INTEGRATED APPROACH FOR CONTROL ROOM AND HUMAN MACHINE INTERFACE DESIGN

Jeremy Shook PE
Laura Nies AIA, LEED BD&C

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Agenda

► Why is Control Room Design Important?
► Control Room Requirements
► Control Room Key Design Considerations
  • Human Machine Interface (HMI)
  • Layout
  • Consoles
  • Architectural
  • Other
► Case Studies
► Summary
Why Is Control Room Design Important?

▶ Reduces chance of human error
  • Improves plant safety
  • Improves plant availability
  • Reduces risk of equipment damage

▶ Improves the health of your operators
CONTROL ROOM
REQUIREMENTS
Types of Requirements

- Functional Requirements
- Client Requirements
- Codes and Standards
- Other Constraints
## Functional Requirements Derived by Analysis

<table>
<thead>
<tr>
<th>Task</th>
<th>Frequency</th>
<th>Importance</th>
<th>Total Score</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Operations</td>
<td>5</td>
<td>5</td>
<td>25</td>
<td>Operator Workstation</td>
</tr>
<tr>
<td>Performance Monitoring</td>
<td>5</td>
<td>4</td>
<td>20</td>
<td>Operator Workstation</td>
</tr>
<tr>
<td>Equipment Condition Monitoring</td>
<td>5</td>
<td>4</td>
<td>20</td>
<td>Operator Workstation</td>
</tr>
<tr>
<td>Shift Log</td>
<td>5</td>
<td>4</td>
<td>20</td>
<td>Business Computer</td>
</tr>
<tr>
<td>Monitor External Perimeter</td>
<td>5</td>
<td>4</td>
<td>20</td>
<td>Security System (Monitor with Joystick/Keypad)</td>
</tr>
<tr>
<td>Visitor Access Control</td>
<td>5</td>
<td>4</td>
<td>20</td>
<td>Security System (Monitor with Joystick/Keypad)</td>
</tr>
<tr>
<td>Ongoing Training</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>Business Computer</td>
</tr>
<tr>
<td>Simulator Training</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>Business Computer</td>
</tr>
<tr>
<td>Time Reporting</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>Business Computer</td>
</tr>
<tr>
<td>Initial Training</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>Business Computer</td>
</tr>
<tr>
<td>Email</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>Business Computer</td>
</tr>
<tr>
<td>Event Reporting</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>Business Computer</td>
</tr>
<tr>
<td>Startup Plant</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>Operator Workstation</td>
</tr>
<tr>
<td>Abnormal/Emergency Operations</td>
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<td>5</td>
<td>5</td>
<td>Operator Workstation</td>
</tr>
<tr>
<td>Shutdown Plant</td>
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<td>5</td>
<td>5</td>
<td>Operator Workstation</td>
</tr>
<tr>
<td>Lockout/Tagout - Normal Ops</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>Business Computer/LOTO Printer</td>
</tr>
<tr>
<td>Lockout/Tagout - Outage</td>
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<td>5</td>
<td>5</td>
<td>Business Computer/LOTO Printer</td>
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<tr>
<td>DCS Configuration Changes</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>Engineering Workstation</td>
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<tr>
<td>Shutdown Operations</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>Operator Workstation</td>
</tr>
</tbody>
</table>
Task Criticality and Adjacency Drives Layout Constraints
CONTROL ROOM KEY DESIGN CONSIDERATIONS
Human Machine Interface: Hardware Considerations

► Types
  • Task Based
    - Normal
    - Time Critical
  • Situational Awareness

► Monitor Sizes
  • Workstation 24”-27” Typ.
  • Overview 40”-75” Typ.

► Computer Options
  • Thick client
    - Console mount
    - Rack mount
  • Thin client
Human Machine Interface: Software Considerations

- Display navigation & hierarchy
- Task inventory
- Amount of information per display
- Trends & bar graphs for analog points
- Alarm concept
- Consistency
Layout

► Console Orientation
► Communication
► Access to all task areas
► Emergency stop locations
► Overview monitor placement

<table>
<thead>
<tr>
<th>Supervisor locations</th>
<th>Linear or arc, one-sided (2.5)</th>
<th>Linear or arc, one-sided (3.5)</th>
<th>Linear or arc, two-sided (2.5)</th>
<th>Linear or arc, two-sided (3.5)</th>
<th>Linear or arc, two-sided (2.4)</th>
<th>Linear or arc, two-sided (3.4)</th>
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<tbody>
<tr>
<td>Linear examples</td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
</tr>
<tr>
<td>Arc: operators inside</td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
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<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
</tr>
<tr>
<td>Arc: operators outside</td>
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<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
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<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Key:
- [ ] Not relevant
- [ ] Shared control role

ISO 11064

Tresco
Ergonomic design of control centres —
Part 3: Control room layout

Conception ergonomique des centres de commande —
Partie 3: Agencement de la salle de commande

### INTERNATIONAL STANDARD
ISO 11064-3

First edition 1999-12-15

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#### Design Guidance

<table>
<thead>
<tr>
<th>Supervisor locations</th>
<th>Linear or arc, two-sided (2 G)</th>
<th>Linear or arc, two-sided (2 H)</th>
<th>Linear or arc, two-sided (2 I)</th>
<th>Linear or arc, two-sided (2 J)</th>
<th>Linear or arc, two-sided (2 K)</th>
<th>Linear or arc, two-sided (2 L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Features</strong></td>
<td><strong>Between supervisors and operators</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sharing workstation equipment</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sharing all workstation displays</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Direct eye contact</td>
<td>$+$</td>
<td>$+$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Verbal communication</td>
<td>$+$</td>
<td>$+$</td>
<td>$+$</td>
<td>$+$</td>
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<td>Low noise interference</td>
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<td>Massage passing</td>
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<tr>
<td>Collection and delivery of paperwork</td>
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<td>0</td>
<td>0</td>
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<td>-</td>
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<tr>
<td>Standing in for supervisor</td>
<td>$+$</td>
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<td>0</td>
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<tr>
<td>Operator training by supervisor</td>
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<td>-</td>
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<td>$+$</td>
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<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Key**
- $+$: Central positioning of workstations required to view or change of workstation displays.
- $+$: Operation of supervisor shall turn around or move.
- **Note**: Better for operators adjacent to supervisor.
Consoles: Features

- Slat Wall
- Cable Management
- Integrated Power Distribution
- Task Lighting
- Environmental Controls
- Swivel/Tilt Monitor Arms
- Articulating Monitor Arms
- Monitor Mounts

Tresco
Consoles: Ergonomics & Adjustability

► Seat selection
► Console Furniture: Sit / Stand
► Fatigue
Architectural Considerations

- **Acoustics**
  - Wall, floor, and ceiling material selection
  - Sound masking

- **Light Levels**

- **Wall & Floor Color**

- **Materials / Durability**
  - 24/7/365
  - High Traffic
  - Anti-static
Research on Environmental Factors

Situation awareness and automation in the electric grid control room

Susan Stevens-Adams*, Kenstan Cole, Michael Harris, Christy Warnier, Robert Jeffers, Laurie Burnham and Chris Foushy

Sinha National Laboratory, P.O. Box 8010, Albuquerque, NM USA

4. Conclusions and Future Steps

Vermont control room operators were interviewed to determine factors that are important to successful control room operations and to identify grid security and resilience. The interviewees expressed that the control room operators, who are responsible for monitoring the grid, rely on their situational awareness to ensure the grid is secure and resilient. The operators explained that they must be aware of any potential issues and be able to react quickly to any problems that arise.

**Lighting up the office: The effect of wall luminance on room appraisals**

Adrie de Vries*, Jan L. Souman*, Boris de Ruyster*, Ingrid Heynderickx*,

*Eindhoven University of Technology (TU/e), Delft, The Netherlands
**Philips Research (Eindhoven, The Netherlands)
***Delft University of Technology, Delft, The Netherlands

5. Conclusion

The findings of our experiment suggest that an increased wall luminance may have a positive effect on increasing the level of subjective well-being. However, further research is needed to determine the underlying mechanisms. The results strongly suggest a psychological effect rather than a biological mechanism, i.e., increased light levels.
Other Considerations

► Fire Alarm & Protection
► Access Controls
► Communications Equipment
► Cable Routing
► HVAC

CLEAN AGENT SYSTEM

PRODUCT QUALIFICATIONS:
Note: Installation per manufacturer’s requirements.
Description: NOVEC 1230 Fire Suppression Clean Agent
Manufacturer: 3M
Style: Gaseous
Color/Finish: N/A
CASE STUDIES
New Plant Control Room Design

- Main Plant Control Area
- Remote Plant Control Area
- Maintenance and Administration Areas
Existing Plant Control Room Modernization

- Boiler Control Area
- Turbine & CHW Control Area
- Support & Security Areas
SUMMARY
Key Takeaways

► Control room design is important!
  • Improves plant safety
  • Improves plant availability
  • Reduces risk of equipment damage
  • Improves the health of your operators

► Use a structured approach to improve your control room design for new and existing facilities
QUESTIONS
THANK YOU

► Jeremy Shook PE
   400 S. Tyron St. Suite 800
   Charlotte, NC  28202
   (704) 450-8924

► Laura Nies AIA, LEED BD&C
   9450 Ward Parkway
   Kansas City, MO 64114
   (816) 333-9400
CREATE AMAZING.