Mandated Human Error Controls in the USA and the Impact on Control Room Design and Operations

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Abstract

The paper will discuss a new approach to safety breaking the traditional barriers of people, organizations and culture and will put the control engineer in the driving seat again for performance improvements optimizing not just control algorithms but people and the way they interface with technology.

In the past the control engineer has been asked, "how many loops can an operator manage" this paper will once and for all provide a rational answer to this question based on years of research and the Best Practices defined by the ASM Consortium.

New Strategy to Improve Profitability and Reduce Fixed Costs

Why is it that **you** always work for the company that has to reduce fixed costs based on some marketing analysis or best practice comparison, that **your** staffing levels are significantly higher than your competitor's sites, even though everyone **you** know has either left or is in the process of leaving the company? You are told that your competitor has fewer operators and they have more responsibility than yours. As a company **you** have to do something to not only catch up to your **competition**, but to get in front of these market leaders, or else.

You have an idea—"lets improve the automation"—but as you start to investigate this solution you discover that this will involve new instrumentation, new wiring, new valves, new software, new hardware, a new control building—and any potential benefits and ROI have already been claimed by other projects. And by the way, don't mention reducing staffing as part of a project justification because that is not politically correct even though you are confronted by the reality of it in the first place.

Your operators need training; they don't use or get much benefit from written procedures because they are too difficult to use, or they are not specific enough, or they have too much detail. You would like to use a simulator but previous attempts to purchase one proved too expensive for current training needs. Your company has frozen capital and is attempting to cut costs using the severed limb or bleeding artery principles. They have attempted to improve reliability; they have reorganized to a point where no one knows what the latest organization is or who works for who.

And after all this, the problem is still there—and maybe a few new ones caused by the recent management improvements.

(If you don't have these problems you must have read the rest of this paper or you are in the process of writing something similar.)

So what is the secret to success? Well, it is doing what you know you should have done a long time ago. This involves new ways of doing projects, maintenance, and operations. It starts with having a "Shared" vision, (Where there is no vision, the people perish – Proverbs. 29:18). The vision will identify the new strategy, for example: - engage the entire production organization in improving reliability, performance, and quality whilst improving efficiency of people, equipment, and materials. So what's so different? **People are part of the vision**.

This will require my favorite 3C's – Commitment, Competence and Cognizance—which can only be administered by Senior Management. These 3C's will allow an organization to become **Production Centered** and have a **Defect Elimination Culture**, because the staff will be competent and well informed. But believe me, it won't be easy because most sites have a history and that history has developed a cultures and set of beliefs and managers will need to change the organization's values and beliefs. Education is not a one time exercise. It's a part of life and the new environment will become a Learning System not just a training program.

Many managers today are putting these basic principles into practice after attending the Center for Process Plant Managements – Leading and Managing Plant Operations Workshop.

In the last 10 years I have worked with one company that has really impressed me. As consultants we often talk about what could be done, but rarely see companies follow through and really do what should be done and could be done. But Nova Chemicals in Canada are a company that once they get wind of a best practice they go about implementing it. One of their V.P.'s was asked during an ASM Consortium meeting. "Why are you (Nova) so willing to share your implementation of these state of the art best practices?" Answer: "Why not? It's not seeing and understanding them, it's having the faith and motivation to do them".

Changes in USA Laws and New Regulations in the UK

Regulators around the world have a history of responding to major accidents by implementing new safety regulations, and the USA and UK are no different. In years gone by the UK government formed the H&SE following major incidents and accidents in the petrochemical and mining industries. Through H&SE many new regulations and acts have been adopted. After the Piper Alpha incident in the North Sea many changes were enacted, including moving responsibility for safety offshore from the Coast Guard to the H&SE.

In 1992, the USA, after the Phillips Petroleum accident and Union Carbides Bhopal catastrophe, OSHA, (Occupational Safety and Health Administration) introduced Process Safety Management (PSM) regulations and the EPA (Environmental Protection Agency) introduced Risk Management Plans (RMP). The regulations are extensive, and many millions of dollars have been spent by companies to comply—but the results have been disappointing to many.

In December 1998, after several refinery accidents, Contra Costa County passed a new industrial safety ordinance (Industrial Safety Order 98-48). This law requires refineries, and some other industries in the county, to develop new safety plans. The plans will help prevent accidental releases of hazardous materials into the community, and also promote worker safety. These are the same goals as that drove PSM and RMP, but **the new safety plans are different**. They require the use of a new approach called "human factors." We'll define this term later. For now, let's just say the human factors looks at safety differently from traditional methods. It's a new way of thinking about safety for refineries, although it's been used before in other industries. The law will impact two critical areas that have been sadly neglected by designers and that is the human workplace, especially the control room, people, and the role they play, and how they interface with the environment and technology. The regulation actually calls for comprehensive Management of Change (MOC) policy for people or organizational changes.

In parallel, in the UK, the Hazardous Installations Directorate (HID) of the Health & Safety Executive (H&SE) have observed that a number of oil, gas and chemical sites are taking steps to reduce staffing levels in their operating teams. There is a concern that such reductions could impact the ability of a site to control abnormal and emergency conditions and may also have a negative effect on staff performance because of the impact on workload, fatigue, etc. This concern has led to a new regulation to effectively implement a comprehensive MOC policy for people or organization changes. Along with the new regulation is a comprehensive structured assessment methodology which systematically covers all relevant issues and will help prevent overlooking potential problems in process operation staffing arrangements when changes are made. We will cover this methodology in more detail later.

Human Factors and Organizational Accidents

Two of my favorite authors, Professor James Reason and Trevor Kletz have both published many books on this subject and have made the subject matter as simple and easy to understand as it can be. Yet, these incidents and near misses continue and we the engineering community keep making the same mistakes over and over again. Our companies don't have mechanisms to pass the knowledge we accumulate on to the next generations, so they learn from the same mistakes that we made. This is what the engineering community calls "Loss of Corporate Knowledge". So what is the problem, how do we fix it, what benefits will it produce?"

In studies done by the ASM Consortium, API, AIChE, CCPS, CMA, etc. all have concluded that 80-% of our catastrophes have a significant contribution from human error, design issues around human factors and how they relate to our basic management systems such as training, procedures, permits, incident investigation, process hazard assessment (HazOp), contractor safety, communications, process safety information, management of change, mechanical integrity, etc.

The research also shows that companies lose significant production opportunity, impact quality, and run at poor efficiencies. The ASM Consortium measured sites with lost opportunity figures in the 3 to 12% range. The data emphasized the role that people and people systems play in contributing to these losses—from simple mistakes like opening the wrong valve to poor response times to intercede when an event is detected. Sometimes this can simply be caused by poor situation awareness because of distractions in the control room. So it goes to show that improved profitability and reduction in fixed costs can be achieved by paying attention to this subject of Human Factors.

A New Approach to Safety

You will find that human factors studies place a lot of emphasis on Human Error, but it's not a question asked so as to assign blame. The goal is to find the reason why errors are made. The traditional safety approach focuses on modifying the behavior of workers. When an incident occurs, the most common thing to do is to investigate what the worker did or did not do. Were the workers following management systems; were they paying attention; did they do tasks in the correct order? The traditional approach often blames the individuals and seeks a solution such that after punishment the worker will work in a safer manner.

Human Factors takes a different view. Instead of looking only at individual behavior to explain an incident, human factors looks at what made the error possible. It tries to identify and eliminate "error likely" situations by studying the whole operation, then seeking ways to remove weaknesses.

The human factors approach is to reduce human error by changing the workplace—and sometimes worker behavior. Sometimes operator error is very likely or even inevitable, given the way the system is setup. You have to look at the whole system to find out why an error happened and find ways to eliminate future errors. This is not very comforting to a widow, so we are challenged to do everything possible to eliminate the weaknesses in our systems before an error occurs. This ideal means we have to be diligent in human factors in design, procurement, installation, operations, and maintenance. Hence, our **vision** to engage the entire production organization in improving reliability, performance, and quality whilst improving efficiency of people, equipment, and materials has just received a little more insight and direction.

Management of Change of People And Organizations

The Contra Costa County regulation requires each employer's safety plan to consider human factors in five areas:-

1. Process Hazard Analysis
2. Root cause incident investigation
3. Operating procedures
4. Management of Change – staffing cuts
5. Employee training

Each of these subjects is important, but for today I want to focus in on one of them—the MOC of people.

How can a site ensure that it has enough process operators with the correct skills and knowledge, ready and prepared to deal with hazardous scenarios?

Control room staffing studies help you rationalize your plant staffing based on your current and future automation, your operating philosophy, and hiring and training practices. Our study methodology is based on an assessment framework developed by Entec on behalf of the Health and Safety Executive in the United Kingdom. This framework aims to systematically cover all the relevant issues and prevent overlooking potential problems in process operation staffing arrangements.

While control modernization projects often afford us an opportunity to reduce control room staffing, such changes cannot be undertaken without some caution. For example,

- Reductions in staffing levels could impact the ability of a site to control abnormal and emergency conditions; and
- Reductions may also have a negative effect on staff performance through an impact on workload, fatigue, etc

Because of these concerns, organizations need a practical method to:

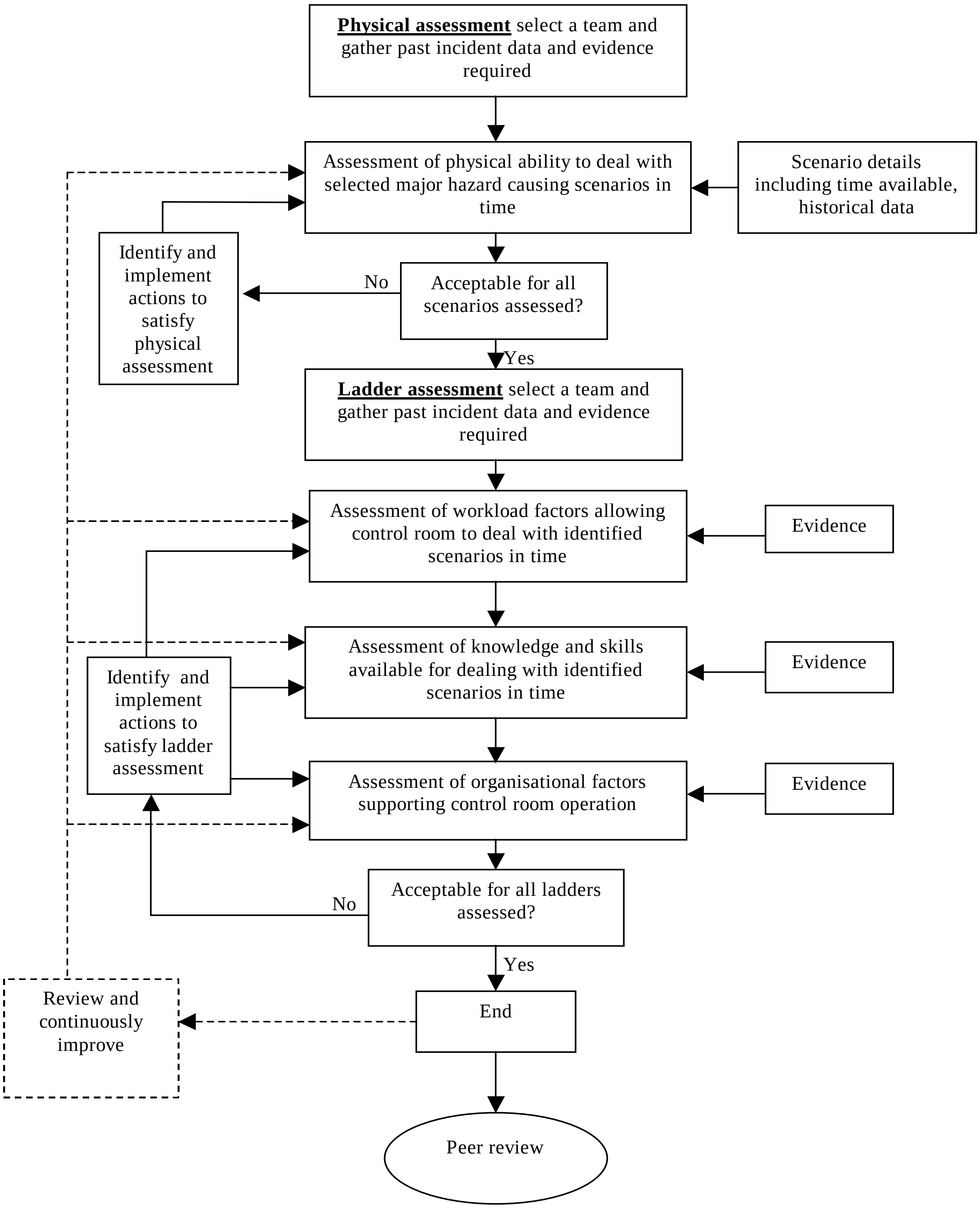
- Assess their existing staffing levels; and
- Assess the impact on safety of any reductions in operations staff.

Method

The UCDS staffing assessment concentrates on the staffing requirements for responding to hazardous incidents. Specifically, it is concerned with how staffing arrangements affect the reliability and timeliness of <u>detecting</u> incidents, <u>diagnosing</u> them, and <u>recovering</u> to a safe state.

The method is designed to highlight when too few staff are being used to control a process. It is not designed to calculate a minimum or optimum number of staff. If a site finds that it's staffing arrangements 'fail' the assessment, it is not necessarily the case that staff numbers must be increased. Other options may be available, such as improved user interfaces, event detection, alarm or trip systems, training, or procedures.

The assessment is conducted in two parts. The first is a *physical assessment* of performance in a range of scenarios; the second is a *ladder assessment* of the management and cultural attributes underlying the control of operations. The overall assessment process is summarized in the illustration below.


Physical assessment select a team and gather past incident data and evidence required
Assessment of physical ability to deal with selected major hazard causing scenarios in time
Scenario details including time available, historical data
Identify and implement actions to satisfy physical assessment
No
Acceptable for all scenarios assessed?
Yes
Ladder assessment select a team and gather past incident data and evidence required
Assessment of workload factors allowing control room to deal with identified scenarios in time
Evidence
Assessment of knowledge and skills available for dealing with identified scenarios in time
Evidence
Identify and implement actions to satisfy ladder assessment
Assessment of organisational factors supporting control room operation
Evidence
No
Acceptable for all ladders assessed?
Yes
Review and continuously improve
End
Peer review

Physical assessment

The physical assessment is completed for a range of scenarios, which should include examples of:

- Worst case scenarios requiring implementation of the off-site emergency plan;
- Incidents which could escalate without intervention to contain the problem on site;
- Lesser incidents requiring action to prevent the process becoming unsafe.

It should also be considered whether it is necessary to assess the scenarios at different times such as during the day and at night, during the week and at weekends, if staffing arrangements vary over these times.
The scenarios must be defined in sufficient detail and historical data relevant to the selected scenarios used in the assessment. Evidence of reliability is required e.g. simulation exercises, equipment reliability data, incident reports.

The physical assessment tests the staffing arrangements against six 'principles':

1. There should be continuous supervision of the process by skilled operators, i.e. operators should be able to gather information and intervene when required.
2. Distractions which could hinder problem detection such as answering phones, talking to people in the control room, administration tasks and nuisance alarms should be minimized.
3. Additional information required for diagnosis and recovery should be accessible, correct and intelligible.
4. Communication links between the control room and field should be reliable. For example, back-up communication hardware that is not vulnerable to common cause failure should be provided where necessary. Preventative maintenance routines and regular operation of back-up equipment are examples of arrangements to ensure reliability.
5. Staff required to assist in diagnosis and recovery should be available with sufficient time to attend when required.
6. Distractions that could hinder recovery of the plant to a safe state should be avoided and necessary but time consuming tasks, such as summoning emergency services or communicating with site security, should be allocated to non-operating staff.

Bottom line is that the physical assessment is concerned with determining if it is possible to detect, diagnose and recover form scenarios leading to major hazards. The assessment aims to give you yes/no on the feasibility of physically dealing with each scenario in time.

Ladder assessment

The individual and organizational factors are assessed using ladders. There are ten ladders in total, organized into three different areas.

Individual factors (workload):

- Situational awareness—Quality of knowledge on current and near future situation. Is it possible to carry out all required monitoring checks in the time available? Includes short term disturbances such as writing work permits. Also covers shift handover and monitoring conditions over a week and re-familiarization after long breaks.
- Team working—Are there support staff available, possibly from outside the control room (role of outside operators0 to assist when there is above normal activity? Are the roles and procedures defined?
- Alertness and fatigue—Use of health programs to monitor possible symptoms of stress. Shift pattern effects on operator fatigue. Sickness rate amongst operators may indicate problems. Includes effect of lighting and temperature on alertness.

Individual factors (knowledge and skills):

- Training and development—For new operators and to refresh existing operators, particularly for major hazard scenarios.
- Roles and responsibilities—Are they clearly defined? Is the team composition defined and based on a structured assessment? Is this reviewed before a possible change to ensure core competencies are maintained?
- Willingness to act—Extent to which operator actions can be influenced by factors such as cost and environment over safety.

Organizational factors:

- Management of operating procedures—System for updating procedures, validating and implementing (including training).
- Management of change—Use of transitional techniques to ease the change whether, people, technology or procedures. Extent of training. Checks in place after a change to review the effects.
- Continuous improvement of control room safety—Techniques expected for continuous improvement include monitoring of product quality; appraisal of operator performance to promote continuous improvement; use of on-site and off-site historical incidents to improve performance.
- Management of safety—Strength of site policy; use of historical data to improve performance; workforce involvement.

Each of the ten ladders is essentially a behaviorally anchored rating scale that provides observable measures and either passing or failing grades. Below are two examples of the ladders. Table 1 is for Training and Development; Table 2 is for Roles and Responsibilities.

Grade	Description
A	Process/procedure/staffing changes are assessed for the required changes to operator training and development programmes. Training and assessment is provided and the success of the change is reviewed after implementation.
B	All CR operators receive simulator or desktop exercise training and assessment on major hazard scenarios on a regular basis as part of a structured training and development programme.
C	There is a minimum requirement for a 'covering' operator based on time per month spent as a CR operator to ensure sufficient familiarity. Their training and development programmes incorporate this requirement.
D	Each CR operator has a training and development plan to progress through structured, assessed skill steps combining work experience and paper based learning and training sessions. Training needs are identified and reviewed regularly and actions taken to fulfil needs.
W	All CR operators receive refresher training and assessment on major hazard scenario procedures on a regular, formal basis.
X	New operators receive full, formal induction training followed by assessment on the process during normal operation and major hazard scenario's
Y	There is an initial run through of major hazard scenario procedures by peers.
Z	There is no evidence of a structured training and development programme for control room (CR) operators. Initial training is informally by peers.

Table 1: Example ladder (for training & development)

Grade	Description
A	Prior to any proposed change to equipment or procedures the core competencies required for the operations team are reviewed and any new core competencies required after the change are introduced.
B	The operations teams are selected and then trained on the basis of the core competencies identified. Operator development is assessed against these criteria.
C	There is a management control in place to ensure that core competencies required for the operations teams are retained during any staffing changes.
V	Additional roles such as First Aid, Search and Rescue team member are taken into account when assessing the operations team's ability to cope with normal and emergency situations.
W	Roles and responsibilities within the operations team are clearly defined so that each individual knows their allocated tasks and responsibilities in normal and emergency situations.
X	A structured approach has been used to identify the required team competencies.
Y	There is a general job description for each member of the operations team.
Z	There is no definition of team roles and responsibilities. There is no identification of core competencies.

Table 2: Example ladder (for roles and responsibilities)

Assessment output

The method identifies areas of unacceptable risk in process operation staffing arrangements and provides target areas for improvement action. Typical output actions include:

- Evaluate costs and benefits of improvement options identified;
- Further investigation required, such as determine the reliability of equipment, further analysis of critical tasks, check assumptions about the behavior of leaks;
- Consult with a human factors expert on key judgments.

The output from the method is an action plan for each assessed element. The priority for improvement actions is:

1) Improvement actions required to ensure the reliability of the operations team being physically capable of detecting, diagnosing and recovering from scenarios.
2) Improvement actions required to move the staffing arrangements above the acceptable line on all ladder elements.
3) Improvement actions required to continuously improve the staffing arrangements towards best practice.

Practical application

It is recommended the staffing assessment be managed similarly to other process safety assessments, such as HAZOP or risk assessments supporting a safety case.

It is recommended the assessment of a defined production area be coordinated and facilitated by one person who is technically capable and has experience of applying hazard identification and risk assessment methods. The role is similar to that of a HAZOP chairperson.

In addition it is recommended that the assessment team constitute:

- Control room operators: experienced and inexperienced plus operators from different shift teams;
- Staff who would assist during incidents, perhaps in giving technical advice to operators or with tasks such as answering phones;
- Management or administration staff with knowledge of operating procedures, control system configuration, process behaviour, equipment and system reliability, and safety (including risk assessments and criteria).

Teams may require assistance from Human Factors specialists.

When to apply the method

Good practice will be to apply the method in full and to review and reapply the method periodically.

Changes in staffing arrangements (or other changes affecting the response to emergency or upset conditions) should be evaluated prior to implementation. Any change that could alter the rating from the method is considered to be a change in staffing arrangements. A guiding principle is that changes should not lead to a reduction in the assessment rating.

The procedure for analyzing proposed changes is:

- Produce an up-to-date baseline assessment of the existing arrangements;
- Define the proposed change and evaluate it using the assessment method, modifying the plans until an equal or better rating is achieved;
- Re-assess the arrangements at a suitable time after implementation (within six months).

Benefits of the method

The comments from the case study participants indicate that the method:

- Brings staffing issues into the open;
- Enables the adequacy of staffing arrangements to be gauged and the impact of staffing changes, particularly reductions, to be assessed;
- Is practical, useable and intelligible to duty holders and inspectors; and
- Is robust and resistant to manipulation and massaging of its output.[1]

Workspace Designed To Optimize People and Technology

Control Building Location Issues

The location of a control building can significantly impact the operating team's performance. The trick is to understand if there is a requirement for a strong collaborative structure and the quality and reliability of remote communications. The question comes down to who is it more important to have face-to-face communications with? Is it other field operators on the same unit or other console operators on an adjacent unit that may impact control through feed or utility relationships between units?

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[1] **The autor acknowledges the work of Entec & H&SE (UK) staffing methodology.**

An example of the complexity of this question was defined in the Nova Chemicals Ethylene Project. A methodology was developed for making a decision on the location for the control building/room. It was more complex than just selecting a space on a map—the decision included discussion on whether all three of the existing Ethylene plants should be consolidated into a single control building; should other units on the site be consolidated into a centralized control building; what would be the benefits; what impact would a consolidated control room have on operations?

The project team first did a literature search to identify what existed in the industry to indicate what are the current standards, issues and benefits. The team identified a draft ISO standard, which was a good basis for a design methodology although it did not address control-building location. The only path forward was to follow sound engineering practices of good project management and identify opportunities and review possible problems.

Multi-disciplined teams met and brainstormed alternative control building solutions and attempted to evaluate strengths and weaknesses of each of the proposed alternatives. Finally each solution was boiled down to four key areas, which were Cost, Impact on People, Safety implications, and Business Opportunities or Issues.

The three solutions reviewed were:

- Remote – Centralized Control Building
- Centralized Control Building within Battery Limits
- Individual Distributed Control Buildings

Initially the team had expected to recommend a remote centralized control building, which would serve all units on the site; though virtually everyone one on the team had their own preconceived ideas on what the best solution would ultimately look like. The great value of the process followed was that the team achieved a **shared vision** for the ultimate solution, including a clear understanding of why compromises had to be made and what it would take to strengthen the identified weaknesses with the identified solution.

Cost was an issue, just like any project, but the team did a good job of identifying the real costs for the project; for example, the costs associated with building a remote centralized control building did not end with the single building's estimate. Instead, the team also identified that any centralized building would require some form of local building structure for field operators and a safe haven for maintenance and contractors. The difference between a remote site and one within battery limits would impact building costs—the local solution would require a blast resistant structure, while a remote structure would require additional buildings.

Costs associated with demolition were also taken into account such as moving existing piping and equipment.

Impact on People focused on communications, collaboration, team activities, distractions, delays, reliance on technology, manning levels and placement of expertise.

Safety Implications looked at the compromises associated with exposure to hazards. It is argued that the closer the building is to the unit the more effective the occupants could be in operating and maintaining the plant by being closer to the hardware they manage or the people with whom they interface most frequently. It is arguable that there is less likelihood of there being an accident due to better communications between key groups of people.

The closer the people are to the unit the higher the risk they run of being exposed to the consequences of the hazards of the plant should these consequences be realized.

To balance these hazards it is important to consider the protection given to the people by the buildings they occupy. The closer to the hazards the more protection the buildings must provide, hence the more it will cost.

Business Opportunities such as optimization and speed of response to change must be weighed against poor performance due to communication breakdowns, lack of teamwork, loss of knowledge and expertise.

The team selected individual control buildings for this site based on the evaluation. This solution was more expensive, but had a stronger positive impact on people as several of the plants units were batch processes which required strong collaboration between field and console operations. The individual ethylene plants had no strong requirement to improve communications between units over and above existing solutions such as computer monitoring of other units by a single unit, use of telephones and radios. In fact a best practice was identified in the way Nova operators work together during a disturbances and how they rehearse potential scenarios after an event. The team felt that this solution provided a better business opportunity as individuals would be focused on the business, security would be improved, increased ownership of problems, less interference and confusion, and less impact on common mode failures.

Control Building Design Process

From this initial project a new way of doing control building projects has been established and used successfully. The first critical step is to create a shared vision for the control building and how it will operate. The activities in this first step include:

- Interviewing a cross section of management, engineering and operations personnel, usually over a one week period.
- A review the current operating practices and opportunities to implement Best Practices
- An analysis of building location based on cost, people implications, safety related risk assessment with consideration of API - RP752, and a business case.
- A review of the impact of the project and it's alternatives on people and organization.
- Developing an order of magnitude cost figure for each of the alternatives based on building type and square footage
- Identifying the benefits and project risks
- And finally developing a list of recommendations covering priorities and ways of achieving long and short term vision goals.

Once the shared vision is created, the work of the detailed control building design can commence. The design process begins with the operator and works outward. The major activities include:

- A task analysis needs to be completed for present and future jobs, especially when remote centralized solutions are implemented. Key issues include whether rotation is required between jobs and if field operator jobs will migrate to equipment specialist roles.
- A clear description of the current human machine interface needs to be documented—what information does the operator need, when does he need it, how and where will he get it, as well as which tasks will be done manually and which will be done by automation.
- Development of a functional specification that includes console layouts and room adjacencies and priorities.
- And finally, development of a control building detailed design specification that includes mechanical systems HVAC , security, lighting, communications including operator log books, telephones, video conferencing, large overview screens, etc. It is in the development of the detailed design that you will find the greatest benefit from an experience control room architect.

A Note about Selecting an Architect

Selection of a suitable architect and builder is a big topic and can impact the functional use of the building. Architects work like project managers and coordinate lots of different disciplines that produce a building, including HVAC Engineers, Structural Engineers, Acoustic Engineers, Lighting Engineers, CAD operators, and interior designers. This sounds good, but when you evaluate an architectural firm you often find that their project management skills fall very short of your company's standards and that their ability to get and understand your functional requirements is almost impossible based on their perception of our industrial world.

Architects often have a major project management role coordinating and managing builders, so it is important that a firm with the right people and significant experience be selected or you will find problems in the final product. For example, the lighting design produces glare problems from ceilings and floors, and the operators retaliate by switching the lighting off. Or that the acoustic s are so bad that the operators cannot hear themselves think as audible alarms and radio noise escalate and conversations get more stressful and louder. Or poor traffic flow in a building can cause unnecessary disturbances to console operators.

Lessons Learned on the Nova Project

The draft ISO standard (11064) did help us with the Nova project; it did not explain how to do the job but gave us some very good clues. Section 1 (of 6) explains that the most important step is to get a shared vision and involve all relevant employees. We have found from past experiences of doing this type of activity it is important to get the senior management's view of the current situation and extract a challenging vision, initially for the next 5 years for the unit and then for 20 years. Our interviews with other managers, project staff, and other employees identifies how well (or poorly) shared the management vision is and how much understanding the management have of what really happens at the sharp end, i.e., if policy matches culture.

Interviews with users of the building such as engineers, managers, supervisors identifies how they interface with the process and the primary users of the building—the operators. Their needs and requirements will be different to the primary users as they are usually on days. The primary user may not be able to articulate what the future looks like but they are a great source for revealing what works and what does not work in the existing environment and they have an insight into what will and will not work in a new solution.

Our experience has been that it is more efficient and productive to interview management individually over a 1-hour time slot and to spend a good part of a shift in the control room with operators observing and asking casual questions and getting their buy-in to a potential solution. We explain that the process we use is an iterative process and the design is refined by lots of reviews with this multi-disciplined team until each person understands why we have proposed something and why we might have rejected an idea or two.

The shared vision will also help us understand how people do their jobs currently and how they may do them in the future; who they need to be adjacent to; who they have loose communications and collaboration with; and which support functions must have a priority adjacency to the control room. The information we gather will identify if the operators need to see each others screens, if they should always have eye contact, how much verbal communication is required, what shared facilities are and were are common mode failures. How and when do we segregate people to avoid disturbances such as permit issue and closure at the beginning and end of the day? How traffic is controlled in the building, how the design will allow view but will isolate disturbances and noise.

Once we have this information we can develop a console layout based on communications and collaboration, a control room layout based on the operators' need for information, and finally an entire control building layout based on priority adjacencies (for example, which is most important, the bathroom, the kitchen, the conference room, the supervisor's office, the engineering workstation, etc.).

The Nova project was a great example of how we managed to maintain one-on-one communication and collaboration between field operators and console operators, and at the same time directing work permitting traffic flow to one segment of the building away from the console operator. This was done by creating a separate field operator work area. Other requirements were to provide supervisors and managers a place where they could observe without crowding the operator, and giving the application development engineers where they could work in isolation but be close top observe and communicate with operators during the testing and commissioning of new software applications.

The other turn that the project took was that Nova had a vision for providing tools for operators on 12-hour shifts maintain vigilance and deal with sleep deprivation in the transition from day shift to night shift. They had developed a loss prevention standard that would support the healthy-body-healthy-mind attitude. For example, operators often struggle to stay awake because their body is physically telling them it should be asleep and not much activity is going on because the process is running smoothly and is not disturbed. As a solution, Nova invested in an exercise room for operators to use during quite periods and at scheduled breaks. They also have Rest Recovery Rooms (nap rooms) were an operator with a sleep problem can obtain permission to take a 40-minute nap as long as the plant monitoring is covered, and the is genuine and approved by the team of operators. The operator does not get into the full sleep cycle, but in a reclined chair can get into the first couple of stages of non-REM sleep and be fit for over eleven hours of productive shift work rather than being slow to respond, sluggish and brain dead for the whole shift. Nova have also invested in dynamic circadian lighting systems to also help operators adjust to night work.

This control building was also unique because it has a maintenance block and a small administrative office facility associated with it, due to the extreme winter conditions in that part of Canada. This impacted traffic flow, parking, noise, and available adjacencies.

In all the methodology produced an outstanding building. But, the building is not the only good thing to happen on this project. The design process identified other opportunities for business advantage. The building is designed to ensure the operators and other personnel have good situation awareness, which is also reflected in the console design and the use of custom consoles to meet the needs of the operator. The information presented at the consoles is also optimized and designed to best practices. After reviewing the best of the best companies alarm management and graphic displays, Nova Chemicals took the work of these companies and the ASM Consortium guidelines and developed a state of the art alarm management system, which was not done as a one-off. They developed a company loss prevention standard that reflected the work of AIChE Automation Guidelines, EEMUA Alarm Management Guidelines and IEC 1508 standards. Plus particle input from BP Chevron, Exxon, Celanese and other ASM Consortium members such as Honeywell.

And finally, a major issue in the past in control rooms is poor design of displays so Nova addressed two major issues; navigation of information and quality of the displays based on ergonomic and human factor standards identified by the ASM Consortium and work that Nova Commissioned with Honeywell Technology Center (Honeywell Labs) and University of Toronto.

Conclusion

Once again the impact of this project has changed the way control buildings will be designed, built, and maintained. Nova is an example of how the ISO 11064 parts 1 and 3 can be implemented and what the benefits are of applying best practices. The project has prompted the ASM Consortium to sponsor a project to measure the benefits of things implemented at Nova.

The basic methodology has confirmed that the shared vision is so important and if no feasibility study has been done this step needs to be done first.

Reference Material

- Managing the Risks of Organizational Accidents – James Reason – Ashgate books
- Human Error – James Reason – Cambridge books
- Lessons from disasters – Trevor Kletz – Gulf Publications
- Computer Control & Human Error – Trevor Kletz – Gulf Publishing
- ISO 11064 Ergonomic Design of Control Buildings
- Assessing the safety of staffing arrangements for process operations – H&SE (UK) Entec (UK)
- California's Contra Costa County Human Factors Industrial Safety Ordinance 98-48
- Cal/OSHA's Process Safety management (PSM) standard
- Cal/EPA's Risk Management Plan (RMP)
- **Assessing the safety of staffing arrangements for process operations in the chemical and allied industries**

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