MOC BEST PRACTICES

Gateway Consulting Group, Inc.
the source for Management of Change expertise and Electronic Document Management solutions

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My Perspective

In this issue we take a look at the use of checklists for scoping MOCs. Why are checklists good, and what kinds of checklists are best?

In my usual style, it's not enough to have an opinion about a topic; I'm always looking for proof that a recommendation is indeed the correct one. In this case, we're using a relatively simple probability analysis to demonstrate why asset-based scoping is the preferred approach.

Best Practices for Using Checklists to Scope MOCs

1 INTRODUCTION

As you know, Management of Change, "MOC", is one of the most complex business processes at chemical plants, refineries and other facilities. In the U.S., MOC is required by a number of agencies including PHMSA, the EPA, and most commonly, OSHA. Various authors [1-4] have contributed to the knowledge of how to address the safety aspects of MOC.

It is a given that MOC must address safety/regulatory concerns. But, some attention should be focused on the efficiency aspects of the MOC business process. To this end, Hoff has adopted a lifecycle approach for characterizing MOC [5, 6].

In a lifecycle model, the business process is divided into a number of states. During each state, certain actions take place. The states during which actions can occur depend on the lifecycle. For a permanent, non emergency MOC, the states are shown in Figure 1.

Figure 1. Lifecycle states for permanent, non-emergency MOC.

When all the action items, belonging to a given state, are completed, then the MOC is "promoted" to the next state (this mechanism is also sometimes referred to as the Stage-Gate™ process [7]). In theory, the process flow can also move backwards, "demotion", or skip forward several states, although these are not shown in Figure 1.

An MOC begins at the Initiation state. The MOC initiator typically completes a form with descriptive attributes, including the name of the MOC, where the change is taking place (area, unit, etc.), expected duration, the technical basis of change, etc.

1.1 Scoping

During the Scoping state, the work of the MOC is "scoped out". At the end of Scoping, the MOC should contain a list of action items, analogous to that shown in Table 1. Some action items, shown in italics with an asterisk (*) suffix, are inherent in the MOC process, so those action items are always part of an MOC. All the other actions are generated by the scoping activity.

The ultimate quality of the MOC is directly related to the quality of scoping:

1. Are all the action items completely described?
2. Are all the action items present?

The first question was addressed in a prior newsletter. The second question is the topic of this newsletter.

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1.2 Checklists

In order to minimize risks, a fully-scoped MOC must have a correct and complete list of action items: anything less increases risk. Gorovitz and MacIntyre [8] identified two causes of human failure:

1. Ignorance: the knowledge to perform a task does not yet exist
2. Ineptitude: the knowledge to perform a task exists, but it is not applied correctly.

Action Item	Type of Action	Execution State	Role
Redline P&ID	Perform	Change Design	Owner
Redline Instrument Loop diagram	Perform	Change Design	Owner
*Conduct PHA**	*Perform*	*Impact Analysis*	*Process Engineer*
Conduct Environmental Analysis	Perform	Impact Analysis	Environmental Rep.
Review MOC	Review	Approvals	Process Engineer
*Approve MOC**	*Sign-off*	*Approvals*	*Area Manager*
Procure instrument	Perform	Implementation	Purchasing Rep.
Install in facility (usually triggered by a work order)	Perform	Implementation	Maintenance
Obtain instrument spec. sheet	Perform	Implementation	Owner
*Conduct PSSR**	*Perform*	*PSSR*	*PSM Coordinator*
Update instrument database	Perform	Close-out	Owner
Update fugitive emission database	Perform	Close-out	Environmental rep.
Update P&ID (incorporate redlines, as-builts)	Perform	Close-out	Drafting rep.
Update instrument loop diagram	Perform	Close-out	Drafting rep.
*Gather metrics**	*Perform*	*Close-out*	*MOC Coordinator*
*Close-out the change**	*Sign-off*	*Close-out*	*MOC Coordinator*

Table 1. List of action items for a hypothetical MOC.

Their interpretation of “ignorance” is strict, inasmuch as the knowledge doesn’t exist anywhere in the world. Normally, in plant MOC applications, the expectation is that the knowledge exists to properly and safely conduct a change, and that the MOC process should guide the user to avoid failures caused by ineptitude. MOC processes often use checklists for scoping purposes:

A checklist is a type of informational job aid used to reduce failure by compensating for potential limits of human memory and attention. It helps to ensure consistency and completeness in carrying out a task. [9].

2 ENSURING THAT ALL ACTION ITEMS ARE PRESENT

MOC scoping can be accomplished in several different ways, which can be labeled:

1. Explicit scoping: starting from essentially a blank sheet
2. Guided scoping: a traditional checklist
3. Asset-based scoping: a checklist with an intelligent ruleset

These different approaches are described in the following sections.

2.1 Explicit Scoping

In "explicit" scoping, the initiator is provided no information about how to proceed with scoping the MOC. The MOC form simply requests the inclusion of "all action items", as shown in Table 2.

No.	Description
	(Please provide a list of all action items for this MOC)
1	
2	
3	

Table 2. Explicit scoping example.

In order to consider the MOC properly scoped, the initiator[1] must produce exactly the list of items (without asterisks) shown in Table 1. The biggest risk in this scenario is that action items are overlooked.

It's possible to make a rough estimate of the probability that the MOC will be properly scoped using the explicit approach. But, in order to develop a realistic estimate, it is necessary to characterize how the (potentially overlooked) action items relate to the MOC, and whether there are any mitigating circumstances.

As indicated in Table 3, the relationship between the action items and the MOCs is characterized as follows:

Inherent Action Items: These "inhere" or are part of the process. The MOC process triggers a PHA, a PSSR, an area manager approval, and so on. So the probability of omitting these action items is 0%.

Critical Path Action Items: These action items are always performed, because the change cannot proceed without them. For instance, if the change is to install an instrument, the change doesn't happen unless the instrument is installed. Installation can't proceed unless the instrument is procured (either ordered or retrieved from the warehouse). However, even though these action items must eventually be performed, it is possible for them to be overlooked during the initial attempt at completing the MOC. This does not result in a compliance problem (since the oversight is eventually discovered); this results in an economic problem inasmuch as schedules are disrupted when parts are not available (due to them never having been ordered). The probability of missing a critical path action item is c%.

Supportive Action Items: These action items support the implementation of the change. For instance putting instruments on a P&ID and an instrument loop diagram make the procurement and installation of the instrument easier. However, it is physically possible to install an instrument without it ever appearing on a drawing (although that immediately creates a Process Safety Information management violation). If a Supportive Action Item is omitted, early in the MOC process, it is normally discovered during the PHA. The PHA team would send the MOC back to the responsible person with the direction to redline a P&ID and a loop sheet (in this example). So, it is unlikely that the P&ID redlining will be totally omitted—the more common case is where the redlines are overlooked and then must be redone in response to a request from the PHA team. Again, the MOC suffers an economic/schedule penalty, not a compliance penalty.

[1] For the purposes of this discussion, it is assumed that the MOC initiator conducts the scoping activity, although scoping can be performed by any competent resource. Use of the term "user" is avoided, since that term tends to be used more in computerized MOC applications. Although the author is very supportive of electronic MOC applications, the discussion in this paper is independent of implementation technology.

2.1 Explicit Scoping ...continued

Informational Action Items: These are action items that record information about what takes place during the MOC. This typically includes:

- obtaining data for the equipment files
- updating drawings (incorporating redlines and as-builts)
- updating document (e.g. procedures) and putting them into their final form
- updating databases

Information Action Items are the easiest to overlook, since there's usually nothing—beyond experience and discipline—to remind a person that they are needed. Informational action items are omitted with a frequency of i%.

Action Item	Relationship to MOC	Prob. of Overlooking This Action	Prob. of Initially Overlooking This Action
Redline P&ID	Supportive		s
Redline Instrument Loop diagram	Supportive		s
Conduct PHA	Inherent		
Conduct Environmental Analysis	Informational	i	
Review MOC	Supportive	s	
Approve MOC	Inherent		
Procure instrument	Critical path		c
Install in facility (usually triggered by a work order)	Critical path		c
Obtain instrument spec. sheet	Informational	i	
Conduct PSSR	Inherent		
Update instrument database	Informational	i	
Update fugitive emission database	Informational	i	
Update P&ID (incorporate redlines, as-builts)	Informational	i	
Update instrument loop diagram	Informational	i	
Gather metrics	Inherent		
Close-out the change	Inherent		

Table 3. Probability of omitting action items, when using explicit scoping.

The probability that an MOC will be properly scoped, i.e. the probability of zero unmitigated scoping errors, can be expressed as follows:

$$P_E = (1 - s)^{n_s}(1 - i)^{n_i} \qquad \text{Eq. 1}$$

where,

P_E	=	probability that no action item is overlooked from an MOC, with explicit scoping
s	=	probability of overlooking an individual supportive action item
n_s	=	number of supportive action items
i	=	probability of overlooking an individual informational action item
n_i	=	number of informational action items

Values of n_S and n_i are determined by the case at hand, such as represented by Table 3, but estimating the other parameters is much more difficult, since these are essentially estimates of human error rates.

2.1 Explicit Scoping ...continued

Various studies have measured human error rates in industrial circumstances[10]. A common case is to measure the error rate of a person who is following a procedure with many steps. Error rates of 0.001 to 0.1 per task appear in the literature, with a value of 0.01/task commonly used by the LOPA community[11]. The comprehensive research of Swain and Guttmann resulted in 0.003/occurrence [10].

Note that procedures guide the person in his/her thinking and actions. When attempting to create a task list, as is required in explicit MOC scoping, this guidance doesn't exist, so one would reasonably expect that error rates are higher. Even if the person is creating a new MOC by using the action item list from a prior MOC, the error rate cannot reasonably drop below the guided task range (0.003 – 0.01).

For the purposes of this analysis, the following values are chosen:

s	=	0.03/occurrence when the person is not guided by the process, as in explicit scoping
i	=	0.1/occurrence when the person is not guided by the process

2.2 Guided Scoping

In "guided" scoping, the initiator is provided with a list of many possible action items and must choose which ones are relevant to the change. Often the checklists group similar items to aid the initiator.

	Check all documents to update as part of this change
☐	Electrical one-line diagram
☐	Instrument loop diagram
☐	P&ID
☐	PFD
☐	Other, please specify _____
	Select all reviewers for this change
☐	Area Maintenance
☐	Environmental
☐	I&E
☐	Process Safety
☐	Other, please specify _____
	Select all approvers for this change
☒	Area Manager
☐	ES&H Manager
☐	Maintenance Manager
☐	Operations Superintenent
☐	Other, please specify _____

Table 4. Guided scoping example.

2.2 Guided Scoping...continued

The analysis of guided scoping is similar to the analysis of explicit scoping, except that the beneficial effects of the list, Table 4, need to be accounted for. The beneficial effects of the list only accrue if the item is actually on the list. This can be expressed mathematically as:

s	=	probability that an action item is omitted
α	=	list benefit factor. If $\alpha = 0$, then having the item on the list provides no benefit. If $\alpha = 1$, then having the item is on the list provides the maximum benefit.
β	=	probability that the action item is on the checklist

By adapting equation 1, the probability that zero action items are overlooked from an MOC, with guided scoping is:

$$P_G = (1 - [1 - \alpha\beta]s)^{n_s}(1 - [1 - \alpha\beta]i)^{n_i} \qquad \text{Eq. 2}$$

Potential values for the parameters are:

α	=	0.7
β	=	0.95

2.3 Asset-Based Scoping

An MOC initiator who is scoping an MOC using the explicit or guided approaches must think about the physics of the change (i.e. the change to be made to the facility), but the expression of those thoughts is entirely in terms of documents, reviewers and approvers. The initiator must be able to reliably translate the change requirements into a set of action items, without much help from the MOC process.

Asset-based scoping overcomes those shortcomings by expressing the checklist items in terms of plant assets. Taking some examples from Matthew's work[12], and adapting them to the present discussion yields a checklist as indicated in Table 5. Note that the checklist is phrased entirely in terms of plant assets—which even the most inexperienced person understands—and not in terms of the resulting action items. Once the checklist, Table 5, is completed, each "yes" answer triggers the creation of one or more action items. The relationships between checked boxes and action items are contained in a "rule set", such as the example in Table 6. Presenting the checklist items, and the resulting action items, as demonstrated in Table 6, can make the MOC form very long. While some companies have implemented asset-based scoping using a paper-based system, it is more common to do this in an electronic MOC system.

	Instrumentation Changes
	Does this change involve…
☐	Adding safety critical instrumentation?
☐	Adding, removing or changing safety critical equipment?
☐	Electrically powered instruments in electrically classified areas?
☐	Changes to or the addition of a control valve?
☐	…
	Relief System Changes
	Does this change involve…
☐	Addition of a relief valve?
☐	Piping on the relief valve inlet or outlet?
☐	Changing hydrocarbon relief valve vent routing (atmosphere/flare/process)?
☐	Changing hydrocarbon relief valve relief rate to atmosphere?
☐	…

Table 5. Asset-based scoping example

2.3 Asset-Based Scoping...continued

In order to make guided scoping more manageable, the checklist items were organized into a number of categories (documents to update, reviewers, approvers). Similarly, asset-based scoping checklists also benefit from organization into categories. However the categories used for asset-based scoping are, as expected, asset-based[12]:

- Piping and valves
- Rotating equipment
- Pressure vessels
- Heat exchangers
- Reactors
- Relief valves
- Instrumentation and control valves
- Structures
- Distributed control systems
- Etc.

	Instrumentation Changes *Does this change involve…*
☐	Adding safety critical instrumentation? If yes, then… • Redline P&ID • Redline Instrument Loop diagram • Conduct Environmental Analysis • Review MOC • Procure instrument • Install in facility • Obtain instrument spec. sheet • Update instrument database • Update fugitive emission database • Update P&ID (incorporate redlines, as-builts) • Update instrument loop diagram
☐	Adding, removing or changing safety critical equipment? If yes, then… • Redline P&ID • Redline Instrument Loop diagram • …
☐	…

Table 6. Asset-based scoping. Example ruleset.

The checklists, Table 5, for asset-based scoping contain scenarios, "adding safety critical instrumentation", rather than action items "redline P&ID". If an initiator scopes an MOC, and the scenario is contained in the ruleset, then the probability of overlooking an action item approaches zero. For those MOCs where the scenario is not contained in the checklists, the initiator is forced to resort to explicit scoping (or guided scoping if that is supported by the MOC procedure).

$$P_A = \gamma + (1-\gamma)(1-s)^{n_s}(1-i)^{n_i} \qquad \text{Eq. 3}$$

where,

γ = probability that the asset-based scenario is contained in the checklist

2.4 Worked Examples

The parameters, identified in this paper, are summarized in Table 7. This permits the calculation of the probability that the MOC is properly scoped, as shown in Table 8.

Parameter	Definition	Typical Value	Value in this Example
s	probability of overlooking a supportive action item, without any guidance from the MOC process	0.03	
n_s	number of supportive action items, unmitigated		1
i	Probability of overlooking an informational action item	0.10	
n_i	number of informational action items		6
α	list benefit factor. If $\alpha = 1$, and the item is on the list, then it cannot be omitted. If $\alpha = 0$, then having the item on the list provides no benefit	0.7	
β	probability that the action item is on the checklist	0.95	
γ	probability that the asset-based scenario is contained in the checklist	0.95	

Table 7. Parameters used in determining accurate scoping probabilities.

Scoping Approach	Variable	Prob. that MOC is Properly Scoped
Explicit	P_E	51.50%
Guided	P_G	80.70%
Asset-based	P_A	97.60%

Table 8. Probability that an MOC is properly scoped.

The results are quite sensitive to the assumptions made for the value of *s*. Indeed Figure 2 shows how the probability of properly scoping an MOC falls dramatically with increasing values of *s*, for both the explicit approach and the guided approach[2]. Asset-based scoping appears much better, and is relatively insensitive to the value for *s*.

2.5 Cases Where Assets are not the Governing Concept

The preceding analysis, particularly Table 5 and Table 6, frame the scoping problem in terms of plant or facility assets. However, there are cases where the assets are not being changed:

- Product changes
- Organizational changes
- Changes in a laboratory
- Etc.

In all of these cases, a concept equivalent to assets can be used to scope the changes. Again, one should avoid expressing all scoping questions in terms of documents and approvers, Table 4; rather, the scoping questions should be expressed in terms of the business need. The following examples correspond to the previous bullet list:

- Is the product composition changing?
- Will this person require a security clearance?
- Will the new protocol involve spectroscopy?

[2] The value of i is constrained so that i =10s/3.

2.5 Cases Where Assets are not the Governing Concept...continued

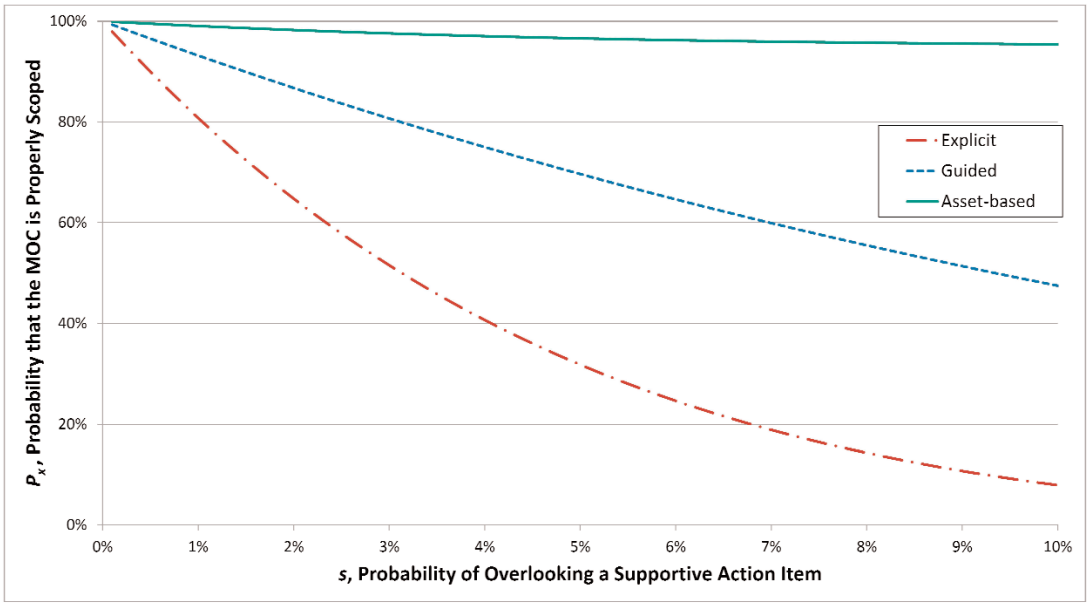

Figure 2. Sensitivity of propoer MOC scoping to human error metrics.

3 SUMMARY AND CONCLUSIONS

In order for an MOC to be properly executed, it must be expressed as a complete and correct set of action items. A major problem is that certain kinds of actions are easy to overlook, depending on how the action items relate to the overall MOC:

- "Inherent" action items are part of the MOC process, and rarely overlooked,
- "Critical path" action items may be forgotten but are always discovered while an MOC is in-process,
- "Supportive" action items may be overlooked at some rate, termed *s*%,
- "Informational" action items are the easiest to overlook, at some rate, termed *i*%.

In order to reduce the incidence of overlooking action items, the 3 common methods for scoping MOCs were identified:

- Explicit scoping: the initiator begins with a blank sheet and attempts to create a list of action items for the MOC.
- Guided scoping: a traditional checklist is used where the initiator considers a list of potential action items, and chooses the ones s/he thinks are applicable. The potential list of action items is usually phrased in terms of documents to be updated and the names/roles of reviewers and approvers. The problem is that the initiator may be inexperienced and not know which documents need to be updated for a particular change, and who should be involved.
- Asset-based scoping: checklists may be used, but they are phrased in terms of the (physics or) assets involved in the process. While more challenging to construct, asset-based scoping provides more guidance and is superior for inexperienced and experienced MOC initiators alike.

An error model was developed and used to determine conclusively that asset-based scoping is far superior to the other scoping approaches.

References

[1] American Institute of Chemical Engineers. Center for Chemical Process Safety., 2008, Guidelines for the Management of Change for Process Safety, Wiley-Interscience, Hoboken, N.J.
[2] Keren, N., West, H. H., and Mannan, M. S., 2002, "Benchmarking MOC Practices in the Process Industries," Process Safety Progress, 21(2), pp. 103-112.
[3] Chosneck, J., 2010, "Managing management of change," AIChE National Spring Meeting, AIChE, San Antonio, TX, p. 12pp.
[4] Sanders, R., E., 1996, "Human Factors: Case Histories of Improperly Managed Changes in Chemical Plants," Process Safety Progress, 15(3), pp. 150-153.
[5] Hoff, R., 2007, "Lifecycles," MOC Best Practices, 1(2).
[6] Hoff, R., 2011, "Quantitative Models for Assessing MOC Performance," AIChE National Spring Meeting, 7th Global Congress on Process Safety, AIChE, Chicago, p. 15pp.
[7] Cooper, R. G., 2001, Winning at New Products, 3rd Ed., Basic Books.
[8] Gorovitz, S., and MacIntyre, A., 1976, "In the 1970s," Journal of Medicine and Philosophy, 1, p. 20pp.
[9] Wikipedia, Unknown, "Checklist," http://en.wikipedia.org/wiki/Checklist.
[10] Swain, A. D., and Guttmann, H. E., 1983, "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications - Final Report," Report No. NUREG/CR-1278, U.S. Nuclear Regulatory Commission, Washington.
[11] American Institute of Chemical Engineers. Center for Chemical Process Safety., 2001, Layer of protection analysis : simplified process risk assessment, Center for Chemical Process Safety of the American Institute of Chemical Engineers, New York.
[12] Matthews, W. R., 2011, "Asset-Based MOC Approval," AIChE National Spring Meeting, 7th Global Congress on Process Safety, AIChE, Chicago, p. 10pp.