PREVENTING CHARLIE'S IN A CHOCOLATE FACTORY: A HUMAN FACTORS PERSPECTIVE OF ALARM HANDLING IN CONFECTIONARY MANUFACTURE

Neville Stanton

Health & Safety Unit
Mechanical & Production Engineering
Aston University
Aston Triangle
Birmingham
B4 7ET

A questionnaire was developed to survey the attitudes of a small population of Control Desk Engineers (CDEs) at a U.K. manufacturing plant. The general aims of the survey were to obtain information to enable an assessment of CDEs responses to their alarm system. Specific objectives of the survey were:

1. To elicit the CDEs' definition of the term 'alarm' ;
2. To examine the CDEs' alarm handling activities;
3. To get information on problems with the alarm system.

INTRODUCTION

There is a need to develop an accurate definition of the term 'alarm', because unless the subject under analysis is clearly pinpointed it cannot be studied properly. A frequently given definition of an alarm is "a significant attractor of attention", however a dictionary (Collins, 1986) gives 9 definitions of the word 'alarm'. This demonstrates the inadequacy of the first definition, because whilst an alarm does attract attention, its 'attractiveness' is only one of its many properties or qualities (Stanton & Booth, 1990a). The main problem with definitions of "alarm" is that they tend to concentrate on one or a limited subset of its qualities. An alarm may be considered from various perspectives (Singleton, 1989), but they need to be integrated into one comprehensive definition if the term is to be understood in its entirety. One Human Factors approach is to consider the alarm within a systems model (Stanton & Booth, 1990b). This uses a 5 main point definition: Specification, Activation, Attraction, Acknowledgement and Action. In breaking the definition down into five main parts, it is possible to suggest how different perspectives might contribute to a more comprehensive definition (Stanton, 1990a).

QUESTIONNAIRE ANALYSIS

Eight self selected respondents from a process plant within the U.K. completed an 'Alarm Handling Questionnaire' devised to assess their attitudes toward their alarm system. Their central control room experience ranged from seven to thirty eight years. Content analysis was employed for analysisng the questionnaire data as many of the items were open ended. Design of the questionnaire was undertaken after an intial visit to the control room and a small pilot study.

The questionnaire sought to gain the CDEs' (Control Desk Engineer) definition of the alarm system(s) with which they are familiar. Content analysis of their responses showed that the majority of CDEs believe that the alarm system:

- was designed to attract their attention to faults,
- provides warning information,
- is used to initiate fault finding activities.

This suggests that the designers' perspective (certainly in terms of the definition) does not always concur with the users' perspective (Stanton, 1990a) and may lead to problems in operation.

Many theoretical models have been developed to explain control room behaviour, but very little empirical evidence has been presented in their support, outside of the experimental laboratory. This questionnaire aimed to get some insight into CDE activities by the use of critical incident technique: to ask them what they did in response to routine alarms, and what they did in response to critical events. The following model was developed from previous research in an unrelated industry (Stanton, 1990b) which highlight the difference between routine incidents involving alarms and critical incidents involving alarms. Typically CDE's report that they will observe the onset of an alarm, accept it and make a fairly rapid analysis of whether it may be ignored, dealt with superficially or require further investigation. Then, even if they feel that it may require further investigation, they may still try to correct and cancel it just to see what happens. If it cannot be cleared, then they will go into an investigative mode to seek the cause. Then in the final stage the CDE will monitor the status of the plant brought about by his corrective actions. The high cognitive level "Investigation" is what distinguishes critical from routine incidents. The model may be considered in terms of previous models of event handling in control rooms which lend some theoretical support from an information processing viewpoint. As it is based on CDEs reported activities it has the benefit of some empirical support also.

This model was largely supported by the respondents answers to the questionnaire. It is proposed that the alarm system should support the six stages of handling, not disrupt them. However the requirements from the alarm system may be different in each of the stages. For example:

- attraction is required in the observation stage;
- time to read and acknowledge are required in the acceptance stage;
- links with related data are required in the analysis stage;
- underlying cause(s) is needed in the investigation stage;
- appropriate corrective action is required in the correction stage;
- and changes brought about by corrective action needs to be shown in the monitoring stage.

CDEs were asked how they diagnose faults based on alarm information. This is mainly based on past experience, but sometimes also includes the pattern of alarms and order of occurrence. The suggestion that past experience plays the major part in diagnosis places a important emphasis on the training of CDEs to present a wide range of conditions, some of which may only be encountered very infrequently. Bainbridge (1984) suggested that past experience can play a major part in diagnosis, but that this could also be a potential source of error, as it may be misleading. It puts an emphasis on encountering a wide range of plant conditions if it is to be a successful diagnosis strategy.

The final aim of the questionnaire was to elicit from CDEs what problems they encountered, and what might be done to alleviate them. The responses it reasonable to suppose that alarms are missed, and 4 examples occurred recently. The major reported reasons for alarms being missed were related to: inadequate training, not being present in the central control room, jamming the audible alarm, system failure and the distraction of other tasks.

If alarms are being missed, then it follows that they have not been detected. This may provide a starting point for consideration of how to support the detection stage of alarm handling. If the alarm has not been detected, the information cannot be passed to the subsequent alarm handling stages. However, it is hypothesised by the author that difficulties in the design of alarm systems are almost inevitable due to the conflicts that arise in the support of each stage of alarm handling. In terms of Wickens (1984) "multiple resource" and "S-C-R" theories there is a possibility of competition over limited cognitive resources. Multiple resources theory suggests that attentional resources concentrated at one stage may subtract from the next, but free channels may enable the use of other input modalities. Whereas, S-C-R theory suggests that there needs to be a compatible relationship between the processing of information from one stage to the next. Further, Rouse (1983) noted that the diagnosis (called 'investigation' in the model presented) and compensation (called 'correction' in the model presented) are in conflict. In response to an incident, a longer wait before intervention may lead to a more accurate diagnosis, but it may also lead to a further deterioration in plant state.

CDEs were asked what aspects of the information presented to them in the CCR hindered the diagnosis of the cause of the alarm. The responses suggest that there is to little information to diagnose from, and what information is made available is difficult to interpret. Goodstein (1985) proposes that these type of problems are typical of using essentially 'raw' plant data. This demonstrates that the alarm system does not appear to be supporting the investigative processes of the CDE during the diagnosis stage of alarm handling.

Half of the CDEs who responded thought that their alarm system could be improved. The suggestions were: aiding the fault finding process, keeping a permanent record of alarms as a 'look-back' facility and the improved use of coding (i.e. tones) to speed up the identification and classification process.

CONCLUSIONS

Whilst it is clear that these are tentative findings, and more research is needed, it does suggest that a new approach to alarm systems is required. There is certainly a need to develop a more accurate definition of an alarm, because unless we know what it is we are studying, we cannot conduct useful research. The definition may allow a controlled investigation of specific attributes or qualities of an alarm system. This should be incorporated with an overall philosophy of deciding the purpose of an alarm. One approach might be to reduce the number of alarms to the important ones. The problem remains that in different contexts what is 'important' might change. So this simplistic approach is of very limited use. Another approach might be to incorporate alarms into better display methods; to display the information in a manner that is compatible both with the task and human thought processes. This does not necessarily mean a reduction in the amount of information available, such as proposed in the first approach, but different means of looking at the information to support the task. Representation of alarm information should ideally reflect the nature of the operators' task, and what they are required to do with the presented information. This highlights the need for a flexible environment for manipulating the raw data, to present the information in a compatible manner. Otherwise the operator has to perform this manipulation internally, which may add substantially to the task.

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