How to Improve Plant Operations through Better HMI Graphics

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This presentation has been developed from ideas and materials from the following resources. We gratefully acknowledge the following great reference materials and their authors.

- The High Performance HMI Handbook
  - PAS - Bill Hollifield, Dana Oliver, Ian Nimmo and Eddie Habibi

- Designing for Situation Awareness (An approach to User-centered Design)
  - Mica R. Endsley and Debra G. Jones

- Human Machine Interface (HMI) Design: The Good, The Bad, and The Ugly (and what makes them so)
  - ICS Triplex - Paul Gruhn, P.E.
What Do the Buzzwords Mean?

- **ASM – Abnormal Situation Management**
  - Developed by ASM Consortium – Honeywell and friends
  - An “Abnormal Situation” is an unwanted event or state that the control system is unable to resolve without operator action.
  - ASM is not a “Standard”, but a set of “Guidelines”
  - Abnormal Situation Management “Guidelines” defines ways to make it easier for the operator to detect and resolve unwanted events

- **ISA-101**
  - ISA-d101.01 Human Machine Interfaces for Process Automation Systems
  - Currently a DRAFT – not yet a published standard
Why HMI Graphics Matter?

- Who wants to be responsible for designing an HMI graphic that can lead to confusion?

Product leaving the Unit
Agenda

- Situation Awareness
- Using Color Effectively
- Interpreting the data
- Depicting Device State
- HMI Display Organization
- Putting the ideas into practice
Situation Awareness
The definition of Situation Awareness (from the ISA 101 Draft Standard)

- “Being aware of what is happening in the process.” (level 1)
- “Understanding the process state now.” (level 2)
- “Understanding in the likely process state in the future.” (level 3)

SA levels should not be confused with HMI display levels.
Situation Awareness

- Situation awareness relates to the goals and objectives of a specific job or function.

- Designers and engineers form in their heads another mental model of the process than an operator.

- By understanding how operators select and use goals, designers can better understand how information is perceived. Without understanding the user’s goals on Situation Awareness, the information that is presented has no meaning.
Situation Awareness

Applying SA terminology to HMI Graphics

- Level 1 SA – P&ID representation with Live numbers.
- Level 2 SA – Provide the operator with the relevant information they require to understand how the plant is operating.
- Level 3 SA – Provide trending data so that the operator can extrapolate the plant’s performance to the future.
- Level 2 and Level 3 SA reinforces the operators mental model of the plant or process.
Evolution of HMI Graphics – The 80’s

- Is the pump in alarm or stopped?
- Are the valves in alarm or closed?
- High Contrast
  - Causes eye fatigue.
Evolution of HMI Graphics – The 90’s

- Is this a good graphic?
- What is the reactor temperature?
- What Percentage of the screen is presenting useful data?
- The pretty 3D objects and Gradient fill are superfluous.
- The flame attracts your attention.
- The moving truck attracts your attention.
- Overuse of color – causes confusion.
Aiding Situation Awareness?

The following objects, when used in a display for a normal situation, all draw your attention to themselves, cause distractions and fatigue, and could cause the operator to miss important data.

- **High contrast**
  - High Contrasting objects strain the eyes and cause fatigue.

- **Warm colors – red, orange and yellows –** Especially when flashing
  - Draws your attention to them, are they in alarm, warning or just a route product indication

- **Movement**
  - Draws your attention to it.

- **Complex graphics and 3D objects**
  - Make it difficult to develop a metal model.
The Use of Trending

- Using trend displays helps provide Level 3 SA projection of future status.

- By extrapolating, the operator can then see where the process is heading.

- The operator can then be proactive and recognize impending problems, rather than being reactive and responding to alarms and problems after the fact.

- Use trending with thought. For instance, a trend display with eight variables is confusing and takes a long time to analyze.
The Use of Trending

- We can see the value and its past trends.
- We can make predictions of what the value is about to do based on its historical behavior.

**BUT**

- What should the value be?
- What is the normal good operating high and low limits?
The Use of Trending

- We can see the value and its past trends.
- We can see what the value should be.
- We can see what are the normal operational high and low limits.
Using Color Effectively
Using Color Effectively

- 7–10% of males are Red-Green Color Blind
- Avoid using color alone to express information
- This not only helps color blind people, but also aids understanding by everyone.
Using Color Effectively

- Only attract attention to an area of the display if there is an Abnormal Situation.

- How
  - For things that are “Normal”:
    - Gray is in fashion – gray backgrounds, gray pipelines, gray vessels.
    - Use low contrast.
    - No animation, blinking or flashing to grab attention
  
  - For things that are “Abnormal”
    - Color, contrast, animation
    - Red and colors containing red for Alarms
Using Color Effectively

- Multiple digital devices can be represented as a light box.

- Running is a normal condition, so there is no need to show a color for its status.

- How about going one step further and removing the normal condition from the screen and only display the item if it’s in an abnormal condition.
Interpreting the data
Interpreting the data

- Is this chap healthy?
- What should the numbers be?
- How long does it take you to scan and interpret the information?
- Do the numbers mean anything to you?
- Are the numbers actually meaningful?
- How much training would you require before you could interpret the numbers?
Interpreting the data

- We can now see the upper and lower limit for these values.
- How long does it take you to scan and compare these numbers?
- How much longer does it take you to calculate by how much they are within range?
- This is data that requires examining and processing (Level 1 SA)
- Data should be presented that supports comprehension (Level 2 SA)
Interpreting the data

What we need is analog

- We need to
  - Provide a pointer to a scale.
  - Provide a clear indication of the normal working range.
  - Clearly show upper and lower limits

- With Analog
  - The brain interprets an analog display quicker than a number.
  - Can easily see WHERE the value is and what it is.
  - Can easily see rates of change.
Interpreting the data

1960’s Science Fiction to the rescue
Interpreting the data

- Normal operational values that are shown in white.
- High and low alarm ranges shown in dark gray.
- Desirable operational ranges that are shown in dark blue.
- Alarm indicator with priority level and color.
- Different shape for alarm priority.
Interpreting the data

Depicting Material Balance

- Two major accidents with flammable material have been attributed to HMI graphics that have **NOT** shown flow in and flow out on the same graphic.

- P&ID representation often leads designers of graphics to split the flow in and the flow out of a vessel at opposite sides of a display, or on separate displays – all too common practice.

- A properly implemented mass balance or volumetric material balance calculation and display of that data could have prevented these accidents.
Interpreting the data

Level Indication

- Provide high and low bad indication on the vessel.
- Provide normal good upper and good lower indication.
- Trend the level inside of the vessel outline.
Depicting Device State
Depicting Device State

- Do not use red for stopped or closed and green for running or opened. Only use color to bring attention to an abnormal condition. A pump simply not running is often not an abnormal condition.

- Consider using a visually different shape within the object to represent running/opened. This not only helps color blind people, but also aids understanding for everyone.

- Use status words that describe the device state that is running and stopped. Words like run and stop could be confused with command words.
Depicting Device State

- Provide feedback to a command or button click within a time window that tells the operator that the command is being acted upon.

- Too slow (ASM states 3 seconds) and the operator may think the command wasn’t executed.

- Too fast (ASM states 0.5 seconds) and the operator may miss the change.
HMI Display Organization
HMI Display Organization

Level 1
Overview Display

Level 2
Process Unit Control Display

Level 3
Process Unit Detail Display

Level 4
Process Unit Support display

Controllers, Values, Alarms, Trends and Status.

Controllers, Values, Alarms, Trends and Status.

Smaller Equipment Groups, Equipment Status.

Interlocks, Diagnostics, Help and Documentation.

HMI display levels should not be confused with SA levels.
HMI Display Organization

- Provide information that helps the operator retain the data in short-term memory.

- Group related information together so that it can be processed as one chunk.

- The average short-term memory can hold seven items plus or minus 2, so group data together to facilitate this fact.

- If you have a vessel that has three specific values relating to it, then display it inside the vessel, this allows the operator to see them as one chunk of data as opposed to placing them outside of the vessel where the operator will see them as three individual pieces of data.
HMI Display Organization

- Be consistent!
Putting Ideas Into Practice
Putting Ideas Into Practice

- Only show information that supports comprehension of the process or plant. (Level 2 SA).
- Represent key performance data as trends. (Level 3 SA).
- Design to allow the operator to achieve their goals.
- Gray background, vessels and pipes, low contrast.
- Use of saturated color for abnormal plant conditions only.
- No movement of objects to distract attention.
 Putting Ideas Into Practice

- Avoid Gradient Shading
- Use analog value indicators
- Low-level details of plant are accessed by clicking to them.
- Consistent navigation across displays.
- Mixed case text is easier to read than ALL UPPER CASE.
The Rockwell Automation Library of Process Objects has embraced these concepts.

Available from the Rockwell Automation Product Compatibility and Download Center.

Further Info - PSUG Session TS05 and Automation Fair® Workshop W14.
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The following guidelines are available as an aid to designing High Performance HMIs:

  - Effective Operator Display Design

- ISA 101, Human-Machine Interfaces - Website

- ISA 101, SharePoint
Thank You for Participating!

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