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Comments of the DGUV civil engineering expert committee on the "VDMA position paper regarding visibility on earth-moving machinery"

Being struck or run over by earth-moving machinery has been known for many years to be the most frequent cause of accidents in the construction industrial sector. Moreover, when operating excavators accident risks may rise from lateral or transversal movements during operation or travel modes, e.g. when the upper structure is rotating, or when the excavator is about to travel backwards or to reverse, or when the excavator boom or other suspended working device is being pivoted. One reason is certainly the insufficient visibility of the danger zone or blind spots. The poor visibility merely constitutes a significant risk, which regularly occurs when operating or using earth-moving machinery as intended. Since this has been a topic of concern for years, manufacturers are obliged to state in detail in their technical documentation how risk assessment has to be performed to assure good visibility for the operator. These risks can be primarily reduced or ideally eliminated by taking relevant technical protective measures meeting the state of the art.

In this context manufacturers have to take due account of the latest technical progress and select the most effective and appropriate technical solutions for the machines concerned.

The VDMA position paper regarding visibility on earth-moving machinery gives the impression that camera monitor systems are not appropriate to eliminate blind spots or visual obstructions. This paper contains in many important points false and undifferentiated technical statements concerning camera monitor systems.

Operators of earth-moving machinery are advised to place a special emphasis on organizational and personal protective measures when selecting the appropriate safety measures: this is against the

basic principles of the machinery safety (T-O-P Principle = technical solution first **then** organizational and then personal) and is an infringement in terms of the German Health and Safety Regulations (BetrSichV).

We would therefore like to refer to the recommendation of the civil engineering expert committee “Visibility when operating earth-moving machinery and compactors” of 26 March 2015.

Neither camera monitor systems nor mirrors provide an ideal and optimal solution. Depending on the machine type and the assembly position, either the first or the last visual aid is the most appropriate solution according to the state of the art. The left hand exterior rear-view mirror on excavators is for instance an excellent visual aid, which has proven its worth in practice for many years. Whereas rear-view mirrors mounted behind the driver or on the right side of the machinery have not proved to be reliable or successful. In these cases, a camera monitor system constitutes the best technical protective measure.

The research project “Optimization of operator’s station of machinery equipment” supervised by the BG BAU, carried through and in the meantime finalized by the German IFA (Institute for Occupational Safety and Health) shows among others that mirrors placed on the right cannot be used by the driver because they forced him to a non-ergonomic unhealthy position.

However, the prerequisite in this context is that the CMS mounted on the machine by the manufacturer has to be suitable for this particular use. For instance, it can be assumed that the rear and side view monitoring systems used in automotive sector to capture the entire rear area of the machine are of good quality, capable of being and remained switched on when the driver starts up the machine.

The enclosed overview in tabular form shows the statements of the VDMA and where required our comments. In addition attached pictures show some examples of suitability of mirrors and of camera monitor systems.

Encl.

- Comments table
- Picture appendix

	VDMA position concerning visibility on earth-moving machinery	BG BAU comments
0	<u>Legal manufacturer obligations (page 1)</u> …. The risk assessment is a constitutive part of the technical documents pursuant to Annex VII A of the Machinery Directive. These documents will remain with the manufacturer. <u>Manufacturer documents (page 2)</u> The technical documents according to Annex VII of the Machinery Directive are internal manufacturer documents. They must be transmitted to the authorities only upon request by the respective market surveillance authority. There is never an obligation to hand them over to the client. <u>Suggestions for transitional period – operator/employer (page 7)</u> …. Due to the above reasons, manufacturers will however neither provide formal declarations nor additional documents, except the declaration of conformity to the operator/employer.	Leaving open whether manufacturers are obliged to provide information on his risk assessment or not, following question should be considered: How should the customer know, whether the ADCO points had been sufficiently considered by the manufacturer? By whom else then? If not by the manufacturer himself? The customer of a new machine must be able to rely on the fact that he gets a safe machine, so designed and constructed that significant risks resulting from standard situations have been taken into account.

1	<u>Camera monitor systems</u> The consequence of the five ADCO Task Force points currently seems to be that camera monitor systems (CMS) will in the future be used as protective measure.	Mirrors are to be mounted, where they: • are at the most ergonomically convenient position and • provide a good view of the danger zone The use of mirrors is a good and reliable technical protective measure and shall further be encouraged. As a positive example to illustrate this, I shall cite the left exterior rear-view mirror on excavators. Where the above criteria cannot be fulfilled, because • mirrors have to be mounted behind the driver or • the visibility might be impaired by moving machinery parts (e.g. excavator arm) or • there are too many mirrors to look at, the danger area is not visible (e.g. big dumper) and in that case a CMS present a better technical solution and shall be appropriately used.
2	A CMS requested as a protective measure as part of a product standard has to be assessed according to the requirements of EN ISO 13849-1 with regard to Functional Safety, in particular concerning the below listed criteria. The introduced CMS available on the market do not yet meet these requirements.	The EN ISO 13849-1 “Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design” applies to safety aspects of control systems, using mechanical, hydraulic, pneumatic and electrical technologies. A CMS is not a control system but a visual aid according to ISO 16001. That is why the CMS available on the market do not need to comply with the requirements of the EN ISO 13849-1. The CMS shall meet the requirements laid in ISO 16001.
3	At present, the available systems can be considered comfort or assistance systems ……	Camera monitor systems are visual aids according to ISO 16001: 2008 “Earth-moving machinery – Hazard detection systems and visual aids – Performance requirements and tests”
4	… but cannot replace construction site organization and communication!	The European Commission examined the harmonized Standard EN 474-1 and concluded that “…… *the earth-moving machinery designed and manufactured according to the standard does not allow the driver to have sufficient visibility in order to operate the machinery without a risk for the driver or third persons*.” Consequently addressing the visibility issue has to do with evaluating which visual aids shall be selected and where they are to be placed, it has nothing to do with the construction site organization and communication.

5	These systems can currently not yet meet reliably the following criteria indispensable for any **safety system**:	It is not about safety systems but visual aids according to ISO 16001. As a matter of fact, manufacturers have equipped their machines (e.g. rail-road excavators) with appropriate CMS for many years now. The criteria set out by VDMA are reliably complied with, see comments for further details.
6.1	- real-time image transmission,	Both the currently valid and the revised version of ISO 16001 require a maximum permissible video latency of 300 milliseconds. The camera monitor systems for rear and side area surveillance, which are currently available on the automotive market, fall below this value.
6.2	- equalising ambient light impact: back light, slanted sun, contrasts,	High quality Camera monitor systems, currently available on the automotive market, equalize backlight and slanted sun and display high contrast images. Good monitor screens have actually a display surface providing effective protection from glare and reflection. <u>Compared to mirrors:</u> Backlight, dazzling or slanted sun on the mirror definitely impair the visibility.
6.3	- taking into account ambient impacts: frost, dust, humidity, aggressive materials (chemicals, organic materials, salts, etc.), vibrations, etc.,	High quality camera monitor systems, currently available on the automotive market, take into account such environmental criteria and complied with the individual relevant standards for these particular environmental and weather conditions. Parts or compounds of these CMS must be accordingly designed, e.g.: • Camera at least IP 69K • Monitor: at least IP 54 • Contacts and switches: at least IP 67 Such cameras are designed to withstand temperature between -30° till 60° Celsius. <u>Compared to mirrors:</u> • The visibility can be impaired by dust and dirt, when using mirrors or CMS, • The mirrors mounted on earth-moving machinery are generally not heated so that they are not protected against freezing and fogging. • Vibration is usually amplified by long mirror holders or brackets so that the visibility through these mirrors is even more restricted. •

6.4	- preventing condensed water formation,	The formation of condensed water is not possible when quality camera monitor systems are used because of : • their design, • the observance of the protection IP 69K and • the integrated heating <u>Compared to mirrors:</u> The mirrors mounted on earth-moving machinery are generally not heated so that they are not protected against fogging (condensed water formation).
6.5	- damage protections (due to work activities and also vandalism),	Camera monitor systems of high quality, currently available on the automotive market, have a sturdy housing and stable mounts which make them resistant to harshest conditions. They have been shock and vibration tested and accordingly designed. Manufacturers can fit their basic machinery equipment with such cameras and mount them in such a way that they are protected from all type of external damage or against vandalism, same as for other fittings or attachments like e.g. mirrors. <u>Compared to mirrors:</u> • It is generally easier to damage and dismount mirrors than CMS • Mirrors are usually placed far outside the machine so that they are easily displaced by vibration, machinery work movements, when for example touched by or colliding with trees, shrubs and bushes. • To adjust the displaced mirror(s), the driver needs the help of a second person, who is not automatically around when this happens. The mirrors currently available on the market are generally not adjustable from the driver's position / seat. •
6.6	- corrosion-resistant also during extreme road and ground conditions,	See above: Such cameras are corrosion and salt resistant.
6.7	- no "still frame" or "freeze frame" possible,	See above: In the event of system failure, such cameras or monitor systems do neither provide a "still frame", nor a "freeze frame". The image fades away or disappears and the screen will turn black, grey or blue. The machine driver understands clearly and immediately that the CMS is defective.

6.8	- ensuring true-sided display of camera image but not via camera itself.	Quality Camera monitor systems, currently available on the automotive market, deliver true-sided images.
7	This means that for the CMS available on the market and used as “comfort systems”, it is impossible to exclude the possibility that functional failures (delayed transmission, freeze frame, etc.) will occur. The required reliability is not assured as applicable for e.g. elements of functional safety.	The CMS cannot be considered as “comfort system” and as elements of functional safety. They are visual aids according to ISO 16001. If quality camera monitor systems are properly fitted by machinery manufacturers, the functional failures described by the VDMA are excluded or prevented with a sufficient degree of safety and reliability.
8	Even if CMS can meet the criteria of a protective measure, they cannot be considered a panacea.	We cannot understand why CMS is described as „panacea“. Neither in relevant publications nor in relevant standards or rules are camera monitor systems considered or referred to as such. See comment under item 1 at the beginning of the table.

9	The driver must already process a plethora of signals even without CMS. One or several additional monitors will fatigue and overburden the driver. Such an overburdening contradicts the basic safety and health protection requirements of the Machinery Directive regarding ergonomic principles. Regarding the driver's field of view to the right, the ADCO requirement to display monitors or mirrors in the forward direction of view (in the 180° arc in front of operator) has even not been sufficiently taken into consideration by the ISO Standard 5006. Placing visual aids by an angle of 45° behind the driver has rather been considered to be admissible. Moreover, another ADCO requirement has not been met in this standard, according to which visual aids must not be obstructed by moving parts of the machinery (such as excavator arms). The solution given to improve visibility on the driver's field of view to the right consists in placing 2 mirrors (one of them being place by an angle of 45° behind him) to be constantly monitored by the driver. This is unacceptable considering the fact that an excavator rotates and swivels several 100 times during a work shift.	Too many and ergonomically unsuitably positioned visual aids can fatigue and overburden the machine driver. It affects the acceptance even more, if the visual aids do not allow the driver to have sufficient visibility of danger zones and the visual are not suitable for the work to be carried out. This is the case when operating excavators of a bigger size: when the driver tries to ensure sufficient visibility to the right with two mirrors, one of which placed up to 45° angle behind him. The overburdening resulting from this mirror arrangement contradicts the basic safety and health protection requirements of the Machinery Directive regarding ergonomic principles. Camera monitor systems can be arranged in the forward direction of view, to be ergonomically visible so as to provide a better visibility and maintain visual surveillance of the danger zone (especially to the right when using larger excavators). They can replace one or more mirrors and would particularly help the driver to cope with his tasks. However, this assumes that appropriate CMS, e.g. quality camera monitor systems currently available on the automotive market, are correctly mounted and arranged, which e.g. • can be switched on automatically when the engine is being started and cannot be deactivated • and have a convenient (at least 5,5“) color monitor.

Picture appendix

Good suitability of mirrors as visual aids, in the case for instance of the front left hand exterior rear-view mirror on excavators:

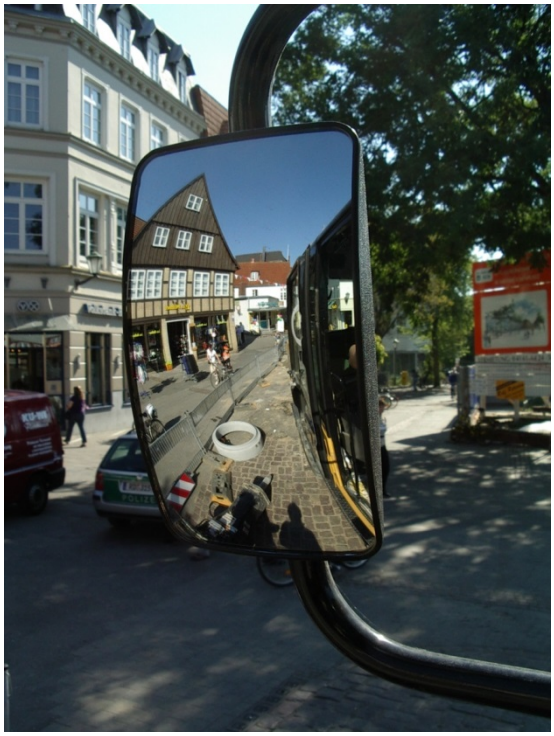
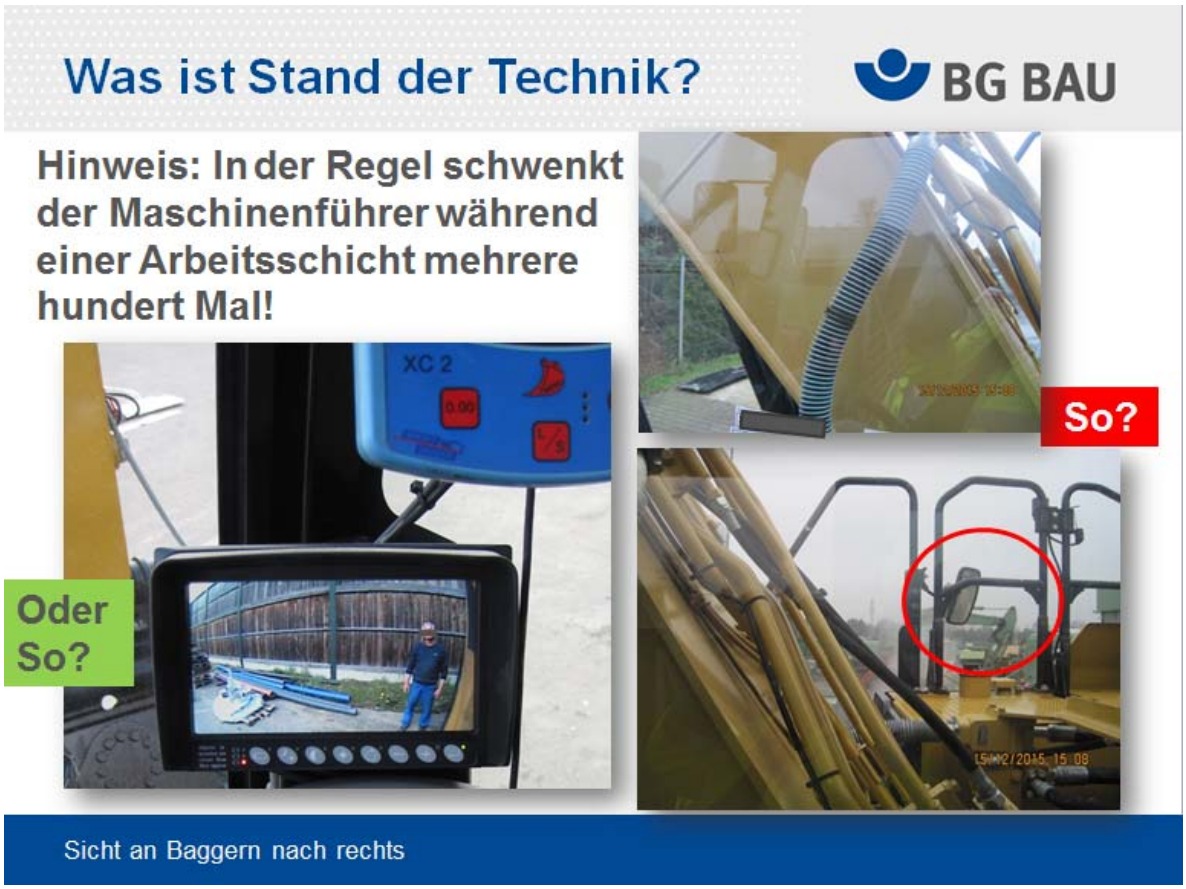


Figure 1: the front left hand exterior rear-view mirror on excavators is a proven visual aid, which is accepted by drivers

State of the art regarding the <u>field of view on the right hand side of larger excavators</u>:

What is the state of the art?
Note: Generally, an excavator slews several hundred times during a work shift!
so? Or so?



<u>Figure 2:</u> When the driver swings back and forth (several hundred times during a work shift), he must be able to see the hazardous area. What is the better solution? When he

- has to look back every time at two different mirrors placed to his right, one of which being placed in an angle up to 45° behind him (how much from the danger zone can be seen?)
- or when he can look at an ergonomically well-placed monitor, located in the working direction and giving the driver a better visibility of the hazardous area so that he is able to carry out his work.

<u>Note:</u> The praxis has shown that such a mirror arrangement on larger excavators did not really work and did not prove successful.

Monitor screens which are not permanently switched on (are inappropriate as visual aids):

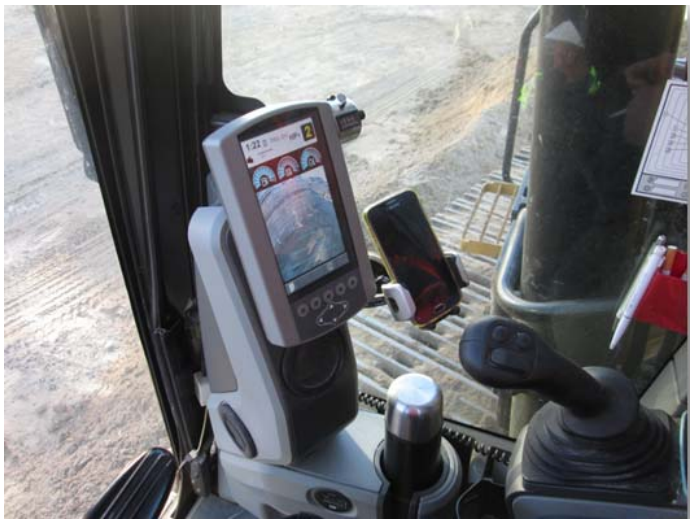


Figure 3: Small monitor, temporarily switched on, which can be used to display machine data and status information

State of the art of rail-road excavators:

Visibility to the right

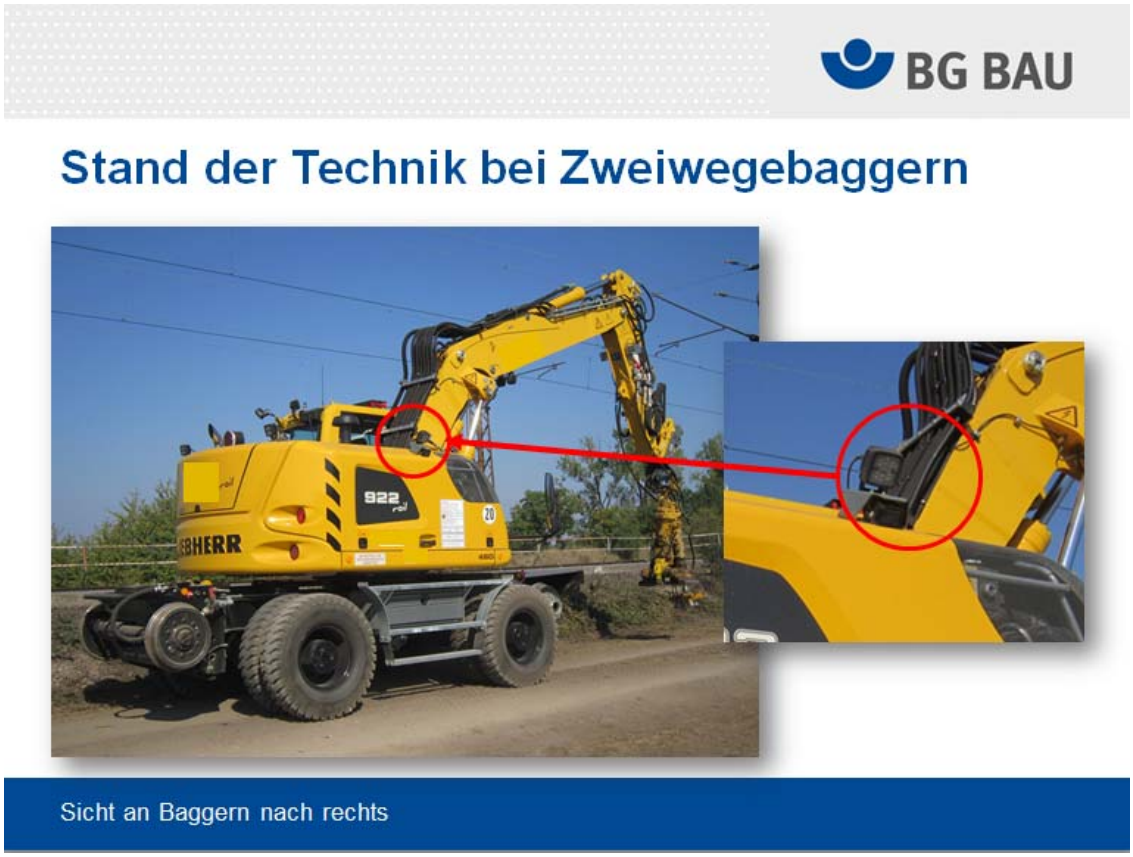


Figure 4: The visibility of the rear and right fields when operating rail-road excavators has been ensured by camera monitor systems for many years. A substantial fall in the number of work accidents resulting from poor visibility shows that the use of CMS has proven success.