TECHNICAL ARTICLE: DON'T LET COLOURS HIDE THE ALARMS!

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Failure to identify alarms and their states quickly and accurately has recently been cited as the cause of many, otherwise avoidable, major capital asset losses. Dealing with alarms properly and quickly is a topic of keen interest to the process manufacturing audience. This article explores the way in which use of colour in process displays affects operator response to alarms and events.

By Cindy Scott

How do we use colour to distinguish the most important information on the operator's display? Until the early 90s, the majority of control systems supported only 16 colours for operator displays. Blink was typically a 'colour,' which meant that red and red blink would be two of the 16 colours. Although limiting by today's standards, these capabilities were pushed to the limit to develop useful and informative operator displays. Black was the preferred background colour. Tanks and other vessels were outlined in white, with the levels in various colours. Piping usually changed colour based on process conditions. Different materials could be represented in different colours. Valves changed colour between green and red for open and closed. Alarms were red, yellow and magenta. The end result was displays with the visual richness of a Christmas tree. (Fig. 1).

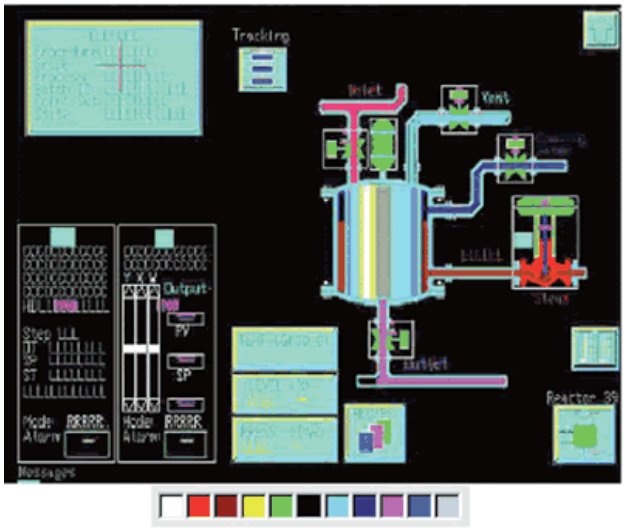

Fig. 1. The end result was displays with the visual richness of a Christmas tree…

Many facilities are still using this same type of control display design. Plant standards for use of colour in displays were developed when these original systems were first configured. This is not only true for plant standards. In September, 2005 ISA announced that ANSI/ISA-S5.5 Graphic Symbols for Process Displays, 1985 was out of date and that a new committee on Human Machine Interfaces, SP101, was to be set up charged with the task of updating HMI display content standards.

When systems were upgraded, the plant display standards were not updated to incorporate the capabilities of the new display technologies, so the basic display layout and colour schemes were maintained. Although this makes sense to minimise cost and operator disruption, it forgoes many of the potential benefits of current graphics capabilities.

For example, standard monitors presently offer up to 16.7 million colours. The amount and types of data that can be placed on a display have also drastically increased. Operators can now view not just traditional PVs and SPs, but can see a wide range of control and intelligent device information. Devices can even be calibrated right from the display. The display resolution has also increased from 640x480 (or less) to 1280x1024 and beyond. Along with display resolution, operator displays can have many layers of data placed on screen under specific process conditions or at operator request. These new capabilities raise fresh questions: How many colours are too many? Which are the 'right' colours to use? When is appropriate to use a dynamic colour? How much data is too much data? What alarms are needed and where should they be shown? And so on…

It is also worth considering the reasoning and justification for changing existing display standards. Just because more colours are available does not mean that you have to use them. It is really becoming quite difficult to determine whether the current system of display design is helping or impeding operators from performing at their best.

Little research is presently available which is specific to the process control industry on operator usability of graphics designs and colours. However, a wide tranche of general visual research relating to computer graphics already exists which has relevance to operator displays.

Where is the alarm?

One good example can be found in the work of Christopher Healey, of the Department of Computer Science at North Carolina State University, who applies[1] what has come to be termed 'pre-attentive' processing to computer graphics. Healey identifies objects that can be detected very rapidly and accurately - and without conscious effort. He explains that 'tasks that can be performed on large multi-element displays in less than 200 to 250 [ms]' can be termed pre-attentive'. Such pre-attentive features, Healy says, include:

- Line orientation; length, width, curvature (a curved line among straight lines);

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- Object size, density, contrast; number, colour (hue), intensity;
- Flicker; direction of motion; lighting direction;
- 3D orientation; and artistic properties.

Healey points out that for a particular item to be picked out rapidly from a group of so-called distracters, there must be a single difference between the desired item and the distracters. Thus a red item can be spotted readily among a group of blue items of the same size and shape, while a round item can quickly be picked out of a group of square items of the same size and colour. On the other hand, a red circle in a group of red squares and blue circles will not leap out from the screen and must be found by searching.

Another good example can be found in research at the University of Southern California iLab[2], which measured how long it took to detect one object amongst many, using simple patterns flashed on a computer screen.

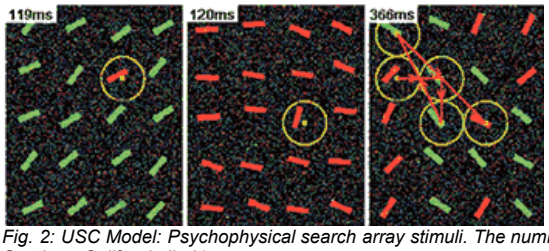

Fig. 2: USC Model: Psychophysical search array stimuli. The numbers indicate average time for the observer to detect the feature. (Source: University of Southern California iLab)

In the first two pictures (Fig. 2 above), when the object was in a different colour or orientation from the rest of the objects on the screen, it was found to be quickly noticed. However, when both colour and direction were needed (the third picture above), it took three times longer to find the object. Consider how we might apply this research to a process graphic - especially an alarm.

An alarm should be as obvious as the red line in the first picture. Alarms are normally distinguished by colours such as red or yellow. The problem arises when the normal display becomes so colourful that warnings and alarms merge together.

For example, if a yellow alarm is next to a yellow pump, it is difficult to identify that the alarm state has changed to yellow. The alarm just blends in with the pump next to it. First, the display cannot be so colourful that the alarm is lost. Second, alarm colours should be used only for alarm conditions. If yellow is an alarm colour it should not also be one of the normal pipe colours.

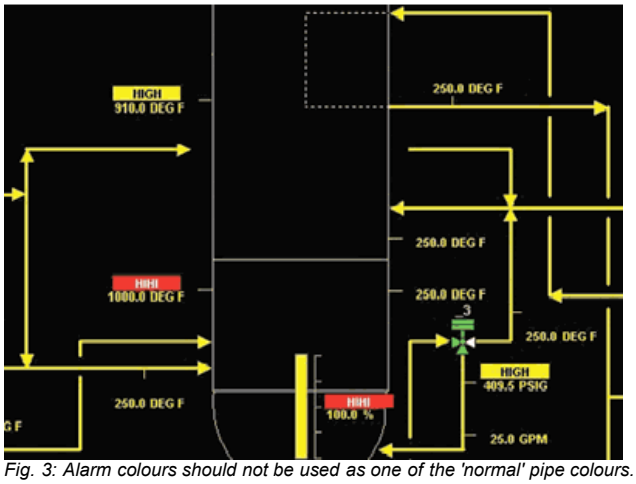

Fig. 3: Alarm colours should not be used as one of the 'normal' pipe colours.

In this display (Fig. 3 above), the red alarms are quickly seen, while the yellow alarms tend to blend in with the other yellow objects. Another important idea from this research is that using shapes can also help to identify what you're looking at. So if an alarm on a graphic had both a unique shape and colour, it would be found more quickly. Different shapes could be used to distinguish a critical alarm from a warning alarm. So a critical might be red, with a black X in a circle. Warning might be yellow with a exclamation point inside a yellow Yield sign. (Fig. 4)

Fig. 4: Use both colour and shape to distinguish alarms importance.

How many colours? Less is more

Now that one may have 16.7 million colours to pick from, what should you use? In order for the alarms to leap out at the operator, the non-alarm colours used in the display must not be visually distracting. This is commonly referred to as 'grey-scale graphics.' Pumps, tanks, pipelines and other process equipment are illustrated in shades of grey, or other muted colours. Bright colours are reserved for alarms and other abnormal situations. As long as you can see a tank, it doesn't have to be chartreuse: grey is just fine. When a grey graphic pops up a yellow square it is very obvious that something needs attention. (Figs 5, 6)

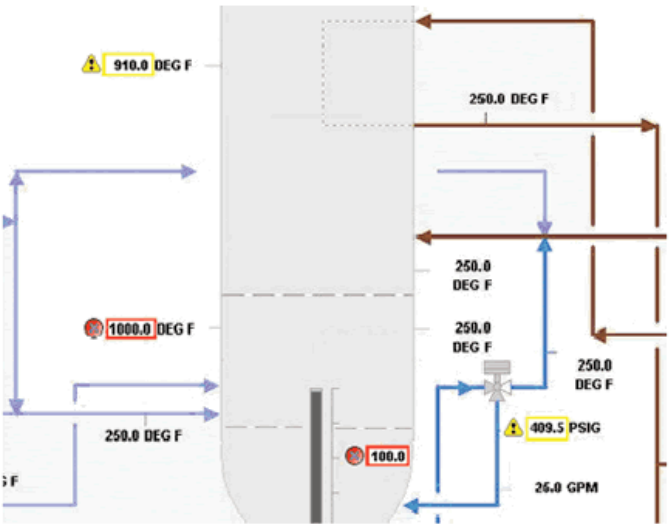

Fig. 5: Using too many colours clutters the graphic and distracts from alarms.

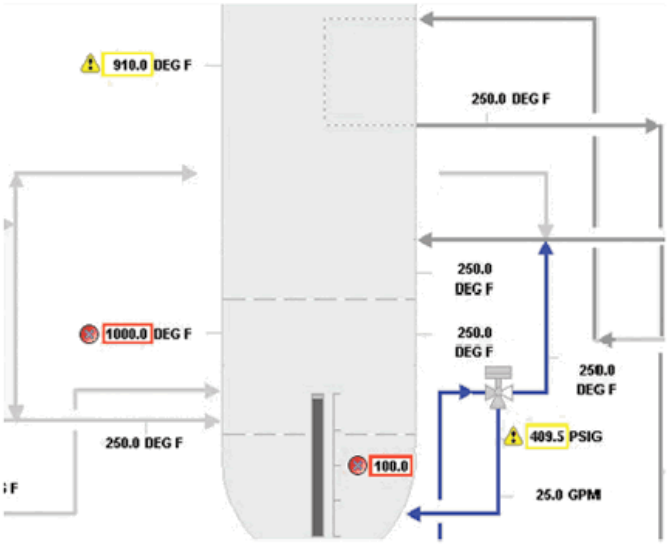

Fig. 6: The proper display colours can make alarms readily apparent.

So although a graphic today may still contain no more than 16 colours, the colours used are significantly different from what was used 20 years ago.

Standardisation efforts
SP60 Chairman, Doug Peck points out[4] that there are standards applying to HMI, from NRC,DoD, IEEE, ISO,AAMI, ANSI, CENELEC, ETSI, JTS, MOD UK DSTAN and SAE. Just the standards from ISA and ISO form a daunting list:

- ANSI/ISA 5.3-1983, Graphic Symbols for Distributed Control- Shared Display Instrumentation, Logic & Computer Systems
- ISA-5.5-1985, Graphic Symbols for Process Displays
- ISO 11064 Ergonomic Design of Control Centres
- ISO 13406 Flat Panel Display Ergonomic Requirements
- ISO 14915 Multimedia User Interface Design - Software Ergonomic Requirements
- ISO 6385 Ergonomic principles in the design of work systems
- ISO 9241 Guidance on Usability
- ISO TS 16071 Guidance on Accessibility of Human-Computer Interfaces
- ISO/IEC 10741-1 Dialogue interaction - Cursor control for text editing
- ISO/IEC 11581 Icon symbols and functions
- ISO/IEC 15910 Software user documentation process

Implementation
Change is difficult in plants; people are used to seeing things a certain way and operators don't want too much change. And there may also be corporate reasons to resist change. In a presentation[3] at ISA 2005 Joe Bingham, Co-Chair of ISA SP101, pointed out that some users are concerned about legacy equipment and wish to avoid the cost or replacing it. In addition, some vendors may consider 'that internal standards may provide a competitive advantage.' Brutally put, it may be thought that non-standard HMIs can assist retention of existing customers. Yet cutting back on the over-use of colour can lead to displays that provide information more clearly so lessening the number of missed alarms. It is important for control system display designers to resist the temptation to add colour to everything, and to use it only where it conveys useful information. Bright colours should be reserved for things that must be seen such as alarms, and must not be masked by using the same colours for non-critical items. Reducing operator errors and accidents hinges on an understanding of visual perception mechanisms.

References
[1] Christopher G. Healey, Department of Computer Science, North Carolina State University: Perception in Visualisation, http://www.csc.ncsu.edu/faculty/healey/PP/#Preattentive
[2] University of Southern California iLab, http://ilab.usc.edu/bu/
[3] Bingham, Joe, HMI Standards Development, The ISA-SP101 Initiative, presented at ISA 2005
[4] Peck, Douglas J, P.E. The ISA HMI Initiative: Background and Needs Review, presented at ISA 2005

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