

# KLEMM Bohrtechnik – The Influence of New European Safety Standards on the Design of Drilling Rigs

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## Preface

The European product standards EN 791 (Drilling Rigs) and EN 996 (Pile Driving Rigs) were replaced February 13, 2015 by the new product standard EN16228. The significance of this harmonized norm is that when utilized, it is understood that the machine complies with the European Machinery Directive (DIRECTIVE 2006/42/EC). This directive regulates by law the placing of safe machinery onto the market place in all EU member states. A such conform safe machine must be labelled by the manufacturer with the "CE" Logo.

The new standard EN16228 is comprised of 7 sections and contains 274 pages. An exhaustive description thereof is not possible in the framework of this article. Using the example of a KLEMM Bohrtechnik drill rig illustrates some of the principle aspects of changes made with regard to the previous design.

Substantial changes can be found in the following areas:

- a) Strength calculations (long life fatigue analysis)
- b) Stability calculations (tipping-over, additional consideration of dynamic loads)
- c) Failure safety of control circuits (performance level)
- d) Protection against moving parts during the working process ("Guarding")
- e) Noise emissions test codes

## Performance Level – Key to the Reliability of the Machine Control

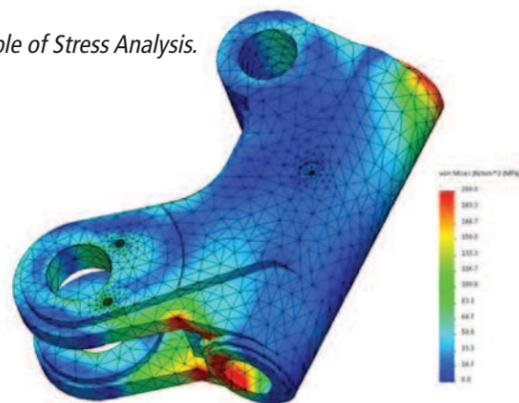
It was common practice with the prior standards that the design engineer evaluated the required reliability of each relevant safety function. Now, the EN16228 standard contains a list of 19 relevant safety functions on drill rigs. Among others these functions are i.e. the brake function of the drive gear, how fast a winch can be halted or the speed at which the rotation and feed functions stop when safety means are activated. For these functions a minimum Performance Level PLr of "C" is required. The Performance-Levels are graded from A to E, where grade A represents the lowest level of failure safety and grade E the highest level within this classification. Performance-Levels are normed according to EN ISO 13849.

For non direct operating control systems i.e. control circuits with a mix of hydraulic and / or electric signal transfer PLr-calculations are quite complex. To verify the correct failure protection and the correct degree of diagnostic coverage (DC) the individual components, installed in the machine, play an important role. The failure protection rates are mathematically described through MTTF (Mean Time To Failure) values. The diagnostic coverages (DC) are dependent amongst other things on the architecture of the control unit and are read out of tables as percent values or can also be calculated.

The verification of the performance level is done within the engineering department of KLEMM Bohrtechnik with the help of SISTEMA software, IFA provides this software. IFA is the Institute for Occupational Safety and Health of the German Social Accident Insurance. If a signal circuit does not achieve the necessary Performance Level (PLr) then KLEMM Bohrtechnik installs a parallel redundant signal circuit, this then ensures that the required PLr can easily be reached.

This issue has to be considered for the further development of drill rigs, because implementing the EN16228 standard forces the designer to install additional safety operation modes. Due to the fact that the safety working modes cannot be economically designed by utilizing the widely known and applied hydraulic pilot control systems the new control systems are designed around electronic control units. This enables the drilling rig to provide the new modes within the required Performance-Levels.

Example of Stress Analysis.



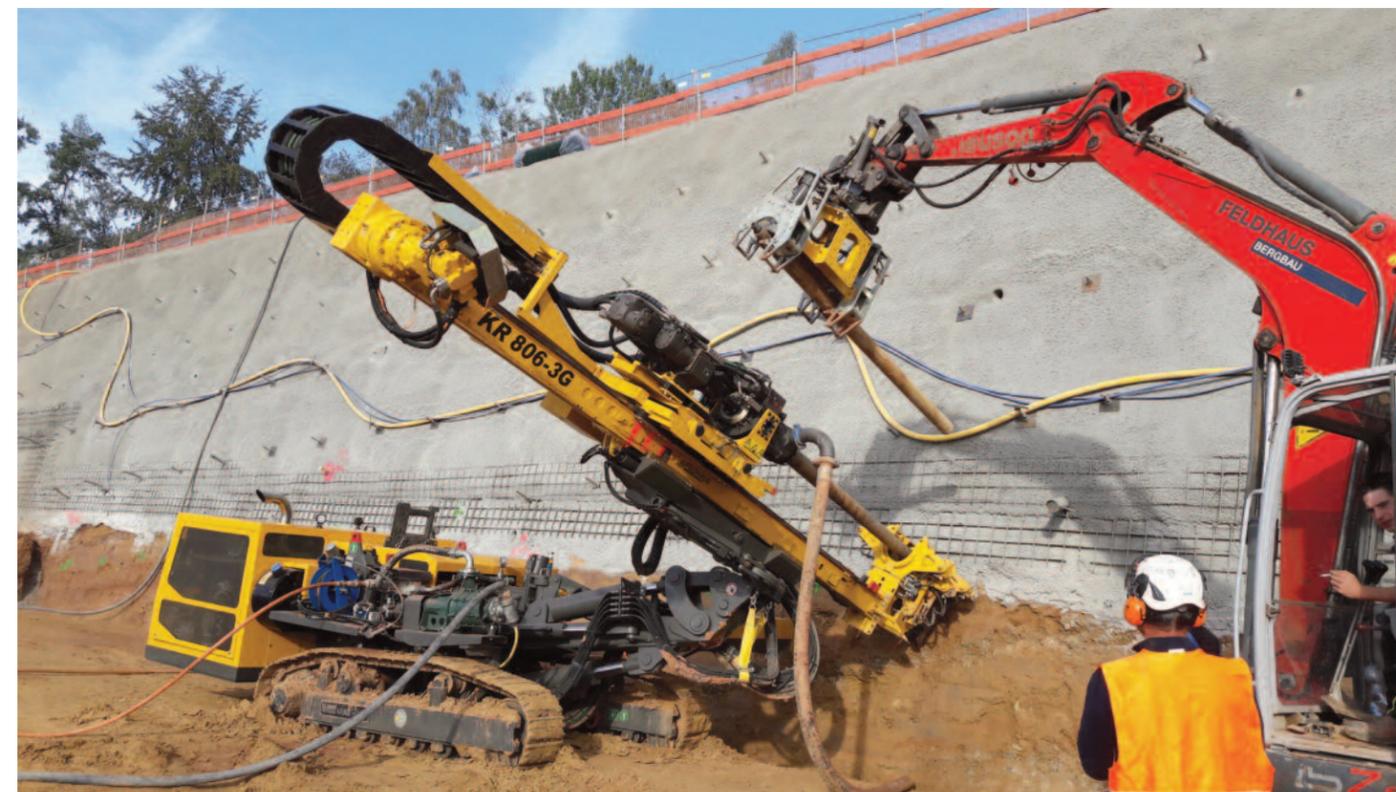
## Protection Against Moving Parts in the Drilling Process

Quite a number of fatal accidents have been reported where operators have been entangled with the rotating auger or drill string on small sized drill rigs. Small sized equipment such as used in soil investigation are often underestimated regarding their power and danger potential. Therefore, the new standard requires general "guarding" systems.

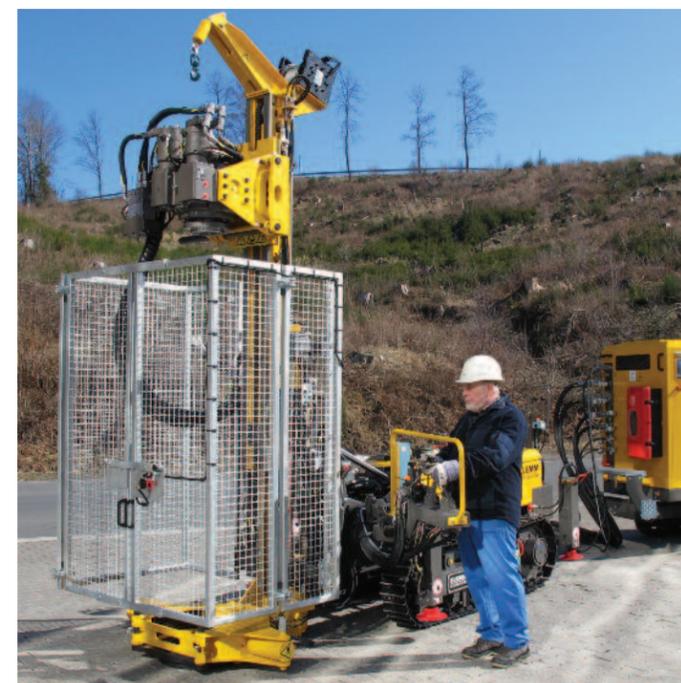
As a rule, fixed or interlocked guards must be installed if the "access to moving parts that are directly involved in the working process during the normal operation of the machine can be foreseen." As there is a wide range of possible operating situations where the above is true, it is up to the end-user of the drill rig, and not the manufacturer, to determine if access to moving parts is foreseen, depending on the given job-site situation.

In order to correctly set-up the drill rig to the actual job-site situation the operator has to select the working configuration on KLEMM Bohrtechnik drill rigs. Using the example of the tieback drill rig KLEMM KR 806-3G this would be as follows:

By choosing a working configuration in the menu on the machines display the functionality of the machine is pre-set. This choice determines



Working with external Manipulator – Access to moving parts is not foreseen.



Interlocking Guard – Access to moving parts is foreseen.

- b) Manual handling of drill string without guarding (if guarding is technically not possible)
- c) Drilling operation without handling of drill string (i.e. single-pass drilling)
- d) Mechanical handling of drill string with the machine's rod loader (i.e. KLEMM MAG-series)
- e) Mechanical handling of drill string with an external handling system (i.e. KLEMM HBR 120-Series, excavator mounted grab)

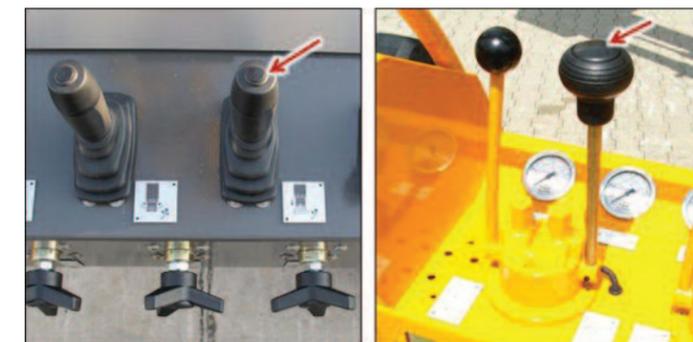
Additionally a machine must have two safety modes according to EN 16228. Depending on the chosen "work configuration" the following

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how the machine will operate. The operator's choice on the intended handling process of the drill string is the determining criteria.

The machine control unit offers five possible "work configuration" options:

- a) Manual handling of drill string with guarding (if guarding is technically possible)



Implementation of Hold-to-Run Functionality.

safety modes are available for the machine operator. They allow full or restricted functionalities of the control elements (Joysticks) and influence the PLC of the machine.

**OFF (Regular Drilling Operation, No Safety Mode Activated)**

Work is only permitted when the machine is equipped with a protection system in terms of fixed or interlocked guards or a contactless guarding device. The guarding system must be closed during the operation. Before the protective guards can be opened the operator must switch into the ROM Safety Mode (Restricted Operating Mode).

**ROM (Restricted Operating Mode)**



Mode Selector and corresponding Signal Tower.

ROM allows the operation of the machine with the guard opened, when loading tooling or for maintenance work. When set the ROM-mode reduces the speed of the rotary head and feed speed to uncritical levels or to inching steps.

This operating mode is determined through the mode selector switch. Until the movable guarding system is closed and locked again this mode governs the machine functionality. As soon as the operating elements (i.e. Joysticks) are released from hold-to-run position the rotation movement is halted in less than half a rotation cycle.

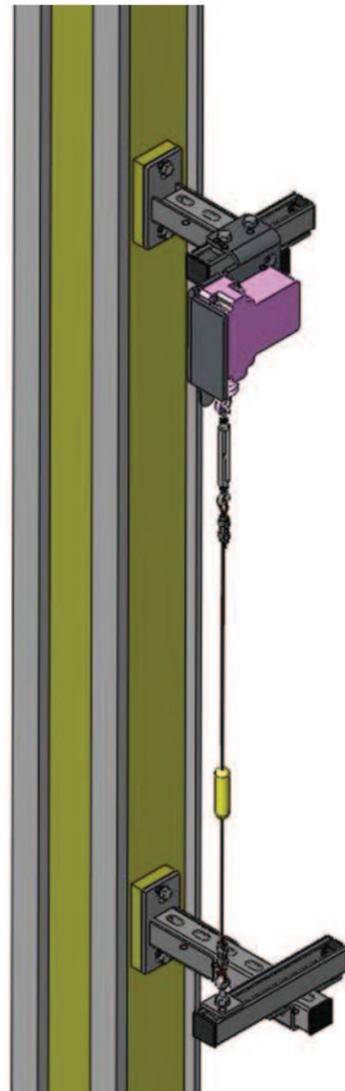
**SPM (Special Protective Mode)**

If guarding as described above is not applicable then the machine can be operated in the mode SPM. KLEMM Bohrtechnik is of the opinion that there are no suitable interlocked guarding systems when working in flat inclined mast angles. At the moment, only the Special Protective Mode offers sensible machine management to work safely without guards in an inclined angle.

When SPM is activated the machine switches independently between the ROM and the SPM modes by registering the clamp pressure. If the clamp is closed (clamp pressurized) the functions feed and rotation are automatically reduced, see ROM description. Another characteristic of

the SPM mode is that the operating element (i.e. Joystick) for the most dangerous operating function, which is the rotation function, is set in the hold-to-run functionality, meaning that the function can only be utilized when an additional push button is activated. This ensures permanent operator's presence at the machine control stand, hence permanent surveillance of the dangerous area.

**The Importance of Supplementary Trip Wires**



Trip-wire Installation.

The trip wires represent a form of pressure sensitive switching elements, which do not restrict the entry into the dangerous working area. In a best case scenario the trip wires lead to a disabling of dangerous machine movements (rotation and feed), when a person is in the danger zone and the safety wire is tripped. The pressure sensitive switching elements are, regardless of the before mentioned safety modes, still mandatory. At present proposals are being considered to recognize the geometrical positioning of the safety wires in order to ensure their effectiveness.

**Wrap-Up**

The essential safety aspects during the design of drill rigs have been explained. The European safety standardization for foundation equipment defines the worldwide highest requirements at present. Product safety is of major significance in North America. This demands that all parties have a deep understanding of the present changes that are taking place. The end-users of drill rigs must familiarize

themselves with this "somewhat inconvenient subject." Even when supposed contradictions to the usual but not necessarily "safe" working methods arise. Due to the fact that there are still many issues with the implementation of EN16228 standards, discussion for amendments are presently being held. KLEMM Bohrtechnik is involved therein and, of course, in constant contact with the end users to provide practical and innovative solutions.



Single-Pass Drilling – Access to moving parts is not foreseen.



Working with integrated Rod loader – Access to moving parts is not foreseen.