# BYPASSING AND DEFEATING PROTECTIVE DEVICES OF MACHINES - A MULTIDIMENSIONAL PROBLEM

☐ Machine
☐ Protective devise
☐ Survey

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**The article gives an overview about an interdisciplinary German research project which identified the reasons for tampering protective devices of machinery. An empirical study consisting of two surveys, in which more than 1,000 occupational safety and health experts were involved, shows the status quo of the research tasks: the dimension of tampering is extensive. The results show that the issue of tampering protective devices is not adequately present in the field of occupational safety and health.**

## CONTEXT

The examination of accidents at work by the *Gewerbliche Berufsgenossenschaften* evince that there are many targeted manipulative actions at protective devices of machines. They are disabled for example by bypassing or disassembling. Up to now the reasons for these manipulative actions remain non-specific. Furthermore there are no reliable statistics concerning the dimensions of the problem of manipulations in companies. The presented explorations, made by the *Berufsgenossenschaftliches Institut für Arbeitsschutz (BGIA)* and the *Berufsgenossenschaftliches Institut Arbeit und Gesundheit (BGAG)*, aim at getting an approximate estimation of the dimensions of the problem; the second aim was to analyse the reasons for manipulations in greater detail by integrating the users' point of view. So, the basis is laid for successful prevention of accidents at work related to manipulations.

## METHODS

Two different surveys were developed to explore the reasons and to get an estimate of manipulations: a general questionnaire with a scope of two DIN A4-pages served for the elicitation of general estimations concerning manipulations (e. g. how many per cent of all protective devices are manipulated). The questionnaire was applied in training centres of the VMBG, the BGFE and the BGAG. The target group of this instrument were occupational health and safety experts, especially technical advisory staff and safety engineers.

Completing the questionnaire needed just a few minutes. The questionnaire consisted of five parts: estimations, how often manipulations occur in the companies, occurrence of manipulations depending on the kind of safety guard, operation mode in which manipulations occur, and personal data. The return run of 940 questionnaires allows valid esti-

mations concerning the amount of manipulations in metal-working companies. It indicates first emphases of upcoming strategies. An excerpt of the results can be seen in *Table I*.

A second instrument, called a special questionnaire, served for the detailed analysis of concrete manipulations detected in the field. This instrument served for the description of all aspects referring to manipulation actions by the technical advisory staff of the VMBG. It could be completed when a manipulated machine or safety guard was detected during routine inspection or when there was a hint given by the staff members. A total of 202 manipulations were analysed. The research focussed on the following aspects: description of the machine type, the safety guard, the kind of manipulation, hazard appraisal (by technical advisory staff vs. the employee), the mode of operation, specific manufacturer attributes, ergonomic aspects of the man-machine-interface, aspects at operational level, and aspects related to the operators' personality.

A highlight is the direct involvement of the operator who can be seen as a potential manipulator. The operator was thus able to indicate his suggestions for improvement and advise operational prevention actions. A first analysis of the usability of the interfaces between man, machine and safety guard was possible by this special kind of data collection and showed that, at some machines, some special modes of operation cannot be applied without any manipulation action.

An interdisciplinary project team analysed the raw data und discussed methods of solution from a psychological, an ergonomic, an organisational, and a technical viewpoint. These specific strategies of prevention served for the development of interdisciplinary action recommendations. These recommendations aim at a systemic procedure against manipulations: on an individual, a technical and an organizational level (compare [1]).

## RESULTS

The analyses of the empirical data already show the timeliness and the interest of the explorations. The following is a small cut-out of the results which are explained in detail in a report [2]:

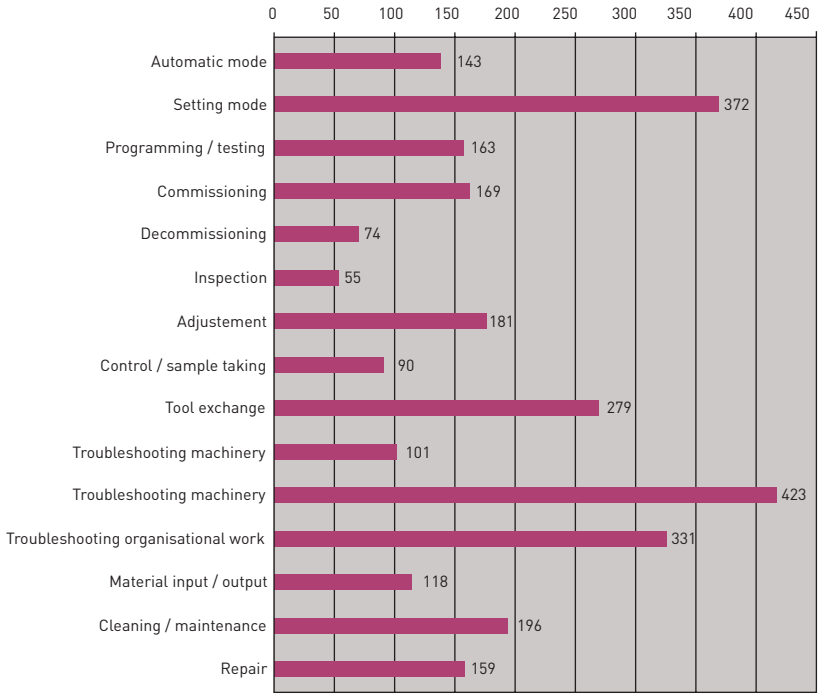
**TABLE 1**

**Results of the general questionnaire (excerpt)**

| Estimations of OSH experts (inspectors and safety experts) | |
|---|---|
| Percentage of permanently tampered protective equipment | 14 % |
| Percentage of temporarily tampered protective equipment | 23 % |
| Percentage of machinery with potential accidents due to tampering | 51 % |
| Percentage of accidents caused by tampering | 25 % |
| Percentage of accidents caused by tampering | 34 % |

**FIGURE 1**

**In which operational mode is tampering necessary?**




- The dimension of the problem of manipulations in the companies is extensive – as the estimations of more than 1,000 occupational safety and health experts show. On average one third of all protective devices are temporarily or constantly manipulated.

Operators show a significant underestimation of the heightened hazard caused by manipulation *(see Figure 2)* ;

- In many cases negative consequences for the manipulator are missing (toleration). In combination with behaviour-strengthening aspects (higher pace of work) this supports manipulation actions.

In many cases the interfaces between man, machine and protective device are not created in a very user-friendly or ergonomic way. So the application of several protective devices reduces the space of work perspicuously and forwards manipulation intentions.

Manipulations are often detected in the following modes of operation: set-up, troubleshooting, reconstruction, and automation mode.

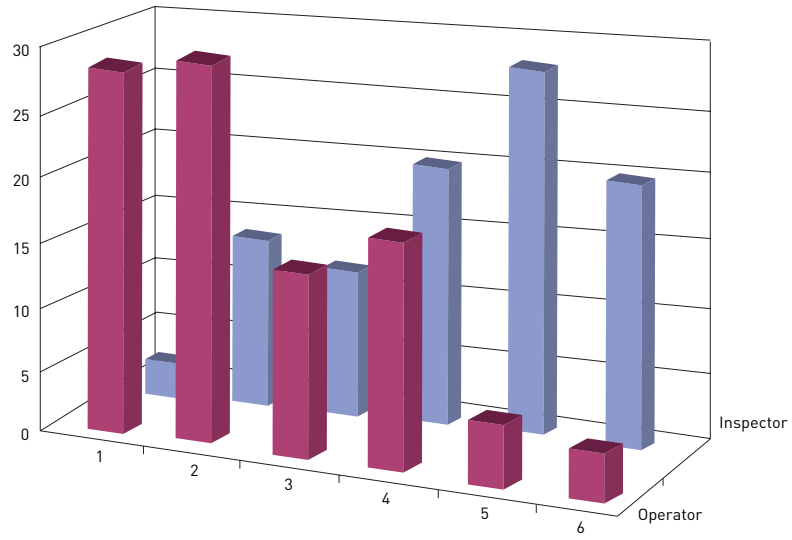
The partially limited observability of the working process is an eminent reason for manipulation actions

Manipulations can also be detected at current and modern machines which obviously do not yet show user-friendly safety solutions.

In some cases manipulations are necessary, e.g. to perform maintenance actions.

FIGURE 2

**Inspectors´ and operators´ estimation of possible hazard, 6-unit scale (1 = very low, 6 = very high)**




## DISCUSSION

The issue of manipulation is not adequately present in the field of occupational safety and health as this explorative study imposingly shows. The analysis of the amount of manipulations in the examined sample (metal-working companies) shows a vast potential to improve the man-machine-interfaces and further on the acceptance of protective devices.

But not just the interfaces are inadequately fitted to human demands; the integration of safety measures in the construction phase of machines is not yet achieved either. Earlier trade-offs between constructing engineers, electrical engineers, and providers of safety equipment are required. Additionally, more use should be made of development tools. The concerned parties should also consider all life and operating stages of machinery during construction. A checklist (liability to be bypassed) could also help to make more use of existing safety solutions. The implementation of usability engineering methods helps to understand the operator's view. So, safety concepts can be developed which do neither "disturb" the operator ergonomically nor cause economical damage, like "intelligent" camera systems.

Furthermore the companies are only marginally aware of the issue in many cases because there is nearly no integration of the problem into their safety culture. A cross-hierarchical exchange of information and solution finding could help here. In addition, the purchase of machinery should be based on checklists/specifications (including information concerning the liability to be bypassed) and on the operator's opinion.

Methods which show the hazards of manipulated machines can make for more realistic hazard cognition. There is also a need for an integration of the manipulation problem in several standards (e. g. ISO 11161, EN 954 or EN 1088).

Last but not least, a lot of education work has to be done to prevent dangerous situations caused by tampered safety solutions:

- education of safety staff (via BG training centres)
- education of operators (in the companies/via technical advisory staff)
- education of construction engineers (universities)

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