Perception of Procedures by Operators and Supervisors

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Abstract

This paper reports a study carried out on the perceptions of supervisors, technicians and operators of the procedures for seven safety-critical activities. Using a questionnaire in which the subjects rated a variety of attributes, and ranked the different procedures in terms of dangerousness, controllability, susceptibility to violation, a mental model was constructed within which the different procedures can be placed. It was found that there are few differences between supervisors and operators, but where there are these probably relate to the time-scale over which control is exerted. The rated quality of procedures was found not to be related to the perceived susceptibility to violation. One important finding was that, contrary to the expectations of safety management systems designers, concurrent operations were rated as both less dangerous and more controllable. The conclusion is that such techniques can uncover major differences between how the workforce see procedures and how management believes they are being used.

Introduction

Procedures form one of the most important ways of ensuring safety and integrity of operations. A well-developed set of procedures, understood and followed by the workforce, should ensure that there will be few problems that can ever lead to incidents. It is, unfortunately, a fact of life that many incident scenarios show that people all too often fail to follow procedures. The study reported here, part of a larger study into the violation of procedures[1], was aimed at understanding how operators and supervisors think about their procedures. If, for instance, they feel that the procedures are of poor quality, inaccurate and inappropriate to the real work at hand, it might not be surprising if they fail to attach as much importance to them as to those procedures that they perceive to be critical, useful and worthwhile.

Differences in perceptions of procedures between operators and supervisory staff may help to explain why some incidents seem so unexpected. The problem is one of the divergence between paper systems and the reality. The procedures may exist and be in place, but that still provides no guarantee that they will be followed. As this study will demonstrate, even the belief amongst those who use the procedures that they are of high quality is not sufficient to ensure that they will, therefore, be followed to the letter.

Questionnaire Construction

A number of activities were selected which are defined as *safety critical* in terms of the NAM Safety Management System (SMS). For practical reasons they also had to meet the requirement that most of the technicians, operators and supervisors would be familiar with them. A selection of 7 activities was made from the NAM "Activity-Hazards Matrix" [2]. From this matrix, in which more than 90 activities are screened on 21 hazards, the following seven critical activities were chosen:

1. pressure testing
2. working in enclosed spaces (wells, tanks)
3. handling dangerous (toxic, flammable) substances
4. scaffolding (not building scaffolds)
5. working with temporary connections
6. making and removing temporary connections
7. concurrent operations.

Of these activities *concurrent operations* is the most risky activity, according to the hazard matrix, as almost every one of the 21 hazards is marked. The danger of concurrent operations was highlighted by the Piper Alpha disaster [3]. If operators who are carrying out the concurrent operations view them as highly sensitive and critical, then the use of

procedures as control should be sufficient. If, on the other hand, the task is taken lightly, then the procedures are likely to be taken equally lightly.

Method

A questionnaire was developed with a number of general questions and sets of questions specific for each of the activities chosen. These questions can be specified as follows:

a. Paired comparisons of the seven activities - each activity is set against each of the other activities so that there are 21 comparisons in total;

b. Rankings of each of the activities on 4 attributes:

1. *Perceived dangerousness* ("Which activity is the most dangerous?");
2. *Importance* (according to the respondents own criteria) ("Which is the most important?");
3. *Controllability* ("Which is most controllable?");
4. *Sensitivity for violations* ("Which is most likely to have people committing violations?").

c. Each activity is given a rating on a 5-point scale, using 18 items, with respect to:

1. the *probability* of accidents,
2. *controllability* of the activity,
3. the content and *quality* of procedures
4. perceived *sensitivity* of the activity for violations and
5. the amount of *experience* the rater has with the activity.

Two questions were included to allow assessment of the respondents' own skills and risky behaviour, when compared to colleagues with comparable experience. Finally there were two open-ended questions in the list in which the respondent was asked to list main reasons for violating procedures and suggestions to prevent the violating of rules.

Twenty questionnaires were distributed on three company sites. Eighteen persons filled in the questionnaire: 5 supervisors, 7 technicians and 6 operators.

Paired comparisons and ranking on attributes.

Respondents made comparisons of the seven activities on 5 point scales (running from ***not at all similar*** to ***very similar)***. They were instructed to use their own relevant criteria in making the 21 paired comparisons.The purpose is to find out if these comparisons, which result in (dis-) similarities, can be used to find a limited number of dimensions which reflect their way of viewing the activities. With the use of a multi-dimensional scaling computer program the "similarities" can be translated into distances [4].

Results. In this study two dimensions were sufficient to represent the mental model that covers the seven activities. The dimensions are themselves abstract and interpretation of the dimensions will be described below. In Figure 1 activities which are perceived as more similar are plotted closer together, and activities perceived as more different are plotted further apart. For example "scaffolding" occupies a more or less unique position compared to the other activities while the activities "working in enclosed spaces" and "handling dangerous substances" appear to be viewed as quite similar. It seems that the similarity ratings of the 18 persons *can* be well represented in terms of such distances.

Discussion. Given this result the conclusion is that the workers are in fairly close agreement in their perception of the activities when they use their own criteria for comparisons. Nevertheless, there are clear individual differences in the way people assign weights to the first and to the second dimensions. These differences are not related to whether individuals are supervisors or not. We had hoped that we could discover differences of this sort between supervisory and other staff. The technique is certainly

capable of elucidating such differences as might exist between different groups, the results suggest that the supervisors consider such tasks in much the same way as those whom they supervise. This internal understanding of how the tasks are related is termed here a *Mental Model*.

Interpreting the Dimensions.

How should the two dimensions be interpreted, defining the 'space' within which the mental models can be plotted? Do certain attributes structure this mental model or not? Four attributes for which this might be the case were chosen: *importance*, *dangerousness*, *controllability and sensitivity to violations of safety procedures*. If, for example, the sensitivity of procedures to violation is a relevant attribute for the respondents in their perception of the activities, then this would fit in the mental model. The same can hold for the other attributes.

Results. The respondents ranked all 7 activities on the four attributes. Usingthe PREFMAP[5] computer program the mean rankings were 'fitted' in the mental space of the activities made up by the same respondents. The (nonmetric) fit values let us know how successful this attempt was. (with fit values respectively for *importance*, *dangerousness*, *controllability* and *sensitivity for violations* of 0.830; 0.916; 0.69 and 1.000). A perfect fit is represented by 1.0, lower values indicate less than perfect fit. 0.69 still represents quite a good fit.

In Figure 2 the attributes are fitted in the mental model with the 7 activities. The arrows (vectors) point in the direction of "less important", "less dangerous", "less controllable" and "less sensitive for violations of procedures". Note that the arrow of "less controllable" points in the same direction as the arrow "more dangerous". However one should bear in mind that the "controllability" attribute provides the least good fit. Either the respondents have less agreement about the controllability of the safety critical activities, or they find it more difficult to assess this attribute.

The attribute with the best fit (1.0) is the sensitivity for violating procedures. The latter finding presupposes that the simple rankings respondents made on this attribute (i.e. assigning ranks from 1 (least sensitive) through 7 (most sensitive) to each of the activities) is almost exactly represented in this figure as the table of the mean rankings shows. (*w* is the Coefficient of Concordance, the value is statistically significant, which tells us that respondents agree quite strongly about this ranking). Only activities 5 and 6 are reversed in order in Figure 3 which shows the order of the activities on the vector/arrow representing this attribute.

	Activity	mean rank
1	working in enclosed spaces	5.29
2	handling dangerous substances	4.91
3	concurrent operations	3.94
4	making/removing temporary bypasses	3.91
5	scaffolding	3.47
6	working with temporary connections	3.32
7	pressure testing	3.15

Table 1. *Assessment of the sensitivity of procedures to violation (N=17)*
w = 0.14; X^2 14.69; df. 6; sign.= 0.02. (one missing value)

Discussion. In general the plot shows that activities that are perceived as *more dangerous* and *less controllable* (like working in enclosed spaces and handling dangerous substances) are, at the same time, seen as *more* vulnerable to violation of the procedures, while pressure testing is seen as relatively 'safe'.

It should be noted that concurrent operations is perceived as both *least* dangerous and one of the *best controllable* activities!. This contrasts strongly with the assessment of concurrent operations in the SMS activities-hazard register. The technique used here has demonstrated that both supervisors and operators clearly take concurrent operations more lightly than do the designers of the SMS. The practice and the theory appear to have diverged already. Possible reasons for this will be discussed at the end of the paper.

The quality of procedures in relation to their sensitivity to violating

It is possible to measure the 'quality of procedures' using a scale constructed from the original questions. The scale initially consisted of 6 items, after removal of one item the scale appeared fairly consistent (Cronbach's a=0.76). The scale was then constructed using the following items, rated on a 5 point scale:

- The procedures are time consuming
- The procedures are typically written from 'behind the desk'
- The procedures are comprehensible
- The procedures are easy accessible on the spot
- There are just too many procedures

But are 'good' procedures more or less often violated than 'bad' procedures? In other words, what is the relation between the quality of the procedures and their (perceived) likelihood of violation? To answer this question the mean scale values of the 'quality of procedures scale' and the mean rank order of the activities on violating can be compared. Figure 4 shows no linear relation between the (perceived) sensitivity to violating of procedures and their quality. For example 'working in enclosed spaces', seen as most sensitive to violating of procedures, also has the highest mean score on the quality of the procedures. This result is surprising at first sight, it implies that evaluations of procedures in terms of their quality can not serve as a basis for predicting whether they will be violated or not.

Differences in perception between supervisors and technicians & operators

Do supervisors differ from technicians and operators in the way they look at the seven safety critical activities?. To answer this question the 5 are compared with the group of 13 technicians or operators on the mean ranks on the four attributes (see Tables 2,3,4 and 5). Table 2 shows that operators and technicians assign a higher mean rank for importance i.e. consider working in enclosed spaces more important when compared to supervisors. Technicians and operators also consider working in enclose spaces as a more dangerous activity than do supervisors (Table 3). Supervisors, however, do assess two activities as more dangerous: working with temporary connections and making/removing temporary bypasses. On the two other attributes there are no significant differences (Table 4 and 5).

Activity	Assistant supervisor	technicians/ operators
pressure testing	8.00	10.08
working in enclosed spaces	6.20	10.77
handling dangerous substances	10.30	9.19
scaffolding	8.30	9.96
working with temporary connections	11.40	8.77
making/removing temporary bypasses	12.30	8.42
concurrent operations	8.80	9.77

Table 2. *The assessment of importance of activities (N=18).Larger ratings mean more important. Working in enclosed spaces is marginally different (p < .10 two-tailed) between supervisors and technicians*

Activity	Assistant supervisor	technicians/ operators
pressure testing	9.20	9.62
working in enclosed spaces	5.30	11.12
handling dangerous substances	8.90	9.73
scaffolding	6.60	10.62
working with temporary connections	12.70	8.27
making/removing temporary bypasses	12.80	8.23
concurrent operations	9.60	9.46

Table 3. *The assessment of dangerousness of activities (N=18)Larger ratings mean more dangerous. . Working in enclosed spaces israted significantly differently (p < .05 two-tailed) between supervisors and technicians*

Activity	Assistant supervisor	technician operators
pressure testing	9.10	9.65
working in enclosed spaces	11.10	8.88
handling dangerous substances	8.50	9.88
scaffolding	9.70	9.42
working with temporary connections	11.70	8.65
making/removing temporary bypasses	6.60	10.62
concurrent operations	10.10	9.27

Table 4. *The assessment of controllability of activities (N=18)Larger ratings mean more controllable.*

Activity	Assistant supervisor	technician operators
pressure testing	7.00	9.83
working in enclosed spaces	11.10	8.13
handling dangerous substances	9.40	8.83
scaffolding	8.10	9.38
working with temporary connections	8.80	9.08
making/removing temporary bypasses	11.20	8.08
concurrent operations	9.30	8.88

Table 5. *The assessment of sensitivity to violation of procedures (N=17)*
1.one missing value. Larger ratings means more sensitive.

Discussion. A possible explanation for the differential assessment of working in enclosed spaces is that the technicians have more direct physical contact than do supervisors. A possible reason for supervisors assessing working with temporary connections and making/removing temporary bypasses as more dangerous is that these activities have consequences for them in the planning for future activities. The operators, in contrast, only see the danger of the immediate work, not of the possible negative consequences of work poorly performed on later activities. Although there are no significant differences between the 2 groups about how they think about controllability, however, as was mentioned before there is no agreement between workers about the order of activities on this attribute. There appear to be no significant differences between both groups about the sensitivity for violation of procedures of the activities.

Reasons for violating procedures

One 'open question' asked the respondents to name the reasons they consider as important for why people violate. The 18 respondents gave 45 reasons. Three researchers,

independently of each other, assigned these reasons to 6 main categories (Table 6). An example of the reasons categorised as 'Organisation/Planning' is time shortage and shortage of manpower. These three raters came to a moderate but significant agreement. The reasons are *perceived* as important by the respondents and need not reflect the real reasons for violating. They do, nevertheless, provide an indication of the reasons people might adduce when deciding to violate. As another study[1] has shown, these reasons are not too distant from the actual reasons for violation, especially the concentration upon Planning and the low importance attached to Supervision.

Reason given for violating	**Proportion**
Organisation/Planning	37%
Procedures	14%
Routine	6%
Motivation	13%
Knowledge/Training	22%
Supervision	8%

Table 6 *Reasons offered for violating procedures (N=45).*

Discussion

This study has uncovered a number of important factors about procedures used to control hazardous activities. One crucial finding was that concurrent operations are perceived as both least dangerous and highly controllable. Another finding was that the perceived quality of the procedures appears to bear little relationship to the expectation that violations will occur. While it was statistically less strong than other factors, the controllability of events is still well enough established to allow us to draw several conclusions.

The extent to which people respect and will follow a procedure is related to the degree to which they feel that they have little control over events. When people feel in charge, procedures are, at best, regarded as a guide rather than a strict command. The differences between supervisors and the workforce only start to come out when the time-scale of events is considered. So technicians and operators tend to evaluate their procedures in a very short term manner, while supervisory staff take a longer view.

References

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5. Meulman, J. & Heiser, W.J.

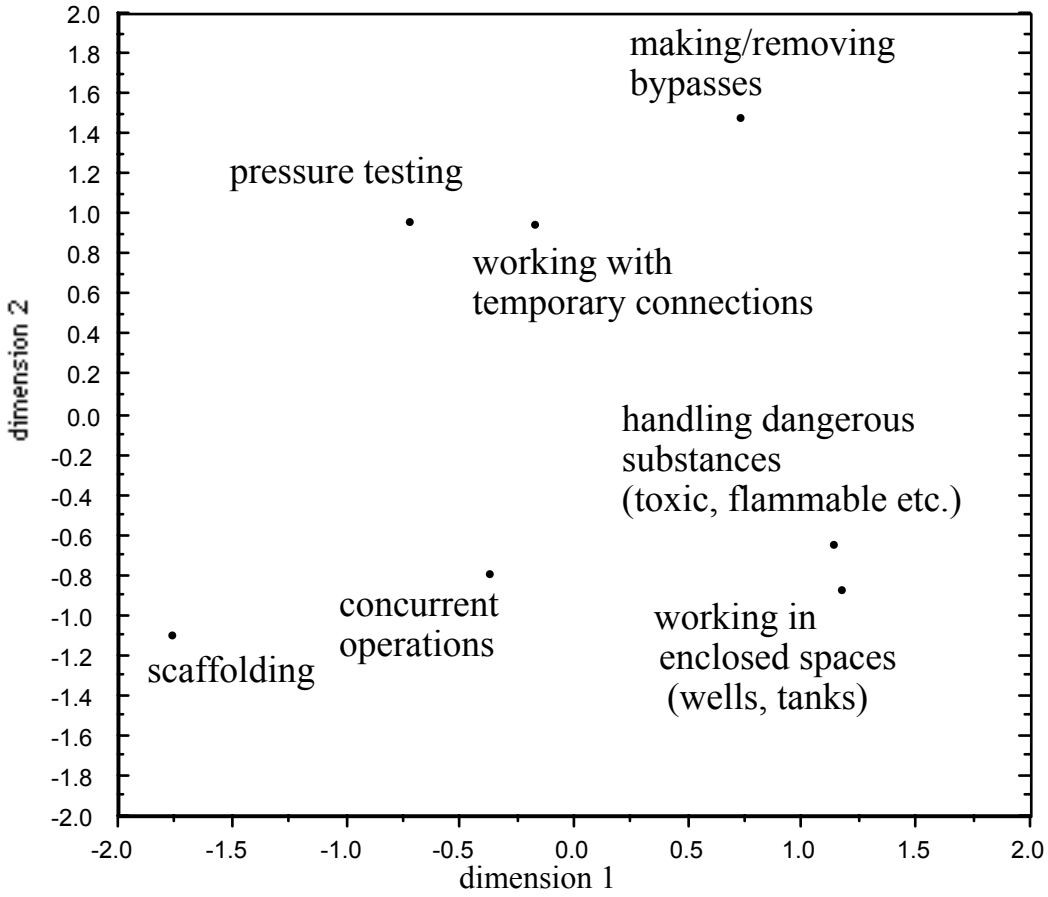

Figure 1 *Seven safety critical activities mapped in two dimensions.*

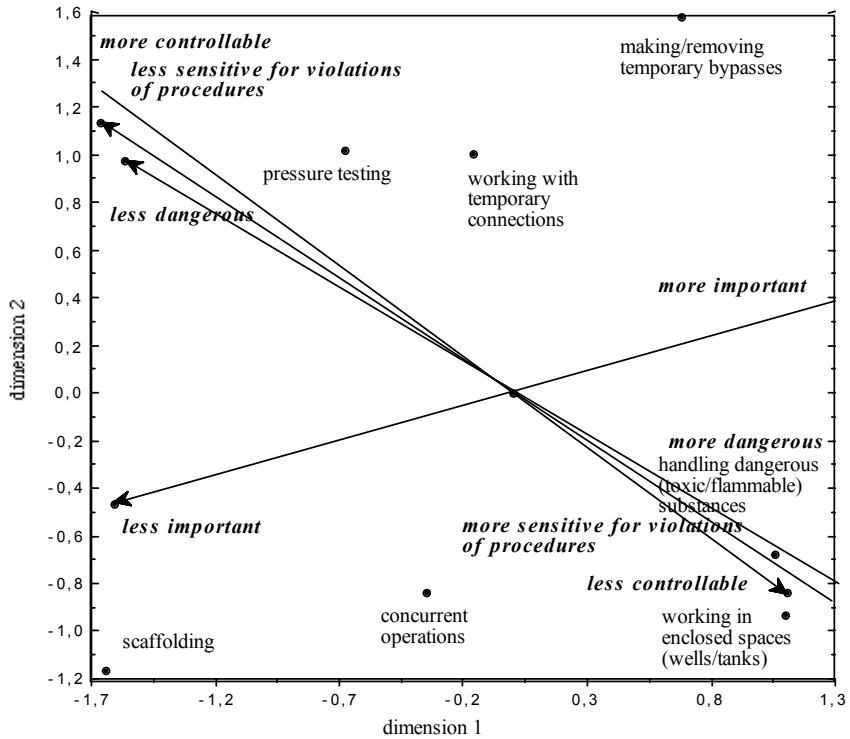

Figure 2. *Four attributes mapped in the activity space*

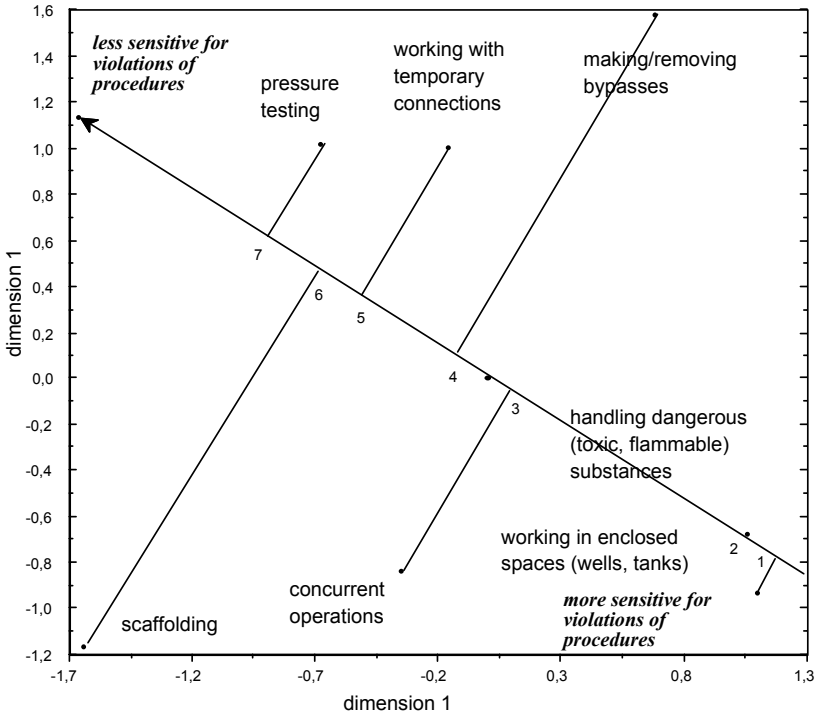

Figure 3 *Activities ranked by their sensitivity for violating the procedures*

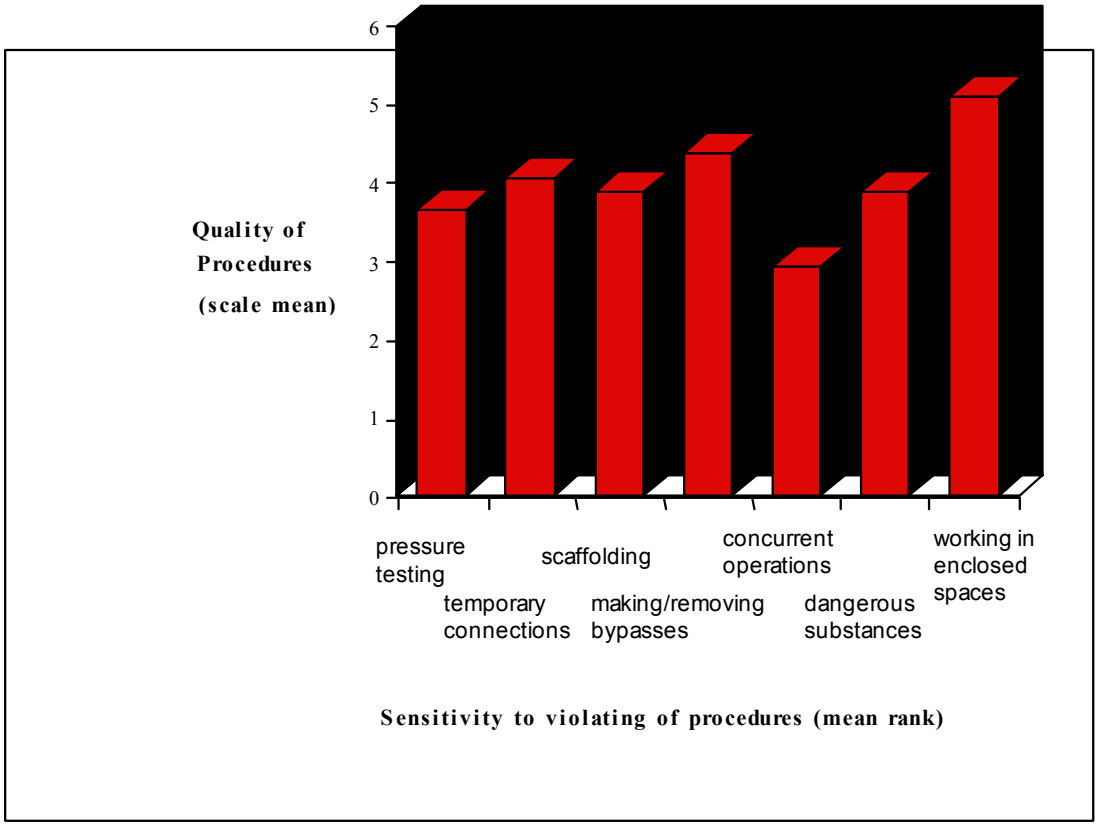

Figure 4 *The rated quality of procedures and their perceived sensitivity to violations for 7 activities*