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Working Document

RESEARCH, TRAINING AND PRACTICAL MEASURES  
IN THE AREA OF SAFETY PROMOTION

Source : Université Libre de Bruxelles  
Laboratoire de Psychologie Industrielle

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## Presentation

The idea of Community Ergonomic Research developed out of previous experience with a Community research project on industrial safety in the ECSC.

At a time when the scope of recent experience in the area of ergonomic action is being questioned (1), it seems reasonable to look into the practical conclusions of reflection on systems of work, their functioning and safety, which began in the context of this first Community research.

The theoretical knowledge has been set out in a printed work (2) and has given rise to training experiments. These experiments and the discussions which followed led to the drafting of this report whose conclusions coincide in many respects with those reached in the document cited in footnote (1).

Dr U. VIDALI  
Director

Luxembourg, 25 May 1975

- (1) Methods and criteria for ergonomic adaptation of industrial work, by Mr THEUREAU and Mr WISNER.
- (2) Reliability and safety - Studies of industrial physiology and psychology. Study No. 7 - Commission of the European Communities.



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Foreword

This document was written at the end of the experimental seminar in Pont-A-Mousson organized on 19, 20, 21 and 22 June 1974 by the Commission of the European Communities, but it is not a faithful account of that seminar : it merely outlines the ideas put forward on that occasion, develops them further, and looks at them from a new angle.

Readers who are particularly interested in this seminar on "Safety and safety training", intended for trade unionists from France, Belgium and Luxembourg, should consult the working report prepared at its conclusion (1). Reference will be made in the following pages to a number of texts distributed to the participants : so as not to complicate our analysis by excessively long descriptive commentaries, we simply refer the reader to the basic documents available from the Commission of the European Communities (2). Finally, a full description of the teaching material used at this seminar can be found in the final scientific report or Research Project No. 6242/11/04 (3).

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(1): "Safety and Safety Training". Cyclostyled report, Free University of Brussels, 1974.

(2): Primarily : 1. An Italian document on the "Working Environment" produced jointly by the three Italian Trade Union Confederations  
2. "Reliability Factors", Industrial Psychology Laboratory of the Free University of Brussels, 1974.

(3): "Research on the structure and organization of the working environment with reference to safety : training in safety and reliability. A few teaching tools and their area of application", cyclostyled report, Free University of Brussels, 1973.

One further note : our analysis has been determined by past experience and we have not made generalisations. Our references to research relate to research work conducted in the field by University teams which are not connected with the industrial undertakings concerned; similarly, the training referred to was carried out by a group of persons indirectly linked with the Commission of the European Communities. This detail is important when it comes to drawing conclusions as to the role which these bodies should play; the role of the EEC Commission in safety training is not identical with, for example, the role in safety training of the trade unions. Consequently, these notes must be read in the specific context of action taken by the Commission.

V.D.K.

## 1. INTRODUCTION

These notes are the result of a comparison of research projects conducted over a number of years in the area of safety and of subsequent training experiments.

The Industrial Psychology Laboratory of the Free University of Brussels <sup>\*)</sup> has conducted a series of studies in the mines and the steel industry since 1967. These studies, which must be seen in conjunction with the work of French and Italian experts, have led to a new and broader concept of safety. The concept of safety in the strict sense of the term - i.e. concerned solely with accidents followed by physical injury - has changed : in future, attention may be centred less on the accident as such than on the circumstances leading up to it; for instance, on the technical incident or breakdown which is frequently noted before an accident.

The idea of an irregularity or breakdown enabled us to go beyond the individual and to consider the production system which includes both men and machines. In this way two major obstacles to preventative action were no longer considered inevitable because they could be foreseen beforehand through incidents; moreover they were no longer considered attributable solely to human error or failure. Instead, accidents were seen as a symptom of a more general malfunctioning - of the system as a whole.

This approach led to research into the various factors which influence the reliability of the system, i.e. the confidence which can be placed in it.

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\*) Under the aegis of the ECSC

These factors - known as risk or reliability factors - were always linked with an operational objective; they could be modified in order to improve safety. In other words attention was not focused on factors which cannot be influenced - e.g. hypothetical accident proneness, impact of psychological components such as aggression or frustration, influence of a disturbed family environment etc... The causal role of these factors in certain accidents could not be disregarded; but as such factors cannot be controlled, the only possible solution would be to make an appropriate selection of employees, which was not our aim in this instance.

It is therefore apparent that the choice of a given category of factors presupposed a close link between research and practical measures even if that link was not immediately explicit.

To begin with a link was created between research and training : the Commission of the European Communities, desirous of ensuring wide distribution for the studies subsidized by it, asked the research bodies to engage in training action. Thus the Psychology Laboratory of the Free University of Brussels was entrusted with the task of preparing teaching material capable of backing up the results of the theoretical work. Training manuals, case studies, films and instructional games were prepared. They all reflected one central idea : safety is not a matter of rules and standards and cannot be learnt; it must be based on the individual's own analysis of his working situation. Consequently, it is important to develop his capacity for analysis.

These materials were tested in the industrial and trade union environments. An experimental seminar intended for union representatives from France, Belgium and Luxembourg was organized in Pont-A-Mousson. Innumerable

difficulties arose - rejection of some material, uncertainty when confronted with risk factors, criticism of the concept of reliability etc... The difficulties could quite easily be listed and commented on; it would be possible to review the teaching materials and exclude the elements criticized; all the ideas put forward on safety could be examined and those which have led to unanimous criticism could be eliminated. But this work of cutting and pruning could only be carried out after the event. In fact the difficulties, apparently isolated from each other, which arise when confronted with a specific audience in specific circumstances, the apparently independent obstacles - such as criticism of productivity linked with reliability and criticism of the game aspect of some teaching materials - ultimately lead to the same question : what is the link between research, training and practical action ?

Practical action means involvement in a real industrial situation subject to constant social and economic pressures with the palpable presence of interacting forces in the enterprise; action is necessary if safety is to be improved; and if the purpose of theory is not to facilitate action and lead to certain measures why should it be confined to "operational" factors ? If theoretical research does not help to encourage measures influencing factors detrimental to reliability what is its purpose ? If the aim of training is not to develop the analytical ability of the participants so that they can influence the system, how can it be justified ? How can it be expected to succeed ? How can it be reconciled with rejection of the idea of human error as the sole cause of accidents ? All these questions raise problems which were encountered in the experiments conducted to gain acceptance for accident theory. To understand these problems an attempt must be made to answer the questions

rather than simply to give an exhaustive list; our conceptual framework must be better defined and an attempt made to remove a certain lack of precision and resolve apparent contradictions.

That is the purpose of these notes. We think that if a dialogue is to be opened with the workers <sup>\*)</sup> in the area of safety, it is essential to clarify our objectives and take account of certain self-evident facts. We intend therefore to summarize the situation, circumscribe the area in which research, training and practical action take place and seek the linking factors between them. The existence of these linking factors which are often considered self-evident but are not closely defined, will have far-reaching implications for the future and will help to pinpoint those aspects which it seems useful to examine in more detail later on.

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\*) In this text the term "worker" is always used in the broadest sense, i.e. to denote any person participating in the production system with reference to this technical function.

2. INITIAL ASSUMPTIONS

The term "safety" in the industrial environment often implies a compromise resulting from the reconciliation of conflicting interests. Even if the concept of "safety" is replaced by that of "reliability", one self-evident fact must be taken into account. The man-machine system includes men, in other words individuals with special interests, needs, aspirations and limits which are not only of a physiological order but precisely reflect the state of a given society : the factory is a microcosm and safety reflects all its tensions. It is also a hunting ground for all kinds of projected notions and suspicions.

If then safety is to be discussed, certain initial assumptions must be defined to avoid sharp criticism. These assumptions may appear self-evident but they introduce an order of priority into the objectives which must not be disregarded.

They also open a dialogue : there is too often a tendency to confuse the fact that the position of certain research teams is external to the industrial system with a lack of any position on the subject of safety. This preamble will help to remove that element of ambiguity.

- a. the human objective
- b. the factory as the focus of attention
- c. safety at the intersection of an interplay of forces.

- a. The human objective of safety and reliability

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Within the industrial system, dominated by production requirements, the primary consideration of safety is man, his health and the avoidance of physical injury. Man as a worker is the constant point of reference; in a

society which has reached the level of technical development we know today, it is not normal for individuals to have to set their life at risk or prematurely wear themselves out at work.

For legal and methodological reasons, the problems of health and safety were for a long time considered separately : yet the tenuous nature of this formal distinction is becoming increasingly apparent. Changes made to the production process with the development of science and technology have led to a great increase in the number of workplaces at which nervous tension takes the place of physical fatigue and where mental and psychosomatic disorders replace physical injury. The new workplaces do not cause injury in the same way as the old ones did : as a result the conventional concept of safety is altered. The aim must now be to protect the mental integrity of individuals and not simply their physical well-being.

This change in the nature of the problem has specific consequences for research.

It compels us to question the validity of the indices used in studies on safety.

Accidents and incidents - in the sense of technical malfunctions - were visible phenomena, easy to locate in time and space and suitable objects for analysis.

But this does not apply to the disorders caused by an excessive mental strain. When do such disorders begin ? How can they be defined ? What is their cause ? One method of answering these questions has been to use indirect indices which can nevertheless be quantified; the influence of certain types of work organization and of certain workplaces on individuals has been studied through the traces left by individuals on the process as such : quality of work, errors, production etc... The assumption then is that a deterioration in these indices reflects a lack of



suitability of the workplace or working method for man - and this lack of suitability is liable to be harmful to him in one way or another. This intellectual approach is commonplace and has been used in several EEC research projects on safety.

Nevertheless it raises a number of problems : to what extent can indirect technical indices reflect human malaise ? The correspondence is not absolute. Here, interestingly enough, we come to one of the criticisms made of research into reliability, namely the confusion found here between productivity and safety as though these two notions could always be perfectly superimposed.

By using indirect indices we in fact introduce the idea of a threshold or limit in safety which is incompatible with its objective and intentions; attention is given - with a view to adapting work, reorganizing the system or modifying the workplace - only to adverse working conditions which influence production. It still has to be shown, however, that an ulcer, at least in its early stages, inhibits work, that repeated insomnia prevents the worker from performing his task on the assembly line and that a heart attack is heralded by a fall-off in production...

It is worth quoting here an anecdote reported to us by a participant in a training seminar : a factory with a paternalistic approach used always to send its retired workers a new year parcel. These parcels were listed in registers and the union delegation decided one day to prepare a breakdown by workshop in the factory. This investigation showed that in one particular sector there had never been any recipients of the parcels. An inquiry was made and the astonishing conclusion reached that there was no one to receive a parcel because no one ever left the workshop to go into retirement ! All the workers quietly died before reaching retirement age... A quite unusual circumstance had been necessary to discover this anomaly.

The margin between safety and health, between psychology and industrial medicine is narrowing day by day : this fact cannot be disregarded.

That is why it is becoming increasingly necessary in research conducted in the enterprise to take into account not only indirect indices linked with the technical process but also subjective assessments by the workers themselves; that is to say their assessments of what they feel and express which cannot be verified by a purely experimental approach. Research workers have of course never overlooked these subjective indices : indeed they have often made use of them to construct their hypotheses. But once their hypotheses had been defined, they were validated through indices derived from the technical process which were alone able to guarantee scientific objectivity.

This is a rigorous approach, but there are other possibilities; a subjective index may in fact be verified by a second, objective index or by its repetition in a similar context by a collective evaluation of the workers concerned.

If thirty persons in a particular workshop complain of headaches there is no need to look at the particular type of production to incriminate the conditions of work as a whole. This is an extreme case, but it is important to recognize that it may be more than a mere example and may provide the basis for a method. The search for subjective indices and their systematic organization in defined situations and the creation of a typology specific to these indices may be a new way of looking at safety with the guarantee of human terms of reference and with the agreement of the workers concerned.

We shall return later to these problems as they relate to research, but it is worth stressing at this stage that the fact of giving priority to a human objective can help to clarify the basic idea of reliability and incidents within the production system : in the man/machine system, the principal axis of reference is man. The breakdown or technical incident

is considered in relation to man : as a threat to his health; rather than the opposite approach : human failure as a serious burden on the technical system.

Any other approach to the question leads to a profound transformation of the problem of safety; and the concept of reliability, instead of widening our horizons, becomes a trap which closes round the worker.

- b. The factory as the focus of attention

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We are concerned here with safety at work : safety cannot be isolated from the work itself and touches on all the conditions in which work is performed, all the constraints bearing on it and the technological development changing it day by day. Consequently, still considering the link between research, training and practical action, we must define the framework for those activities.

Since the industrial situation is the place where accidents occur and the area in which practical measures can be taken, it is normal for it to be taken also as the point of departure for research and theoretical considerations.

Clearly, there are close links between living conditions and behaviour at work - a worker who is tired by two hours of travel in the morning will be more vulnerable than another, cramped and insalubrious premises are not likely to make for a relaxed state of mind in the worker - but this is a two-way relationship and, for operational reasons, we start from the production process.

In analysing the causes of accidents, the factors which can be directly influenced are considered first; we begin by considering a change in the organization and working conditions and then move into a wider context. The reasons for this choice are not only methodological

but also pedagogical - concentration on very general and remote causes of unreliability must be avoided. They are also fundamental : work and the way it is performed and organized, and the attendant risks, are seen as the mould in which the face of human society is cast.

- c. Safety at the intersection of an interplay of forces  
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While in theory every undertaking is interested in safety, in practice safety measures are always influenced by a certain interplay of forces within the undertaking, by a fluctuating economic situation, current legal provisions, the nature of the particular factory which may be flexible or rigid, and by the specific beliefs of certain executives etc...

In short, safety is ultimately the result of a whole set of shifting and contradictory influences. The basic role of safety in the complex industrial system completely determines the measures taken. To quote one example : an undertaking pays a set contribution to ensure its workers against accidents. But in fact the rate of this contribution depends on the number of accidents recorded : beyond a certain accident frequency the premium is increased. This threshold or limit conditions the factory's policy on safety : as soon as the limit is approached, safety campaigns are organized and investments made to ensure that the critical level is not reached.

Another example : a steelworks emits a high level of dust and fumes. The workers complain. But extraction of the dust and fumes would require a very expensive installation. The factory therefore proposes masks which interfere with the work and are not worn by the workers. Shortly afterwards legislation becomes more stringent and a dust control installation has to be set up.

Further examples could be quoted, but our aim is not to indulge in easy criticism. These examples help to stress that safety cannot be isolated from constraints arising from the real industrial situation - it is not sufficient to expose accidents or incidents; safety will always be a matter for discussion and on occasion for confrontation. The economic criterion will play an important part and the social climate will not be a negligible factor... It might even be maintained that the broadening of the concept of safety to cover all working conditions and the inclusion of increasingly refined indices and earlier analysis will not solve these contradictions : they compel us to take account of factors associated with the well-being of workers which are difficult to analyse statistically in the short-term. And few enterprises are willing to envisage this at the present time.

### 3. RESEARCH

If we consider the position of research in relation to training and practical action rather than in isolation, the potential for change and transformation is immediately apparent.

We propose to discuss here research as an integral part of a process of change. At the same time research is considered as a scientific practice, i.e. a privileged method for the development of knowledge. This approach determines the following observations.

Is it possible to conduct research and apply scientific practices in the area of safety, and if so under what conditions ?

What is the position regarding the generation of knowledge ?

Does the obligation to work in a given place - the industrial environment - on living and fluctuating material with a situation consisting of a whole range of constraints, allow room for scientific practice ?

In an attempt to answer these questions we must define what we mean by scientific practices. We would characterize the latter as a form of cognitive appropriation of reality thus subscribing directly to a materialistic line of thought. This means that reality - i.e. the microcosm of the factory - is the point of departure for our consideration; but its appropriation implies more than a simple translation : a transformation of this reality into concepts which are defined and expressed in a theory. We call this transformation "cognitive appropriation".

Any operation which consists in sticking to reality without venturing into abstractions and which tries to report all the apparent movements of reality is an ideological enterprise, since it involves all the imaginary representations required for the maintenance and reproduction of certain living and working conditions, without going beyond those representations.

Let us take the case of an undertaking which, faced with an increase in the number of accidents, decides to send its staff to follow courses of training in safety. If its action is limited to this initiative, the ideological dimension can very easily be isolated : it means that in the analysis made by that enterprise of the causes of accidents, priority is given to the human factor. Man had the accident and it is he who ultimately made the mistake which led to physical injury; he must therefore be trained to avoid such errors in future.

This superficial analysis - which will be found in most accident reports - sticks very close to the facts and does not look beyond them. An accident report made out by the Centre d'Etudes des Problèmes Humains du Travail (Centre for the Study of Human Problems of Work) reflects the two possible lines of investigation :

"At 14.30 on 3 July last, at truck hitching point 3 0001, two trucks were derailed on the empties line. The hitcher left his post to assist in replacing the trucks on the rails. One truck was replaced and the second remained resting on the buffer of the first. The hitcher was told to go farther up the line and try to drop the truck back onto the rails. The dispatcher told him to hurry; he became irritated, wanted to hurry and, while walking down the steps of the basement of the control station, he slipped and fell on the small of his back. It was 15.00; the hitcher had to stop work. A replacement accustomed to this work was called up but he was busy at the higher level and needed half an hour to reach the scene. Meanwhile the derailed truck was put back on the rails and movement had to continue. A tractor driver, Mr DUPONT, was on the scene and available. He was asked to do the work and everything was done successfully; Dupont was sitting on the bench hitching the trucks. The replacement then arrived. Dupont turned round and showed him a hook for his haversack. Accidentally he placed his right hand on the rail. A passing truck crushed his hand. It was then 15.50".

Many interpretations can of course be given to this report. The easiest one is to attribute both accidents to a lack of attention on the part of the foreman, Mr Dupont, and the hitcher : the text lends itself to this interpretation "he became irritated and wanted to hurry", "he accidentally placed his hand"... Another more elaborate interpretation, still centring on the human factor, would consider the succession of incidents and not merely the accident as such : it would stress the lack of familiarity of the persons concerned with the work given to them. The normal substitute is busy and Mr Dupont helps out in the interval; the hitcher leaves his post to assist in replacing trucks on the rails.

The description of the events is detailed enough to enable the idea of the human factor to be developed : it is not however sufficiently detailed if we approach the matter from a different angle, for example, if we seek to ascertain how the work is organized, and to determine the type of relationship between maintenance and production, and the technical factor which caused the trucks to become derailed - were they too heavily laden or were the signals defective ? In short, there is not sufficient information to attempt to discover what may cause a technical incident in the technical process involving all the various relationships, capable in turn of disorganizing work and creating incidents and accidents. Here the analysis is not proposed in terms of the subject but in terms of a chain of events, relationships and interaction.

It is an ideological decision to make the individual responsible, even in the broadest and least critical sense because that tends to hide other relationships which have a decisive effect on the dynamic of the production process. But it is utopian to suppose we can live without ideology : ideology is present in all our social practices, institutions and cultural values; it is closely linked - as history shows - with the progress of science but to



highlight the contrasts and links between research and training it is important to recognize the constant presence of ideology.

The mere fact of using scientific techniques does not mean that we are following scientific practice : for that the information gathered must be located in a system which links, explains and determines it. A theory is required to explain and locate one fact or element in relation to others : it is not sufficient to accumulate facts; they must be brought into relationship with each other. An analysis is described as concrete - as the concrete is not immediate - if it expresses a situation in terms of relationships rather than providing an isolated succession of items of information faithfully reflecting reality.

In this case the cognitive appropriation would therefore be an abstraction resituating objective facts in a context where relationships which were initially hidden come to light. Thus transformation of reality, establishment of relationships and production of concepts are the key elements enabling us to reconsider the research already undertaken in the area of safety.

Accident theory proposes, in a manner which is perhaps restricted, and too heavily centred on the technical system - where other variables are lacking - a canvas to explain certain phenomena of unreliability, allowing forecasts to be made and preventative action taken. At the same time it appears still to be in the developmental phase... It seems interesting to us to consider the achievements to date in the light of the above considerations. We shall take as our reference document the popular manual on "Reliability factors" intended more specifically for training<sup>\*)</sup>.

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\*) Manual presented during the seminar in Pont-A-Mousson, June 1974.

This text lists the risk factors discovered during research and subdivides them into three categories :

1. Factors linked with the workplace : their impact will generally be mastered by ergonomic adaptation. Examples are lack of suitable adaptation to anthropometric characteristics, non-standardized adjustments, wear on the equipment etc...
2. Factors linked with the work situation and organization : these factors are much more general and depend on the way in which tasks are arranged in relation to each other. They include coactivity, succession, bottlenecks etc... Action on these factors amounts to a modification, at least in part, of the enterprise structures.
3. Factors linked with man : this heading includes primarily the factors of human knowledge of the process - in some cases these are risk factors : change of workplace, lack of adequate training, transfer, rapid technological development etc... Even when they are in the nature of strictly behavioural characteristics, these human factors are never assimilated with errors but, as we shall see later, are explained in terms of structures and organization of work.

This list therefore includes two groups and not three kinds of factors : firstly, factors which can be qualified as immediate - linked with the workplace and depending on a single criterion: an anthropometric characteristic, or physical characteristic of the job to be performed - where the problem is simply one of adapting the equipment to a particular point; secondly, there is the group of factors which are not immediately apparent as such since they lie at the intersection of a wide range of influences - these are the

structural factors which cannot be modified in themselves but only through other action with wide-ranging implications.

The document on reliability factors is therefore not homogeneous : a second classification - the immediate and structural - can be superimposed on the apparent, spatial classification - the workplace, situation and man. We stress this other possible reading because it leads to the difficulties encountered in training and, to an even greater extent, in practical action. We cannot automatically assume that situational factors are of a structural nature and workplace factors of an immediate nature.

A few examples will suffice to show that such a superficial classification misses the point; these examples also serve to illustrate more clearly our aims.

#### 1. Factors linked with the workplace

Two examples are quoted here. One is classified under the heading "Lack of adaptation to anthropometric characteristics" and concerns adjustments to the workplace made without reference to the individuals working there, e.g. a step which is too high, a stairway which is too steep, a handle which cannot be reached by a man of average height etc...

The second relates to "catachresis"; catachresis means here the use of a tool or a working method not originally intended for that particular job. An example would be the use of an iron tube as a lever attached to a wrench to release a recalcitrant bolt.

It is not sufficient in this case simply to expose the dangerous process. When we look into the background to the catachresis we find reasons linked with the organization of work : adequate equipment is not available or the distance which has to be covered to fetch it is too great, or else the conventional method has resulted in failure and

is no longer used etc... The phenomenon of catachresis occurs very generally when the organization of work is poor - or in the event of sudden disorganization following an accident or an incident in the recovery phase - and it can only be countered or mastered - must we really prohibit all spontaneity in the performance of tasks ? - by acting on factors which are not immediately apparent. On the other hand once the inaccessible handle or the step which is too high has been altered to suit average human dimensions it will no longer be a reliability risk in that particular sector.

## 2. Factors linked with situation

The factors in question here are all structural in nature - with one exception. They express the general idea that the incident or accident is the result of a phenomenon of interference between schemes of activity; in this case it is fairly easy to apply observations borrowed from road traffic.

These factors in themselves provide a satisfactory framework of interpretation for many work situations - and immediately relate to problems of job organization and structuring, of relations in the hierarchy and so on... They have been called "reliability black spots". One example among many others is the "frontier" factor. It has been found that there is a zone of unreliability in a factory at the points where there is a change of service, supervision or regulation separating successive activities in the production process. The reasons for this are generally due to a lack of communication between the services and a lack of appropriate signalling.

That at least is the first conclusion which can be drawn. But it is worth recalling here the observations made by an expert in a detergent powder factory. He noticed the close functional interrelationship between two successive workplaces in the production process accompanied by an absence of any exchange of information between those workplaces. In this particular instance, the geographical distance between these two places was very short : it was simply necessary to walk a few dozen metres. In fact, however, that short distance was never crossed because the operators at the two workplaces belonged to different areas closely defined in the hierarchy and limited their geographical area of intervention, keeping to their separate zones.

It seems likely that there are many cases where a substantial increase in the formal channels of information would not suffice for them to be used when a binding social division of work is superimposed on the technical division. It is therefore apparent that from this angle the frontier factor is much more complex than might appear at first sight and its far-reaching ramifications do not lend themselves to purely mechanical intervention.

Attempts to render working tasks less isolated - for example certain experiments carried out by Volvo in Sweden - involve the frontier areas which often appear as walls erected arbitrarily by a division of labour which there is today a tendency to question - and it is worth noting that the origins of this questioning may be extremely contradictory.

Among these structural factors - which include coactivity <sup>\*)</sup>, succession <sup>\*)</sup>, intersection <sup>\*)</sup> and bottle-necks congestion on the factory floor <sup>\*)</sup> which does not lend itself to this categorization

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\*) See pages 13, 15, 16 and 17 of the document entitled "Reliability factors".

should also be mentioned. It belongs in fact under the heading of "Immediate factors" since direct action to reduce it at once can be carried out.

### 3. Factors linked with man

To a large extent these factors gravitate around the idea that experience, by which we mean experience of the specific characteristics of a task, is a positive factor in reliability; when there is a lack of experience, e.g. because of a change of workplace, the reliability of the system is threatened. But the knowledge of the process at issue here is not simply ordinary knowledge of the process; on the contrary it concerns everything specific to a particular situation, i.e. the constant disparity from an imaginary mean. Clearly then the acquisition of this knowledge implies either training in situ, which is not without risks, or the spontaneous communication of the necessary information by more experienced workers. The situation here resembles to some extent that with the succession factor : people cannot be forced to communicate when, for a variety of reasons, they prefer to keep their knowledge to themselves. This is usually the case with experience; social conditions in the undertaking - lack of status accorded to certain tasks, stimulated rivalry between individuals - mean that experience remains of great personal value so that the remedy cannot be sought through training - what type of training would be possible since this is not the kind of knowledge available from technical manuals on the subject ? Once again we are faced with a non-immediate factor to which there is no simple answer. The knowledge factor is not the only one at issue; there is also the attitude factor. It is quite usual to

suggest that certain types of behaviour are dangerous; but research has shown to what extent risk-taking is determined by factors external to the individual and not by an instinctive taste for danger.

A very interesting research project carried out in the French mines provides a convincing example of the hold of the system over the worker. It follows the development of the behaviour of coal face workers with reference to two variables : the ergonomic variable of production and the objective risk incurred at the coal face which varies as a function of the state of undercutting of the roof. This behaviour is the direct result of a compromise between the requirements of production and safety. For example, with an equal objective risk level, differences are found in the safety of the behaviour pattern adopted depending on the pressures of production.

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These few examples taken from the document on reliability factors and from ECSC reports on Community research clearly show the spirit in which work of this kind is carried out. This spirit accords with the scientific attempt to formulate a theory in the sense in which we defined it previously. The factors noted - or some at least that we have stressed - are expressed in terms of relationships; they are an abstraction of immediate reality.

As FAVERGE \*) puts it :

"Studies are strictly local, carried out in a specific technological context; they are in the nature of a monograph, but the results sought are independent of this specific context. Generalization is permitted because these results concern patterns of the relationship between man and his environment (...) The accident or breakdown with which we are concerned are by-products of the operation of a system whose frequency

can only be changed by structural changes".

Far-reaching action to improve safety therefore involves structural modification. That is the lesson of research. We have already seen from the examples quoted that the social division of labour - as opposed to the technical division - plays an important part in safety. It is not so much the technical characteristics of a particular task but their inter-relationship and the way in which they are controlled and performed at an imposed rate which become factors of unreliability that are difficult to determine.

These factors form the background to the research. But they do not give an immediate answer to the question of how structures can be changed.

How can structures be determined in a specific situation ?

If we close this section with this observation it might seem to be an admission of failure. If safety is a result and that result requires such an upheaval, can research reasonably be expected to be anything other than purely descriptive and completely cut off from action which while practical has a limited impact ?

That of course is the conclusion reached if we do not seek the link between theory and practical intervention.

Under certain conditions that intervention may take the form of training in safety measures.

But before passing on to this second component of our analysis let us take a closer look at the concrete possibilities for research in the field at the present time. Who should carry out these studies ? Workers, external research specialists or mixed teams ?

The ideas we have put forward on the subject of scientific practice take as their basic requirement the need for an accumulation of data, comparison



and systematic arrangement of results.

While investigations in the field can never in future do without subjective indices - see Introduction - this does not mean that such indices should replace all other analysis; they are simply the beginning of a task of cognitive appropriation, the point of departure for a longer progress requiring characterisation of the social and economic system through relevant variables - the social and economic system must be correctly related to these subjective indices.

Let us consider the example of a bank in which one department has been fully automated; interviews with staff showed dissatisfaction as the staff concerned said that they were much more tired than the employees in another identical non-automated department.

This provides the point of departure for an analysis if the final objective is to improve working conditions; abolition of the department is probably neither realistic nor the best solution. It is therefore essential to take account of more refined characteristics of the social and technical system and compare it with other systems with different levels of mechanization; human variables must be introduced - the possibility of maintaining satisfactory contacts, the question of work supervision and the probable change in production constraints etc...

But that research implies a measure of organization. Can it be done solely by the workers themselves ?

There are places where a constant collective evaluation is made of the working situation in enterprises by homogeneous groups of workers - we are thinking for example of the Italian situation.

But this is not the case in Belgium or France for instance; moreover it may be said that this type of organization of the workers conflicts profoundly with the notion of delegation which is at the root of the existing bodies operating in the enterprises, such as trade unions. Consequently it is not possible to conceive of ideal research structures in absolute terms and we must take account of a prior analysis of the real-life industrial situation. So far Community research has been conducted by teams of research workers external to the factories coming from university environments. While this may be the result of certain constraints it creates the risk of bypassing the real problems and concentrating on topics which are not those felt to be the most important by the workers; there may then be a regrettable confusion between the possible objectives of the work. That is why we are moving slowly towards mixed research structures including representatives of organized labour at some point or another in the analysis.

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#### 4. TRAINING

Research has enabled incidents and accidents to be seen not as the result of human error but as symptoms of the malfunctioning of the systems at the heart of which they occur, primarily the social and technical system. They reflect the inadequacy of this system, possibly to meet the production targets set, but above all with regard to the presence of man as an individual with specific characteristics, desires, limitations and constraints. To speak in ergonomics terms the conditions of work are not adapted to man.

The relevance of this conclusion to training is immediately apparent; training by definition deals with the human factor.

For our purposes - this is a fundamental consideration - it does not deal with the human factor as the cause of accidents but as the only factor able to modify working conditions in the light of man's own requirements. It is precisely because man, the worker, supervisor or director, is potentially capable of bringing about far-reaching changes in the enterprise structures - which are directly questioned when the reliability of the system is low - that training in safety and reliability is necessary.

This training must be envisaged as a pre-condition for change.

But there are different kinds of change.

To the external observer some changes appear as total modifications of the system of work organization and power relationships within the enterprise; they are accompanied by a collapse of the hierarchical pyramid and tolerate other forms of work control.

This category includes recent Scandinavian experiments in job enrichment. But these changes are less the result of an analysis of working conditions which applied before the innovation - this analysis being specific to each workshop - than of an a priori idea, the model of organization which departs from Fordian concepts which have been overtaken by events and no longer enable productivity to be increased or the growing malaise of a society which sees the crisis approaching to be faced.

The innovations therefore correspond to an enterprise project - sometimes almost a gamble - an expensive experimental project whose extension is not self-evident. Moreover only the giant companies - which use assembly line forms of production - can be involved. This explains why our considerations cannot be based on experiments which do not and cannot for a long time concern all workers, when each day's important and safety and health are always matters of immediate concern.

That is why, without denying the value and interest of job enrichment as conceived in certain privileged but isolated cases, we are thinking in terms of a much more modest change, at least in the early stages. This would correspond less to an overall enterprise project than to an opportunity for workers to express themselves. It would not have the value of an experiment but it would be a daily practice; it would not be an adjustment to a new pattern of job organization but it would result from a permanent analysis of working conditions and the working environment. It would not be sudden transformation, but a strategy of change based on an estimate of the harmful factors in the situation which are accessible to intervention.

But while workers unanimously call for changes in their working conditions they are not the masters of those conditions : we must guard against excessive spontaneity.

This is where training comes in : it must ensure that change does not take place blindly on an isolated basis because of chance factors and disorganized trends in a fluctuating interplay of forces; it must ensure that change is not reduced to small improvements without real substance; it must prepare for the more distant future.

Unless training is associated with the wider problem of long-term action on structures it will be destined to failure.

Participants in safety training programmes who only receive theoretical instruction without reference to the practical conditions in which they work not only do not benefit from this but on the contrary lose in the process; they remain for a long time convinced both of their inability to take appropriate action and of the inhibiting nature of their environment - an environment which seems to them to leave no room for changes of any kind. We then have a return in force to the idea of "defensive safety", consisting entirely of standards, instructions and means of protection and imbued with the notion of human responsibility; the accident once again acquires the character of a chance incident - but a chance incident with a very special nature : it is seen quite simply as the result of the impossibility of mastering known factors.

In rigid environments, where all change is impossible, safety can only be repressive; training can only point to the human factor as the prime cause - and discussion with participants in training of this kind would not show any other ideas : the stereotypes and cultural barriers to safety flourish spontaneously under these conditions.

"Accidents are inevitable", "people should take greater care" etc...

It is therefore apparent that these ready-made ideas which one would like to dismiss as hasty and unfounded convictions complicate the problem because they refer back to the fundamental question of the possibility of influencing the structure of the enterprise and the organization of work grafted on to it.

It is therefore in relation to the content of accident theory and the resulting teaching methods that the problem of safety training must be circumscribed.

What are the conditions necessary for a theory of this kind to be an integral part of change or the causal factor in change ? How should it be presented ? What should its practical form be ?

So far the question of determining how and under what conditions the analysis is translated into action has not been dealt with in the teaching materials produced under the auspices of the Commission of the European Communities : it was considered self-evident<sup>\*)</sup>.

However, the brief description of certain structural reliability factors - see Section 3 Research - clearly shows that the continuity between knowledge and action cannot be considered self-evident. Experience seems to confirm this oversight : the experimental seminar in Pont-A-Mousson, organized by the Commission of the European Communities for Trade Unionists, revealed the gap between theory and practice, and thus enabled a considerable step forward to be taken in the area of training.

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\*) All these materials spoke of the need to develop a spirit of analysis among participants. The theory taught that only environmental changes could influence the safety and reliability of the system in the long run : it advocated an operational view of the causal factors of incidents but failed to show the conditions under which those incidents might be influenced.

Basing ourselves on the results of this seminar and on other examples taken from industrial life, we shall try to lay the foundations for methodological considerations on this subject.

Recalling what was said in particular in the section on research, we shall characterize training as a two stage operation :

- 1 need to leave the immediate reality in order to achieve a more structural view highlighting relationships which were originally hidden.
- 2 need to effect a new transformation of acquired knowledge in order to locate it in reality again and enable it to serve as a stimulus for change <sup>\*)</sup> .

This two stage operation which links the level of abstraction with that of operational intervention might be seen strictly from the instructional angle : that is to say as the condition necessary for the complete success of training in the sense in which Piaget would have used the term. But this would also amount to considering training very narrowly as an end in itself related to the individual subject.

We prefer to see it as an element which cannot be isolated from a more general structure : it thus acquires a collective social status - training is not an end in itself but a means of changing something.

It is therefore important to ensure harmony between the teaching conditions necessary for the success of this training and the aims

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\*) It is apparent, as we shall see in paragraph 5, that in the final analysis intervention on the environmental structures will depend on the interplay of forces in the enterprises and the decision will be of a political and economic nature; however, this argument is too often invoked to hide the lack of a programme of change and the lack of systematic reflection on the subject of safety.

pursued, with a view to improving the reliability of the system - the worker of course always being the axis of reference for this reliability.

Let us therefore consider the two stages again and develop them further.

1 ...need to leave the level of immediate reality

The hidden relationships which determine the dynamics of a system cannot be revealed simply by stating these relationships. Active participation by the person studying them is also necessary. Simple enumeration during a course of training of "non-immediate" reliability factors overlooks the aspect of creative activity which is essential in the participant and at the same time creates confusion by tending to minimise the margin between immediate and non-immediate factors, thus making all factors homogeneous.

Let us explain this more clearly : the reliability factors linked with the workplace for example cannot for the most part be equated with reliability black spots - see Section 2, Research. The former can be reduced by isolated ergonomic acts whereas the latter are more general and hidden under many different manifestations. They cannot be mastered at once and require readaptation.

But it is not sufficient to stress the heterogeneous nature of the factors involved; we must also show - or make it apparent - that these structural factors are not only general and not only hidden by some chance condition but are in reality hidden by the situation itself.

Let us take a simple example, that of the film "Learning Safety" produced by the Industrial Psychology Laboratory of the Free University of Brussels under the auspices of the European Commission, in an accelerated vocational training centre of the Belgian National Employment Office. The National Employment Office provides accelerated training for unemployed persons and workers wishing to acquire qualifications better adapted to available jobs.



This training takes place in centres which have all kinds of specialized workshops but whose structure is - paradoxically enough - administrative. The film was written and acted by instructors and trainees in a particular centre and showed six accidents in six different workshops. One of them contains the following situation : twenty trainees in carpentry and concrete shuttering are assembling scaffolding; this task, of which the main action takes place on a raised platform, requires the transport of wooden beams.

During one of these transport operations a trainee stumbles and falls off the platform. A filmed analysis follows this accident and extremely interesting : the trainees and instructors who produced the film and therefore belong to the accelerated vocational training centre in question, express what they see as the causes of the accident.

Among the many opinions expressed some refer to the clumsiness of the workers or say that they should have been wearing a helmet with a chin-strap, whose effectiveness in the fall would of course be minimal - but nobody stresses the situation of co-activity which is nevertheless characteristic : the scene takes place on a cramped platform with constant movement and each trainee working individually in his little corner.

We consider this omission in the analysis extremely interesting. Especially as it was repeated whenever the film was used in this centre for training purposes - the participants who had watched the film were asked to supplement the filmed analysis of the accident by their own opinion - but the omission was never observed when this instructional film was screened outside the centre, even when the screening formed part of the training course for people attached to the National Employment Office. What is the explanation for this ?

Structures have an imprisoning power which guarantees their own stability; they draw their own frame of reference within which reflection

takes place. Any attempt to change them, however slightly, involves a considerable effort and obliges a different approach to be adopted.

In the case of this film elimination of the situation of co-activity amounted to interference with the organization of apprenticeship - and here the cumbersome administrative nature of the semi-state body applied with all its weight. Consequently - see the filmed commentaries - safety was understood in repressive terms with instructions and infringements, or defensively, with helmets and chin-straps.

Thus the need is apparent for abstraction from reality although this abstraction is rendered difficult by the constraints and hold of the environment : there are obstacles and cultural barriers. What pedagogical lessons can be drawn from this analysis ? First the individual, the participant, must be set at a distance from his own situation. The teaching material must amount to a removal from his usual surroundings. But at the same time it must be rich material reflecting reality. It is easy to design teaching tools which are nothing but simplistic caricatured reflections of narrow reality; by controlling at the source critical factors, aspects which are always masked by the constraints of associated political, social and economic systems appear as established data. The mechanism of critical discovery is not called into play.

Hence the new idea in safety training of working not on the basis of an exhaustive list of reliability factors - but with reports supported by industrial monographs, the characteristics of which are fully known; the participants are then asked to work with this living material and extract the pertinent factors for themselves.

The criticism voiced during the Pont-A-Mousson seminar of the educational game approach - presenting analogies with the classical business games - are therefore readily understandable.

This tool appeared as the prototype of a technocratic training instrument which, having removed the essential characteristics of safety - in particular the aspect of lying at the point of intersection of various social and economic influences while seeking despite everything to maintain primacy for the individual above all technical considerations - presented safety as an ideological reflection of reality.

We thus noted absolute rejection by the workers of all teaching material taking the form of games - whereas the film referred to above was given a better reception as being an altogether credible "slice of life".

## 2 ...a new transformation of acquired knowledge

However, knowledge already acquired through the work of deciphering teaching material - and guaranteeing a distance from the initial working environment of the participants - does not automatically bring the desired changes.

Even if the fact of recognizing the mechanism by which certain relationships are hidden leads to a wish to change frozen structures, that wish in itself is not enough. To change something, and to control the transition from one state to another, concrete references and fixed points are needed.

Initially reliability factors seem to provide no fixed references at all.

They are inherent in almost any working situation and if they are to become references they must be defined in one form or another.

When a train begins to move and leaves the station, the passenger can only recognize the fact by watching a point on the platform : to speak of movement we require a fixed reference in relation to which a distance can be calculated. The fixed element - the origin or reference - referred to here deserves all our attention.

We can attempt to see how it has been interpreted in certain applications of accident theory in order to extract certain general conclusions.

It appears that in some cases the material transposition of a general factor is possible in the specific incidence of a given environment. The ergonomic analysis of a monorail carried out in 1971 in the coalmining industry by a team of researchers from the Centre for Human Studies and Problems provides a convincing illustration of this. The research workers tried to characterize a transport system serving the coalfaces from the angle of reliability and with a view to practical improvements. They therefore defined a series of variables based directly on factors stemming from accident theory but transposed and adapted to their own working environment. We shall choose two of these variables, the first concerned with the factor of coactivity and the second with that of signalling.

a. "coactivity"

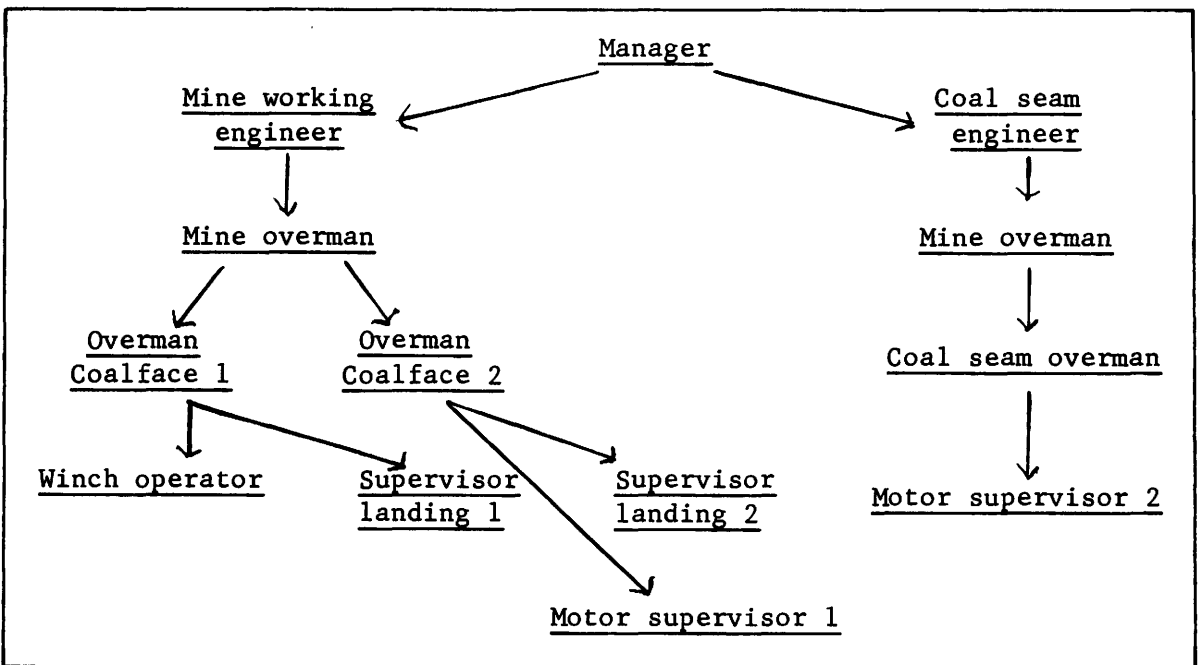
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It was necessary to determine a variable, referring back to the coactivity factor, but enabling a monorail system to be compared from this angle with an alternative system - the relative merits being weighed up. The variable chosen was the hierarchical distance between individuals working together in the installations.

A quotation from the text shows how this choice - which appears strange at first sight - was arrived at :

"In most organizations the different working cells are arranged according to a hierarchical structure. This becomes apparent when the staff organigramme of the organization is drawn up. One of the roles at each hierarchical level is to coordinate the cells dependent on it. The greater the distance between cells (calculated by counting the number of points on the hierarchical graph between two cells), the less easy it will be to ensure coordination. The presence at a single place of several working cells widely separated in hierarchical terms, is a cause of many difficulties.

The term coactivity is also used to designate situations of the same kind : cells with different aims, working habits and tools which have to exist side by side. An example of these situations and their consequences is provided by the maintenance personnel working at operating stations under poor conditions (drive head lubricator in a roadway with a monorail system, locomotive drivers depending on more than one pit).



example : the distance between motor supervisors 1 and 2 is 8

In this case the coactivity at a particular coalface served by a monorail of a given type becomes something palpable which can be modified by a reorganization of the work and individual tasks, by a different layout of the monorail; a practical calculation can be made by adding together the total recorded indexes, divided by the number of individuals.

But this example is specific to the environment in question; let us return for a moment to the situation of coactivity shown in the film "Learning Safety". On the platform with its many trainee carpenters - concrete shuttering workers, the hierarchical distance calculated in this way would have been two in each case; in this instance a relevant index would have had to take account of the space, the number of different tasks to be performed and the number of trainees.

Consequently we begin to recognize the highly subjective nature of the reference points taken : they are only meaningful in relation to a specific context and the degree of meaning is determined by a collective evaluation. This subjective character of the variable, even when it appears quantified, is even more apparent in the "signalling" factor.

b. "signalling"  
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The document states that "For the driver's workplace (...), a comparison is made between the signals which can be recognized in the cab and the signals which are useful for driving purposes. Each signal is given a mark between 0 and 2.0 - means a signal which cannot be detected, 1 - a signal which can be barely detected and 2 - a clearly perceptible signal".

The workers themselves therefore have to determine what is useful or not, satisfactory or not; the criterion or standard taken, on the basis of which the change will later be measured, depends

ultimately on a group consensus. The study in question insists on the essential need to reach agreement between the groups concerned : the management, foremen, workers and representatives if the operation is to be successful. In another study which we ourselves conducted, a structural index for the reliability of a rolling mill was found by the same method, i.e. by questioning workers in the field. It was thus possible to quantify a variable not in arbitrary terms but on the basis of a subjective estimate of its relevance; we needed an index for regulation of the rolling mill line. Investigations conducted among the staff in the factory led to the conclusion that good regulation was reflected in a particular configuration of the incandescent bars waiting in front of the different cages. When this configuration did not appear, the regulation variable was zero; when it did appear the variable assumed the value of 1.

An external research worker could not have arrived at this configuration which was based on the experience of workers. The same idea of reference to subjective assessment for the purpose of fixing the valid norm for reliability or safety is also found in the Italian document entitled "Ambiente di Lavoro" ("Working Environment") drawn up jointly by the three Italian trade union confederations.

This text, which provides a method of analysing the working situation with a view to determining criteria for improvements to this environment stresses the fact that ultimately it is the subjective criterion which must be taken into account for safety purposes.

When a temperature is measured with the aid of suitable instruments the measurement is only relevant in relation to a collective judgment and not to the letter of the law - the workshop may give the impression of being cold, even though the temperature is 22°C. The same applies to

the concentration of toxic gases : there are legally acceptable maximum concentration values, but these are reduced if thirty workers declare that they are adversely affected by concentrations lower than those stipulated in the legislation.

c. ...conclusion

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Whenever an attempt is made in research and training to combine analysis and action, we are faced with the same requirement : working from very general factors characterizing the relationship between different systems, objectifiable indices must be drawn up on the basis of a norm determined by a consensus of all the workers involved \*) .

Because safety, as it is understood in the research conducted under the auspices of the European Commission, is not normative and contains the idea that there are no ready-made solutions or necessarily good lines of conduct, it is set apart from current regulations and contains an implicit reference to the experience and judgments of workers in the sectors under consideration.

However, this concept - which is clearly reflected in the industrial applications of reliability - has not been incorporated into the teaching material produced so far. This is an important gap which will have to be filled : more work will have to be done with examples representing

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\*) The idea of a norm or reference must not be confused with the scientific assumption that everything must be quantified at all costs; that is certainly not our point of view.



a practical reflection of general factors if safety training is to become a bridge between theory and the experience of the participating persons, and a basis for action in the field carried out in the interests and with the cooperation of the workers concerned.

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We are only interested in norms insofar as they represent a collective evaluation and serve as a reference point for change.

## 5. PRACTICAL ACTION

Action is undertaken as soon as a decision is reached on the factor or factors to be changed. Action on the working environment may therefore be said to escape from the direct responsibility of research experts. It will in each case be the result of an interplay of forces in which politics, economics and social considerations play the key role.

An attempt can be made to influence this interplay; we may try to find arguments capable of tilting the balance. An attempt might be made for example to persuade unenlightened employers that improvements in reliability would have favourable economic consequences, that safety and productivity are linked. Trade union representatives might be told that the inclusion of safety among their demands would strengthen their position and union power. Safety may be given an instrumental character and different observations made about it, depending on the person to whom the observations are addressed - safety thus assumes many different facets; the choice of words and scope of the arguments used would then depend on a given framework and not on the content. The latter would be drained of all substance. We do not consider it desirable to move along those lines.

There is no doubt, indeed it is normal and inevitable, that safety will assume a different colouring when it becomes part of a specific practice exercised by a given institutional apparatus - the union or the industrial channel as such.

But some concepts of safety can at the outset only come from external sources, breaking with the constraints of the enterprise and the cultural barriers specific to individual situations.

The contribution of the Commission of the European Communities in the matter of research and training in the area of safety must not be merely an

appeal or a convincing line of argument but a means of widening the range of possible action : while the criteria of productivity and legal provisions have an important bearing on safety and practical action in this sphere, they are not the sole determining factors.

Often the decisive argument "It is not for us to take the decision", "We have no authority to..." is put forward simply to hide an absence of practical thought on the matter.

A strategy is after all always possible : if reliability is threatened by a series of factors, one or the other may be influenced depending on what is desirable at a particular time. The notion of choice and strategy, of short and long term, centre directly on the comments made in the previous paragraphs. The concrete analysis of a system and its evaluation enable us to choose the point of attack and determine modifications for the future. It enables us to correct, compare and anticipate - anticipate the impact of a reorganization, a new machine installation, a new timetable etc.

The original contribution of research-workers in the area of safety resides in the elaboration, with the workers directly concerned, of a very precise analytical policy which pushes back the limits of what is possible, opens new paths and blocks all idle arguments.

Let us return for a moment to the study of the bank where two departments were compared : one in which operations were done manually and the other where they were done by computer. When employees were questioned they stated that nervous fatigue was greater in the mechanized service than in the other.

Presented in these terms, this study leads workers to a deadlock situation. It is unlikely that they would manage to have the automated service abolished and such abolition would not solve the problem.

The philosophy of Rousseau, a return to the craft era, is a facile trap often held out to workers. Of course certain forms of job enrichment are desirable; we cannot accept a soul-destroying form of assembly line work on the pretext that it is economically viable; but sufficient emphasis is not placed on the fact that mechanization or automation is not itself responsible; the problem lies in the way in which it has been designed and introduced - programmed and supervised.

Nervous fatigue is an overall index; what are the employees bothered by : the working rates ? noise ? the loss of certain human contacts ? the impossibility of taking a break ? A study of the reliability of the system - as we understand it, i.e. calling upon indices determined by the workers themselves - would show in a more operational manner than a negative judgment on mechanization in general, the type of reorganization to be proposed - and here we arrive at the area of practical action to be advocated and applied.

Finally it appears that the task of research and training in safety is basically to begin a forward movement and show the factors in the real situation which must be called into play so as to avoid hasty and superficial corrections and to rationalize the working environment, not merely in technical and economic terms, as is usually the case, but against the background of ultimate objectives which it is for others to defend and meet.

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