Tips for the Creation and Application of Effective Operating Procedures

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Abstract

Specific requirements exist in all Safety Management Systems Guidelines/Requirements (e.g., Process Safety Management, Risk Management Program, Safety and Environmental Management Systems) for the creation, content, quality review, and periodic update/certification of Operating Procedures. However, the creation and actual implementation of Operating Procedures is fraught with challenges that often result in safety deficiencies, regulatory citations, and in some cases, unfortunate tragedies.

Although Operating Procedures concepts involve the straightforward documentation of specific steps and precautions to take for safe and effective operation, many process facilities struggle with:

- securing the focus and specific content from operations personnel for the creation of quality procedures
- securing feedback from operations personnel if procedural steps do not coincide with actual practices
- ensuring the steps outlined in procedures avoid introducing additional process hazards
- creating procedures that are in a user-friendly format and written to facilitate training and understanding
- identifying the most effective level of information and depth to include in the procedure
- determining sensible levels of detail for consequences of deviation and the appropriate corrective actions
- implementing meaningful competency testing
- assigning the correct "skill set" to the development and update of Operating Procedures
- addressing all modes of operations, including defining appropriate responsibilities

Beyond the requirements, good-quality Operating Procedures are critical for encapsulating operational best practices for all of the different operating modes that the process may have to address and also provide a basis for ensuring consistent quality assurance. The objective of this paper is to convey an understanding of the challenges

that must be considered with the development of Operating Procedures and provide tips and specific examples that will facilitate the creation and ongoing application of this important element of Safety Management Systems.

1. Introduction - Operating Procedures Defined

1.1 What are Operating Procedures?

As one element of Process Safety Management (PSM), Operating Procedures are a part of a management program designed to manage safety for facilities with hazardous materials or processes. In addition to risk reduction, Operating Procedures also provide a documented way to consistently perform a specific task while minimizing deviations. Generally, Operating Procedures, sometimes referred to as "Standard Operating Procedures" (SOPs) or "General Operating Procedures" (GOPs), are a collection of instructions on how to safely and consistently operate a process. Different facilities may have different interpretations of what constitutes an operating procedure and how it may differ from other forms of procedures or manuals. The following definition, taken from the Center for Chemical Process Safety's (CCPS) "Guidelines for Writing Effective Operating and Maintenance Procedures" [1], provides the concept that will be focused on in this paper.

> Operating Procedures: Written step-by-step instructions and associated information (cautions, notes, warnings, etc.) for safely performing a task within operating limits.

There are several key concepts in this definition that will be further highlighted and expanded upon in this paper, but it is important to note that Operating Procedures aim to address both the safety concerns of a process and keeping it within its operating limits or design intent. This intent is often captured in an operating manual. Though this term is sometimes used interchangeably with Operating Procedures, for the purposes of this paper the operating manual may contain a set of individual operating procedures as well as a collection of operating and process safety information which includes the operating intent [2].

A final distinction should be made between operating and maintenance procedures. While Operating Procedures focus on the performance of a process, maintenance procedures provide the instructions to perform general maintenance to ensure equipment operability, and typically fall under the Mechanical Integrity element of Process Safety Management.

1.2 Why are Operating Procedures Important?

Written operating procedures are an integral part of an effective Safety Management System (SMS) program that provide a number of benefits to the facility, its operators, and the general public. The key driving factor in the requirement for Operating Procedures is to avoid or minimize the occurrence of potentially disastrous incidents. As part of this,

Operating Procedures are required for both infrequent, high-risk tasks and more frequent, low-risk tasks that maintain the facility within its operating intent. As past incidents and near misses have shown, failures of Operating Procedures, often in conjunction with failures of other PSM elements, have led to hazardous events that have resulted in injuries and loss of life.

While reducing the risk of process safety incidents through minimizing human error is the main goal of Operating Procedures, a good program also provides operational benefits. These benefits include ensuring consistency of operations, which is important for facilities that have multiple operators operating the same system. Different personnel may operate the same system using different methods and with different limits in mind. A comprehensive set of Operating Procedures should capture those deviations obtained through general operating experience and should document the most effective method. Through an iterative process, Operating Procedures create a documented way to safely and efficiently operate the process.

2. Regulatory Requirements (RMP/PSM)

In order to establish a basis for the development of the Operating Procedures, this section will provide an overview of the Risk Management Plan (RMP) and PSM regulatory requirements for Operating Procedures. As shown in Figure 2.1, Operating Procedures (OP) make up a significant portion of regulatory citations. The additional elements listed are Process Safety Information (PSI), Process Hazard Analysis (PHA), Mechanical Integrity Inspection and Testing (MI – Insp. & Test), Recommendations (Recom.), Mechanical Integrity Operations (MI – Oper.), Management of Change (MOC)).

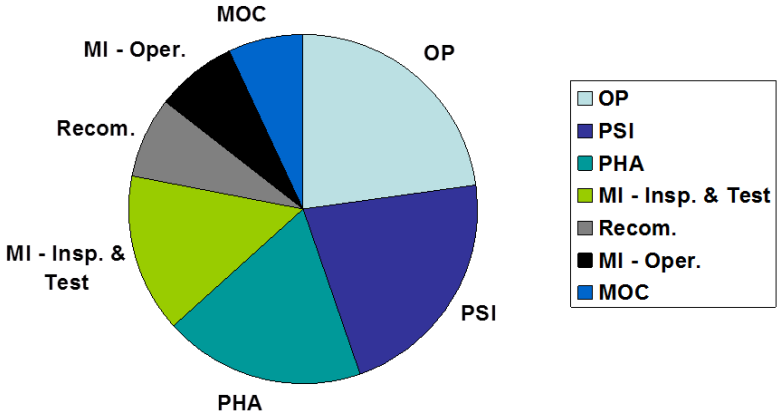

Figure 2.1 – Select OSHA Citations. [3]

The EPA's RMP Rule lays out specific requirements for Operating Procedures dependent upon program level. Program 2 (40 CFR §68.52) [4], the less stringent, outlines the basic requirements, while Program 3 (40 CFR §68.69), which is analogous to OSHA's PSM standard (29 CFR §1910.119(f)) [5], requires a more all-encompassing Operating Procedures program.

The following discusses the requirements for RMP Program 2 facilities. First, the facility must ensure that operating procedures address all of the modes of process operation, listed below.

- Initial startup
- Normal operations
- Temporary operations
- Emergency shutdown (ESD) and operations
- Normal shutdown
- Startup following a normal or emergency shutdown or a major change that requires a hazard review

In addition, the facility's procedures are required to address consequences of deviation and steps to correct or avoid deviations (collectively referred to as "consequences of deviation"). Procedures must also address inspections of process equipment. The final requirement is that Operating Procedures must be updated to be accurate whenever a change in the process occurs.

RMP Program 3 and OSHA PSM requirements build upon the Program 2 requirements to develop a more stringent Operating Procedures program. Expanding on the different operating modes, Program 3 and PSM require that procedures for emergency shutdown include the conditions under which an emergency shutdown is required and the assignment of shutdown responsibility. In addition to consequences of deviation, the procedures must also address the safety and health considerations of the chemicals in the process and any safety systems and their functions. The facility must also implement procedures that cover safe work practices, such as lockout/tagout, confined space entry, opening process equipment or piping, and control over entry into a stationary source. It is also important to note that the safe work practices also apply to any contractors working on the covered process. The final requirement for RMP Program 3 and PSM is that Operating Procedures must be certified annually to be current and accurate. The table below provides a comparison chart between Program 2 and Program 3/PSM.

Table 2.1 – RMP Program Comparisons

Procedure Requirements	RMP Program 2	RMP Program 3 / OSHA PSM
Written Operating Procedures	X	X
Address all operating modes	X	X
Emergency shutdown conditions		X
Operating limits		X
Consequences of deviation	X	X
Equipment inspections	X	
Safety and health considerations		X
Safety systems and their functions		X
Readily accessible		X
Current and accurate	X	X
Annual certification		X
Safe work practices		X

3. Development of Operating Procedures

3.1 Resources

Writing effective Operating Procedures, like most projects, requires identifying goals, establishing a schedule, and gathering and assigning resources. Gathering the proper resources provides a good foundation for developing an outline of the required procedures. Resources include technical information specific to the process and are typically comprised of the following:

- Operating manual and control narrative
- Piping and Instrumentation Diagrams (P&IDs)
- Process Hazard Analyses (PHAs)
- Material Safety Data Sheets (MSDS)
- Vendor Installation, Operation, and Maintenance manuals (IOMs)
- Relevant existing operating procedures

It is important to ensure this information is up-to-date prior to use. Older facilities may have undergone several upgrades or additions that may not have been captured in the technical information. Having the most accurate information generally means that fewer revisions will be required later on. Corporate standards can also serve as a basis for information to contain in the procedures. These can include company-wide safe work practices or Job Safety Analysis (JSA) exercises and may be incorporated by reference. For facilities already in operation, experienced operators and engineers are also a valuable resource that may be able to provide additional information gained from hands-on operation of the process. Compiling these resources helps get to the end goal of encapsulating the relevant knowledge for safe and effective operations.

Aside from facility technical information, the facility must also dedicate personnel resources to the procedure development team. The team usually consists of personnel with relevant expertise to the process and should also reflect the goals and expectations of the stakeholders of the procedures. The figure below provides an overview of a basic team.

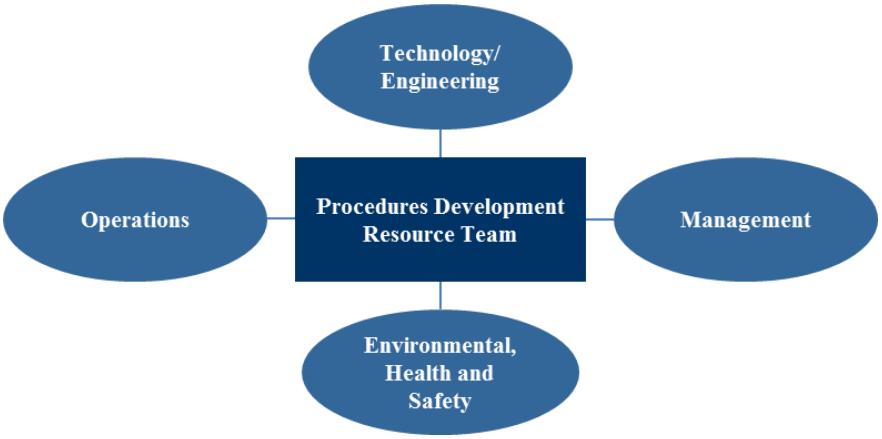

Figure 3.1 – Example Resource Team

As shown in the figure, the resource team is comprised of individuals with experience in the process and other stakeholders in the Operating Procedure program. This includes operations personnel (the end-user of the procedures), engineering, environmental, health, and safety (EHS), and management. Maintaining a balanced team with each group involved ensures that the end product will satisfy the goals of each of the stakeholders. In addition, other individuals may be involved through reviewing and clerical support to provide a resource for consistency.

3.2 Tips for Effective Procedure Development

It should be noted that there is no single, correct way to develop procedures and the needs and requirements will vary from facility to facility; however, this paper will provide a few general tips that may be applicable. Once all relevant information has been gathered, it must be put together in both a useful and useable way. It is important to keep in mind that the end user of operating procedures is always the operator. A format that is user-friendly to the operators will ensure that the procedures are a document they want to use. The following are some tips to consider when beginning the development:

- Template: The template should be approved by all stakeholders (operations, engineering, EHS, management, etc.). This ensures that all parties involved in the project, from development to continued use and updates, are able to get their desired information into the procedure without overloading it with superfluous information.
- Format: Easy readability and user-friendliness are goals to strive for when developing the procedure's format. In addition, consistent formatting across the facility's operating procedures will minimize possible deviations stemming from operators switching between differently formatted procedures.
- Referencing: More often than not, processes are intertwined, and often, operations in one unit will affect operations in another unit. To avoid creating long, cumbersome procedures, it is recommended to break down processes into separate units. Maintaining a template that is easily referenced by other procedures (and other policies in place at the facility) will help streamline jumping between operations and reduce clutter.
- Depth of Information: The most effective level of information should also be established, to streamline detail in procedure and prevent a lack of consistency. If a procedure presents too little information then it becomes more of a guide and less of a step-by-step procedure, which undermines its ability to control specific hazards. If too much detail is present, then the procedures may become cluttered with irrelevant and useless information that may be covered in operator training. Once the desired depth has been established, the training program should be adjusted to match the Operating Procedures.

To provide an outline of the procedure and make it easier to read, some procedures make use of the "T-Bar" format. In this layout, the page is divided into two columns (creating

a "T" with the table header) with outline steps in the left column and specific details on the right. Table 3.3 provides an example of the T-Bar format.

Table 3.1 – Example T-Bar Format

Procedure		
Step		**Details**
1.	Fill the Tank.	Open the 2" valve. Close the valve when the level reaches 6'.
2.	Start the Pump.	Open the suction and discharge valves on the Pump. Start the Pump by turning the switch to the "On" position.
3.	Monitor conditions.	Monitor the level in the Tank. Ensure the Pump is functioning properly. Stop the Pump as described in Step 4 when the level reaches 1'.
4.	Stop the Pump.	Stop the Pump by turning the switch to the "Off" position. Close the suction and discharge valves on the Pump.

With this format, an operator can easily see the general actions to operate the process without getting bogged down by too many details. In scenarios where a few steps need to be quickly verified, an operator can skim down the left column to the desired action and verify the specific details. This format is also applicable to some procedures where multiple operators are required to perform the procedure. The left column could be substituted to contain the roles while the right column contains the assigned actions. This ensures that each role is clearly designated. In these cases, flowcharts may be helpful as a visual representation of how the task is to be completed [1].

After the format and template are established, then draft development may begin. First, each procedure must have a clearly defined purpose. The purpose serves as a focal point for the procedure and all information in the procedure should help the operator complete the defined task. Information contained in the procedure that does not help accomplish the purpose is typically extraneous material and can cause confusion.

Writing good Operating Procedures is in iterative process – drafts are developed, reviewed, and revised. As previously mentioned, the end goal is to get a straightforward, useable document that provides instructions to safely operate the process. As part of this, it is important to maintain clarity in each step of the procedure. A common shortfall of procedures occurs when a single "step" lists multiple actions to be performed. This increases the general clutter of the procedure and devalues the step. Consider the following example.

Table 3.2 – Example Step Comparison

Procedure A		Procedure B	
#	**Step**	**#**	**Step**
1.	Fill the Tank by opening the 2" valve. When the level reaches 6', close the valve.	1.	Open the 2" valve to fill the Tank.
2.	Open the suction and discharge valves of the Pump and then start the pump by turning the switch to the "On" position.	2.	Close the 2" valve when the level reaches 6'.

Procedure A		Procedure B	
#	Step	#	Step
3.	Monitor the level in the Tank.	3.	Open the suction and discharge valves on the Pump.
4.	When the level in the Tank reaches 1', stop the Pump and close the suction and discharge valves.	4.	Start the Pump by turning the switch to the "On" position.

While it may be clear in both examples how to perform the operation, Procedure B is more concise and in a quick reference is easier to follow. It should also be noted that each step in a procedure dictates an action, and these actions have a measurable outcome (e.g., it is measurable that the valve has been opened). It should also be noted that the capitalized "Tank" and "Pump" refer to the names of a specific tank or pump. Capitalizing and referring to the exact name ensures no confusion between different tanks or pumps.

To provide information that may help the operator in the next step, provide some operational background, or warn of potential hazards, notes, cautions, and warning statements are often used to designate the information as separate from a step. Table 3.2 provides information on the use of notes, cautions, and warning statements.

Table 3.3 – Notes, Cautions, and Warning Statements

	**NOTE:**	Notes are information only and are typically limited to: • information needed to perform the action safely • prepare the user for the unexpected • explain the reason for the step • reference other materials • help the user know when the action begins or ends • give other pertinent information regarding the action step.
	**CAUTION:**	Cautions are statements that are not part of the actual step but are used when an incorrect action is likely to lead to adverse consequences to unit operation, poor product quality, equipment damage, or harm to the environment.
	**WARNING:**	Warnings are statements that are also not part of the action step but used when an incorrect action is likely to lead to personnel injury or harm to the surrounding community.

4. Implementation and Ongoing Integrity

4.1 Successful Implementation

Operating Procedures, like the other elements of RMP/PSM, are a living program. Once a program has been put in place and procedures have been developed, continued involvement is necessary to maintain an effective program. The following are some management tools of effective Operating Procedures.

- Ownership/Control: Having a document owner ensures that procedures are taken care of and updated properly, which includes annual certification for RMP Program 3 and PSM facilities. RMP Program 2 facilities can benefit from document control by ensuring procedure accuracy and consistency.
- Accessibility: The RMP/PSM regulations require that operating procedures are accessible to those operating the process. Typically, controlled copies of the procedures are kept on the company's intranet, with printed, uncontrolled copies at key workstations. Maintaining electronic copies allows all employees to access the procedures for reference. In addition, accessibility control ensures that if changes are to be made to procedures, they are done so properly.
- Integration with Operator Training: Incorporating Operating Procedures into the operator training program helps familiarize operators with the process and procedures. Training also serves as a good avenue for securing feedback from operators for continuous improvement.
- Reviews and Audits: The RMP/PSM Compliance Audit is required every three years, but it is recommended that smaller, Operating Procedure-focused audits be incorporated into the annual certification program.

These tools will help ensure that the Operating Procedure program stays up to date and in-use at the facility. However, as the last bullet pointed out, continuous reviews are a reliable way to manage the content of procedures. Aside from audits, reviews may be initiated by other PSM elements such as Management of Change (MOC) or Pre Startup Safety Review (PSSR), Incident Investigations, or Process Hazard Analyses. Securing feedback during these reviews will also alert management to the need to retire obsolete procedure or the need of any additional procedures to be developed.

Over time, operators gain experience and operational knowledge of the process. Using management tools, this information could be extracted to help form typical operating ranges and troubleshooting guides, which help satisfy the operating limits and consequences of deviation required in procedures. Table 4.1 below provides an example.

Table 4.1 – Example Operating Limits

Operating Limits			
Parameter	**Limits**	**Consequences of Deviation**	**Steps Required to Correct or Avoid Deviation**
V-100 Level	30 – 70%	**Low** Potential gas blowby to Vessel V-200. **High** Potential liquid carryover to Compressor C-100.	Monitor level indicator LI-100 for low alarm LAH-100 or high alarm LAL-100. Adjust set point of level controller LIC-100 as necessary. Check level gauge LG-100 during rounds.

During initial procedure development, this information may be difficult to acquire. However, as operators become familiar with the process, this information could be tailored to the specific upsets that typically occur at the facility.

The following section provides a look at some common deficiencies in Operating Procedures as well as suggestions for improvement.

4.2 Common Deficiencies

As previously mentioned, many facilities are presented with challenges in their Operating Procedures. It is the objective of this section to point out some of the commonly deficient issues found in operating procedures. Listed below is a summary of these deficiencies, which are further elaborated in this section.

- Lack of annual certification
- Written procedures not synchronized with operator's actions
- All operating modes not addressed (especially temporary operations)
- ESD roles and responsibilities not clear
- Operating Procedures not current for all normal operations
- Procedures not in the language of the end user.
- Normal operating limits not documented
- Contractors not included

One of the most common difficulties for Program 3 and PSM facilities, especially large facilities with hundreds of procedures, is the annual certification of their procedures. It is often found that the procedures are not only lacking in annual certification but are outdated as well. The annual certification is required to ensure that the facility is aware that their procedures are up-to-date. A thorough review and update may not necessarily be needed if nothing has changed, however the facility must certify the procedures to show that they are being monitored. Table 4.2 provides an example of a sample procedure header to help track the annual certification.

Table 4.2 – Example Procedure Header

Operating Procedure for XXX				
Procedure: SOP-100	**Revision:** 01	**Effective Date:** **Next Review Date:**	May 2013 May 2014	**Owner:** Operations Manager
Objective: To complete Task XXX safely and efficiently.				

Another common deficiency is that Operating Procedures are not accurate for all modes of operation. Operations may constantly change throughout the life of a facility without being captured in the procedures. Though it may not be practical (or even possible) to address all the operating deviations that may arise, the procedures should match the general operating intent of the facility.

Many procedures also fail to address each mode of operation, as discussed under the regulatory requirements. For some facilities it is difficult to assign the operations performed to one of the modes of operations outlined in the regulations, particularly temporary operations. The objective of assigning operations to different operating modes is to ensure that all routine and non-routine operations are properly documented to reduce

hazards. A facility may not have an operating procedure for a particular task, but it must be captured through a program (Operating Procedures, Job Safety Analysis, Management of Change, etc.) that will address all the potential safety and hazard concerns.

Synchronizing Operating Procedures with the operators' actions is also a challenge for facilities and could be reflective of several failures in the PSM system at the facility. In the Operating Procedures program, this could mean that the procedures have not addressed all oeprations or captured all relevant knowledge of the process. This could also reflect a deficiency in the Operator Training program, such as competency testing. Operators could be performing actions that deviate from the procedures because they have not been properly trained on why those specific steps outlined in the procedure are important. This is particularly important for hazardous processes where any deviations could potentially cause releases or exposure to hazardous environments.

When synchronizing procedures with operator actions (or vice versa) it is important to ensure that the procedures are written in the language of the end user. Procedures are typically written from an engineering standpoint which may not be useful to operations. Use of equipment tag numbers instead of the common name may lead to uncertainty, as shown in Table 4.3.

Table 4.3 – Example Equipment Clarification

Procedure A		Procedure B	
#	**Step**	**#**	**Step**
1.	Place PIC-237A in AUTO at 100 psig.	1.	Place PIC-237A Pressure Controller on Depropanizer Reflux Accumulator (V-237) in AUTO at 100 psig.

During a quick review of Procedure A, the operator may not be able to quickly recall what vessel PIC-237A controls. Adding the descriptor as shown in Procedure B eliminates all chances for confusion be specifying exactly which controller should be adjusted.

5. Conclusion

Although there are a number of challenges associated with the development and implementation of Operating Procedures, it is clear that they are an important element of RMP/PSM Programs and provide a number of benefits to the facility and its personnel. Without the proper management program in place, Operating Procedures will suffer from a variety of shortfalls leading to operational inconsistencies, regulatory citations, and possible process safety hazards. However, successful implementation will streamline operator training, reduce the risk of incidents, and ensure quality assurance.

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