Optimised procedural operations

More focus is now being placed on procedure effectiveness in the management of abnormal situations and process state changes. This helps to increase profitability as well as provide safer and more effective operations

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Over the past ten years, refineries have focused on improving operations through process control, including model-based control and process optimisation techniques. These areas continue to provide tremendous benefits, but additional focus is now being placed on procedure effectiveness in the management of abnormal situations and process state changes to further increase profitability as well as provide safer and more effective operations. This article explores the best practices and state-of-art tools used by world-class organisations to discover, plan and improve procedural operations.

Commonly executed procedures have a major impact on operations and include startups, shutdowns, emergency procedures, bringing equipment to intermediate safe operational states and equipment changeovers. Variation in procedure executions and deviation from procedural best practices can be costly. Examples of tangible costs include:

— Increased time required for decoking operations due to improper furnace startup/shutdown sequences

— Incorrect procedure execution at peak loading, resulting in safety incidents or compliance issues

— Skipped procedure actions, resulting in equipment damage and loss of production

— Reduced operational efficiency due to operator overload at critical processing periods

— Transition to a shutdown state when the proper execution of a best practices-based procedure could have resulted in less downtime, safer operations and a faster transition to full production

— Increased time required to start up or shut down a process unit.

These risks and their associated costs can be avoided or reduced through the use of effective procedural operations. These can provide an easy-to-implement path to reduced risk and bottom line dollar benefits.

Why are we seeing a change in how we execute operating procedures? As an industry, have we not been utilising procedures since processes were created? The fact of the matter is, while most refiners have had procedural systems since the initial startup of production, the impact of human factors on profitability and the value of consistent procedural execution are only now becoming conventional wisdom for the industry. In fact, there are still many refiners whose procedures in operation differ significantly from those procedures they have documented.

From years of studies and direction from the Abnormal Situation Management Consortium (ASMC), guidelines/practices and experience are available to set up and utilise procedural operations to derive real plant benefits. There is no longer any reason not to drive toward best practices procedural execution.

With the increasing acceptance of the benefits available from better procedural operations, a demand has come from refinery operators for solutions that can enable effective procedural execution. Here is where the process control industry must respond with solutions that can drive true and measurable bottom line benefit. It truly is the tools, techniques and planning that make procedural operations effective.

Over the years, process facilities have invested in distributed control systems (DCS), historians, advanced controls and any number of other technologies designed to enabled efficient operation of processes when operating at a fixed operating point (for example, common feedstock and common product slate). As those technologies mature, companies are demanding new sources of benefit from control suppliers. Suppliers must respond to challenges such as increasing operating flexibility to allow faster response to market opportunities. This requires the ability to flawlessly move from one operating mode to another as fast as possible.

Other challenges include the drive to lower or eliminate further costs by reducing the costs of abnormal situations; reducing the impact of incorrect execution of procedures (for example, because they could not be found, were out of date, were not suitable, were not detailed enough, incorrect data); elimination of non-value-added work by the operators in executing procedures so that they can focus on processing cost and efficiency; and the loss of knowledgeable staff due to retirement or moving on to other responsibilities. The needed retention of knowledge can be achieved by encoding procedural know-how into a system. In addition, many facilities are:

— Looking to improve transitions between operating modes or feedstocks in response to market demand

— Correcting for procedures that are frequently not followed correctly, resulting in losses in production and off-spec material

— Looking to reduce operator workload in non-value-added areas to consolidate the workforce, thereby allowing operators to have more time to focus on cost control and profit maximisation.

Procedural operations

An effective procedural operations implementation will help make changes consistently and do it as well as the best operator. Procedural operations as described in the *Effective procedural operations practices and tools definition* report from 2002 ASM Consortium Research Subcommittee Proposal states:

— **Operating procedures** Operating procedures are a set of explicit guidelines and instructions that, when followed by the operational personnel, will minimise deviations from design or operating intent

— **Design or operating intent** Design or operating intent refers to how the plant is to be run, as specified by operating targets and limits (Sutton, 1997). Typically, operational targets are explicitly defined in the operating instructions and the control system settings. Operating limits may be explicitly or implicitly specified, depending on plant practices.

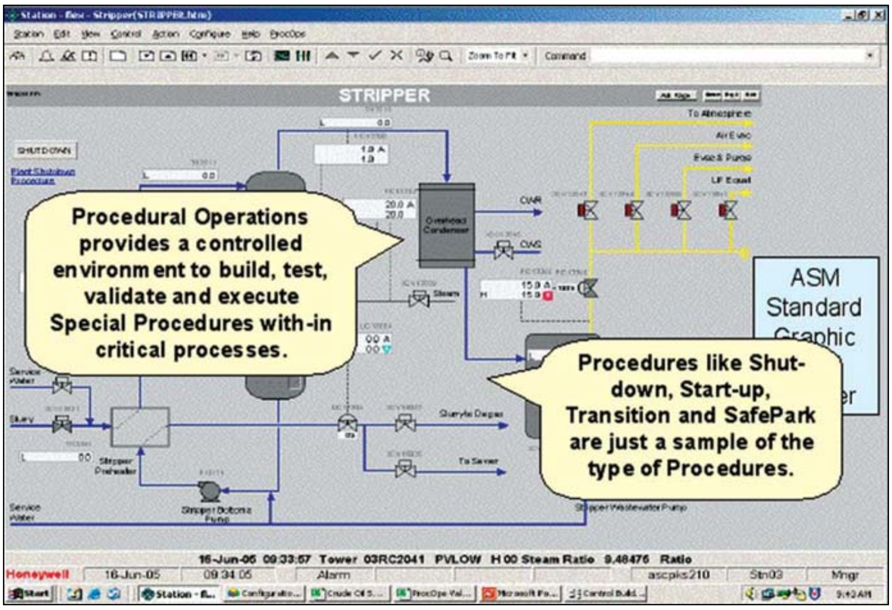

Figure 1 *Screen capture depicting how a manual procedure is converted to an effective semi-automated procedure using a stripping column in this case where the procedure has been encoded into the PCS*

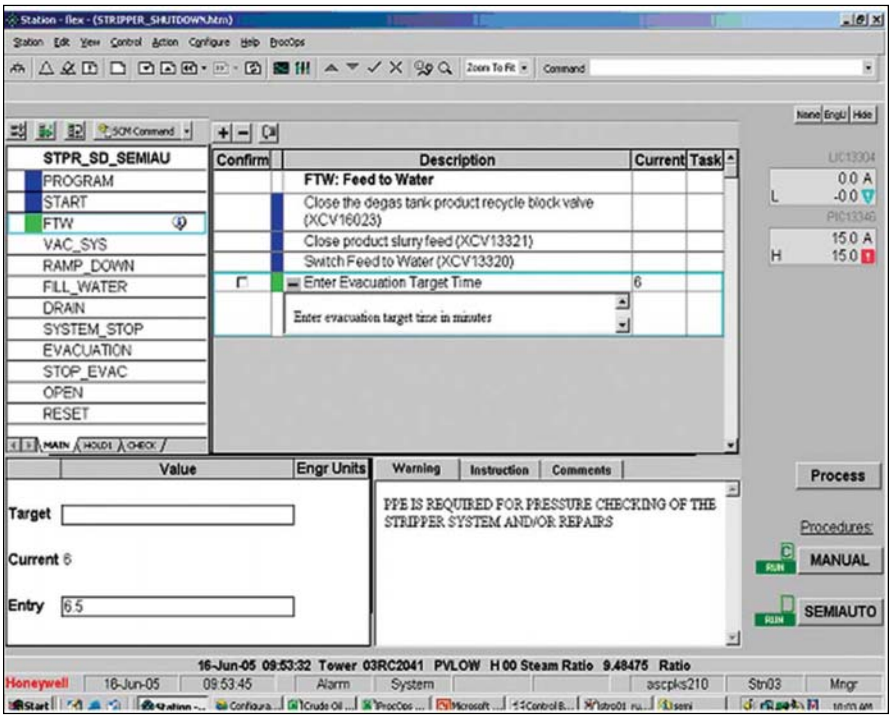

Figure 2 *Post-shutdown view of stripper automated procedure*

Therefore, within the confines of this article, procedural operations are the result of automating, semi-automating or guiding the operator with real-time control intelligence that is part of the control system itself. That is, an integrated part of the standard operations tools and process control system. And a properly implemented system is one that is designed and executes effectively.

What is the value and benefit of an effective procedural operations implementation? Effective procedural operations (in this context) were created to provide for the following needs:

— **Shutdown/startup** Seldom executed, so subject to error or inconsistencies

— **Grade change** Normal production change (grades, rates and equipment)

— **Abnormal condition resulting in "safepark"** Bringing the plant to a safe holding point that may be resumed by operations, or subsequently to shut down the plant

— **Cyclic planned activities** Activities repeated, based upon well-defined criteria and normal operations (regeneration, pump changeover and decoking).

The value may be described from at least three perspectives:

— **Safety** In one site study of incident failures, 8% of all root causes were of procedure-related incidents. This not only cost an additional $12.8 million over five years, but also caused personnel to be at higher risk. We can only think what value to place on life. Safety experts have long argued that the majority of accidents are caused by human error

— **Efficiency** During a site study, it was identified that improvements in one procedure reduced execution time by four hours. Multiplied, corporate sites might see a benefit of more than $6 million

— **Reliability** Performing procedures in the same validated way as the most experienced operators, based on operational best practices, automated as much as possible and with the ability to measure and correct deficiencies is a good path to improvement.

Value and benefits summary

A proper implementation of procedural operations saves time by reducing the time to execute special procedures like shutdown, startup and transition. Time is related to product scrap, product degradation and the cascade effect through the plant.

As an example, when a crude switch is optimised by using effective procedural operations there can be a 30% decrease in downtime/slowdown through the first two units. This downtime/slowdown ripples through the rest of the units like the coker unit. Reducing downtime/slowdown is where the largest benefit in money may be found and could amount to millions from just a few procedures.

Further benefit is gained from collecting and preserving the expert knowledge of the operators by moving that knowledge into a traceable and improvable system. Most plants are facing retirements of their older knowledge base. Refineries need a solution to capture this knowledge before it walks through the plant gate for the final time.

Next up is safety. By executing the procedure the correct and validated way, the same every time, we significantly reduce the risk of human-induced incidents. Further, if something does go wrong, a safepark can be initiated quickly with automation, if possible.

Finally, the reliability of the process and equipment is improved, because there are fewer errors and better methods are used. This includes equipment damage, decreased lifespan of equipment or materials and possible compliance issues.

Effective procedural operations example

Real value and benefits can be demonstrated when converting a manual procedure to an effective semi-automated procedure. In the previous example, a stripper procedure had been encoded into the process control system. This example will be used to obtain an idea of a procedural operations implementation. In Figure 1, a link labelled Shutdown Procedure, in the upper left-hand corner, has been programmed into the procedure to view the manual procedure that was used to create this semi-automated version. Also, right above this button, another button labelled Shutdown is used to switch to the semi-automated procedure screen. Pressing the shutdown procedure link allows the viewing of the manual procedure (Figure 2).

The operator is switched to Figure 2 after pressing the Shutdown button. Note that this example is just one possible solution, and that these screens are reusable components that can be leveraged as defined by operators and/or templates of display components that may be reused, based upon operator-specific user interface requirements. Following the example, the automated procedure has been started. The blue checkbox seen in Figure 2 indicates a completed step, and a green checkbox is currently executing.

Note that three steps have executed automatically and the operator is now being prompted to enter the evacuation target time. This is an example of automated and assisted manual steps. Also, note the Entry prompt in the lower-left corner and the warning/ information text in the lower-right box of Figure 2.

The system is now instructing the operator to execute a manual field operation (Figure 3). In this case, the field operator is asked to carry out this portion of the procedure via a phone call, radio or a portable field unit like the IntelaTrac tool. After completion, the step is confirmed by checking the box Confirm (Figure 4). Reasons for converting a manual procedure to a semi-automated one could be that the manual procedure was out of date, had not been updated in two years, or there had been equipment changes and the operators never followed the procedure because it always made for a difficult shutdown. Or perhaps the operators were having problems managing the conditions on two units they were monitoring.

After confirmation, the procedure executes automatically to the next manual step input to confirm the evacuation pump is running. Note that there are a number of steps that can be executed automatically but require the console operator to manually confirm the actions taken and the results achieved

The entire execution of the stripper procedure is executed automatically, semi-automatically or via assisted prompts, with checks and measures that

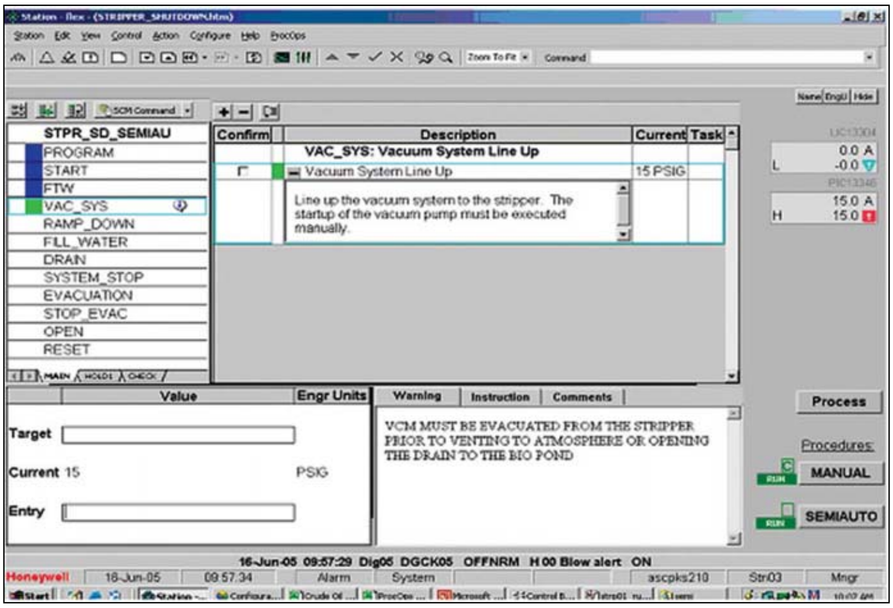

Figure 3 Execution of a manual field operation

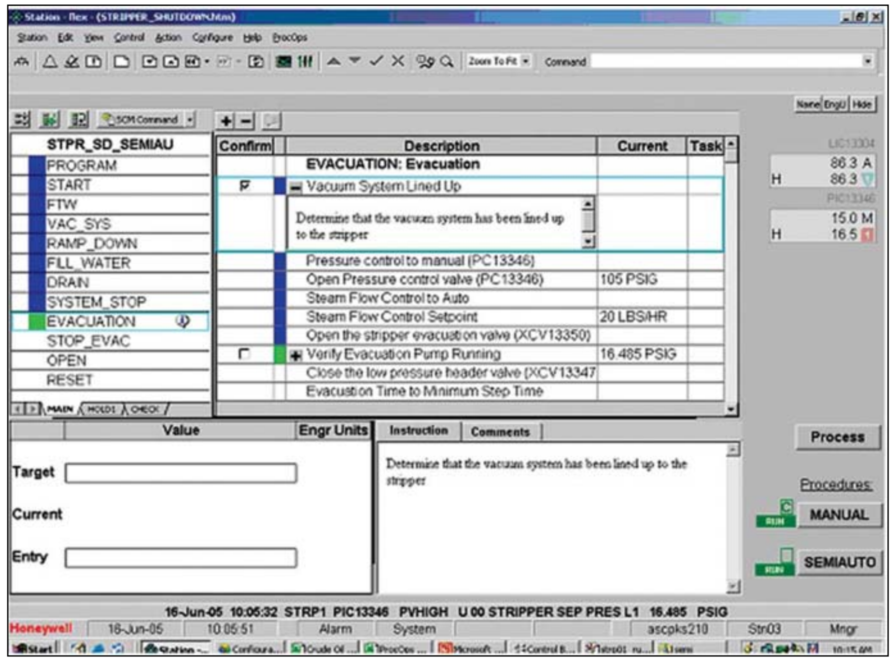

Figure 4 Completion of manual execution

have been tested and verified prior to use. Execution can be a combination of purely automatic actions (no console operator intervention), semi-automatic actions, where console operator intervention is needed, and entirely manual field operator tasks.

Also, the metrics of execution can be saved, analysed and reported. Changes to the procedures may now be measured to verify improvement. Measuring the criteria of the procedure execution can lead to a classification of procedures such as the Golden Procedure.

An entire management of change (MOC) process can be created to effectively manage special procedures; that is, procedures that are dynamic (changing as the plant and operation work practices change). Yet refiners want to accomplish this under a well-defined MOC process including revision control and tracking.

As an example of why this is important, suppose a unit is shut down once every two years, and a critical parameter may be pressure. Can the operator compare the pressure profile of an executing procedure with a prior execution so they know if it is proceeding normally? Can the procedure be easily compared to identify areas of optimisation, improvement or potential training? Integration into the process control system is the key to greater benefits.

Value calculator

From the sample value calculator of Table 1, the values under the entry column are input based upon plant operations. Note the time-reduction entry, which is the

Value calculator - PVC stripper example		
Total annual savings	**$12 100**	**Total savings**
	Entry	**Comment**
What is your annual production of PVC? (million)	1000	
How many operating days do you have per year?	330	Usually 330
What is your average operating profit? (¢)	4	1–5¢is typical
How much lost production do you have annually for all reasons? (million)	250	Industry data typical 10–30% of annual total production
How much lost production is due to stripper outages? (%)	8	Industry data typical 5–10%
How many planned and unplanned stripper outages do you have annually?	30	Industry data typical 2–3 per month
How many hours would a stripper shutdown last without automated procedures?	5	Typically accomplished in less than one shift
Percentage of time reduction with automated procedures	80	%
Number of hours to execute with procedural operations	1	Hours

Table 1

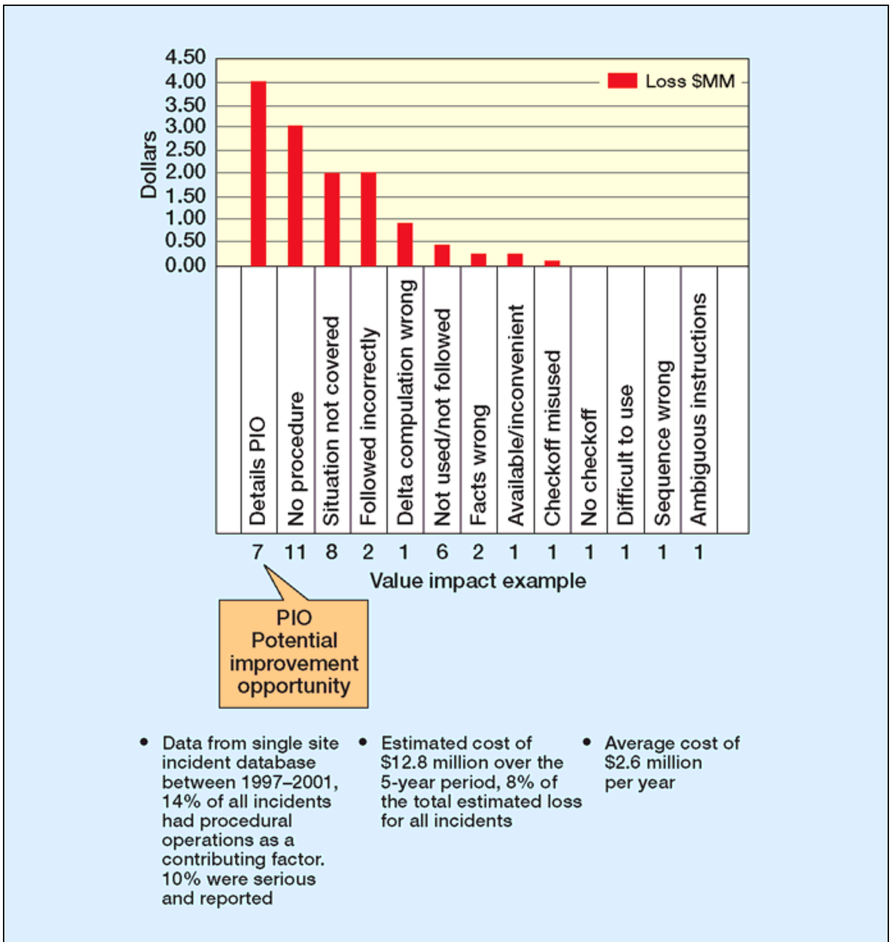

Figure 5 *Implementation of procedural operations showing data acquired from a site study conducted by the ASM Consortium*

percentage of time saved by automating this procedure. Normal reduction time is in the range of 5–30%, but in this case we saw 80%. This is calculated to be a bottom line adder of $12 100 for the one procedure executed over 30 stripper shutdown outages. There are hundreds of these examples on process sites.

Value impact

Another form of value from a proper implementation of procedural operations is shown in the Figure 5 data acquired from a site study conducted by the ASM Consortium. In this study, dollar loss is spread over a five-year period and shows that 8% of all incidents are procedure related at a cost of $2.6 million per year. Figure 5 shows by priority the cost relationship to causes. Note that the largest share of losses are known as potential improvement opportunities (PIOs). The root cause of these PIO losses is that there was not enough detail or too much ambiguity in the details of performing the step or procedure.

These PIOs become visible during the implementation of a proper procedural operations analysis. This pre-work is important and should not be put off. A PIO can be as simple as saying “turn the valve” instead of “open the valve to 50% flow rate” or “with the valve, ensure a 50% flow rate”. The implementation of procedural operations forces operators to think through the details, especially as it relates to control systems interactions.

Planning, implementation and maintainability

If the refiner is aware of the problems and solutions, the fix is downhill. The first priority is that site management has to be fully aware of the process gaps, solution capabilities, benefits and competitive challenges.

An effective procedural operations solution provides the vehicle to measure and close the gap between where you think you are and actually knowing the effectiveness of executing non-routine procedures like shutdowns, startups and transitions.

Some sites have implemented makeshift systems to control a procedure, but more often failed because of necessary control upgrades, complex coding, personnel turnover and continuing maintenance of the system. Key items of success are not only the operational interaction effectiveness of the solution, but also the supportability of the solution to continue and derive values over the entire life. Know exactly were your site measures up, and take the edge from your competition.

Before starting to code automatic procedures, be sure you know where you are going, what your priorities are, how you are getting there and the correct metrics to show success. This is not a trivial point — failures in implementation are often traced to poor scoping and a lack of good planning. Steps to proper implementation include:
— Scoping workshop
— Project support
— Procedure evaluation and design

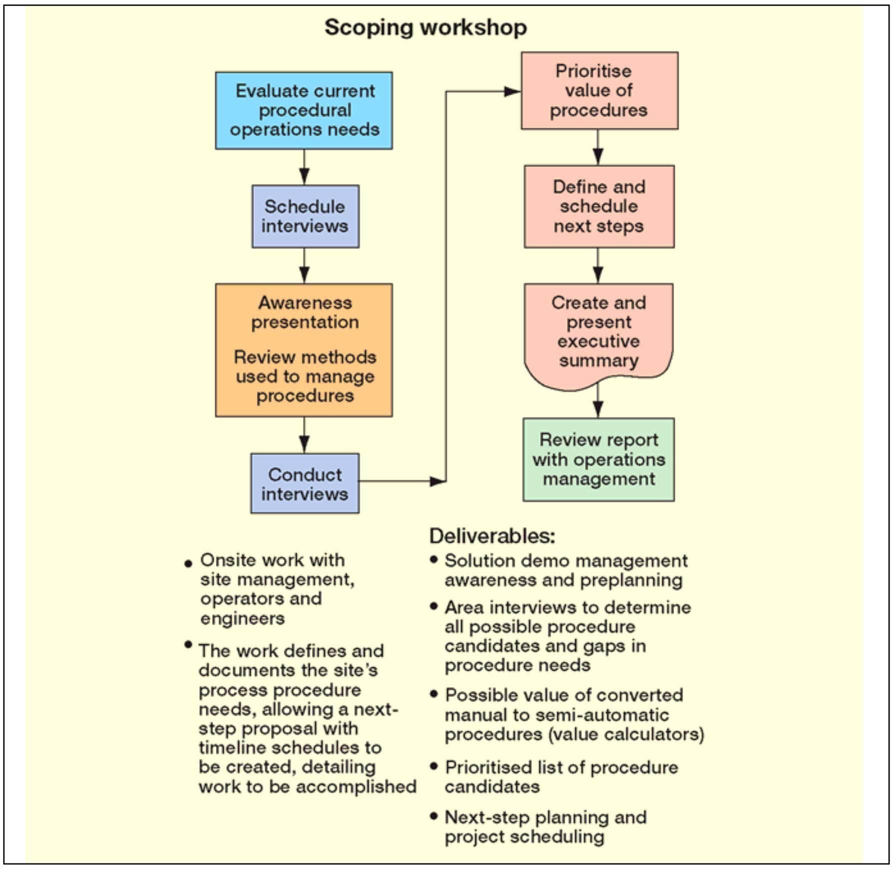

Figure 6 *Flowchart of scoping workshop*

— Best practice benchmarking
— Automated procedure value analyses
— Procedure workflow
— Simulation and verification
— Continuation lifecycle support.

Scoping workshop

The scoping workshop is the first task to perform. The result will be a plan including scheduled tasks of what must be completed and a process on how to find the dollar value from converting manual procedures to semi-automated procedures. These scheduled activities will prepare and execute what is needed to implement an effective procedural operations project.

Activities may range from prioritising procedures, deciding what makes a system effective, gathering information to verify procedure needs, what current economic data does the site have, setting up a system to track economic benefits, what tools are necessary to be effective, workflow, risk assessment criteria, change management, system installation, testing and verification (Figure 6). Project support is the work of setting up the applications and manual conversion planning to semi-automated procedures within the control system. This work is accomplished via programming the control module using the control system toolset.

Plan the verification and testing process of the procedure execution. A simulation technique can be improvised where proper process simulation systems are absent, at least to the exit of the control signals from the controller. Some sort of simulation is necessary prior to on-line connection. Planning should be a multiple stage of testing/ qualification — from the upfront logic verification to the execution against normal and abnormal simulated variables, to the walkthrough of the procedure along with the operator, allowing for participation and verification of each control action done.

What is needed to be effective? Site problem awareness — does everyone fully understand what procedural operations can deliver? Some sites believe manual procedures are enough, but are they? Recent ASMC-sponsored studies point out sites where many believe their manual procedures are sufficient but they may still have unknown problems.

Are procedure-related incidents recorded and tracked properly? Is there a measurable improvement system for critical procedures? How are golden procedures measured and compared to non-golden procedures? Can a small change be measured for reliability and efficiency? Are these procedures executed the same across shifts and personnel? How does a known decrease in execution time reflect on production dollars? How can continuous improvement opportunities be provided if the key areas of contention or bottleneck cannot be measured?

Where do we start and where are we going? Awareness is the first step. Does my site need procedural operations?

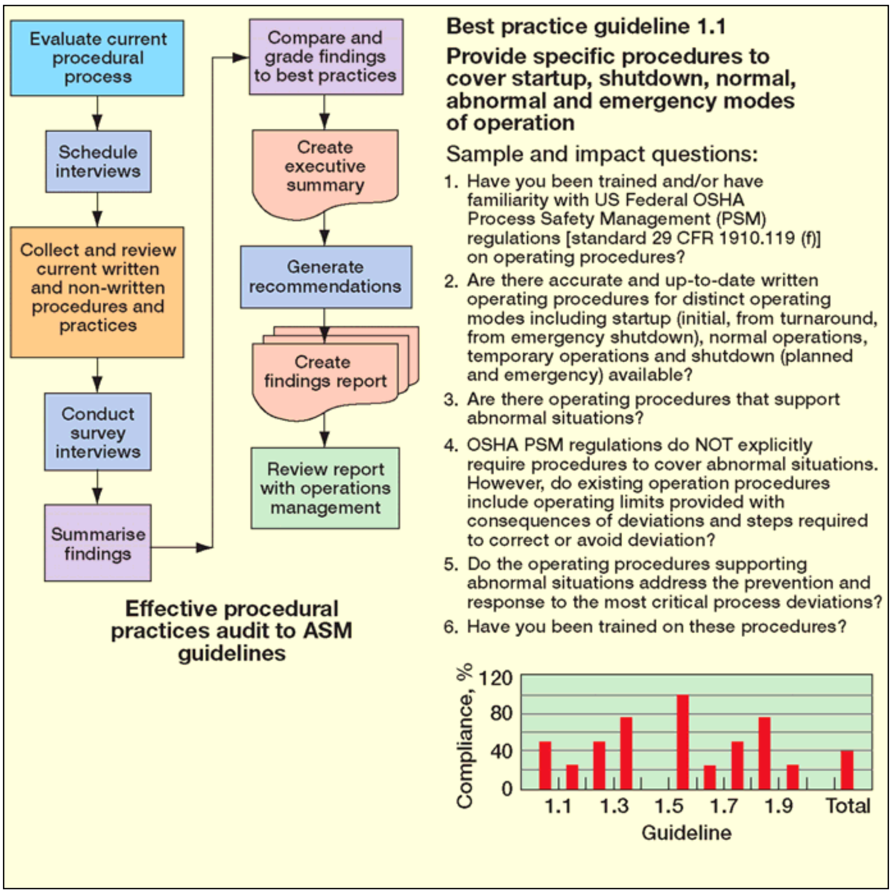

Figure 7 *Example of best practice guideline process*

Who should be involved? What kind of procedures are being considered? What is needed to make an educated decision? What are the economics of effective procedural operations? What are the priorities? How do other companies start? What are the goals of being effective? Answers to these questions are the objective of the scoping workshop. The scoping workshop will collect the necessary data to make the next-step decisions and plans. From awareness of what effective procedural operations are to what safety, reliability and cost savings the site could expect.

Best practice assessment

There are 39 best practice guidelines. The Best Practice Assessment is designed to compare current procedures and practices to ASM procedural practices. A findings report is generated and reviewed with operations management. The findings of the assessment are used to discover and fix gaps within departmental procedures.

The important point here is the documenting of the difference (focus/methology) between manual procedures and semi-automated or automatic procedures. This is part of the classification, as it shows more value can be obtained from one semi-automated procedure (due to timing, impact of incorrect action) than many manual procedures (Figure 7).

Value assessment

To complete the value assessment, personnel interviews, data assessment from incident reviews and assessment findings are needed, plus the percentage of procedure-caused incidents compared to the total cost of incidents and the cost of procedure failures. Also, how is training applied and the risk of failure reduced by training? Documenting the bottom line value and cost metrics of the startup, shutdown and other manual procedures will highlight areas for improvement. Improving procedural effectiveness by finding and fixing errors and inconsistencies will not only save money by reducing incidents, but may also save personal injury.

We should not ignore what we do not know. We should discover where we are and plan to improve, or at least correct, the situation. From “stop, fix, go” to “planned, smooth transition” in the safest, most reliable and efficient method.

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