with all of the signatures and the flow of approvals, the handling of the pre-startup requirements, and the training requirements. Many medium- to large-sized organizations are implementing electronic MOC approval systems.

Just when you think everything is going very well, try an audit. Audits are required by the PSM Standard and the first audit can be an eye opener. Check work order logs and engineering projects logs to see if some types of activities are slipping by the MOC procedure. Also emphasize complete authorizations prior to the introduction of highly hazardous chemicals into the area.

A quick summary of this section is found in Table 11-1.

**Clear Definitions Are Imperative**

The nonmandatory section of the PSM standard under Management of Change states that organizations must define what is meant by change. Each organization needs definitions that fit their circumstances. Note the definitions and examples.

**Definition of Replacement in Kind**

A *Replacement in Kind* (RIK) is a replacement that does not vary from documented plant specifications—a replacement of an instrument, electrical, piping, or other component with an identical part or an equivalent approved and specified by the applicable engineering standard. Some RIK examples include, but are not limited to:
• Raising a reactor operating temperature within the safe operating envelope.
• Changing from an Autumn turnaround to a Spring turnaround within the run time limit for the effective operation of equipment in the unit. [2]
• Raising the maximum storage tank level within the safe operating envelope for that tank.
• Replacement of a vessel or piping with equipment of the same size, metallurgy, wall thickness, pressure rating, and design temperature.
• Replacement of gate valves with ball valves (within the plant valve specifications or within regular usage for that service). (Depending on the level of maturity of your organization, and your written program, this valve substitution and the two examples that follow could require an MOC for this type of situation.)
• Replacement of lubricants for pumps and valves that have been determined to be of equal specifications approved by an experienced maintenance engineer.
• Replacement of heat exchanger tubes with a more corrosion-resistant material which has been approved by an experienced corrosion engineer.
• Promoting a properly qualified operator to a lead operator. [2]
• Replacement of a previously installed compressed asbestos gasket with a substitute gasket material that has been approved by engineering and written into the plant specifications.

A Change Requiring a Process Safety Risk Analysis

A change requiring a process safety risk analysis before implementing is any change (except “replacement in kind”) of process chemicals, technology, equipment, and procedures. The risk analysis must assure that the technical basis of the change and the impact of the change on safety and health are addressed. The analysis must also verify that any potential hazard introduced is recognized, controlled and understood by those affected.

Definition of Process Safety Change

A Process Safety Change is any modification which is significant enough to require a change in the Process Safety Information or Operating Procedures of the facilities being operated or changes to facilities that affect a covered process. Basically, it is any process change other than a “replacement in kind.”

Some examples of Process Safety Change include, but are not limited to:

• Process equipment changes to alter production rates, or equipment change of service.
• Facility changes made to significantly increase storage capacity of a hazardous material.
• Feedstock, equipment, inhibitors, catalyst, and other chemical changes, or procedural changes made to increase production yield or increase product purity.
• Alterations to protective equipment systems, such as changes to critical settings for alarm, interlock, or shutdown systems; or changes involving safety relief or vent systems.
• Changes made to compensate for unavailable or out-of-service process equipment, instruments, rotating equipment, or vessels, such as using jumpovers, hoses, and vacuum trucks, without established SOPs.
• Proposals to operate at significantly different pressures, temperatures, flow rates, acidity, etc., which are considered outside the well-understood and documented “Safe Operating Envelope.”
Proposals to improve personal safety, process safety, or for increased environmental stewardship that deviate from standard practices.

Plans to change materials of construction for major components and lesser components such as new gasket materials which are under experimental service conditions.

Unique “one-time specialty maintenance” such as chemical cleaning, hot tapping, freezing water in pipelines to work downstream of the ice plug.

Schemes for coping with temporary situations such as: pipe clamps on leaking high hazard lines; operating with a heat exchanger out of service; changing delivery methods, such as accepting a truck delivery when the normal method was by drum or pipeline.

Restart of a unit after being idle for six months or more.

Decommissioning and demolition of parts of units.

Any change in the physical plant which could increase business interruption potential, which may not have been identified above.

Any item that the second-level supervisor or the process safety engineer believes requires additional examination.

Standard Operating Procedure changes (other than minor text changes).

The Safe Operating Envelope has been defined as the range of process parameters (such as temperature, pressure, flow, level, composition) that are critical to safe operation. The Safe Operating Envelope upper/lower limits are listed in the Safe Operating Envelope tables maintained under Process Safety Information. Operating beyond these limits will cause a process upset. Key maximum and minimum limits are set based on manufacturer's specifications, theoretical calculations, or operating experience.

Key Steps for an Effective Management of Change System for a Medium or Large Organization

For an enthusiastic uniform support within the plant, each level in the organization management must visibly champion and continuously reinforce the policies which are designed and implemented to reduce spills, releases, fires and explosions. There must also be clear roles and responsibilities defined. Each type of change can be different, each review can be different, but Table 11–2 can assist in establishing a review procedure for a medium or large organization.

Introducing an Idea

Good ideas can be generated anywhere in the organization. If they originate from a chemical process operator, it can be a verbal suggestion or a written one and it is usually routed to the unit supervisor. Many maintenance improvement ideas are also routed to the unit operating supervisor. Process Engineering or Process Control ideas could travel different paths. The idea and technical basis should be defined.

Preliminary Appraisal

Often the front-line operating supervisor performs the initial appraisal. This supervisor must consider whether the idea is of potential significant value and fits in with all of the
known constraints of budget, labor contract, engineering specifications, environmental permits, and the whole range of other concerns.

The supervisor must determine if it seems to be a true change or a “replacement in kind” as previously defined. In an ideal situation, the unit supervisor and the second-level supervisor (SLS) should discuss the proposed change prior to spending a lot of time generating the MOC form and starting the evaluation. It may be that the second-level supervisor has information that such changes have been unsuccessfully tried before, or there is no money in the budget or similar roadblocks.

**Initiate MOC Form**

For changes proposed by employees (salaried or hourly, operations or maintenance) working within process units, a supervisor of the affected process unit initiates the MOC form. Typically, for changes that are inherent in capital projects, the engineer responsible for the project will initiate the MOC form.

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**TABLE 11–2 Key Steps in an Effective Management of Change Procedure**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introducing an Idea</td>
<td>The idea needs to be well defined and communicated. Is the purpose and technical basis clearly defined?</td>
</tr>
<tr>
<td>Preliminary Appraisal</td>
<td>Is it something that should be pursued? Is the idea a “replacement in kind” or is it a “change” and therefore requires further evaluation? See examples of “changes” above.</td>
</tr>
<tr>
<td>Initiate MOC Form</td>
<td>Start the process by filling out a “Safety Assessment Form” such as Form 11–1 on p.263</td>
</tr>
<tr>
<td>First-Step Risk Analysis</td>
<td>A checklist review helps stimulate the risk analysis thought process to help determine who (if anyone) needs to perform subsequent reviews. This first-step risk analysis should help determine if specialists should be consulted or if additional information should be developed. A form such as Form 11–1 can help.</td>
</tr>
<tr>
<td>Additional Analysis</td>
<td>Identify and utilize additional resources needed for a complete evaluation. The results of any risk analysis are recorded on the form.</td>
</tr>
<tr>
<td>Second-Level Review</td>
<td>The form is submitted to the affected second approval level supervisor or department head for approval. Is an additional specialist or additional analysis necessary? These parties may request a multidisciplined Technical Safety Review Committee.</td>
</tr>
<tr>
<td>Authorization to Proceed</td>
<td>This allows funds to be spent for engineering, the development of training, etc. However, startup cannot proceed until the Pre-Startup Safety Review is successfully completed.</td>
</tr>
<tr>
<td>Pre-Startup Safety Review</td>
<td>This step is actually another element of the OSHA PSM standard, but a number of organizations have worked this element into the MOC. If this is part of the MOC process, then a number of steps in updating P&amp;IDs, operating procedures, and training must be completed. See below.</td>
</tr>
<tr>
<td>Startup Authorization</td>
<td>The second-level supervisor or department head assures that PSSR requirements have been addressed and documented in the PSSR Form.</td>
</tr>
</tbody>
</table>
Naturally, some of the boilerplate information such as requester’s name, a good description of the proposed change, any associated equipment numbers, a target date for completion and other descriptors must be filled in on the form. The reason (or the technical basis) for the change must also be described. In addition, any supplementary documentation that would be helpful for evaluation should be routed with the MOC form. See form 11–1 on the following page.

First-Step Risk Analysis

A checklist review helps stimulate the risk-analysis thought process to help determine who (if anyone) needs to perform subsequent reviews. This first-step risk analysis should help determine if specialists should be consulted or if additional information should be developed. A form such as Form 11–2 can help.

The questions on Form 11–2 are less than two pages. From personal experience, I have learned many engineers designing an MOC system want to create long lists of risk analysis questions. Later PSM Auditors reviewing MOC will probably want to add even more questions. Form 11–2 provides an optimum minimum of general questions for many plants which do not have combustible dusts or severe static electric problems. A chemical plant trying to develop a set of questions for a specific location should consider the 45 pages of excellent questions in the Guidelines for Hazard Evaluation Procedures, Second Edition, with Worked Examples. [5]

Additional Analysis

Employees should understand the review process. Form 11–1 lists a whole set of resources that can be contacted to address concerns. Some plants and organizations will have more and some could have fewer available technical resources.

Larger projects or complicated schemes often receive HAZOP Studies. But smaller more straightforward modifications may not require such an effort. If the type of proposed modification under consideration is not covered by plant specifications, codes or design and operating philosophy, or if unanswered questions are generated by an assessment form, then it is a candidate for further review and further approval levels.

Second-Level Review and Approval

The request is then submitted to the affected second-level supervisor (SLS) or department head (DH) for review and further processing. The SLS or DH may reject the requested modification and file the form if he disagrees with the request or if he decides the proposal is not a change that impacts the concerns of process safety and health.

The SLS or DH reviews the risk analysis to assure complete evaluation of the change and identification of potential hazards. He uses the analysis results and documentation to determine if further analysis indicates there is a need for consultation with specialists or to make a “Go/No Go” decision to proceed with making the change. He records whether the change is approved or denied by checking the appropriate box on line 7, signs and dates the form.
### Form 11–1

**Safety Assessment Checklist for Modifications**

<table>
<thead>
<tr>
<th>Change Register No.:</th>
<th>Date Submitted:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title of Proposal:</td>
<td></td>
</tr>
</tbody>
</table>

**Specific Plant Area:**

<table>
<thead>
<tr>
<th>Proposed Startup Time:</th>
<th>Rush?</th>
</tr>
</thead>
</table>

**REQUESTER** to provide

1. **Description of the proposal:**
   
   Reason for the Change:

2. Supervisor answer “First-Step Risk Analysis” questions found on Form 11–2.

3. Identify Resource(s) or Further Analysis Utilized to address the technical basis and the impact of the change on safety, and health, and regulatory compliance.
   
   □ Loss Prevention  □ Process Engineering  □ Environmental
   □ Materials Engineering  □ Project Engineering  □ Fire Chief
   □ Information Technology  □ Maintenance Engineering  □ Safety and Health
   □ Technical Safety Committee following Loss Prevention evaluation

4. List Additional Analysis Required or Analysis Results (additional conditions, limitations, supporting documentation if significant)

5. Submit to Second-Level Supervisor or Department Head.

**SECOND-LEVEL SUPERVISOR (SLS) or DEPARTMENT HEAD (DH) to address:**

6. SLS or DH review/evaluate “First-Step Risk Analysis” question list.
   
   Is further review required? Yes ____ No ____

7. Check one: □ Design Approved/Proceed with Change
   
   Signed ________________ (SLS or DH)  Date ____________

   □ Change Denied

   Signed ________________ (SLS or DH)  Date ____________

8. Complete and attach Pre-Startup Safety Review.

9. Authorization to Proceed with Startup.
   
   Signed ____________ (SLS or DH)  Date ____________

10. Suspended items from Pre-Startup Review are complete.
    
    Signed __________________________ (SLS or DH)  Date ____________
First-Step Risk Analysis

The second-level supervisor and the sponsoring supervisor are to review and answer the following questions to assure that the impact of the change is addressed. This is to stimulate a risk analysis thought process to provide Risk Analysis information to any reviewer.

Does the proposed change properly address these process concerns? Please respond YES, NO, or N/A (not applicable).

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does the proposal introduce new chemicals in the form of new reactants, solvents, catalysts, or impurities?</td>
<td></td>
</tr>
<tr>
<td>2. If so, are the new chemicals flammable, explosive, toxic, carcinogenic, irritants, capable of decomposition, an oxidant, etc.?</td>
<td>If so, are safety data sheets available?</td>
</tr>
<tr>
<td>3. Does the rate of heat generation and/or reaction pressure increase as a result of this new scheme?</td>
<td></td>
</tr>
<tr>
<td>4. Is there a potential for overtemperature during startup, shutdown, normal operation or other cases as loss of agitation, loss of utilities?</td>
<td></td>
</tr>
<tr>
<td>5. Does the change involve revisions to critical operating procedures that could result in operating outside of the defined “safe operating envelope”?</td>
<td></td>
</tr>
<tr>
<td>6. Are the vent and pressure relief systems sufficient under the new conditions?</td>
<td></td>
</tr>
<tr>
<td>7. Is there a risk of creating a damaging vacuum condition?</td>
<td></td>
</tr>
<tr>
<td>8. Is there an increased risk of backflow or cross contamination?</td>
<td></td>
</tr>
<tr>
<td>9. Does the proposal introduce flammable liquids or gases or combustible dusts into areas that do not have the proper electrical area classifications?</td>
<td></td>
</tr>
<tr>
<td>10. Does the proposal introduce a source of ignition (including hot surfaces, flame, mechanical sparks, static electricity, electrical arcing, etc.)?</td>
<td></td>
</tr>
<tr>
<td>11. Does the change involve the use of one-time maintenance items such as chemical cleaning, hot tapping, jumpovers, freezing lines to temporarily plug, or the temporary repair of hazardous chemical leaks?</td>
<td></td>
</tr>
<tr>
<td>12. Does the change involve the alteration of a pressure vessel?</td>
<td>And if so, is the code certification preserved?</td>
</tr>
<tr>
<td>13. Is there sufficient pressure different between the new operating pressure and the maximum allowable working pressure of the vessel?</td>
<td></td>
</tr>
<tr>
<td>14. Is the relief capacity adequate for process upsets, valve or tube failure, fire, loss of utilities, etc.?</td>
<td></td>
</tr>
<tr>
<td>15. Are remote-operated isolation valves now needed?</td>
<td>Are “double-block-and-bleeds” required?</td>
</tr>
<tr>
<td>16. Have Safety Critical process alarms and shutdown systems been modified to include the new situation?</td>
<td></td>
</tr>
<tr>
<td>17. Will the gas detection systems, fire-water systems, diking or drainage need to be changed to accommodate the change?</td>
<td></td>
</tr>
</tbody>
</table>
Authorization to Proceed

If the change is approved, startup cannot proceed until the Pre-Startup Review is completed (line 8) and the SLS or DH signs off on line 9. To proceed with the change any affected documentation is updated, and the change is engineered and constructed. Any requirements identified for later completion are suspended as required. People whose job tasks will be affected by the change are informed and trained in the change prior to startup of the process. Individuals who are off shift or absent are trained upon resumption of their job responsibilities.

Pre-Startup Safety Review

Prior to startup of new facilities or facilities that have undergone changes, a Pre-Startup Safety Review (PSSR) must be performed by a supervisor of the affected process unit. If the supervisor is assured that construction and equipment are in accordance with design specifications and that affected procedures, process safety information, and training are updated, he completes the PSSR Form (Form 11–3). If any of the pre-startup requirements have not been met satisfactorily, the supervisor sees to it that the deficiencies are corrected and

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Form 11–3

**Pre-Startup Safety Review Checklist**

Does the proposal properly address the procedural, training and documentation requirements as noted below? Please answer YES, NO, or N/A (not applicable).

1. Have the process, mechanical and instrument drawings been updated, where required? __________

2. Have the new Material Safety Data Sheets been provided to Operations and Maintenance? __________

3. Have the startup, normal shutdown and emergency shutdown scenarios and procedures been reviewed? __________

4. Have the schematic wiring, instrument/electrical troubleshooting and other electrical drawings been updated? __________

5. Have the equipment files been updated to show the addition of pressure vessels, storage tanks, or revisions to them? __________

6. Have the sewer and underground drawings been updated, where required? __________

7. Have the alarm listings and safety critical prooftest procedures been developed? __________

8. Have all the other necessary maintenance testing and inspection procedures been developed? __________
the Pre-Startup Safety Review is repeated. Certain items on the PSSR may be completed after startup only if a suspended condition is generated for later follow-up. The supervisor forwards the MOC and PSSR forms and any attachments to the second-level supervisor or department head for approval to startup the change.

Startup Authorization

The second-level supervisor or department head ensures that PSSR requirements have been addressed and documented in the PSSR Form. He may elect to secure additional approvals. His authorization signature (line 9) grants approval to start up the new or changed facilities. If any of the pre-startup requirements have not been met satisfactorily, he notifies the supervisor of the affected process unit to correct the deficiencies and repeat the Pre-Startup Safety Review. (Note: Authorization to proceed with the change, completion of the PSSR, and approval for startup may occur at the same time for changes of a minor nature.)

Complete Suspended Items

Requirements may be identified that will need to be addressed before the Management of Change procedure is complete. The second-level supervisor or department head is responsible to assure that suspended items within the PSSR are completed. Suspended items could include updating master drawings with the hand-corrected “as built” mark-ups, completing the documentation to set up proof tests or vessel inspections or other important items that should not necessarily delay a startup.

Key Steps for an Effective Management of Change System for a Small Company

Employees in smaller companies must also be very familiar with the MOC review process. Management must visibly support and continuously reinforce the MOC program. A small company should at least have a system with a “Change Originator” and a “Change Authorizer.” [2]

There needs to be provisions to deal with the “Key Steps in an Effective Management of Change Procedure” as outlined in Table 11–2. The concepts of introducing the idea, providing a preliminary appraisal, and initiating an MOC Form need to be developed. Some useful ideas of simpler MOC systems proposed before the OSHA PSM standard are available in Appendix A to this chapter—“Some Historical Approaches to Plant Changes.” In some Management of Change systems, Form 11–1 may be too cumbersome. A form similar to Form 11–4 might be more acceptable in a smaller operation. Form 11–4 should be used with additional review with something like Form 11–2, the First-Step Risk Analysis.

The more difficult task for a small organization is the risk analysis activities. The “Change Authorizer” should decide if the change is within specifications, or within the boundaries of “replacement in kind,” basic good engineering judgment or normal variances. A key to the success for this simple system is for both the change originator and the change authorizer to recognize the limitations of their expertise and to seek technically qualified assistance when appropriate.
A Safety Assessment Checklist for Modifications in a Small Company

Change Register No.: __________ Date Submitted: _______________________

Title of Proposal: ______________________________________________________

Name of the Change Requester: _________________________________________

Specific Plant Area: ____________________________________________________

Proposed Startup Time: _______________ Rush? __________________________

Description of the proposal: _____________________________________________

Reason for the Change: ________________________________________________

________________________

________________________

________________________

Circle those factors that may be changed by the proposal

**Proposed Classification**  **Maintenance Considerations**
Capital Improvement  Equipment Inspection
Environmental Improvement  Premodification

**Process Change**  **Preparation for Maintenance**
Abnormal Operations  Instrument Drawings
Emergency Operations  Process Drawings
A Short Term Test  Wiring Diagrams
Temporary Change  Trip and Alarm Procedures
Materials Change  Trip and Alarm Procedures

**Process Conditions**  **Engineering Considerations**
Temperature  Plant Layout
Pressure  Pressure Relief Design
Vacuum  Flare and Vent Specifications
Flow  Design Temperature
Level  Isolation for Maintenance
Composition  Static Electricity
Flashpoint  Drainage

Reactive Conditions
Toxicity
Corrosion Potentials

List Additional Analysis Required or Analysis Results (additional conditions, limitations, supporting documentation if significant)

________________________

________________________

________________________

Signature of the Change Authorizer __________

Date Authorized __________
Let’s face it. The “Change Authorizer” should be a talented individual of authority with significant experiences and abilities. In a system that examines all proposed changes within a small chemical handling facility, it is anticipated that most changes will require minimum investigative work. However, it would be wishful thinking if the “Change Authorizer” had an available resource to contact if he wanted reassurance.

In an ideal world, an easy-to-contact, responsive “modifications man” would be available for questions generated in Operations, Engineering, and Maintenance. This “modifications man” could be a Process Safety Engineer, Loss Prevention Engineer, or a mechanical or chemical engineer that has been trained in chemical process safety. Preferably, this individual would be an on-site plant employee, but he could be a company regional engineer, a property insurance consultant, or a contractor. The “modifications man” person must understand the basic loss prevention principles of proper layout, fundamentals of fire and explosion protection, overpressure protection, electrical area classification, property insurance guiding principles, and the like. It is unrealistic to have such a well-trained individual who can think of all the right questions, so “A Safety Assessment Checklist for Modifications” should be utilized. Form 11–4 was adapted from Trevor Kletz’s publications. [6]

If available, a “modifications man” should be asked to review certain modifications that unit supervisors feel need additional scrutiny. If the type of modification under consideration is not covered by plant specifications, codes, or design and operating philosophy, or if unanswered questions are generated by an assessment form, then it is a candidate for further review and further approval levels.


Multidisciplined Committee Can Provide an In-Depth Look When Identifying Hazards

When there is concern during the “First-Step Risk Analysis” that the reviewers have incomplete understanding, then help can often be achieved most effectively with a hazards identification procedure or a multidisciplined committee. Most medium-sized and large chemical and petrochemical corporations have or should implement flexible procedures for several layers of process safety reviews for capital projects as major modifications, and expansions. There should be a procedure to alert or assign a “modifications man” to examine the early stages of the proposed change. If the change is covered by specifications or plant policy or properly addressed by codes of practice, the review may stop at this point with or without a brief note depending upon systems.

If a proposed change falls outside of plant specifications, codes of practice, or is relatively new technology, then a chemical process safety review team evaluation may be in order. Different organizations provide various names to process safety review teams, such as: Safe Operations Committee, Hazards Review Committee, Technical Support Team, Facility and Operations Change Review Committee, or Chemical Process Safety Review Team. Typically, this technical safety committee is chaired by mid-level supervision. The committee can be lead by: a Technical Manager, Engineering Superintendent, or Manager of Process Safety, who are not directly affected by the budgetary constraints or the startup deadlines.
Some successful chemical process safety review committees have a nucleus of two or three individuals supporting the committee chair. A well-rounded process engineer from engineering, an operations representative, and a Process Safety Coordinator are often key central players in such a committee. The committee should be rounded out with more individuals who can make specific contributions: process control engineers, chemists, mechanical engineers, unit supervisors, chemical process operators, environmental engineers, project engineers, fire protection engineers, reliability engineers, and safety personnel. Progressive organizations include the chemical process operators, shipping tankermen, and other “hands-on” personnel if the occasion warrants their presence.

In certain cases, such as changes created by a significant expansion, it is better to have a small group of specialists first identify the potential hazards and seek our inherently safer designs prior to any type of committee review. Brief descriptions of various approaches to hazard identification are presented in Appendix B to this chapter.

The points of agreement of Chemical Process Safety Committee meetings should be captured in meeting minutes. In some organizations a review team of senior management reviews the minutes and approve the conclusions. Once the minutes are accepted, the commitments made by various participants should be recorded and the progress of each recommendation should be periodically reviewed until such items are accomplished.

Periodic compliance questionnaires should be sent to the operating unit to review the progress on those recommendations that were made to reduce risk, but were not required to be or completed before startup. It is necessary to verify recommendations have been completed and this must be acknowledged in the records. Recommendations which were further studied and later deemed impractical or capable of creating additional troubles must not be allowed to remain in limbo. These items should be resubmitted to the process safety committee for reevaluation.

Operational Variances for Maintenance Need a Close Examination Too

In August 2001, the U.S. Chemical Safety and Hazard Investigation Board (CSB) released a new safety bulletin entitled, “Management of Change.” [7] The safety bulletin discusses two incidents that occurred in the United States in 1998. One tragic west coast refinery incident resulted in a fire with six fatalities as a crew attempted to open a refinery coker drum. The other incident, within an east coast chemical plant, was a reactor explosion and fire which injured four people. Property damage to the chemical complex was estimated to reach $13 million. Both of these incidents involved opening equipment that contained either a very hot tarry mass or a reactive sludge-like residue from unique operating conditions. Each vessel was to be opened to clean the material from the vessel. According to the CSB, neither of the activities required rapid decision making. Both situations could have been avoided using the principles of management of change, the associated structured approach and analytical risk evaluations.

The serious reader should locate and study the complete CSB safety bulletin on management of change (No. 2001-04-SB). The bulletin may be found on the CSB website at http://www.chemsafety.gov/bulletins/2001/moc082801.pdf. The thrust of the management of change bulletin is the same as that of this chapter, but the CSB’s exact focus was on changes for special maintenance vessel-clearing activities (which the CSB called operational deviations and variance). The introductory paragraph of the management of change safety bulletin states,
An MOC methodology should be applied to operational deviations and variances, as well as to preplanned changes—such as those involving technology, processes and equipment.

**Variance, Exceptions, and Special Cases of Change**

All deviations from normal plant policy requirements must follow a prescribed procedure. It must be approved by authorized individuals and properly documented prior to implementation. In ideal situations, all variances are submitted in writing.

**A Procedure to Address Taking Alarms, Instruments, or Shutdown Systems Out of Service**

A “Safe Operating Procedure” developed to create a uniform method to ensure that appropriate steps are taken prior to bypassing or removing an alarm, instrument, or shutdown system from service is offered. This procedure can provide an effective way of communicating the status of an impaired instrument. The procedure has been in use for over five years. It assumes that all instrumentation has been classified into three priorities.

Safety critical systems are classified into three classes. [8] (These classes have been defined in Chapter 10, but are repeated here.)

**Critical Consequence—Class 1.** Safety Critical instruments whose failure would either cause, or fail to inform of, situations resulting in accidental fire, explosion, uncontrolled release of dangerous materials, reportable environmental releases, or major property or production losses. The safety critical instruments assigned a “Class 1” include those that have been mandated as such by: regulating agencies; an in-house technical safety review committee; reliability studies; and specific shutdown systems and specific alarms deemed critical by operations supervisors.

Class 1 safety instrumentation loops include alarms and trips on storage tanks containing flammable or toxic liquids, devices to control high temperature and high pressure on exothermic-reaction vessels, and control mechanisms for low-flow, high-temperature fluids on fired heaters. Other Class 1 instruments include alarms that warn of flame failure on fired heaters, and vapor detectors for emergency valve isolation and sprinkler-system activation. All of these alarms, shutdown valves, and other critical instruments are regularly proof-tested to a well-defined schedule.

**Serious Consequences—Class 2.** Safety Critical instruments whose failure could either cause, or fail to inform of, serious conditions involving environmental releases, property or production losses, or other non-life-threatening situations. These instruments are given a slightly lower priority, but are also prooftested on a regular schedule.

Class 2 Safety Critical instruments include alarms or trips on refrigeration systems, rectifiers, cooling towers, kettles, and stills. [8]

**Normal Consequences—Class 3.** Instrument systems that are used to alert the chemical process operator of a nonhazardous abnormal condition that might otherwise be undetected. The failure to react to one of these alarms may create an off-specification product such as a low temperature alarm on certain distillation columns. These systems are not included in the prooftest program.

1. *If an instrument or instrument system malfunctions, the operator tries to correct the problem.* If an alarm, flow or temperature measuring instrument or shut down system malfunctions, the operators first response should be an attempt to restore it to service. It may be a
plugged impulse line, inadvertent flow shut off to an analyzer, etc. If the Instrument System is a Class 1 or 2, immediately go to Step 2. If the alarm is a Class 3, the Lead Operator (or Shift Foreman) should be consulted and follow established procedures and his knowledge of the unit and the specifics of the situation to determine the temporary steps required. At the minimum, a note in the maintenance log book must be made to initiate repairs. Stop Here for Class 3 Alarms.

2. If the instrument system is considered a Class 1 or Class 2 system, the Lead Operator (or Shift Foreman) must be consulted and follow established procedures and his knowledge of the unit and the specifics of the situation to determine the temporary steps required. (Typically a Class 1 Shutdown System would have already tripped by this time.) The Lead Operator will decide if it is tolerable to take the instrument out of service. If it is safe to do so, the Lead Operator will complete an “out-of-service” tag and mount it on the control panel. (This is a small brightly colored tag with adhesive on the back, like a “Post It” tag. It should be mounted on the control panel or other prominent place.)

At the minimum, the lead operator will make a note in the Operations Logbook and the Maintenance Logbook. An orderly shutdown may be required, if so the Shift Supervisor should be consulted.

If the situation arises which requires an instrument to be out of service for a very short period of time such as: an instrument mechanic is “freeing-up” a stuck shutdown valve with the operator present; or temporarily pulling alarm cards to help identify “mystery alarms,” etc. In these cases, the lead operator should be informed and the operator gives his undivided attention to the problem, but an “out-of-service” tag may not be filled out.

The “Out-of-Service” tag is not a substitute for promptly performing maintenance. The tag serves only to effectively communicate the status of instruments in need of repair.

3. The Lead Operator must take immediate action to restore the out-of-service instrument.

On a normal day shift, this will require contact with the supervisor who may direct the efforts of a mechanic, or generate an “Emergency” work order. On the back shifts or holidays, this may mean having the Shift Supervisor summon the mechanic(s) from home.

4. When repairs are successfully completed and the safety critical instrument is restored, the Lead Operator will remove the “out-of-service” tag from the control board.

He fills out the blank which requests the date when the instrument was restored and tapes the small slip into the log book.

5. A “Weekly Out-of-Service Tagging Checklist” will be completed by each unit every Monday morning before the Day Shift arrives.

This is a check of all the standard panel alarm lights and a review of any work that remains to be accomplished. (This panel alarm light audit is not for the new technology of distributed control instrumentation.) As a cross-check, a review of all the “out-of-service” tags of the previous week will be made. Each of the safety shutdown system valves that have been bypassed during the previous week will be inspected in the field to ensure that they are neither blocked nor operating with the bypass open.

Safety Critical Instrument Setting Changes

Critical values of operating temperatures, pressures, flows are often established prior to the startup of the unit. As experience is gained, it may be necessary to fine tune the alarm points and shutdown values. At a minimum, this should be approved by the second-level supervisor or unit manager.
If the shutdown system is complex, or there are reactive chemicals involved, it may require additional help from individuals in research or the lab.

Delays to Safety Critical Instrument Test and Equipment Inspection Frequencies

Occasionally, there may be business pressures or maintenance scheduling problems that would encourage the delay of proof testing of safety critical alarms and shutdown systems. Such situations can also delay of vessel inspections and safety relief valve testing. Some type of variance procedure or review policy should be defined to handle this occasional need. Such a policy ought to require the review of all of the inspection and test records on the specific equipment involved as well as an approval of the superintendent of the area.

When Hazard Studies are performed on new plants and modifications, certain inspection and test frequencies are defined. There should be a review process for changes. If equipment and instrumentation inspections reveal a pattern of failing to meet expectations, the testing or inspection should be increased and alternate equipment must be considered.

There must be an approval mechanism to reduce unnecessary inspection and testing if repeated testing shows ideal performance. Many test frequencies are initially self-imposed to be annual, which could be too frequent. Those type of changes should have an approval trail which includes the unit manager, or second-level supervisor, the critical instrument testing supervisor and a process safety representative.

Should the MOC System be Paperless?

Just after the OSHA Process Safety Rule was initiated, a number of organizations chose to develop better electronic systems to provide more up-to-date, meaningful records on a wide range of supporting data. Initially, there were not many commercially management of change software systems available to purchase (there are several on the market now). As a result, many large organizations explored practical ways to make an electronic MOC system. Many smaller organizations chose a paper system.

My company, PPG Industries, developed an electronic management of change system four or five years after the MOC regulation took effect. The electronic system was tailored to the organizational structure of the plant and was cumbersome to use at first. However, the electronic MOC has been improved, enhanced, and reworked several times to reflect our organization's needs and is now second-nature to our operation. A 2001 survey by a leading university indicated that about 40% of the responding organizations still handle MOC creation, approval, and documentation in paper systems. [8] (See details of the survey in the next section.)

In the spring of 2003, it was refreshing to hear a younger engineer who was excited about developing a paperless MOC system for a local chemical plant. On April 9, 2003, Ms. Amy Caldwell of Basell Polyolefins made a presentation to the Process Safety Support Group of the Lake Area Industries—McNeese University Engineering Program (Lake Charles, Louisiana). Ms. Caldwell detailed some of the problems that her company experienced with the paper system during 2002. She plainly stated the obvious problems of the difficulty to track the paper system, as the form is only viewable by the person who possesses it, and that few people know exactly where the paper form is at any given time.
Furthermore, the paper system requires a lot of walking around to get the sign-off signatures and/or to inform people of required work.

Her organization wanted something more efficient, manageable, and comprehensive, so they created their own electronic MOC system. Their newly created system is user-friendly. Interested individuals can search MOCs by production area, initiator, type, status, or manager, and they can also view support documents by clicking on a link. The problems of losing an MOC document have evaporated. The exact status of a project involving an MOC is known. The retrieval system can also help with PHA revalidations, as it is simple to retrieve all MOCs for an area.

Caldwell mentioned that, during the introductory period, some employees were more comfortable with a paper system. She was pleased that the MOC system is understood and accepted for all physical changes. Her company is stressing the use of MOCs for such activities as changing special operating procedures (e.g., using a different method to clear a vessel for maintenance) and the temporary removal of a piece of equipment from process service.

Developing an electronic MOC system is no easy chore, and you will need to determine what is best for your organization if you do not currently use an electronic MOC system.

Over Two Dozen Plants Share Their MOC Practices

Nir Keren, an experienced plant engineer and talented graduate student at the Mary Kay O’Connor Process Safety Center at Texas A&M, took on a benchmarking study to compare MOC practices. He developed a questionnaire and distributed it to more than 50 chemical and petrochemical industries, refineries, and gas plants. There were responses from 26 facilities. The survey asked about 25 probing questions. His comprehensive paper was presented at a Mary Kay O’Connor Process Safety Center Symposium in October 2001 and later published by the American Institute of Chemical Engineers. [9]

Who Responded to the Survey

About 80% of Keren’s data is from responses from the chemical and petrochemical industries, and the rest is from refineries and gas plants. The responses were received from organizations that had over 100 employees, and 80% were from companies with 1,000 employees or less. The remaining 20% of the responding companies had between 1,001 and 2000 employees. [9]

MOC Policy Development

Nir Keren’s survey revealed that plant MOC procedures in the group who responded to the survey were most often developed by the local staff, without assistance from corporate staff or PSM consultants. However, he learned that in some cases the corporate staff provided a framework and the plant used those guidelines to fashion site-specific procedures. Some plants reported using MOC procedures from other plants and tailoring them to their specific requirements. [9]

MOC Document Management

The survey determined that about 40% of industries used a paper system exclusively for their MOC records. Some 40% of the facilities used a combination of electronic and paper
systems for their records, about 10% used electronic methods only, and a few respondents were silent on the issue. [9]

Mr. Keren found that MOC software is not commonly used. Two-thirds of the participants did not use software for creation, approval, or tracking of MOC efforts. Only two participants of the 26 indicated that they chose a commercial software product for implementation of a MOC Program. [9]

Authorization of a Change

The data from the survey showed a wide variance in the authorization requirements. About 27% of the organizations surveyed required a single authorization, and 76% of those who responded accepted four or fewer authorizations. One company required seven authorizations, and another required 10 authorizations. These seemed to be the maximum determined on a case-by-case basis, according to the perceived risk level. Less than half of the organizations reported to employing the MOC procedure for organizational changes. [9]

MOC Program-Awareness Training and Refresher Training

The survey shows a range of approaches to training. Over 50% of the respondents indicated they provided new employee training classes for change approval awareness. Some of the same organizations provided additional MOC program awareness at informal safety meetings. Some respondents reported regular annual training. A few respondents reported no training at all. [9]

This text’s author’s personal chemical plant experiences include training needs checklists for both new salaried and new chemical process operators. These checklists include an entire array of personnel safety, process safety, and Department of Transportation and environmental stewardship focus points. Unfortunately, unauthorized and inept changes can ruin products, equipment, reputations, and more, so MOC refresher training must be conducted more frequently. A yearly refresher course on MOC is a condition of employment. I am familiar with a course that is a locally developed, computer-based training module.

MOC Survey Summary and Conclusions

The Mary Kay O’Connor Process Safety Center survey is the only comprehensive review that I have seen. I have taken the following quotes from the second to last paragraph of this review.

Only half of the respondents in this survey apply MOC procedures to organizational changes. MOC policies and procedures are developed almost entirely by the local plant personnel without external assistance, except in a few cases. . . Lack of training was noted most in audit recommendations and may raise the question of the need to develop guidelines for training for MOC programs [19]

Here is a quote from the final paragraph.

“Unfortunately, only about a third of the participants measure MOC effectiveness. An interesting piece of information was the opinion of the respondents regarding the level of implementation of the MOC at their sites. Of the 50% that responded to this question,
38% indicated that the program needed improvement while the remaining 12% were satisfied with their program.” [19]

Management of Change Approvals, Documentation, and Auditing

Approvals, Endorsements, and Documentation

A responsive modification review and approval system with competent reviewers can gain acceptance quickly. If a modification approval system is unnecessarily cumbersome there can be tension between the sponsor and the reviewer or there can be attempts to circumvent any proposal.

We all must realize that a modification control system, especially for the many little but vital changes, must not be so formal that an answer cannot be expected in a reasonably short time. A multiple layer system must be in place to deal with the entire range of proposals from the very simple change to the very complex.

Auditing the Management of Change Program

Common sense and the OSHA Chemical Process Safety Management Law requires an audit of compliance to the Management of Change. Periodic review and documentation of a site’s activities in managing aspects of personnel and process safety is often a part of an organization’s culture. A good audit can measure the “actual” versus “intended” effectiveness of various programs.

Each organization must devise their own way to conduct an audit. Other readers may wish to consider details of “Audits and Corrective Actions” or Chapter 13 of Plant Guidelines for Technical Management of Chemical Process Safety, [4] which covers broad topics such as “Scope,” “Staffing,” “Frequency,” “Reports,” and “Internal and External Auditors.” It is not the intent of this book to cover that aspect of auditing.

Some Generic Management of Change Audit Questions

These are some common-sense audit questions for the Management of Change. Other questions can be found in Appendix 13A of Plant Guidelines for Technical Management of Chemical Process Safety. [4]

- Is there a formalized documented policy in place for the review and authorization of changes in the hardware and the operating procedures in units that produce, use, handle, or store hazardous materials?
- Do all of the affected individuals including the engineers, supervisors, chemical process operators, maintenance mechanics, purchasing employees, etc., understand that there is a management of change policy?
- Is there a “modifications man” available who can provide expertise; has the time to review changes; and can promptly answer process safety questions?
- Is the system to track and verify process safety recommendations working well and is it up-to-date?
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- Is there a procedure to cope with and authorize “minor” temporary changes such as operating without some critical alarms and a system to assure that these “minor” temporary changes are restored?
- How is the Management of Change policy perceived by operators, supervisors, mechanics, engineers, etc.?
- Have any recent incidents appeared to have been created by a change within the plant, either authorized or unauthorized?

Closing Thoughts on Management of Change Policy

The material in this long chapter may not cover the needs of every chemical plant and every petro-chemical plant, but the ten or fifteen “Management of Change” procedures developed by major corporations and reviewed by me did not seem to exactly fit the needs or culture of my own organization. Trevor Kletz has said many times that improper plant modifications have been a major cause of chemical plant accidents. I have been working in a process safety function for three decades and my experiences have been similar. It just seems appropriate to repeat the first three paragraphs of the second section of this chapter, as a fitting close.

There must be a formal method to deal with change in the chemical industry. The safety designed into the original process often occurs after a multidisciplined design team agonized for the optimum arrangement of process and layout. This process safety must not be jeopardized by poor quality modification schemes.

No recipe or procedure can be devised to be universally acceptable. The exact approach used to scrutinize a proposed change must be site specific and developed for that location. There must be a sustained management commitment to the management of change program since this may require a change in culture within many organizations.

Each chemical plant and refinery must adopt or develop a procedure tailored to fit the specific hazards, the available technical resources, the culture of the organization and required governmental regulations. It must be practical and workable without undue delays.
Appendix A

Some Historical Approaches to Plant Changes

Many of the management of change practices developed by farsighted companies in the 1970s and 1980s are still valuable today. In April 1976, four chemical corporations shared their progressive modification procedures at a Loss Prevention Symposium sponsored by the American Institute of Chemical Engineers. Those technical papers were published in the AIChE's *Loss Prevention*, vol. 10.

In one paper, Peter Heron described the approach that BP Chemicals International, Ltd. London used at that time. He pointed out that all process and plant changes were subjected to a regime of formal scrutiny and authorization. Minor alterations such as: the addition of a valve, a change in materials of construction, or the switch in the type of mechanical seal were made at the discretion of the group manager, or the supervisory level above the unit supervisor. This individual must satisfy himself that adequate consideration was given so that there were not any undesired side effects. [17]

Major changes to existing units in BP Chemical, at the time the article was published, required consideration and formal authorization by personnel at the departmental management level. A procedure that was used at one of the BP Chemicals Plant was included in the article, and it included important items to be considered. Parts of two items on the list of 14 items are quoted here: [17]

*The proposal initiator and plant manager [the British “plant manager” is equivalent to the U.S. second-level supervisor or unit manager], plant engineer, chemical engineer and instrument/electrical engineer, as appropriate, should together discuss any proposed modification. They will prepare a set of notes and a sketch describing the modification and submit these for approval to the relevant staff.*

*The plant manager will assess the effect of the proposals on all plant operations, including normal and routine operations, startup, shutdown and emergency actions. He must also check that hazardous conditions cannot arise due to mal-operation.*

*The plant engineer and/or instrument electrical engineer will assess the effect of the modification on maintaining plant and equipment and will also ensure that the proposal meets:*

- The original plant design standards were appropriate
- The level of good engineering standards demanded on site

Peter Heron's article concludes with a statement that all of these procedures bring together a multidisciplined team that ensures fewer problems in implementing, commissioning, and operating modified units. He further reflects that there is often a dilution of experience in management and these procedures assist in ensuring consideration of a broad spectrum of potential side effects. [17]

Trevor Kletz presented a number of very suitable examples of modifications that went sour in his article at that same symposium in 1976. After presenting several pages of problems with modifications, Kletz stated: [6]

*None of the accidents described here occurred because knowledge was lacking on methods of prevention; they occurred because no one saw the hazards, nor asked the right questions. To prevent similar accidents in the future, a three-pronged approach is necessary.*
There must be a rigid procedure for making sure that all modifications are authorized only by competent persons, who, before doing so, try to identify all possible consequences of the modification then specify the change in detail.

There must be some sort of guide sheet or check list to help people identify the consequences. An instruction and aids are not enough. People will carry out the instructions and use the aids only if they are convinced that they are necessary. A training program is essential.

Kletz's article also presented the 1976 procedures utilized by Imperial Chemicals Industries, Ltd. (ICI) Wilton, England. It stated that within the Petrochemicals Division of ICI, any modification, even if it is very inexpensive, or temporary, must be authorized in writing by a competent manager (or, in the United States, a second line supervisor) and an engineer. [6]

The ICI Procedures required the use of a “Safety Assessment” guide sheet, which discussed overpressure protection equipment, electrical area classification, changes in alarms and trips, and other categories that might diminish the safety of the system. The guide sheet also had questions on the relevant Codes of Practice and Specifications, questions on the materials of construction and fabrication standards, and any necessary changes in operating conditions. This ICI “Safety Assessment” Guide sheet widely published first in 1976, seems to have withstood the test of time. It was published again in 1992, in a “how to” section of a current book of practical guidelines.

It would be unreasonable to think that either of these companies are operating even remotely similarly to how they did in the 1970s. Many chemical companies restructured and reduced the size of their technical staffs in the mid-1980s, and many other organizations added chemical process safety professionals. However, these approaches still seem very useful and workable.

How Are Chemical Plants Addressing Plant Modifications during the 1980s and Beyond?

In 1985, the Canadian Chemical Producers Association (CCPA) released a pamphlet entitled, *Essential Components of Safety Assessment Systems*. This pamphlet was developed to aid Canadian chemical producers determine the adequacy of their process safety programs. Modifications to a plant or process was one of the nine internal programs examined by the CCPA. The guiding principles required a management program to formally examine and approve any significant changes in chemical components, process facilities or process conditions whether temporary or permanent, prior to implementation. The procedure, as recommended by the Canadian Chemical Producers Association, addressed 12 elements. It was intended that each element would be reviewed by qualified individuals to assess if the proposed change could jeopardize the integrity of the system. The following considerations are based upon the CCPA’s publication and could be used as a simple evaluation form. [18]
KEY CONSIDERATIONS WHEN REVIEWING MODIFICATIONS

(Adapted from the Canadian Chemical Producers Association.)

1. Does the change involve any different chemicals which could react with other chemicals, including diluents, solvents, and additives already in the process?
2. Does the new proposal encourage the production of undesirable by-products either through the primary reactions, through side reactions or introduction of impurities with the new chemical component?
3. Does the rate of heat generation and/or the reaction pressure increase as a result of the new scheme?
4. Does the proposed change encourage or require the operation of equipment outside of the approved operating or design limits of chemical processing equipment?
5. Does the proposal consider the compatibility of the new chemical component and its impurities with materials of construction?
6. Has the occupational health and environmental impact of the change been considered?
7. Has the design for modifying the process facilities or conditions been reviewed by a qualified individual using effective techniques for analyzing process hazards, particularly when the modifications are being made in rush situations or emergency conditions?
8. Has there been an on-site inspection by qualified personnel to ensure that the new equipment is installed in accordance with specifications and drawings?
9. Have the operating instructions and engineering drawings been revised to take into account the modifications?
10. Have proper communications been made for the training of chemical process operator, maintenance craftsman, and supervisors who may be affected by the modification?
11. Have proper revisions been made to the process control logic, instrumentation set points, and alarm points, especially for computer control systems, to properly respond to the modification?
12. Have provisions been made to remove or completely isolate obsolete facilities in order to eliminate the chances for operator errors involving abandoned equipment?
This excellent, 44-page Canadian booklet lists 58 references covering, but not limited to: Emergency Planning, Process Hazards Reviews, Fault Tree Analysis, Evaluation of Toxic Vapor Cloud Hazards.

The Center for Chemical Process Safety

The American Institute of Chemical Engineers (AIChE) has been involved in Chemical Process Safety and Loss Prevention for chemical and petrochemical plants for decades. In early 1985, the AIChE established the Center for Chemical Process Safety (CCPS) to intensify development and dissemination of the latest scientific and engineering practices for prevention and mitigation of catastrophic incidents involving hazardous chemicals. The CCPS serves as a focus for developing literature and courses to continue to improve chemical process safety.

New Recommendations and New Regulations

In December 1988, the Organization Resources Counselors, Inc., in order to assist the U.S. Occupational Safety and Health Administration (OSHA), prepared a report entitled “Recommendations for Process Hazards Management of Substances with Catastrophic Potential.” This document was drafted to help OSHA revise standards for handling hazardous materials.

Organization Resources Counselors, Inc. (ORC) is a Washington, D.C.–based private industry group with many representatives from the chemical industry. The ORC agreed to help because they were concerned about another world-wide disaster that may cause the United States Congress to quickly develop legislation which may be ineffective. The ORC was also concerned about the proliferation of similar regulations at the state level and they felt a performance standard was essential if the law was to be effective.

The Organization Resources Counselors, Inc. indicated their report was capable of being a useful starting point in the development of a policy or program for dealing with chemical process hazards. The report specifically indicated that it was intended as a guideline or starting point only, and it should be extensively reviewed and analyzed before being implemented.

The American Petroleum Institute developed Management of Process Hazards—API Recommended Practice 750 and released it in January 1990. This sensible 16-page document is based in part on the ORC report.

The Chlorine Institute developed and released Pamphlet 86, Recommendations to Chlor-Alkali Manufacturing Facilities for the Prevention of Chlorine Releases, in October 1990. This 15-page pamphlet acknowledges the ORC report “Recommendations for Process Hazards Management of Substances with Catastrophic Potential” was one of the primary documents used to develop it.

In 1991, the American Institute of Chemical Engineers Center for Process Safety released a book entitled, Plant Guidelines for Technical Management of Chemical Process Safety, 1989, there was a chapter dedicated to management of change. Six different approaches to management of change were offered as examples of workable systems.

The Organization Resources Counselors’ (ORC) document emphasized the application of management control systems to facilities processing highly hazardous chemicals. The
How Should Potential Hazards Be Identified and Evaluated?

Frank Lees begins chapter 8 of *Loss Prevention in the Process Industries*, “Hazard Identification and Safety Audit,” [17] with the following paragraphs:

*The identification of areas of vulnerability and of specific hazards is of fundamental importance in loss prevention. Once these have identified, the battle is more than half won.*

*Such identification is not a simple matter, however. In many ways it has become more difficult as the depth of technology has increased. Loss prevention tends increasingly to depend on the management system and it is not always easy to discover the weaknesses in this. The physical hazards also no longer lie on the surface, accessible to simple visual inspection.*

*On the other hand, there is now available a whole battery of safety audit and hazard identification methods to solve these problems.*

No single identification procedure can be considered the “best” for all companies or all situations. Large refineries and large single train industrial chemical producers with limited products and large technical staffs will by nature approach their reviews differently than specialty batch operations for making limited campaigns of products which are herbicides, insecticides, and other specialty chemicals.

Some considerations for choosing the type of evaluation would include:

- Potential “Worst Case” Consequences
- Complexity of the Process or Facility
- Experience Level of the Available Review Members
- Time and Cost Requirements
- Corporate Standards, State, and Local Requirements

Any and all reviews should take an orderly, systematic approach. Also it may be sufficient for a general qualitative review, except for some sophisticated portions of the proposed modification. The review team should be responsible for determining deficiencies, but not defining solutions. Lees [17] notes many selected references to help evaluate processes.

The AIChE’s *Guidelines for Hazard Evaluation Procedures, Second Edition* (1992) [5] offers a wide variety of alternates to review systems for hazards. These review procedures can be used to evaluate some plant modifications. No single identification procedure can be considered the “best” for all companies or all situations. Two basic categories of evaluations are (1) adherence to good engineering practice and (2) predictive hazard evaluation.

Adherence to Good Engineering Practice

Adherence to good engineering practice means that the modification is reviewed and compared to corporate or plant standards, state and local codes, insurance regulations, and societal codes. Many companies have developed excellent checklists or standards based upon years of experience with the manufacture, use, and handling of various chemicals.
Checklists, “What If” Methods, and Multiple Discipline Reviews are often an excellent method to review a modification. These methods can ensure that design specifications are adhered to, that previously recognized hazards are identified, and that P&IDs, and operating procedures are updated. “What If” type studies have been used to some degree for years. This type of questioning activity was often the method a junior process engineer would experience when presenting a proposal to a review team in previous years. Not much has been written on this type of group brainstorming activity. However, the “Guidelines” [5] offer examples of a systematic approach. The method is suitable for an experienced staff reviewing a modification.

Checklists can be user friendly if properly prepared by experienced engineers. Such checklists can be very useful tools to assist less experienced engineers in considering situations that Fault Trees Analysis may find if given enough time or that “What Ifs” may overlook.

A one-page memory-jogging safety assessment checklist was made available by Trevor Kletz in 1976. [6] The checklist is still valid today. After a review of several “Management of Change” policies from several major companies, it appears that Kletz’s checklist or a similar checklist was used as a basis for a few companies’ procedures.

Frank Lees [17] has cataloged and presented a number of checklists in “Hazard Identification and Safety Audit.” Lees states: One of the most useful tools of hazard identification is the checklist. Like a standard or code of practice, a checklist is a means of passing on hard-won experience. It is impossible to envisage high standards in hazard control unless this experience is effectively utilized. The checklist is one of the main tools available to assist in this.

Checklists are only effective if they are used. There is often a tendency for them to be left to gather dust on the shelves. This is perhaps part of the reason for the development of other techniques such as hazard and operability studies.

The Guidelines for Hazard Evaluation Procedures, Second Edition [5] also offers 45 pages of sample questions in its Appendix B. These questions cover process, (i.e., flowsheets and layout), equipment (reactors, heat exchangers, piping, and instrumentation), Operations, Maintenance, Personnel Safety, and other broad areas.

Other practical engineering information which can help evaluate modifications may be obtained from individual organizations, such as the American Institute of Chemical Engineers, the American Petroleum Institute, the Institution of Chemical Engineers (England), the National Fire Protection Association, etc. Chapter 13 lists a number of such resources and the mailing addresses to obtain helpful information.

Predictive Hazard Evaluation Procedures

Predictive hazard evaluation procedures may be required when new and different processes, designs, equipment, or procedures are being contemplated. The Dow Fire and Explosion Index provides a direct method to estimate the risks in a chemical process based upon flammability and reactivity characteristics of the chemicals, general process hazards (as exothermic reactions, indoor storage of flammable liquids, etc.) and special hazards (as operation above the flash point, operation above the auto-ignition point, quantity of flammable liquid, etc.). Proper description of this index is best found in the 57-page Dow’s Fire and Explosion Index, Hazard Classification Guide, 5th ed., AIChE, New York, 1981.
The HAZOP Study is a very popular predictive method which was developed in the Mond Division of Imperial Chemical Industries during the 1960s. A HAZOP (Hazard and Operability) study is an analysis method for identifying hazards and problems which prevent efficient operation. Trevor Kletz was an early promoter of the HAZOP Method and in one of his recent books [18], he states:

A Hazard and Operability study (HAZOP) is the preferred method, in the process industries, of identifying hazards on new or existing plants.

... We need to identify hazards before accidents occur. Check lists have the disadvantage that new hazards, not on the list, may be overlooked so we prefer the more open-ended HAZOP technique. It allows a team of people, familiar with the design, to let their minds go free and think of all the deviations that might occur but it is done in a systematic way in order to reduce the chance of missing something.

Note that HAZOP identifies operating problems as well as hazards.

Although HAZOP has been used mainly in the oil and chemical industries it can be applied to many other operations.

The technique is applied to a line diagram, line-by-line. Using the guide word “NONE” we ask if there could be no flow, or reverse flow, in the first line. If so, we ask if this would be hazardous or would prevent efficient operation. If it would, we ask what change in design or method of operation will prevent no flow, or reverse flow (or protect against the consequences). Using the guides, “MORE OF” and “LESS OF” we ask if there could be more (or less) flow, pressure or temperature in the line and if this would be hazardous, etc. Using the guide words “PART OF” and “MORE THAN” we ask about the effects of changes in concentration or the presence of additional substances or phases. The guide word “OTHER” reminds us to apply our questioning to all states of operation, including startup, shutdown, catalyst regeneration and so on and we also ask if the equipment can be safely prepared for maintenance. We then study the next line in the same way. All lines should be studied including service lines and drains.

A HAZOP Study Team is best when it is a multi-disciplinary group formed to bring a broader base of experience to the review. A HAZOP may not be suitable for the small modification of a few extra valves or a new run of pipe, but it is desirable for the medium-sized and larger modifications.

Robert Johnson presented a technical paper in April 1992 entitled “HAZOPS Today” [19] in which he stated, “The hazard and operability studies (HAZOPS) method has likely become, over a period of less than ten years, the most widely-used hazard evaluation procedure in the process industries.” Johnson also explained that HAZOPS is a relative latecomer to the United States and it has attained a high degree of prominence in the U.S. process industries. The method began in the United Kingdom and has now spread throughout western Europe and North America. (See Figure 11–1.)

Another widely-used predictive method is the use of Fault Tree Analysis. This is a “reverse-thinking” method. The analyst assumes an accident or specific undesirable event—the so-called “TOP Event.” This could be the release of a toxic gas from a reactor safety relief valve.

The analyst must then define the various equipment failures and human failures that could lead up to that event. For the release of toxic gas from a reactor safety relief valve, the analyst may consider loss of cooling and the operator ignoring the high pressure alarm. Another path to this leak of toxics may be a double charge of one of the energetic reactants.
Failure rates for both equipment and people's responses are assigned and the frequency and severity of a TOP Event can be calculated. Should the risk be found to be unacceptable, additional process safety hardware or additional procedures can be recommended. Then, calculations can be made to determine the benefits of the additional hardware or procedures. The Fault Tree Analysis method of evaluation is very sophisticated and a detailed explanation is beyond the scope of this book.

References
6. Kletz, Trevor A., “A Three-Pronged Approach to Plant Modifications,” *Loss Prevention* 10, 1976: pp. 91–98. This material is also available as "Hazards of Plant Modifications—Hazard
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Workshop Module 002" (available as a training kit with slides, booklets, guides, etc., by the Institution of Chemical Engineers, Rugby, England).


