

Safety from the testing of ergonomic machinery design

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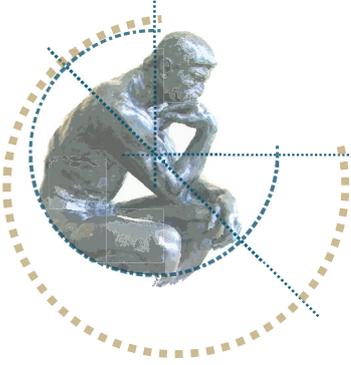
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The European Machinery Directive 98/37/EC [1] requires that "...the discomfort, fatigue and psychological stress ... must be reduced ... taking ergonomic principles into account." By obtaining conformity certification, the machine manufacturer demonstrates to his customer compliance with this essential health and safety requirement. The purpose of the project "Development of a checklist for the testing and certification of ergonomic machinery design" was to help test and certification bodies as well as machine designers to check that the machine does in fact meet ergonomic requirements. A checklist for the ergonomic design of selected machine tools was drawn up at the BGIA on the initiative of and in cooperation with the MFS Committee of experts of the BG Metall Süd. The objective was to develop a checklist that these bodies are able to apply in practice. In 2005, a number of publications, presentations, seminars and individual consultations have been carried out in order to stimulate the interest of machine manufacturers and encourage them to introduce the checklist. This paper presents the contents of the checklist, some experience with its application, and manufacturers' initial feedback. The checklist is available in German at the BGIA internet server www.hvbg.de/bgja (Webcode 1738466).

Selon la directive Machines (directive européenne 98/37/CE), « ... la gêne, la fatigue et les contraintes psychiques (stress) de l'opérateur doivent être réduits au minimum envisageable compte tenu des principes ergonomiques. ». Par la déclaration de conformité, le constructeur s'engage auprès du client sur le respect de cette exigence comme de toutes celles qui figurent dans la directive. Nous avons mis en place un projet de liste de contrôle permettant de vérifier et de certifier la conception ergonomique des machines, afin d'aider non seulement les organismes d'essai et de certification mais aussi les constructeurs à vérifier la conformité des machines aux exigences ergonomiques. Au BGIA, une liste de contrôle a été élaborée pour certaines machines d'usinage des métaux, à l'initiative et avec le concours du comité technique compétent de la caisse d'assurance accident de la métallurgie pour le Sud de l'Allemagne (BG Metall Süd). L'objectif était de fournir aux experts des organismes d'essai et de certification un outil utilisable sur le terrain. En 2005, une série de publications, de communications, de séminaires et de rencontres individuelles ont été l'occasion d'intéresser les constructeurs de machines et de les aider, au début, à utiliser la liste de contrôle. On présentera la liste de contrôle, quelques exemples d'application et les premières réactions des constructeurs. La liste est disponible en langue allemande sur le site du BGIA (www.hvbg.de/bgja (code web 1738466)).

Die Europäische Maschinenrichtlinie 98/37/EC [1] fordert, es „... müssen Belästigung, Ermüdung und psychische Belastung ... unter Berücksichtigung der ergonomischen Prinzipien ... reduziert werden.“ Mit der Konformitätserklärung bestätigt der Maschinenhersteller seinem Kunden auch die Übereinstimmung mit dieser wesentlichen Gesundheits- und Sicherheitsanforderung. Mit dem Projekt "Entwicklung einer Checkliste für die Prüfung und Zertifizierung der ergonomischen Gestaltung von Maschinen" war beabsichtigt, den Prüf- und Zertifizierungsstellen, aber auch dem Maschinenkonstrukteur bei der Überprüfung, dass eine Maschine tatsächlich ergonomische Anforderungen erfüllt, zu helfen. Im BGIA wurde auf Initiative von und in Kooperation mit dem Fachausschuss MFS der BG Metall Süd eine Checkliste für ausgewählte Metallbearbeitungs-



maschinen entwickelt. Das Ziel war, eine in der Praxis dieser Stellen anwendbare Checkliste zu entwickeln. Im Jahr 2005 wurden eine Reihe von Veröffentlichungen, Vorträgen, Seminaren und individuellen Beratungen durchgeführt, mit dem Zweck, die Maschinenhersteller zu interessieren und bei der ersten Anwendung der Checkliste zu unterstützen. In diesem Beitrag werden die Inhalte der Checkliste, einige Erfahrungen in der Anwendung und erste Reaktionen von Herstellern präsentiert. Die deutschsprachige Checkliste ist beim BGIA unter www.hvbg.de/bgia (Webcode 1738466) verfügbar.

Introduction

The European Machinery Directive 98/37/EC [1] includes the following requirement: "Under the intended conditions of use, the discomfort, fatigue and psychological stress faced by the operator must be reduced to the minimum possible taking ergonomic principles into account." (Annex I, clause 1.1.2d). By obtaining conformity certification, the machine manufacturer demonstrates to his customer compliance with this essential health and safety requirement. But how does the machine designer check that his machine does in fact meet ergonomic requirements?

Although many years of experience of ergonomic design aided by the analysis of customer preferences may well in fact help to improve the ergonomics of a machine, conformity to European standards is always indispensable. In addition to normal machine operation, it is essential for other work activities such as installation, adjustment, maintenance, cleaning, repair and machinery transportation to be taken into account. An analysis of the product standards for the machine tools concerned shows that about half of the average of 40 basic standards referred to in the product standards are concerned with ergonomics (Fig. 1).

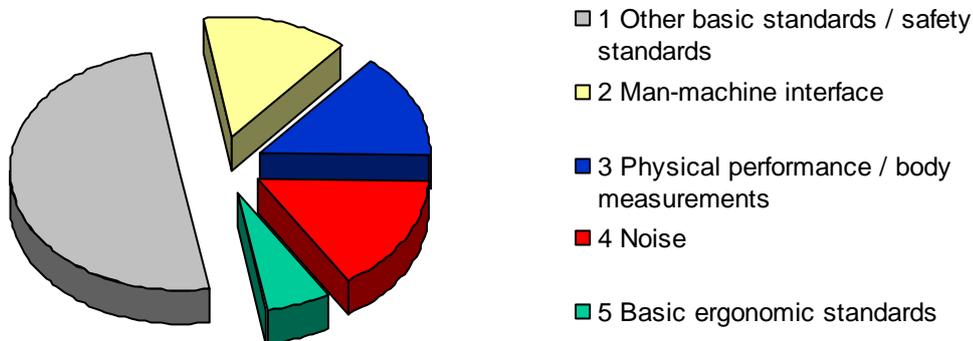
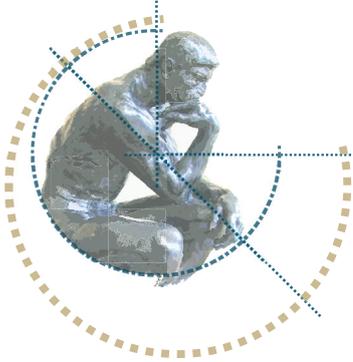


Figure 1: Typical distribution of standards references in product standards for machine tools

The ergonomic aspects of machines are already the subject of many standards and other projects, e.g. the KAN study "European standards on ergonomics – status review and systematisation" [2]. In this study, the basic ergonomics standards available were first classified, thus revealing gaps and shortcomings. A structure extending from basic standards to product standards was introduced. Second, a guide to assist product standards developers in the application of ergonomic standards during the design of machinery was drawn up in the form of EN 13861:2002 "Safety of machinery - Guidance for the application of ergonomics standards in the design of machinery and for the drafting of ergonomics clauses in standards" [3]. The subject of ergonomics has therefore been addressed and dealt with in depth in the standardization process.



However, these activities have not yet provided test and certification bodies with a satisfactory solution for the treatment of machinery ergonomics in real-life testing. The existing requirements and definitions are often too general, incomplete and in some cases contradictory. It is not easy for testers to summarize and apply requirements originating from many sources (Fig. 2). Designers of machinery thus lack clear guidance on how to achieve conformity with the Machinery Directive. The project "Development of a checklist for the testing and certification of ergonomic machinery design" (completed in 10/2004) was intended to help close this gap.

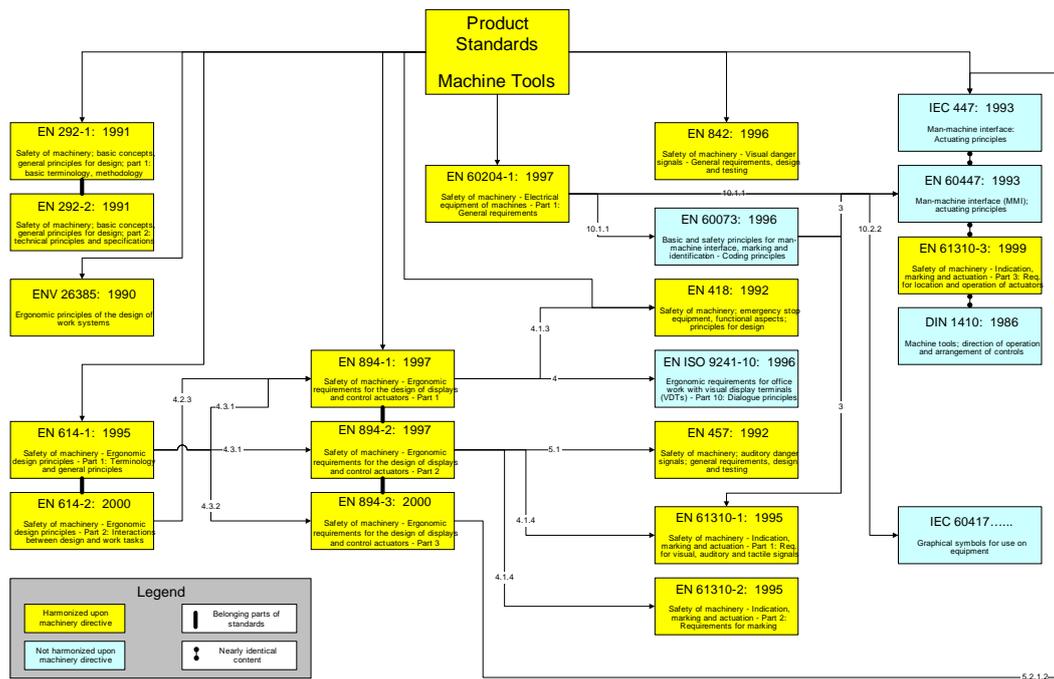


Figure 2: "Jungle" of standards references relating to man-machine interaction

Safety relevance

Since growing attention has been devoted to the ergonomics of machinery, it is worth investigating whether there is an identifiable relationship between insufficient ergonomics and reported accidents at machines. However, here we have the problem that the affected firms and inspectors obliged to report these accidents are often not able to detect these specific accident causes. For this reason, such causes are not listed in the accident statistics of the HVBG. Only in the event of fatal accidents are detailed investigations carried out to identify the causes.

Nevertheless, it is worth taking a glance at an evaluation of the statistics for 1996 to 2000. In this period it was reported that in about 60% of 677,000 accidents at stationary machines, e.g. machine tools, the machine was instrumental in an accident while performing functionally correct motions, i.e. without any obvious failure. In 40% of all accidents, the accident occurred during operation and control of the machine (Fig. 3).

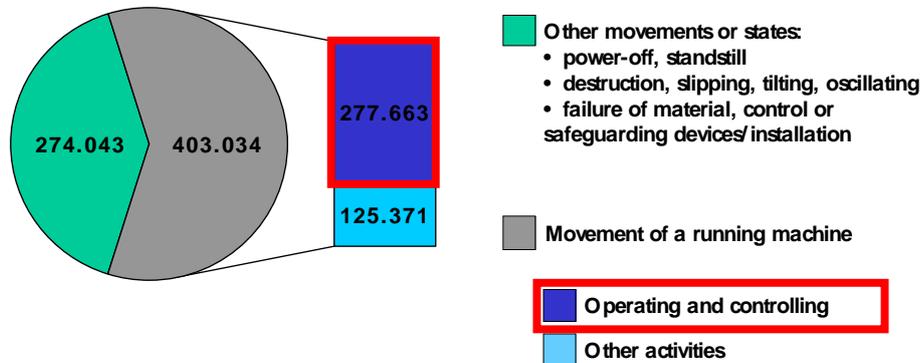
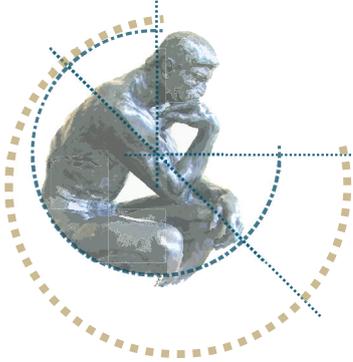


Figure 3: Accidents at stationary machines, 1996 – 2000, HVBG statistics

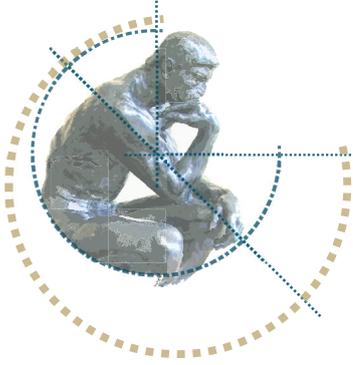
Until now, the following possible causes have been suspected, e.g.

- Lacking or insufficient safeguarding of danger zones
- Incorrectly designed or fitted protective devices
- Deliberate defeating of safety devices
- Unintentional faulty operation due to the insufficient usability of operating and safety equipment
- Environmental disturbance with transient failures, e.g. electromagnetic interference
- Operation of the devices outside the device specifications
- Unidentified random device hardware malfunction
- Systematic software error with transient failures.

A still unknown proportion of this remarkably large number of accidents could thus be attributable to deliberate defeating or unintentional faulty operation due to inadequate machinery ergonomics. As to the problem of defeating and bypassing, the authors are pleased to refer to the conference paper on this subject "Bypassing and defeating protective devices of machines – a multidimensional problem" (by K. Lüken/BGIA, H. Paridon/BGAG and D. Windemuth/BGAG), which outlines the possible effect of inadequate ergonomics on the tendency to defeat safety devices.

Method

A checklist for the ergonomic design of selected machines was drawn up at the BG Institute for Occupational Safety and Health (BGIA) on the initiative of and in cooperation with the MFS Committee of the BG Metall Süd [4]. It is based on the most important standards, generally accepted scientific findings, and the BGIA's own research. An interdisciplinary team of experts from the fields of occupational biomechanics, man-machine interfaces, and machine safety was formed for the purpose of this project. The objective was to develop a checklist which is binding on the test and certification bodies and which these bodies are able to apply in practice. Since the rules and findings in this area are subject to continual change, subsequent updating had to be made possible from the outset.



There is an abundance of standards and scientific literature. To start with, all the relevant requirements were therefore identified. These in turn were used to draw up a complete list of the identifiable check points. All the same, the aim of the project was to evaluate adherence to ergonomic requirements. Thus, if application was to remain feasible in practice, it would only be possible to formulate a selected number of check points in detail for use in the checklist. The range of applications is confined to metalworking machinery, e.g. CNC machining centres and fully automatic lathes, conventional manually operated lathes, milling machines, box-column drilling machines, hacksawing machines, folding presses and guillotine shears. The task of researching and formulating the check points was accompanied by large-scale inspections of machines in order to assure the relevance and suitability of the checklist for practical application.

Particular attention was attached to the sound planning and evaluation of the checklist. This assured that the checklist itself is designed ergonomically. It must also be suitable for application by the uninitiated in the ergonomic field. A comprehensive guide booklet was therefore also produced. A database application was created as a tool for the collection and processing of the information; this will enable work to be performed in parallel whilst assuring consistency. This tool will enormously simplify future updating of the checklist.

Here is a summary of the key challenges of this project:

- The relevant ergonomic requirements must be identified for the machine tools concerned.
- The aim is to define simple, objective criteria for visual checks or measurements.
- Ergonomic novices must be able to use the checklist.
- For the practitioner, going through the checklist must take as little time as possible.
- In addition, there must be a balance between ergonomic and safety requirements.

Contents of the checklist

The checklist is composed of following core items:

- Observability of the production process and the integral lighting of machines
- Design of the man-machine interface
- Mechanical design (dimensioning) of workstations at machinery
- Work intensity from the manual handling of weights and the application of human force for machinery operation.

One remarkable aspect of the checklist is the integration of psychological standards regarding the design of the man-machine interface (arrangement of control actuators and displays, design of user dialogue).

Observability of the production process and the integral lighting of machines

The observability of the production process is one of the areas in which ergonomic and safety requirements apparently conflict with one another. The Machinery Directive states: "Guards and protection devices must: ... cause minimum obstruction to the view of the production process ...". In many cases, however, the view of the production process is limited by excessively small protective windows, by flying chips or cooling lubricants, or by the protection devices themselves. Suitable technical solutions for improved visibility are rarely employed (Fig. 5). So far there have been no standards implementing this protection goal of the Machinery Directive.

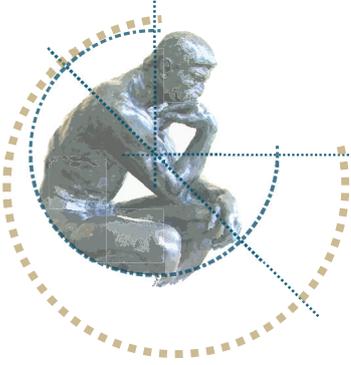


Figure 4: Measurement of the strength of integrated lighting



Figure 5: Spin windows to improve visibility in the event of serious contamination with cooling lubricants

An important factor for process observation is lighting. The Machinery Directive demands that machines be equipped with integrated lighting if the lack of such lighting can pose a risk despite normal room lighting. In this case the machine's manufacturer must issue his own test report on his lighting system.

Our own spot checks in industry (Fig. 4) showed that actual lighting falls in some cases well short of the lighting strength of 500 lux at the workpiece usually demanded in product standards.

Design of the man-machine interface

The operation/control of the machine with actuators, keyboards, input devices, indicators and displays is only supposedly a field well covered by standards. This is because the existing standards no longer fully reflect the current state of operating technology. There is a rapid technological trend away from hand-operated actuators and discrete displays towards the fingertip-pressure operation of software interfaces. It is not therefore easy for the design engineer to appropriately implement such protection goals of the Machinery Directive as "information needed to control machinery ... must be unambiguous and easily understood ... must not be excessive to the extent of overloading the operator". One of the chapters in the checklist is therefore devoted to software interfaces.

A frequently observed problem is that control elements or machine functions are totally or insufficiently marked or the marking wears off after a while and has to be subsequently replaced by the operator (Figs. 6 and 7).

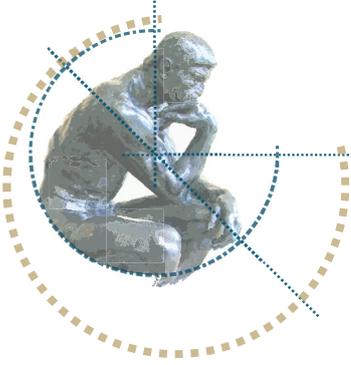


Figure 6: Poor or impermanent marking of a control panel

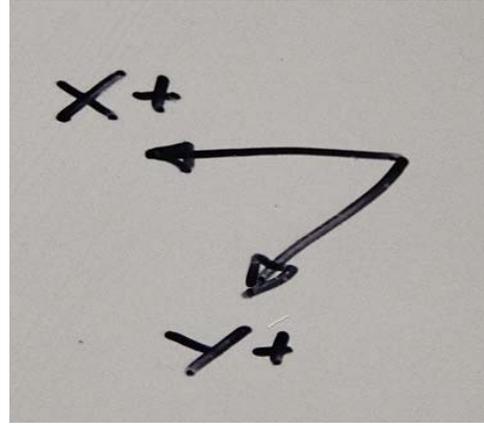


Figure 7: Subsequent marking of axes on a manual milling machine

Mechanical design (dimensioning) of workstations

The checklist starts with the dimensions of access openings on the machine, which are mainly used during maintenance and servicing work. In the case of encapsulated machines and machining centres, the dimensions for whole-body access are also relevant. The dimensions given in the checklist are based on the so-called "95th percentile" for men and incorporate general allowances for work clothing, work shoes etc.

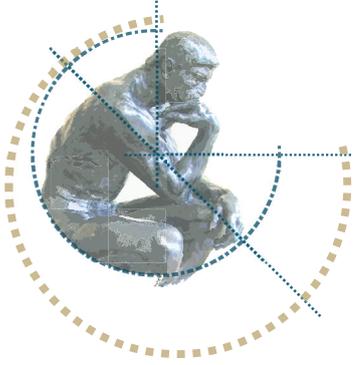
A considerable number of questions are then devoted to the dimensions of the workstation. The goal is to enable machine users to adopt as close to optimum posture as possible during subsequent machine operation. Irrespective of the chosen main work posture, this includes the right working height and good accessibility and observability of the operator interfaces. Figure 8 shows a particularly poor example.



Figure 8: Unfavourable, static upper arm posture from having to reach beyond the arm's range

Since the user's body measurements are not usually known at the time of machine design, the following stipulations were made in this checklist:

- These are machine workstations where the operator works standing up.



- The workstation dimensions are scaled for men.
- The machines have a fixed working height.

Work intensity

The operation of metalworking machines generally demands the application of physical force. The resultant load factors can vary greatly. The checklist gives special consideration to the manual handling of objects and the application of force during machine operation. In this case the present so-called “case of force application” has to be selected from DIN 33411-5 (Fig. 9) and the measured static force, e.g. required to open the protective door of an encapsulated lathe, has to be compared to the maximum action force permitted in standards.

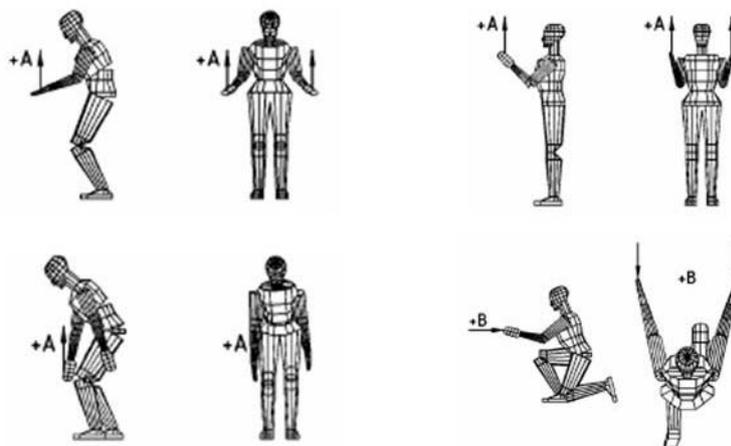


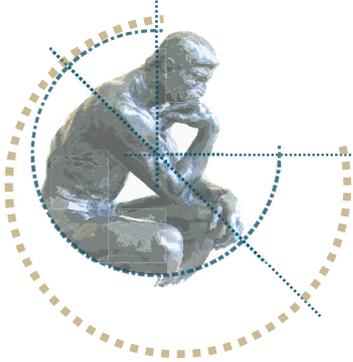
Figure 9: Examples of the application of force (from DIN 33411-5) for the determination of the maximum static action force

The manual handling of objects includes all lifting and carrying processes associated with the machine, in which workpieces or tools, for example, can be freely manipulated by human physical effort. The recommended force limits for machine operation refer to the forces that have to be applied to firmly attached machine parts such as protective doors or chip pans. The decisive parameters here are force and its direction of application. The design and positioning of grips are also assessed in the checklist.

The checklist excludes the subjects of noise, pollutant emission, climate and the effects of shop organization, because these are not associated in the Machinery Directive with risks due to the neglect of ergonomic principles.

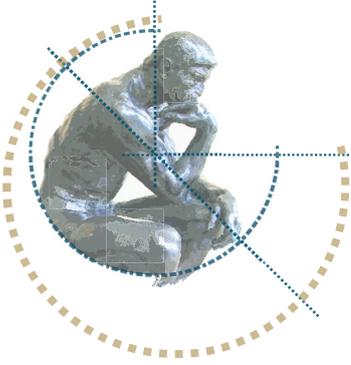
Available documents

The results of the project take the form of a checklist (Fig. 10) with an assessment form, and a booklet of comments. The documents are only available in German. The booklet contains explanatory information and thus supports the use of the checklist. The assessment form contains a list of those points on the checklist embodying requirements from standards.



5.4 Bewegungsrichtung von Stellhebeln und Handrädern		Entfällt <input type="checkbox"/>	
Sind die Bewegungen der Stellteile kohärent (d.h. stimmig) mit den Bewegungen der gesteuerten Maschinenteile?			
Diese Anforderungen gehen für Stellteile, die Bewegungen von Maschinenteilen in zwei entgegengesetzte Richtungen wie links/rechts oder runter/hoch erzeugen.			
a) Stimmen die Bewegungsrichtung von Stellhebel und Maschinenteil überein?		Entfällt <input type="checkbox"/>	
477	Funktionsprüfung an der Maschine	siehe Merkheft	Ja <input type="checkbox"/> Nein <input type="checkbox"/> <input type="radio"/>
	Norm	Absatz	
	DIN 1410:1986	2	
	DIN EN 60447:1994	5	
Kommentar:			
b) Stimmen die Drehrichtung von Handrad und die Bewegungsrichtung des Maschinenteil überein?		Entfällt <input type="checkbox"/>	
478	Funktionsprüfung an der Maschine	siehe Merkheft	Ja <input type="checkbox"/> Nein <input type="checkbox"/> <input type="radio"/>
	Norm	Absatz	
	DIN 1410:1986	3	
	DIN EN 60447:1994	5	
Kommentar:			
c) Wenn ein Maschinenteil über eine Druckastenreihe bewegt wird: Sind die Drucktasten jeweils in gewünschter Bewegungsrichtung angeordnet?		Entfällt <input type="checkbox"/>	
479	Funktionsprüfung an der Maschine	siehe Merkheft	Ja <input type="checkbox"/> Nein <input type="checkbox"/> <input type="radio"/>
	z.B. die rechte Drucktaste in einer Reihe bewegt das Maschinenteil nach rechts.		
	Norm	Absatz	
	DIN 1410:1986	4	
	DIN EN 60447:1994	4	
Kommentar:			
d) Bei einer Vorwählrichtung zur Umschaltung der Wirkung eines Stellteils auf das Maschinenteil: stimmen die Wirkungen für die häufigsten Stellvorgänge?		Entfällt <input type="checkbox"/>	
480	Funktionsprüfung an der Maschine		Ja <input type="checkbox"/> Nein <input type="checkbox"/> <input type="radio"/>
	Zumindest für die häufigsten Stellvorgänge sollten die Regeln für die Bewegungsrichtung eingehalten werden. Es ist günstig, wenn mehrere Bewegungen mit gleichartiger Bewegungsrichtung (wie z.B. nach hinten, oben, rechts) auf dem selben Stellteil angeordnet werden.		
	Norm	Absatz	
	DIN 1410:1986	5.1	
	DIN EN 60447:1994	5	
Kommentar:			
Gesamtbewertung:		Ja <input type="radio"/>	Nein <input type="radio"/>
Sind die Bewegungen der Stellteile kohärent (d.h. stimmig) mit den Bewegungen der gesteuerten Maschinenteile?		Empfehlung	Mangel

Figure 10: Excerpt from the checklist (one main subject with 4 detailed questions)



Further steps

The checklist is being applied for the first time in a BG-PrüfZert test body and the updated documents were first published at the end of 2005. In 2005, a number of publications, presentations, seminars and individual consultations have been carried out in order to stimulate the interest of machine manufacturers and encourage them to introduce the checklist. This means that, at the beginning of 2006, we can contribute the following to the ISSA Symposium:

- A presentation on project progress (2002 to 2004)
- The latest updates of the resultant tools (checklist, guide documents, test tools etc.)
- Report on experience with the application of the tools in the evaluation phase by testers from a certified BG-PrüfZert test body
- A strategy for the transfer of knowledge of ergonomic machinery design to the machine manufacturer
- The pro's and con's of budget discussions on the integration of ergonomics in machine design.

As far as the ergonomics of machinery is concerned, our impression is that there seems to be sufficient scientific knowledge and standards specifications. What really counts now is the creation of awareness and informing and convincing manufacturers and machine-operating companies that ergonomics pays off in the long run.

Results of initial application of the checklist

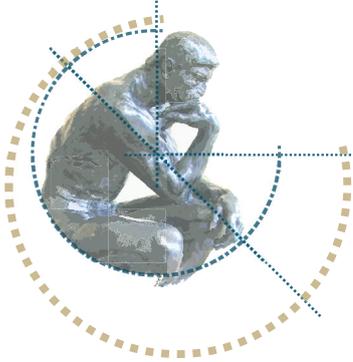
Initial hands-on experience in brief:

- There are sufficient directives and standards on ergonomics, with only a few exceptions (process observability).
- This variety of information is difficult for the designer to grasp because product standards themselves hardly ever contain ergonomic details but refer to other sources.
- A hierarchy of ergonomic measures is difficult to establish due to the lack of empirically reliable data on the causal relationship between ergonomic factors and accidents.
- Many ergonomic factors can only be evaluated against the background of machine operation, taking account of work organization and workstation conditions.

Time required

During the evaluation of the new ergonomics checklist, the following initial experience has been gathered on the premises of several firms that operate metalworking machines. The time required for checking a machine tool with the aid of the list mentioned depends greatly on the machine type and size and on the experience and aptitude of the user of the list. It makes a huge difference whether the checklist has to be gone through at a simple box-column drilling machine (with just a single main command device) or at a large, complex CNC machining centre with numerous accesses and user terminals. The checklist currently runs to over 300 questions covering 95 pages, although only about half of the questions are relevant to simple machines without a software interface. The booklet accompanying the checklist has about 65 pages of notes, which have to be read at least once and understood.

Every user of the list has his own personal experience and abilities. If he has already had experience with checklists for checking compliance with the requirements of European directives and standards, he won't have any great difficulty with the new checklist. The individual's learning speed is also a factor. During the



first evaluations, we have discovered that users take about 8 hours when using the 95-page checklist on a large CNC lathe unaided. If assistance or instruction is provided in difficult situations, users were able to work through the checklist in about 4 hours. Users that have already used the checklist several times on machines require an average of 3 hours without further assistance.

Feedback from manufacturers and implementation of ergonomics improvements

There are numerous good reasons for applying the checklist, aside from the importance of the ergonomic design of workstations at machines itself. The checklist permits the rapid systematic analysis of important aspects of a machine. In the event of changes to the basic individual European standards, the checklist will be revised by the BGIA – just as a toolmaker has to overhaul his tools from time to time.

The first point of criticism, though this is not a genuine drawback of a checklist, is the extra expense engendered by this check. The three hours for the check itself are not so much the problem as the extra costs incurred by machine manufacturers from any necessary design changes. It is very important to make distinctions when discussing this point.

A series machine, which is built or brought into circulation continuously in large numbers, is usually subject to supply agreements with component suppliers for subassemblies supplied on a monthly or yearly basis. These cannot be modified straight off. However, we do not expect an immediate new design as a result of the checklist. By using the checklist it is possible to systematically analyse the existing design, which already embodies many improvements adopted over a period of decades. Flaws are uncovered, as a result of either the requirements or the recommendations of individual European standards.

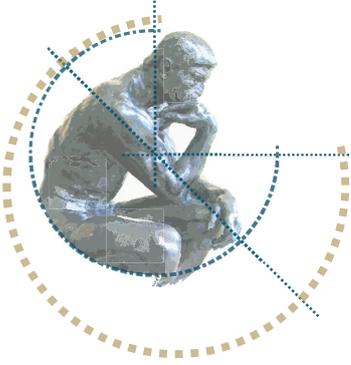
The design engineer can then identify the subassemblies or components that would be affected by a revision of the design. Furthermore, the specific need for modification in terms of the affected subassembly/component can then be defined. This takes a certain input of time, which depends on the manufacturer's process organization. This task culminates in the drafting of a specification for the next revision of series design, inclusive of compliance with current standards.

After this it is a question of time until the specification is applied in the next revision of the series machine. Often, this only takes place when an order of a certain magnitude is placed. The ergonomic aspects are then relatively inexpensively integrated along with other points such as function, technology and safety.

On series machines, it would appear that a medium-term ergonomic revision of machine design can be both efficiently and effectively implemented.

In the case of individually built machines (i.e. in the case of very small numbers or purpose-built machines), it is possible to modify machine design at a much earlier stage. With reference to the list, it would be possible to assess ergonomic design and adapt the design at short notice even for the very next order. The work steps are then similar to those for the series machine (see above), but the necessary changes can be integrated gradually in the machine design.

In addition, we have also found that certain design engineers tend to regard their design as “the best” for a period of years. For instance, the control panels of certain machine manufacturers have retained the same basic layout for decades. If the operator changes from a smaller to a larger machine from the same maker, the idea is that he can apply his existing operating experience (“operate it with his eyes closed”) and learn



the ropes faster. Any supplementary functions are added in specially allocated places of the control panel. A modification of the control panel as such would then be a violation of "corporate philosophy".

In response, it must be borne in mind that these technical solutions are associated with utility designs, patents, works standards and the personal interests of these design engineers. These oppose any short-term abandoning of the existing (and possible unergonomic) design.

Here again, the checklist makes it possible to question the decades-old design (and the designer's own loyalty to it) and possibly, after a certain time, to send an even better solution into series production (again for a relatively long period). In addition, technology surges force design engineers to integrate new technologies from time to time and thus automatically initiate redesign. Ergonomic principles are also adopted via supplied components (input devices, displays). It should be mentioned in this context that the checklist's assessment form also helps to distinguish between requirements ("must") and recommendations ("should") in European standards.

In conclusion, it must also be stated that large companies that operate machines employ safety officers to research information on the Internet and effectively ensure that their suppliers/manufacturers meet their obligations. The publications about the checklist on the Internet are already having an effect on machine manufacturers via interested operators.

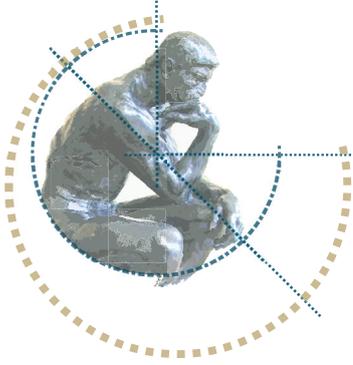
Knowledge transfer

The implementation of ergonomics in machine design perhaps used to be so difficult because the design engineer had to refer in principle to dozens of individual standards on ergonomics in addition to the standards on machine safety proper. The new checklist represents an ideal tool that brings together the ergonomic requirements and recommendations from numerous individual European standards, broken down according to subassembly, and can thus be put to practical use by the design engineer.

First of all, however, design engineers have to be made aware of the checklist and instructed and trained in its content. Knowledge transfer takes place through the publication of the checklist, assessment form and other documents on the Internet, through presentations and the motivation of safety and health experts at talks at the BGIA, BGAG, Verein Deutscher Revisionsingenieure (VDRI) etc. A specialized symposium has already been held for about 50 design engineers, in December 2005. On request, individual consultations are given on the premises of machine manufacturers by the committee consultants of the statutory accident insurance institutions. A new course is also being designed in connection with the BG training of the BGMS and VMBG. Several courses are planned for 20-25 participants per year.

Conclusion

With the aid of the machine ergonomics checklist it is our intention to boost the awareness of ergonomic design among engineers and provide a practical tool. We are confident that the design of machine workstations will gradually become more ergonomic and thus even safer in the coming years.



Application note

In its roughly 300 questions, the checklist encompasses the key requirements and recommendations that should be complied with and thus helps the machine designer to assess the ergonomics of his machine design better. Owing to its deliberately limited scope, the checklist is not however comprehensively applicable to the ergonomic design of all machines. The individual standards on which it is based are also subject to change from time to time. The checklist makes no claim to be complete. The provisions of the law apply without reservation. To obtain complete information on the requirements relating to the ergonomic design of machines, it is therefore necessary to study the wording of these provisions.

References

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