Beville Engineering's Newsletter

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Cough Once for Danger

In an attempt to improve cockpit operation, research was conducted on the use of unique sounds (coughing, brakes screeching, elephant trumpeting) rather than the more abstract tones currently employed (Perry, N., Stevens, C., Wiggins, M., and Howell, C. "Cough Once for Danger: Icons versus Abstract Warnings as Informative Alerts in Civil Aviation, Human Factors, Vol 49, No. 6, 2007, pp1061-1071). The unique sounds, referred to as iconic warnings, were faster to learn and had better reaction time and accuracy when used. This held true for both high and low workload conditions.

On the Other Hand…

Signal detection theory holds that the greatest benefit from alarms comes from any alarm, and that increasing levels of specificity have increasingly fewer benefits. Researchers at MIT investigated the use of a single master alarms versus more specific individual alarms (Cummings, M., Kilgore, R., Wang, E., Tijerina, L., and Kochhar, D. "Effects of single Versus Multiple Warnings on Driver Performance" Vol 49, No 6, 2007, pp-1097-1106). Not surprisingly, there was no measurable performance difference between the "relatively uninformative" master alarm and the "information-rich auditory icons".

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Human Performance Limits and Process Alarms

Setting target alarm rates for the evaluation of the adequacy of alarm management is both reasonable and prudent. Different target rates are needed for the two distinct modes of plant operation: steady state and abnormal. However, current published target alarm actuation rates (six per hour steady state and 10 per 10 minutes in an upset) are not consistent with the human performance literature as is sometimes implied. The notion that the steady state rate is a product of human performance limitations is internally inconsistent and nonsensical. If the operator can handle ten in ten minutes, why/how can they only handle six in an hour?

However capricious the steady state target is, the target (limit?) for abnormal situations of one per minute (ten in ten minutes) is equally suspect. Several studies indicate that an operator can read and process 15 alarms per minute (four seconds per alarm), with some studies showing higher rates possible[i,ii,iii]. What was missing in the research was time to respond, which can range from the time it takes to radio, "Start the spare reflux pump", to longer and more complicated coordinated sets of tasks. One alarm per minute leaves 56 seconds for action if four seconds are needed to read and understand the alarm. Look at your watch for 56 seconds, doing nothing else, and see if you agree that only one response could be achieved? So while 15 alarms per minute <u>may</u> be too many, one alarm per minute is definitely well below what is likely reasonable. Singleton proposes five alarms per minute, based apparently upon choosing a reasonable point between the extremes[iv].

Perhaps more importantly, current targets totally ignore the impact of alarm priorities. Members of the Center for Operator Performance (website: OperatorPerformance.org), in reviewing an early draft of this newsletter, rightly identified that the processing demands and stress of alarms should increase with increasing alarm priority. In addition, since the capability of the crew and the time in the shift will interact with the alarms/priorities, any "target" value has to be viewed as a rule of thumb at best.

So how do I evaluate the "quality" of my alarm system during upsets? It is generally agreed upon that the priority distribution should be pyramid shaped, with most of the alarms the lowest priority and the fewest the highest priority. [Beville recommends a 10%-35%-55% distribution of Emergency-High-Low priorities, while others recommend 5%-15%-80%) Combining this with the desired alarms per unit of time yields the following equation:

<table>
<tr><td># Emergency</td><td rowspan="2">+</td><td># High</td><td rowspan="2">+</td><td># Low</td><td rowspan="3">≤</td><td rowspan="3">1.0</td></tr>
<tr><td>(#/Unit Time * Target %)</td><td>(#/Unit Time * Target %)</td><td>(#/Unit Time * Target %)</td></tr>
<tr><td colspan="5"># Priority Categories (3)</td></tr>
</table>

A value of one indicates that the (number of alarms)*(priorities) for a given period of time met the goal. Any value less than one show the goal was exceeded. Values greater than one indicate a failure to meet the goal. The equation weights alarm priorities, so that poor distributions combine with the number of alarms to capture the quality of the alarm system.

Both the target alarm rate and even the exact priority distribution are subject to debate. The Center for Operator Performance will be doing research in the future on both, as well as other factors influencing alarm processing abilities (e.g., how the information is displayed). In the meantime, a range of values is available to use in the equation, from ten alarms per ten minutes to 50 alarms per ten minutes, and 10%-35%-55% priority distribution to 5%-15%-80%. The result is a metric that hopefully can aid in the operation of the alarm system and not hamper it with prescriptive, and potentially erroneous, limits.

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[i] Danchak, M.M., "Alarm Messages in Process Control" InTech, 35(5), 1988. pp 43-47

[ii] Halstead-Nussloch, R., Granda, R.E., "Message based screen interfaces: the effects of presentation rates and task complexity on operator performance" Proceedings of the Human Factors and Ergonomics Society, #28, 1984, pp 740-744

[iii] Holywell, P.D., Marshal, E.C., An experiment to support the design of VDU-based alarm lists for power plant operators. In Stanton, N.A. (Ed), Human Factors in Alarm Design, Taylor & Francis, 1994, pp 31-44.

[iv] Singleton, W.T., The Mind at Work, Cambridge Press, 1989, pp 229.

Question of Control Room Etiquette

If you are talking to a consultant in a central control room and hear snoring from one of the other consoles, do you (a) ignore it and hope the visitor doesn't hear it, (b) make noise at your console in hopes that it wakes the other operator, (c) ask the other console an inane question and risk a startle response, or (d) block in the other unit's rundown and wait for the alarms to wake them. The operator I was talking to chose (a).