Figure 1. ISO 11064.

Designing a control building

Ian Nimmo, User Centered Design Services LLC, USA, provides valuable information on what aspects to consider when building a new control building.

One may be faced with an instrumentation and control system upgrade, or be fortunate enough to be building a new unit, but both of these require design of a new control building. Most plant engineers do not have a great deal of experience of doing this because the opportunity only comes around once every 30 years, which can be both a blessing and a curse.

Building location

To date, the international standards for control building design do not attempt to address this issue and are very generic, meeting the needs of other industries and not just petrochemical and refining. One of the few documents that provide some guidance is the API Recommended Practice RP752, Management of Hazards Associated with Location of Process Plant Buildings. The publication states that this recommended practice (RP752) should provide guidance for identifying hazards that may affect process plant buildings and for managing risks related to those hazards.

An analysis process set forth in this recommended practice provides a structured approach that can maximise worker safety by the following:

- Continuing to improve the understanding of identified hazards.
- Continuing to focus on accident prevention and addressing identified hazards.
- Managing risk.

The methodology recommended in this document will help to provide the user with an understanding of the relative risk of each building studied. This relative risk should be considered in long range planning and projects that involve building changes, such as control building consolidation, office building replacements and so forth[1].

The document focuses on occupancy criteria such as the length of time that an operator will spend in a building; in practice they are spending longer than anyone anticipated especially as their jobs become more computer driven. The criteria is difficult to justify especially if you say that one person is fine but 10 are not acceptable, and the union says, 'Hold on, are you putting a value on an individuals' life?' So these studies can become extremely political and emotional.

The document does not address critical issues such as:

- How close should people be to the unit to satisfy close monitoring and response to emergency situations?
- What is automated or should be automated?
- What is dependent on an individual to do in an emergency?

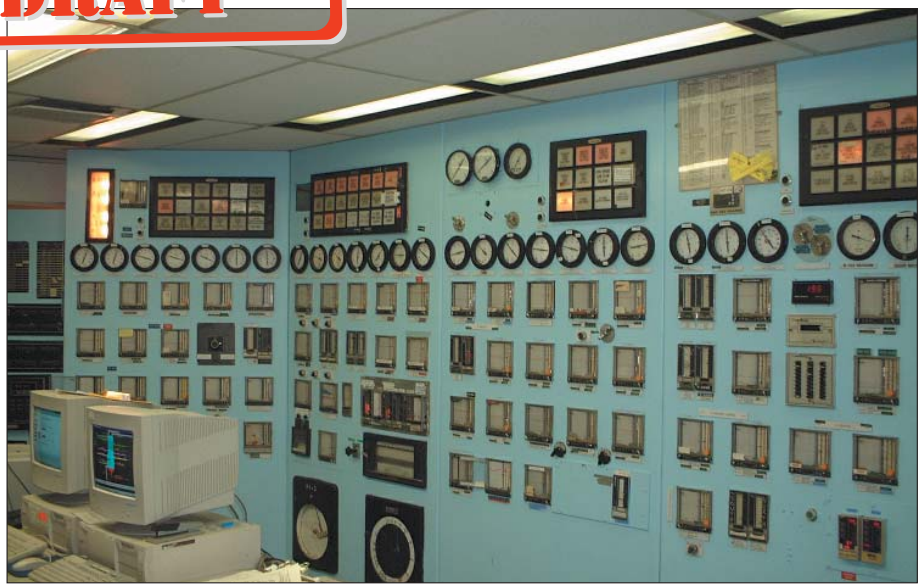

Figure 2. Traditional instrument panel to be replaced by DCS.

- The document does not distinguish 'walk time', the time from becoming aware of a situation to getting to the equipment under control.
- Operators still have some functions that demand that they be present at the sharp end, such as lighting furnace or introducing energy source. Many valves that are required to isolate a unit are still manual and require an operator to manhandle them, a lot of rotating devices require reset and start in the field.

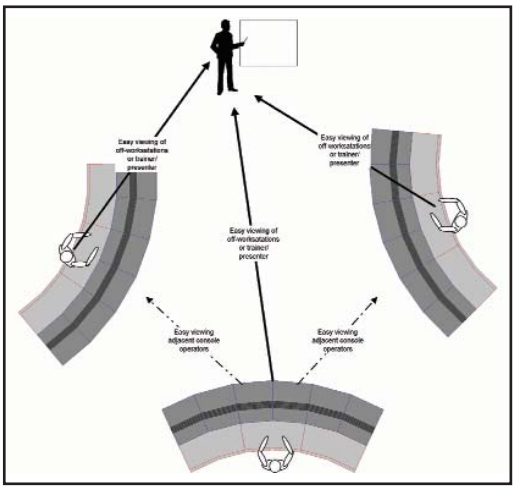

Figure 3. Console adjacency 90˚ relationships.

Task analysis will help designers to establish where the optimum building location is to meet this criterion. Other questions that must be reviewed for each operating state are:

- What is the communication and collaboration required between operating team members such as field operator to panel/console operator, console operator or unit operator to similar positions on another unit?
- Does the console operator have charge and direction over a field operator who is not in his unit?
- Can a situation occur because of breakdown of information between teams?
- During a startup do operators need to meet face to face to establish and confirm strategies?
- What alternative design can be made if the operators are separated by distance?
- What happens if radio communication is lost?
- Does the plant have redundancy for communication or do the operators have a procedure to follow in the event of common mode failure of communications equipment?

Often this type of project forces companies to move from inside/outside operator roles to dedicated inside/outside operators, which can have a big impact on safety, communications and existing management systems.

These are important issues to consider and some guidance is required, the person doing this job for the first time may never get to these and similar questions until it's too late. The building would be built, but unfortunately in the wrong place and will remain that way for at least 30 years, maybe forever.

The closer the building is to the plant, 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. It is arguable that there is less likelihood of there being an accident due to better communications between key groups of people.

However, the closer the people are to the plant the higher the risk they run of being exposed to the consequences of the hazards of the plant should these consequences be realised.

To balance these hazards it is important to consider the protection given to the people by the building they occupy. The closer to the hazards, the more protection the building must provide and hence, the more it will cost. However, if the decision is made to reduce costs and then later build a building for the field operators and maintenance personnel these cost savings soon disappear.

Motivation so far has been the safe location of people. Other benefits come from consolidation that may impact operating efficiency and this is the opportunity for upstream, downstream and utilities console operators to collaborate. However, relocating several groups of console operators into a single control room will not ensure collaboration. Many design issues inside a single room have re-enforced segregation of console operators. Minor issues such as different lighting requirements, different environmental requirements (some like it hot), disruptive maintenance activities in one area, constant field radios communication, likes and dislikes of background music and excessive alarm activation.

Operators will sometimes be stubborn and ask for things that are not correct, their motivation is biased by what they know and they often have good reasons for asking for them. They ask for segregation because previous designs allowed noise disturbances from radios, fans, printers, people traffic and glare from task lights. Someone has to understand their issues and have logical solutions to the problems they are concerned about.

Part of the International Standard Ergonomic Design of control centres: ISO 11064 is creating a shared vision, this involves education at all levels in the organisation and it requires managing conflict and negotiating compromises.[2]

The focus should not be limited within the building but should extract the needs of the field to control room operator collaboration and communications. Instinct never gets communicated in formal communications and from previous installations, major problems and an increase in incidents can be seen due to this.

Implementing control building standards

Once the building location has been established it is important to document the shared vision, which will be a summary of the management team's projection for the future of the business, identification of related projects, a clear understanding of the instrumentation and control vision/strategy.

The vision will contain understanding of the staffing/organisational needs and training plans. The final part will be the integration of the primary and secondary users needs and how the people will work in the building and what facilities will be provided for them. Aspects such as alertness recovery and how to deliver solutions that will help operators stay alert and awake should be considered.

The ISO 11064 –1 Phase A addresses these and many other issues by working through a section called clarification of goals and background requirements. It treats all the individual requirements as subsystems to a target system: the final design. The standard identifies but does not provide any detailed information about quality.

The standard has bullets to investigate general description of the target system (control building within the plant system), safety and security requirements, operational and control requirements, ergonomic requirements, restrictions and constraints. This is more of a documentation exercise and does not show how to use the information in the design.

Phase B: analysis and definitions, addresses the role of the operator in the building and is more practical but requires some experience in task analysis and plant operations to successfully do the analysis it alludes to.

Phase C: integration concept proposal; to develop, based on task requirements for the human/machine/system and on job specification assigned to each operator, sets of validated functions or specifications for the design of control centres:

- Conceptualisation of control centres.
- Verification and validation of the proposed control centre concept.

Within the nest of tasks is a very critical step buried within the jargon and that is the future alignment of staff after the project. Most projects like this do not start life consolidating jobs or purposefully eliminating positions, but the opportunity to align units that provide feed or have a critical impact of the product being produced and to provide improved communications, collaboration and better situation awareness drive the project and the benefits that the project achieves. Experience reveals that it is best to get this information by talking to operators about their jobs, what works well and where the challenges lie. Ask the operator to walk through different plant scenarios such as a startup, shutdown, common disturbance and worst case scenarios such as loss of electricity, steam, feed, etc. Confirm this and more detailed information around unit interactions with a process development engineer. Review incident reports or near misses, sometimes a write up of these cannot be found and the information has to be extracted from the plant personnel. There is no substitute for knowledge and experience here.

UCDS's goal in user centred design is to maintain good situation awareness and have dedicated breaks for rest recovery, which could potentially include some coffee breaks (as per shift worker circadian technology practices); exercise, which is a proven technique to stimulate individuals and similarly so is taking a shower. Newer, more political techniques such as power naps are available in approximately 20% of the industry according to recent reports but it does come with many controversial issues that often get in the way of the benefits of this technique.

Selecting an architectural firm

Selection of a suitable architect and builder is a big topic and can impact the functional use of the building. Architects are not judged by their drawing skills, or creative building design skills, which is common in other buildings, they work like project managers and co-ordinate many different disciplines critical to the integrity and functional use of the building. These include HVAC Engineers, Structural Engineers, Acoustic Engineers, Lighting Engineers, CAD operators and interior designers. This sounds impressive, but when an architectural firm is evaluated, it is often found that their project management skills fall very short of one's own company standards and that their ability to understand one's functional requirements is almost impossible based on their perception of one's industrial world and their ability to manage contractor costs and schedules.

Architects often have a major project management role co-ordinating and managing builders, so it is important that a firm with the right people and significant experience is selected or problems in the final product, scheduling delays and budget overrun will occur. For example, the lighting design produces glare problems from ceilings and floors and the operators retaliate by switching the lighting off. Or the acoustics 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.

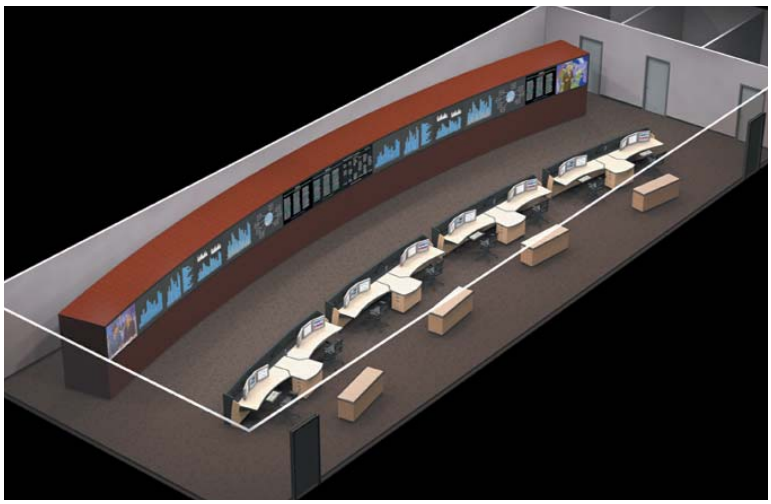

Figure 4. Bringing the big picture back to the control room.

Remember architects are often paid by the ft^2 so they have an interest in big, eye pleasing buildings, often in conflict with the user requirements and desired functionality. Some industrial control buildings have been built more like churches with fancy materials and dome ceilings that provide inadequate lighting, noisy control rooms and poor functionality.

The building design is only one element and having an architect that has their own resources and disciplines in the structural design, electrical design, civil engineering and interior decoration can be an advantage reducing the project management issues and delays in the schedule.

Selecting a builder

Selecting a builder is often completed in collaboration with the design architect. The architect likes to have the builder employed on the project at a very

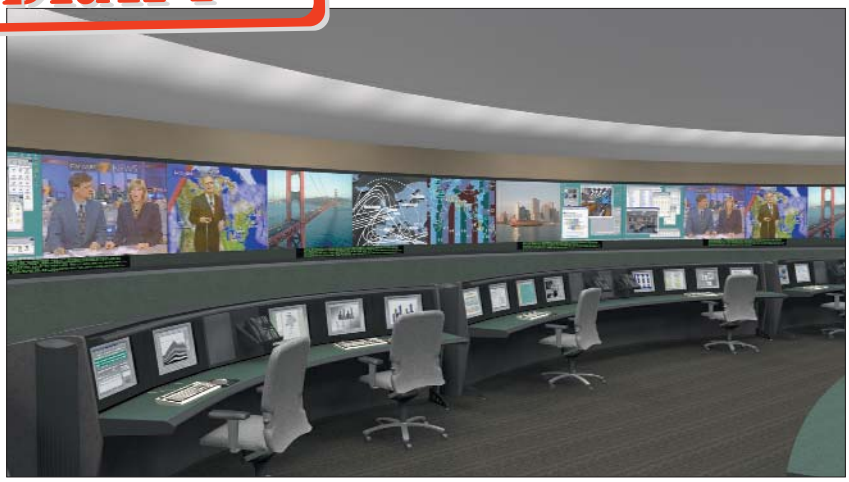

Figure 5. Theatre seating view.

early stage in the programme. Some builders can eliminate the need for an architect on smaller projects as they often have all the necessary resources to design and build the building. These companies often do not specialise in a type of building and do not have the detailed knowledge to extract the user requirements for a control building. Involving people (consultants) knowledgeable in the ergonomic design area can mitigate this shortfall. A company's experience of a builder can be a critical element in the decision process, especially extremes of experience good or bad. It is important that the customer understands the contract conditions and a good architect can help the customer understand the contract implications.

Console layout and ergonomic considerations

Console layout is determined by user needs. The most important needs are communication and collaboration, considering information sharing if visual or verbal and the use of common equipment. Some companies have a goal to bring the 'big' picture back into the control room and are using large overview displays, which often cause a conflict with workstation grouping (Figure 4). The conflict arises due to the theatre seating view required to exploit the large overview displays (Figure 5).

To determine the features required for the workstation grouping it is important that the ISO process is followed, the shared vision is determined and the task analysis is completed. Within the task analysis it is recommended that this is carried out based on real life scenarios dealing with start-up, shutdown, product changes and known disturbances. Within each of these scenarios the communication, collaboration and information sharing is determined together with potential distractions such as increased radio traffic and people movement in the control room.

The final influence is the room configuration; with a new building the console layout determines the room shape and size, but with an existing building compromise is always necessary.

In the past companies have put console operators sitting back to back (Figure 1). The back to back configuration has few positive features and one that is suggested by the ISO is questionable. They consider noise interference to be reduced, but when consoles are configured this way the speakers for radios, phones, PA system and alarms all face into the centre and interfere with adjacent operators. People accumulating behind the console operator cause disturbance.

Having the console face walls allows the designer to utilise acoustic panels to absorb the sounds generated at the console. A more modern style inline with the ISO features demonstrates the 90˚ configuration, which highlights a limited front viewing, easy console operator eye to eye contact and verbal communication. This layout also facilitates speaker noise to be directed at wall and acoustic panels (Figure 3).

People changes and management of change

Modifications to plant equipment and processes have been covered for many years now by a comprehensive management of change programme regulated by EPA and OSHA regulations. The current MOC programmes carry out some form of risk assessment and a comprehensive documentation of changes. Recent thinking has evolved to include people or organisational changes in this requirement. A close coupling to human factors issues has been included in this new area.

One tool developed by the UK H&SE and implemented by User Centred Design Services LLC provides a staffing assessment that meets these mandates.[3]

Conclusion

Designing a control building requires experience and knowledge of today's effective practices and industrial guidelines. When building a control building it needs to be adaptable for the changes in the daily functions:

- It is a communication and information centre.
- It is the distribution, co-ordination and control centre for plant work.
- It must be suitable for 24 hour operation in 8 or 12 hour shift system.
- It is a alertness recovery facility for console operators.
- It is the main training facility for operators.
- It is an emergency response centre.
- It may be a control application development centre, used in the definition design testing and maintenance of software applications.
- It may be the facility to coordinate plant optimisation.

It is important to remember that what is invested in today will be in service for probably more than 30 years, so it is best to get it right or the company's future could be impacted.

Control buildings are not just a place to fit equipment; they facilitate human performance, protect employees and facilitate communications, collaboration and plant optimisation.

Most companies do not have the staff with the skill set to design and build a control building, selecting contractors can be critical to the future of a business, there is no substitute for experience, knowledge and use of standards, guidelines and effective practices.

References

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3 NIMMO, I., 'Mandated Human Error Controls in the USA and the Impact on Control Room Design and Operations by UCDS LLC', *Assessing the safety of staffing arrangements for process operations in the chemical and allied industries* Prepared by Entec UK Ltd for H&SE Contract research Report 348/2001CEP 11/02.
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Acknowledgements

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