

Protective vision panels

at metalworking machine tools

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This DGUV information is mainly directed to users but also to manufacturers of machine tools. Guards or protective enclosures which are arranged around the work zone of machine tools prevent access to hazardous points from outside. Furthermore, they retain chips, broken pieces and metalworking fluids ejecting during operation. The protective vision panel which allows observation of the machining process while the machine is running is of particular importance in this process.

In order to meet the requirements of a sufficient impact resistance in case of hazard, the retaining part of the protective vision panel consists of the plastic material "polycarbonate" and thus represents the current state of the art. New polycarbonate of sufficient strength and properly installed has a higher retaining capability than most other comparable transparent materials. In comparison to some competing plastic materials, polycarbonate is widely preferred.



Figure 1: Protective vision panel within the protective enclosure of a lathe

In the most basic design, the protective vision panel consists of a simple unprotected piece of polycarbonate. More complex designs usually consist of several panel layers, even of different materials, which are held in a frame.

1 Selection criteria for basic dimensioning

Polycarbonate protective vision panels in conjunction with a stationary enclosure of the work zone or the protective door represent an important part of the machine tool guard.

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Therefore, they have to be considered and treated as protective device and safety component according to the Machinery Directive 2006/42/EC [1].

Protective vision panels of machine tools which are placed on the market for the first time, consequently have to show sufficient impact resistance. Information is provided in the annexes of the relevant harmonized product standard for the machine type it refers to.

For machine spare windows, this means that the protective vision panel as original spare part must have at least the same safety characteristics and impact resistance as the originally built-in protective vision panel. If this is not fulfilled, a "significant change" of the machine cannot be excluded.

Protective spare windows which are separately placed on the market (e.g. not by the machine tool manufacturer) are falling within the definition "safety component" as stated in the Machinery Directive. They must also provide at least the same or better safety characteristics and impact resistance as required for the special machine type they are built in.

Additional requirements include individual CE marking and individual operating instructions containing information on particularities of the individual protective vision panel:

For example with regard to:

- The frequency of visual inspections.
- The description of damages which render the protective vision panel unusable.

- The machinery manufacturer's recommendations on replacement intervals of the protective vision panel
- Recommended cleaning methods and agents.
- The machinery manufacturer's information on installation and disassembly

As described in DIN EN ISO 23125, item 6.2.1 e [2].

Therefore, it is strongly recommended to purchase protective vision panels directly from expert machine or vision panel manufacturers. The required minimum thickness of the polycarbonate panel can be taken from the annexes of the relevant harmonized product standard for the machine type it refers to:

- DIN EN ISO 23125 Turning machines. This standard refers to protected polycarbonate vision panels if protection against ejecting parts has to be provided and if the protective vision panel is also exposed to embrittling influences. For the following machine types which are exposed to embrittling influences, overall protected polycarbonate vision panels should be taken into consideration.
- DIN EN 12417 Machining centres [3].
- DIN EN 13128 Milling machines including boring machines) [4].
- DIN EN ISO 16089 Stationary grinding machines. [5].
- DIN EN 14070 Transfer- and special-purpose machines [6].

According to test experiences, a fixation by clamping is recommended (no fixation by screwing through the protective vision panel). Furthermore, there must be sufficient overlapping of the polycarbonate panel (or the frame) in the opening of the guard. Information on required minimum overlappings for panel dimensions of 500 mm x 500 mm can be found in the "BG"-paper [7] (special edition). In tests with shootings on the panel center, the following minimum overlappings have been determined:

At least 40 mm overlapping, at a panel thickness of 8 mm and 25 mm overlapping at a panel thickness of 12 mm and a projectile mass of 2,5 kg (considering the safety concept for lathes according to DIN EN ISO 23125 item 5.13 / (small) NC machines).

Additional information is provided in DIN EN ISO 16089 indicating the panel overlappings of stationary grinding machines. Further overlappings are indicated in the stated literature.

However, it has to be taken into account that the different safety concepts the machine tool types are based on can lead to different minimum overlappings. For adequate safety against pushing the vision panel as a whole through the opening of the guard, preference should be given to large overlappings. Panels which are much larger than the indicated 500 x 500 mm also require larger overlappings. In case of doubt, own proofs are advisable. This service can be provided by external test bodies.

The installation of special vision systems into the vision panel may be problematic, if they are fixed with screws passing through the vision panel. This weakens the vision panel and metalworking fluid with embrittling effects may come into direct contact with the polycarbonate through the screw holes.

2 Problems on old machines

Old machines built before 1995 have to meet the requirements of the Ordinance on Industrial Safety and Health (Betriebsicherheitsverordnung - BetrSichV) [8].

This means that safeguards protecting against ejected parts must be available. At that time, glass panes (made of silicate or mineral glass), Plexiglas or acrylate glass were commonly used. They had to show a higher impact resistance to ensure similar safety compared to modern protective vision panels of polycarbonate in new machines today.

Unsuitable panels were built in machines even after the year 1995, at least partly, since there was no harmonized product standard available (in compliance with the former applicable Machinery Directive (98/37/EC)) that included information on the required impact resistance. Analogous to the old machines mentioned, for the operation of these machines the minimum requirements according to BetrSichV including suitable safeguards have to be met as well.

Panes made of glass, Plexiglas or acryl plastic as they were commonly used in the past, although they were not suitable, represented the state of the art at that time. Therefore, this aspect has to be included in the assessment of working equipment as required by the Occupational Health and Safety Act (Arbeitsschutzgesetz - ArbSchG) [9] and the Ordinance on Industrial Safety and Health (BetrSichV) in order to ensure safe use. For risk reduction, there is the possibility to operate the machine with reduced speed. It is recommended to limit the speed by technical means. An alternative is to equip the machine with polycarbonate protective vision panels of current design provided the protective enclosure and door which have to be taken into account for the assessment are sufficiently rigid. Changing only the original parts made of glass, plexiglas or acrylic glass as spare protective vision panels only pretend to be safe and should therefore be avoided.

3 Embrittling of protective vision panels

Polycarbonate as retaining component of state-of-the-art protective vision panels is sensitive against metalworking fluids and may embrittle when being exposed to it. It may also be affected by unsuitable cleaning agents (brake cleaner containing toluol) and chemicals as for example acetone. This embrittling - usually not visible - may result in a drastically reduced impact resistance as accidents have proven. The vision panel manufacturer often guarantees the impact resistance for its undamaged panel for a certain period of time. Together with the date of manufacturing indicated on the panel (compare Figure 2), this results in a "date of expiry" of the protective vision panel. Using the vision panel beyond the stated "date of expiry" may pretend deceptive safety .

If this information is missing, it has to be obtained from the instruction manual or directly from the machine or vision panel manufacturer.

Protective vision panels which are damaged for example by cracks, scratches, visibly intruded metalworking fluids or unsuitable cleaning agents should be replaced immediately since there is a risk of an already existing or developing embrittlement. The annex of this paper shows damaged protective vision panels which have to be replaced.

The improper use of the protective vision panels, e.g. beyond the „date of expiry“ or an ongoing use of a damaged window may result in the consequence that the liability passes from the manufacturer to the user (if the vision panel is not replaced in time).



Figure 2: Example of indicating the year of construction (Period of use, here $t = 8$ years.)

4 Purchase of machines

The lifetime of a protective vision panel, the manufacturer guarantees for, is dependent on its design and composition. A frequently required change carried out by the user - particularly for unprotected polycarbonate panels - represents a considerable operating cost factor of the machine. Therefore, it is recommended to include this in the purchasing criteria prior to purchasing a new machine in order to avoid expensive "surprises" for maintaining machine safety.

An important aspect when buying machines is the consideration whether the protective vision panels have already been exposed to metalworking fluids. This may be a trial operation with the machine standing at the dealers place. It may be as well the regular operation of second hand machines in production. It has to be taken into account that the remaining period for the necessary replacement of the protective vision panel until the date of expiry is shortened.

5 Residual risks to the operator

Especially when adjusting CNC-machines or when positioning workpieces in production, operators tend to stand very close to the protective vision panel with their face, in order to have a good view to the cutting process. In case of a sudden ejection of larger broken pieces, the intact protective vision panel will bulge (embrittled protective vision panels break) and hit the face if the distance is too small. Therefore, the operator should stand outside the probable ejection way of pieces and keep enough distance to the vision panel surface.

Even worse is the ejection of a whole workpiece. The machine enclosure - including the protective vision panel - offers only a relative protection. That means its impact resistance is limited to a specific impact power and there is **no** guarantee of complete protection. Ejected broken pieces or workpieces can have or take up so much energy

that even a correctly dimensioned protective enclosure or protective vision panel may break.

These are residual risks on which the operator has to be instructed and be permanently aware of (compare also EN ISO 23125 pt. 5.13.1 h).

6 Quick check

Critical questions when buying machines:

- The safety concept - to be explained by the trader/manufacturer.
 - suitable material, as e.g. protective vision panel made of polycarbonate.
 - nominal thickness appropriate to the safety concept of the machine (e. g. according to product standard). Sufficient overlapping? Are there (voluntary) proofs of impact resistance?
 - is the protective vision panel almost new or can ageing be expected because of preceding operation?

Later during operation:

- instruction of operators regarding the safe observation position.
- use of suitable cleaning agents and cleaning accessories.
- regular check of the protective vision panel according to risk assessment in accordance with ArbSchG (German Occupational Health and Safety Act) and the BetrSichV (Ordinance on Industrial Safety and Health) on damages and the remaining time until date of replacement.

7 Summary and limits of application

This DGUV information (former expert committee information sheet) is based on expert knowledge gathered by the expert committee woodworking and metalworking, subcommittee machinery, robotics and automation of DGUV in the field of guards, particularly protective vision panels on machine tools. It has been prepared in cooperation with interested parties.

This DGUV information is intended as orientation on the particularities and special hazards, which may occur with protective vision panels on machine tools in practice. The examples given in the annex indicate at which degree of visible damages protective vision panels on machine tools have to be replaced.

Besides references to the Machinery Directive 2006/42/EC, there are also references to the Betriebs-sicherheitsverordnung (BetrSichV) (Ordinance on Industrial Safety and Health) which is based on EU Directive 2009/104/EC [10] and to the Arbeitsschutzgesetz (ArbSchG) (German Occupational Health and Safety Act) based on EC Directive 89/391/EC [11].

Relevant requirements from EC Directives, national laws and other technical standards apply without any reservation. New findings are not impeded by this DGUV information. In order to get detailed information, it is necessary to consult the applicable wording of the rules.

The expert committee woodworking and metalworking is composed of representatives of the German Social Accident Insurance Institutions, federal authorities, social partners, manufacturers and users.

This DGUV information replaces the expert committee information sheet No. 049 of the same title (issue 03/2012). An updating has become necessary due to editorial amendments.

Further DGUV information and information sheets of the expert committee woodworking and metalworking (Fachbereich Holz und Metall) are available for download on the internet [12].

As to the aims of the DGUV information, refer to DGUV information FB HM-001 „Aims of the DGUV information published by the expert committee woodworking and metalworking.

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Annex: Examples of visible damages at protective vision panels - need for replacement



Figure A1



Figure A2



Figure A3



Figure A4

Figure A1 - A4: Due to a leakage (hole) between individual panels, metalworking fluid is getting on retaining polycarbonate panel



Figure A5: Swelled panel sealing due to metalworking fluid. The lateral tightness to the polycarbonate panel edges is no longer existent (applies also to cracked panel sealings).



Figure A6: Cracks starting from the panel edge in embrittled polycarbonate panel

Further criteria for the need of replacement [13]:

- **Plastic deformation of the protective vision panel (swelling) due to previous impact.**
- **Destroyed or damaged protective vision panel (film) on the work zone side or the operator's side.**