Control rooms
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Overview

- A successful control room requires more than using latest technology or standards
- A control room is only a component of a complex system consisting of equipment & people
- The impact on individuals, jobs and the organisation are often overlooked
- Methods are available that encourage challenge of accepted practice and assumptions.

What is a control room?
Key issues for control rooms

- The control system
- System interfaces
- Communications
- Control room layout
- Individual workstation design
- Control room environment
- Staffing/workload
- Maintenance
- Emergency response role.

What do Control Room Operators do?

They are the most sophisticated and capable controllers in any plant
- Control – monitor – operate
- Normal Situations
  - Communication - face to face including handovers
  - Other communication - radio/telephone
  - Administrative tasks
  - Eat meals
  - Issue permits to work
  - Training - themselves and others.

What do Control Room Operators do?

Emergency situations
  - Raise the alarm
  - Notify emergency services
  - Co-ordinate communication
  - Keep the log
  - Accounting for personnel
  - Monitor process for escalation.
Changes in the Control Room

- New technology
- More automation
- Less people
- More remote
- A different job
  - More passive
  - More lonely
  - More responsibility.

The impact of modern control rooms

Benefits
- Relieve people of boring, unpleasant and potentially hazardous tasks
- More consistent and reliable operation

Negative outcomes
- Operators overloaded with alarms and data
- Non-intuitive interfaces – people have to work harder
- A smaller ‘window’ on the system
- Over reliance on technology
- Managers becoming more distant from the operators.

Nature of the Control Room Job

<table>
<thead>
<tr>
<th>Features that make a job satisfying</th>
<th>The Modern CRO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill variety</td>
<td>Lots of monitoring, not much action</td>
</tr>
<tr>
<td>Task significance</td>
<td>Lots of automation - CRO responds when things go wrong</td>
</tr>
<tr>
<td>Task identity</td>
<td>CRO responsible for large number of plants/systems</td>
</tr>
<tr>
<td>Autonomy</td>
<td>Minimal - working to very tight specifications</td>
</tr>
<tr>
<td>Task feedback</td>
<td>Aim is to avoid upsets and incidents</td>
</tr>
</tbody>
</table>
Hazards for control room staff

- Normal workplace (similar to an office)
  - Slips, trips and falls
  - Electricity
  - Fire
- Nature of the job
  - Lack of physical activity
  - Mental exertion
- External events
  - Fire, explosions, toxic release
  - Terrorism.

Hazards to others

- Operating errors – doing things wrong
- Failure to detect, diagnose and respond to abnormal events
- Consequences can be devastating
- Not addressed by ‘normal’ risk assessments or evaluations focussed purely on control room arrangements.

Control room location

- Close to the plant
  - Enhances teamwork
  - Route for others to the plant
  - Need to protect against plant events
- Further from the plant
  - Technical and managerial support more available
  - Communication between plants (centralisation)
  - Operators need to be better organised
  - Can have windows.
Control room layout

- Number of people to accommodate
- In all modes of operation
- Equipment needed
- Proportions (length, width and height)
- Acoustics
- Ventilation.

Equipment to accommodate

- Control system interface
- Emergency system interface
- Other computers
- Storage
  - Shelves for manuals and procedures
  - Carousel for easy access to emergency job aids
  - Room for personal items
- Tables for log, viewing drawings etc.
- Seating.
Understanding plant operation for interface design

Actions

<table>
<thead>
<tr>
<th>Status</th>
<th>Aim</th>
<th>Interface</th>
<th>Automatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal operations</td>
<td>Avoid disturbed</td>
<td>Graphics</td>
<td>Control system Optimiser</td>
</tr>
<tr>
<td>Disturbed</td>
<td>Return to normal</td>
<td>Graphics</td>
<td>Help or hinder?</td>
</tr>
<tr>
<td>Upset</td>
<td>Avoid hazardous</td>
<td>Alarms</td>
<td>ESD</td>
</tr>
<tr>
<td></td>
<td>Return to normal</td>
<td>Graphics</td>
<td></td>
</tr>
<tr>
<td>Hazardous</td>
<td>Make safe Mitigate</td>
<td>Graphics</td>
<td>Blowdown Fire fighting</td>
</tr>
</tbody>
</table>
Graphics
- The operators’ ‘window’ on the plant
- Balance
  - Information density vs. number of pages
  - Task specific pages vs. operator experience
- Human behaviour
  - Poor at vigilance
  - Jump quickly from vigilance through analysis to action
  - Tunnel vision when in action mode
- Designed for the size of display
  - Misuse of large/projection displays.

Typical screen design issues
- Lack of overviews
- Form over function
  - Pictures of plant and equipment
  - Mis-use of colour
  - May look nice but does not provide, or can even hide important information
- Too much information on a screen
- Too much unnecessary information on the screen
- Too many key-strokes required
- Task-relevant information spread over many pages

Outcomes of poor graphic design
- Difficult to see problems developing
- Falling behind and running by alarm
- Lack of the big picture
  - Tunnel vision during incidents
- High demands on operators
  - High mental workload
  - Data overload
  - Reliance on good memory.
Hierarchical page arrangements

Further considerations
- Need easy access to and between pages used most often
- May want different plant overviews
  - Pressure/temperature profile
  - Equipment status
  - ESD valve status
- May want task specific displays
  - Start-up/shutdown
  - High/low throughput
- Identify content then work out how to display it.

Display standards
- Purpose of graphic to display plant information
  - Not show how plant works or what it looks like
- Need consistent use of symbols, colours, flash
- Background colour
  - ‘Windows grey’ to minimise eye fatigue whilst maintaining contrast
  - Darker colours for trends allows more line colours
- San serif text
- Call up a display in less than 3 seconds
- Refresh rates depend on
  - Type of display (text vs. trend)
  - Importance of rate of change
Graphic design

- Use the human ability to recognise patterns
- Show relationships
  - Between data points
  - In relation to limits
  - Time based trends.
- Choose the format for the information to be monitored.

Large screen displays

- Usually specified without any idea of
  - Information to be displayed
  - When they will be used
  - Who will use them
- Can be useful
  - Find information more quickly
  - Keep track of events
  - Improved collaboration
  - Current status easily visible to all personnel when they enter the control room.
Alarms

- An alarm is a warning to an operator that timely action is required.
- The purpose of an alarm system is to assist the operator in:
  - detecting process problems
  - prioritising response
- To do this they need to be at the boundary of the disturbed and upset.

Non-alarms

- Status information
- Sequence messages (e.g. batch reports)
- Things the operator “needs to be aware of” but doesn’t need to do anything about

EEMUA Guide – Alarm systems

- Prioritise
  - 5% high, 15% medium, 80% low.
- No standing alarms
- Long-term average alarm rate during normal operation
  - No more than one every ten minutes;
- Following a major plant upset
  - No more than ten displayed in the first ten minutes.
How would you describe your alarm system?
- Often ignored because the operators are overloaded
- Operators do not have a chance to optimise performance because they have too many alarms to react to
- Stable during normal operations, but create overload during upset
- Achieves EEMUA
- ‘Intelligent’ system meaning every alarm is a genuine warning.

Alarm rationalisation
- What is the operator required to do?
- What are the potential consequences if the alarm is missed?
- How soon is a response required?
- Does the alarm make sense to the operator?
  - Do they relate the process parameter with the scenario?
  - Do they understand the alarm description?

Developing alarms from scratch
- What are the process conditions you need to avoid?
- What will indicate that problem?
  - Multiple-variable
  - Rates of change
- What does the operator need to know to confirm diagnosis?
- Develop a solution that combines alarms and graphics.
Alarm Group Exercise

- Hypothetical vessel with one inlet and one outlet
- Once the level is 100% it will overflow.
- Trip at 90% level which will shut the inlet
  - Assume this does not have any significant knock-on effects
- At the maximum normal inlet flow with no outlet flow the level would rise by 10% in 15 minutes
- What alarms would you have?
  - Level
  - Priority.

Alarm Group Exercise

- 90% to 100% in 15 minutes
- Level: 100%

Implementing a new control room

- New building/room with new equipment
- Replacing existing equipment
- Refurbishing the room, keeping the same equipment
- Adding new equipment to old.
Changes to control rooms are major
- The drivers for change
  - Obsolesce of existing equipment
  - Perceived benefits of new technology
  - Cost savings and efficiency gains
- New or upgraded control rooms often coincide with process, system or organisational changes
- Different approaches used
  - Re-instrumentation – run by instrument engineers
  - Process improvement – run by operations
  - Organisational – run by business managers

Risks often underestimated

Common themes
- Assumption that a new control room will be successful
- Viewing a control room as a stand alone system
- End users asking for what they are used to
  - Focus on normal operations
  - Plant equipment orientated
  - Do not like change.
- Mixing technology
  - The loudest noise or brightest light will be perceived as most important

Human centred design
- Human factors considered throughout design
  - Integral not separate activity
  - Requires ergonomics expertise
- Based on end user requirements
  - Involved throughout
  - User trials
- Includes
  - Task analysis
  - Information needs analysis
  - Communication link analysis
  - Workload assessment.
End user involvement

- Essential
- Structured, practical approach required
- Not a token or rubber stamping exercise
- Need to understand the tasks performed and their context
- Multi-disciplinary team
  - Operational expertise
  - Control and instrumentation
  - Designer/architect.

Other users and visitors

- Field operators
- Supervisors
- Technical support staff
- Managers
- Maintenance staff.

BS EN ISO 11064

- Part 1 – Principles for the design of control centres
- Part 2 – Principles for the arrangement of control suites
- Part 3 – Control room layout
- Part 4 – Layout and dimensions of workstations
- Part 5 – Displays and controls
- Part 6 – Environmental requirements for control rooms
- Part 7 – Principles for the evaluation of control centres
- Part 8 – Requirements for specific applications
Remote operations - CRR 432/2002
- Provides guidance and checklists covering:
  - Location of the control room
  - Methods of communication – especially when not face-to-face
  - Interface – differences between old panels and modern VDU
  - Automation
  - Team arrangements.
- Useful for evaluating existing control rooms and considering risks of change

Conclusions
- A control room is only a component in a system
- A tool for people to operate the system
- A new/upgraded control room is a major change
  - Usually multiple drivers
  - Can fundamentally change the way people work
- End user involvement is essential, but will not guarantee success
- A picture is only worth a 1000 words if it shows useful information
- A good design does not guarantee good operation.