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Control Room Design: Best Practices and Lessons Learned From a Multi-Disciplinary Perspective

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Introduction

Control room design directly affects the safety of the operations, whether it's a new build or a renovation. Regardless of the type of project, there is a unique opportunity to optimize the human performance within the system. By using a best practice approach and hiring the right multi-disciplinary team early in the design process, the road to a state-of-the-art control building is paved with technical and financial efficiencies. A one-stop shop/ one team approach that includes the client, architects, human factors engineers (HFE) and interior designers with control room experience can make the design process much more streamlined rather than a struggle. Best practices and lessons learned are automatically interwoven into the design process to make for a seamless approach.

This paper describes a best practice approach to control room design, the importance of using an experienced and integrated multi-disciplinary team and some key issues that need to be considered.

Steps to a Successful Control Room Project - New Construction or Renovation

Following a set methodology, each control room design process can deliver exceptional and tangible results. When a project need is identified a design team is formed. Who that team is can facilitate the project process. An experienced control room design team integrates lessons learned and best practice knowledge for the new facility. The design is fine-tuned throughout the design process based on feedback from many parties. As a result, the end product, **the building**,

will have received input from operators, staff and key project stakeholders and is a multi-disciplinary collaborative creation.

Figure 1: There are Steps to Successful Control Room Design

The Need for a New Building or Renovation

Why build a new control building or renovate an existing building?

There comes a time when existing control buildings are no longer safe to occupy at the plant because of proximity to potential overpressure scenarios, or because they no longer meet current fire or building codes. They may not be ergonomically correct, or provide a human-centric work environment. There also may be a need for an automation upgrade or a refresh requiring workstations that may be larger or re-positioned to facilitate better operator communication and efficiencies. Another important consideration is the need to attract and retain the up-and-coming millennial workforce that will not want to work in 1950's era concrete-block buildings that haven't been appropriately upgraded since they were built. Engaging the right team can provide an introduction to the 21st century of great control building design.

Build a Great Design Team

The motivation to design a state of the art facility starts with the owner. Engaging an experienced architectural team consisting of architects, engineers, human factors engineers and interior designers all under one roof, rather than a piecemeal approach simplifies the design effort.

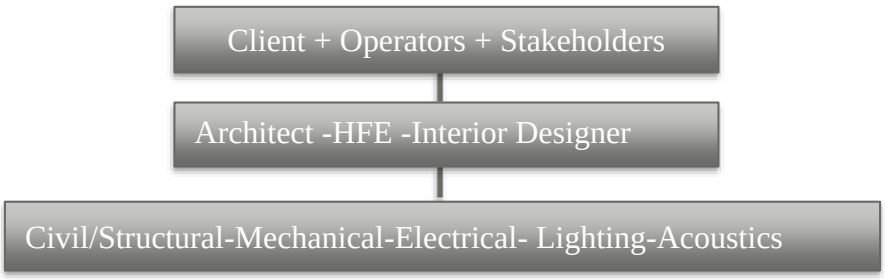


Figure 2: Ideal Control Building Design Team

The roles and responsibilities of each discipline are a vital piece to a complex puzzle:

- **Architect** oversees the overarching concept and the design team (including structural, mechanical, electrical among others) and keeps the project on course
- **Human factors engineer (HFE)** ensures a human-centered approach based on ISO-11064 and industry best practices
- **Interior designer** integrates all of the disciplines together into an operator centric, ergonomic and functional environment

By hiring experts in the design of control buildings ensures the building will be designed correctly the first time, reducing human error, avoiding costly renovations, accidents and illness related to poor design. Together, the team of specialists works collaboratively to design a control building that meets the needs of the operator. Lastly, an experienced building contractor can make or break the project by providing cost and schedule control to keep the project on budget and on time, as well as risk mitigation so that the jobsite stays safe. Collaborating with the owner and architect, the contractor turns the team's vision into a reality.

Planning and Managing the Change

Many organizations are often good at managing **technical** change. Some have change management systems and processes which help to ensure that technical changes are risk assessed so that fewer unforeseen consequences occur.

The same cannot generally be said for **organizational** changes which may not be subject to the same degree of scrutiny. Organizational changes also need to receive comprehensive planning, risk-assessment and management through the transition to reduce the risks related to major accidents. The key success factors for Managing Organizational Change are:

- effective planning for the organizational changes
- communicating and involving key site personnel
- assessing the risks relating to the change:
  - risks from the process of change
  - risks from the outcome of change
- introducing and monitoring the change as it transitions.[1]

Specific change management preparation for staff includes:

- providing up-front technical training to prepare for new systems
- selecting and nurturing a highly respected project team
- preparing leaders to lead the change in their areas and to collaborate across enterprises/departments
- following a disciplined change process
- sustaining new positive behaviors after implementation[2]

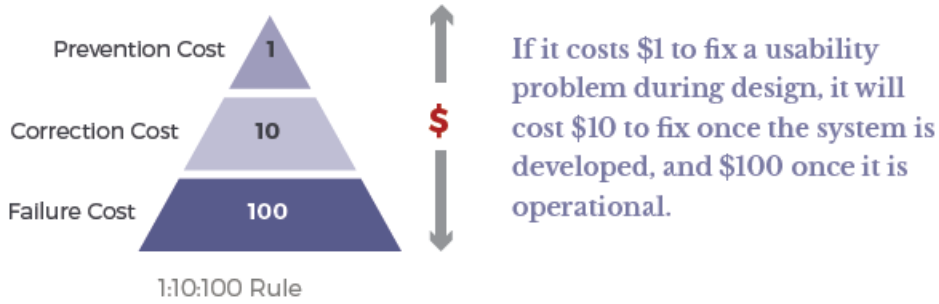
As the change is implemented, senior management should be the positive example for the change behavior and reinforce those behaviors in others with positive feedback to move from resistant to resilient.

[1] Keil Centre MoOC document 2016
[2] Chevron El Segundo ROC PowerPoint for Honeywell Users Group 2016

"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change". [3]

Front End Engineering and Design (FEED) Planning

Best practice includes allowing sufficient time in the Front End Engineering and Design (FEED) phase to adequately plan and design a control room integrating HFE and ISO 11064. Before the project gets too far down the road, **risks and tasks** are analyzed, adjacencies and future expansion needs are identified. Drawings are produced and revised until general consensus is reached. To have upper management commitment and better yet, a HFE champion and liaison from the company on board to work with the team from the beginning and throughout all phases of the project offers the most successful approach to control room design. Involving HFE early in the FEED stage to provide expertise at the beginning lays a strong foundation for the development of the successful design. Involving end users in decision making throughout the process makes for a stronger design solution and allows for their early buy-in. Designing the work environment ergonomically to suit the user is proven to reduce human error, accidents and illness, and designing it right the first time utilizing the expertise of an HFE and control room architect can save costly redesign efforts after the building is up and running. The 1:10:100 rule of thumb has been established through experience and case studies. If it costs $1 to fix a usability problem during design, it will cost $10 to fix once the system is developed and $100 once it is operational.[4]



The goal is to design it right the first time by eliminating safety risks and hazards like noise, fumes, glare, ineffective room layouts and furniture that lacks ergonomic considerations. Identification of any factors that may negatively affect the operator and the ability of other personnel to detect deviations, diagnose the situation and take action following a given abnormal situation are then used as a basis for design recommendations.

In renovating an existing facility, the same logic applies. The team can provide an audit to evaluate the control room referencing ISO 11064 for issues such as the following:

- architectural / structural considerations such as columns

[3] (Megginson, 'Lessons from Europe for American Business',*Southwestern Social Science Quarterly*(1963) 44(1): 3-13, at p. 4.) A similar version is in Megginson's 'Key to Competition is Management', *Petroleum Management* (1964) 36(1): 91-95.
[4] Retrieved 9/1/2016 - https://totalqualitymanagement.wordpress.com/2009/02/25/what-is-1-10-100-rule/

- control equipment interface
- adequate operator workspace
- adjustability of workstation screens
- view range of the operator to see overhead screens
- access to equipment for maintenance
- adequate ceiling height in the control room
- unobstructed circulation and egress
- room for expansion
- ease of communication
- adequate acoustics
- sit/stand workstations
- adjustable seating
- dimmability of lighting
- glare on screens
- finishes in the control room
- heating, ventilation and air conditioning

Facility siting studies

The architect can assist with planning the best location for a new building. In addition to the regulatory compliance and legal liability protection benefits inherent in developing a facility siting risk-mitigation plan, developing a master facility plan is critical to the long term planning for a site. It not only addresses the immediate risk assessment requirements, but also addresses long-term (5 yr./10yr./15yr.) facility infrastructure improvements and asset optimization, addressing security, IT infrastructure, site circulation, and workforce optimization.

Design from the Operator - Out

Figure 3: Operator Centric Design is the Best Approach

The operator is key to the successful design of a control room. His/her input is invaluable throughout the entire design process. Beginning in FEED the operator should be engaged in design charrettes all the way through to 100% design and consulted for workstation design, screen graphics and the Human Machine Interface (HMI). Understanding the operator's needs, how they interface with complex systems within a high-pressure environment, is square one, and all other design decisions flow out from that central point. The most successful control buildings have been designed with the operators involved as part of the team from the project start.

Design "Charrette"

A charrette is a workshop style meeting that is used to gather structured information from operators and stakeholders from which the building blocks of the new building take shape. The goal is to achieve consensus by the end of the 3 day process on a block plan direction. Integration of best practices in control room design is woven throughout the approach. HFE is an integral part of the control room charrette and the data gathered informs both the building, control room layout, control system and console design.
The tools of the charrette are:

- Room List
- Adjacency Matrix
- Room Blocks
- Building Block Plan

HFE focuses on what the control room needs to achieve.
Tools of the HFE aspects are:

- Role Analysis which defines each primary control room user to define responsibilities and staffing profiles for different scenarios (for example steady state, plant upsets, emergency situations which can differ dramatically in how they are performed).
- Task/link analysis is used to identify the detail for each role and interactions between roles within the control room to determine the size and layout.
- A list of workstation equipment is generated to determine the footprint and arrangement, based on how the equipment is used.

Iterative Review Process on Planning and Design Involves Operators, Stakeholders, and the Entire Design Team

ISO 11064 recommends an iterative review process for the design of control buildings involving operators and engineers that will be working in the control room in meetings and decision making. It leads the design work towards the best possible solution, and will create buy-in and a sense of ownership in the design.

Weekly webcam type meetings for the team are the best and least expensive way to review plan development and to move the design forward. Regular discussions keep the topics fresh on the minds of the participants, especially if weekly meeting minutes record decisions and action items for individuals to report on for the next meeting.

In-person review meetings at important project milestones allow face to face communication which is the most beneficial way to discuss and agree on the details of a project that might get missed with a webcam. The nuances of verbal and non-verbal communication are more apparent with a group meeting and less information is misunderstood. There are fewer distractions to lose focus during these meetings as with a webcam since participants are all in the same room.

In these meetings, participants need to identify risks associated with design. Some examples of this are:

- Control room not designed to current ergonomic standards
- Not including enough area for future expansion
- If building is in a remote location, not having skilled workers to provide construction labor
- Poor onsite security
- Poor communication because of multi-cultural team

Lessons Learned

After designing more than100 control buildings over the past 25 years the following are some of the many lessons BAW has learned from its projects:

- Allow enough time in FEED to start a control room project off right.
- Workstations, small and large screen placement should be designed concurrently with the building design
- Incorporate area for future growth in the control room, rack room and infrastructure
- Communication and collaboration with operational staff is key to a successful organizational change and successful design

Conclusions

Control room projects are a success when an operator-centric design approach is used by an experienced multi-disciplinary design team. When correctly executed, these projects will provide the best value for the money by incorporating best practices and lessons learned. The operators and staff moving into these new facilities must be a part of the design process to achieve buy-in on the design and a sense of ownership. Regular team communication and drawing reviews are key to the iterative development of a successful design. Designing the control room right the first time provides the most value of all.

By incorporating all of these important elements, the final product will be a control room that the client and staff will be proud to claim as their own.