The effect of up-to-date Operating Procedures on Process Safety

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Introduction

First, let me first break down the title of this paper. `The effect of up-to-date Operating Procedures on Process Safety`. This might raise a few questions. The title could suggest the effect can be measured and quantified. I´ve tried to unravel the title by the following additional questions. Thorough cases studies delivered directions for solutions and interpretation for answers.

Figure 1: Control Process Safety with adequate Operating Procedures

Questions

- Can Process Safety be positively affected by up-to-date Operating Procedures?
- How do Operating Procedures contribute to Process Safety
- Is it proved incidents are the direct result of inadequate Operating Procedures?

Despite all precautions, incidents happen

The Process Industry implies considerable risks. Although the Industry is aware of these risks and takes precautions to prevent, incidents still occur. Some recent examples:

- BP Texas City refinery accident, 23 March 2005
- Explosion MSPO2 Shell Moerdijk, 3 June 2014
- Explosion natural-gas-condensate, Nederlandse Aardoliemaatschappij, Warffum, 31 May 2005

Inadequate Operating Procedures can lead to incidents

Operating Procedures are considered as the third line of defence after passive safeguards[1] and active safeguards[2].

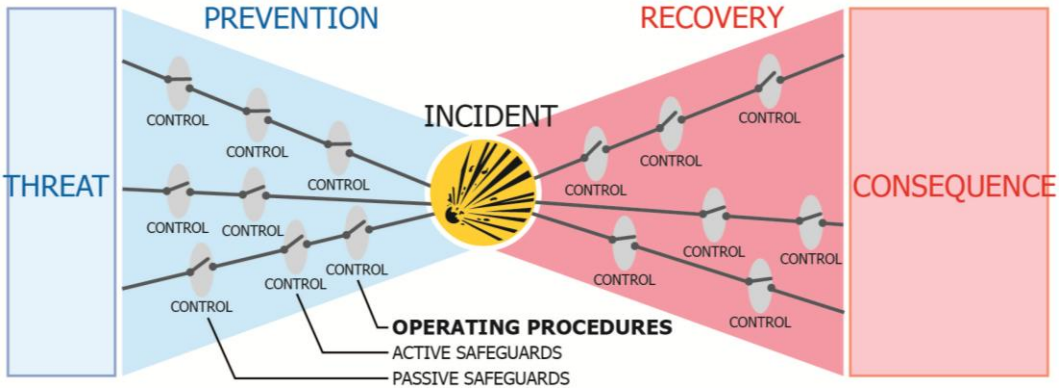

Figure 1 Operating Procedures third line of defence

[1] For example: Reduced inventory of hazardous substances. Use of chemistry with reduced toxicity
[2] For example: Emergency shutdown systems, flare stacks

Studying incident investigation reports resulted in the following quotes:

BP Texas Refinery Accident [3]: "During the start-up, operations personnel pumped flammable liquid hydrocarbons into the tower for over three hours without any liquid being removed, which was contrary to start-up procedure instructions".

Apparently Operations Personnel didn't act according to the start-up procedure instructions. It seems adequate Operating Procedures were available, but Operations Personnel didn't act accordingly. This has to do with company culture.

The report also states: "The tower experienced dramatic swings in liquid level during 18 of the 19 previous start-ups, making control of the start-up difficult for operators, yet the instrumentation and equipment were not reviewed nor were methods for handling swings in liquid level addressed in the procedure".

So in this finding it appears essential information wasn't provided in the procedure.

Furthermore the following findings are described in the report illustrating the Process Safety was jeopardized by inadequate procedures:

- Procedural Changes Without Management of Change (MOC)
- Start-up Procedure Lacked Sufficient Instructions
- In 2001, 4 year before the accident: "The PSM audit finds a substantial number of PHA action items still open well past their stated due dates, and a number of unit operating procedures that are not current"

It is expected the Plant can't operate without the first two lines of defence are fully established. But the third line of defence is probably the one to which the most can go wrong. The incident investigations reports almost always conclude findings regarding Operating Procedures. Apparently Operating Procedures in general aren't getting the attention they should get.

The U.S. Chemical Safety and Hazard Investigation Board concluded in the report about the BP Texas Refinery Accident as a root cause: "Managers did not ensure that Supervisors and Management enforced the use of up-to-date plant policies and procedures".

The Dutch Safety Board states in their report about the Explosion at the MSPO2 of Shell at Moerdijk [1]:

"For a proper understanding of the incident, it is important to know the Operators and the Process Engineer treated the warming up of the unit with ethyl benzene as a non-hazardous process step. Therefore they hadn't identified critical process conditions for the heating and these weren't available in the work instructions".

A start-up of the unit takes place every 3-4 years and requires experienced Operators. In this case the start-up was executed by experienced Operators. They were in fact, experienced with normal day-today Operations but weren't experienced in a start-up of the unit. So how could the Operator have known about the critical process conditions? Not from own experience and not from work instructions.

One of the conclusions of the report: "Crucial information has gradually lost ("over the years")".

"There have been in the course of time several technical changes to the unit 4800. In addition, in an effort to shorten work instructions, information was lost and disappeared from operational work procedures".

According to the design criteria the installation should be heated up with 30°C per hour. This information wasn't laid down in the Operations Procedures and wasn't recognized as critical. The Operator team choose to heat up with 50°C per hour. Furthermore the Operator team choose for a Nitrogen flow of 240 kg/hour. Operations Procedures didn't indicate the criticality of the flow and didn't provide any figures. Apparently 1.700 kg/hour Nitrogen flow was required. This lower nitrogen flow is one of the causes of the incident. "Because of the low Nitrogen flow, the ethyl benzene wasn't effectively distributed over the catalyst pellets in the reactor. This resulted in insufficient wetting of the pellets. The ethyl benzene wasn't able to cool sufficiently which resulted in hotspots and pressure raise[3]".

In the report about the incident investigation of the Explosion of a Condensate Tank at Warffum, 31 May 2005 [4] shows that the "Procedures and work instructions have not been fully complied with". One of the conclusions is: "Procedures and agreements were not clear enough".

Despite the effort of creating Operating Procedures it's at least equally important to ensure that they are clear and that they are observed.

[3] Runaway

Operating Procedures are entirely useless – even when one single item is missing

Besides Safe Design, competent Operators, fool proof control systems, adequate and reliable Operating Procedures are essential. Incomplete instructions have led to disasters. Even if one single instruction is missing or information is incomplete, incorrect or outdated the entire Operating Procedures set is useless. The thing is, the Operator doesn't know which Operating Procedure is reliable and which isn't. He can't trust anything. So he has doubts about everything. It's not a question if it will result in an incident, the question is: "When will the incident occur"? This could be represented in the following figure.

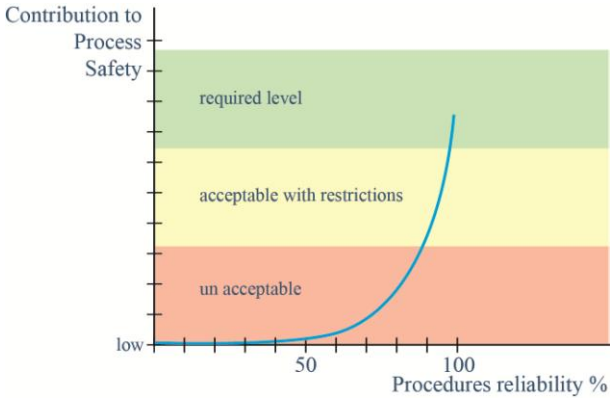

Figure 2 Outdated Operating Procedures are useless

Engineers are not Technical Authors

Engineers who design a process plants are –together with HSE experts - very much capable to assess all relevant start-up and operational aspects. Engineers however, are in general not Technical Authors. It takes special skills to translate the design and operations knowledge into clear instructions for Operators. It has been recognized this has led to comprehensive process descriptions which do not provide the Operator with turnkey information in what to do. Often instructions are much too extensive with information which isn't actually necessary for Operations. Not to speak about the involved costs for maintenance of these excessive procedures. It's is sometimes interesting to know how a process control is designed and what happens within the "black box". But it isn't essential for Operations. It is far more relevant the Operator must know which control panel he should pay attention to and which button he should use, where he can find to wheel to turn on to open or close a valve, outside the control room. He should know how to respond on system alerts.

What happens next is that Operators are assigned to maintain and update the Operating Procedures. Operators aren't Technical Authors as well. They first have to simplify the excessive procedures from the Engineers. This is too much asked. It appears very difficult to judge whether information may be skipped or not. Usually they end up with still unreadable Procedures. It's almost impossible to downgrade the overkill of information into a convenient "hands-on" handbook. Furthermore trained Operators are likely to be incomplete in their writing because their routine Operations work. "Steps in a procedure are so obvious for them and may therefore be forgotten.

Operating instructions are not for training purposes

It's often seen that operating instructions try to provide operating information and training information simultaneously. This is strange when you realize that operating instructions are intended for trained Operators. Any training information forms overload. It furthermore complicates the instructions and results in decreasing intelligibility. Moreover this complicates the maintainability of the instructions which can results in update backlog and unacceptable high instructions maintenance costs. For instance: "one doesn't learn to drive a car from the car manual".

Validity – inadequate update frequency

During the incident investigation of the BP Texas City refinery accident [2] it was found that:

"Information from refinery-level interviews and other information that the Panel obtained also indicates that training manuals used at the refineries were often outdated".

New staff was offered outdated training manuals although this was already recognized two years before the accident occurred.

The U.S. Chemical Safety and Hazard Investigation Board states in their report [3]:

"Management did not ensure that the start-up procedure was regularly updated, even though the start-up process had evolved and changed over time with modifications to the unit's equipment, design, and purpose. The procedure did not address critical events the unit experienced during previous start-ups, which could severely damage equipment and delay start-up. In addition, specific instructions for unique start-up circumstances were not included in the procedure. Management had also allowed operators to make procedural changes without performing proper Management of Change (MOC) hazard analysis, thereby encouraging operators to make unplanned (and potentially unsafe) deviations during start-

up. All of these managerial actions (or inactions) sent a strong message to operations personnel: the procedures were not strict instructions but were outdated documents to be used as guidance".

This finding shows the procedure was outdated and there wasn't a system in place for regular update. It also shows that lessons learnt weren't translated into procedure update. Operating Procedures should demand the same attention as any other critical element. Within Engineering processes it's well recognized to assess the Safety Critical Elements and Performance indicators should be established. Which Performance Standards are established for Operating Procedures? Why does this third line of defence get substantially less attention than the first two? Is this acceptable?

Plant Modifications

Plant modifications are inevitable during the lifetime of a plant. Plant modifications also form a high risk in for incidents if instructions aren't properly updated. The Management of Change Process should cover these risks together with an adequate Deming[4] Process. Operating instructions should be assessed, timely planned, updated and afterwards signed by the responsible Operator and the Management before Start-Up after modifications. It is often seen that Operating Procedure update must be realized in very short time frame under pressure of time and results in moderate update, usually full of gaps and holds. Nevertheless they are common seen and signed as "good enough" for start-up. The show must go on. Please, if you want to gamble, go to the casino.

Brain drain

Research shows approximately 85% of the knowledge is in the heads of the Operators, only 15% is documented. Looking at the life time of many industrial plants including the competent staff, it's expected that experienced operators will retire soon. Companies are only just beginning to realize this major brain drain forms a threat for Process Safety in the future. Operating knowledge is one of the most valuable company assets which deserve the required attention.

Solutions and Recommendations

Based upon thoroughly research of incident investigations reports it is proved that the Process Safety can indeed benefit from up-to-date procedures. These actual incidents are partly the direct result of inadequate Operating Procedures.

How keep the Operating Procedures up-to-date?

- Pay sufficient attention to Operating Procedures
- Don't consider Operating Procedures as a mandatory hobby for Engineers or Operators. Operating Procedures requires Technical Author skills, ownership and usually can't be combined with day to day Operator work.
- Design and implement system to incorporate lessons learnt – especially those from other major incidents - into the Operating Procedures[5]
- Establish system for both regular, as prompt update of Operating Procedures
- Maintain database for abnormal conditions and upsets on a daily basis as a reference for future consulting purposes
- Perform Risk Assessment to the critical Operating Procedures
- Ensure that process start-up procedures are updated to reflect actual process conditions
- Prevent brain drain, do not waste valuable time, and start saving essential company knowledge before it's too late.
- Assign capable experts including Technical Authors skills to the update process

It's furthermore obvious that regular maintenance of the Operating Procedures, result cost reduction.

[4] Plan, Do, Check, Act Circle
[5] Common lessons learnt have reduced effect on major incident prevention [1] [2].

References

1. Report “Onderzoeksraad voor Veiligheid[6]”: “Explosies MSPO2 Shell Moerdijk”
2. The Report of The BP U.S. Refineries Independent Safety Review Panel (Baker Report)
3. U.S. Chemical Safety and Hazard Investigation Board - Investigation Report - Report No. 2005-04-I-TX - Refinery Explosion and Fire
4. Explosion Condensate Tank, NAM Warffum, 31 May 2005

Figure 3 Prevention was required…

[6] Dutch Safety Board