1 Introduction
Possible collaboration of humans and robots is a shared workplace without perimetre guarding opens up new possibilities and concepts in industry and production. The standardisation and legal situation allows for human-robot collaboration (HRC) within defined limits.

This document provides guidance for manufacturers, distributors and integrators and points out relevent rules and standards. This document and the standards mentioned herein serve to provide information for end customers (operators).

To implement such workplaces it is necessary to study the Machinery Directive (law) and standards comprehensively. In order to meet the Machinery Directive, manufacturers, distributors and integrators and points out relevant standards, laws and requirements regarding the safety in the collaboration between humans and industrial robots to the manufacturers of robot systems.

The position paper serves as a guideline and provides an overview of relevant standards, laws and requirements regarding the safety in the collaboration between humans and industrial robots to the manufacturers of robot systems.

It does not claim completeness or provide an exact interpretation of the existing statutory provisions.

2 Basics of Human-Robot Collaboration (HRC)
In robotics, the term “collaboration” (lat. co = “with” + laboe = “to work”) refers to cooperation between features and robots. This cooperation is limited to a precisely defined collaborative workplace.

The four basic safety principles applicable to HRC are

1. Safety-rated monitored stop
2. Hand guiding
3. Speed and separation monitoring
4. Power and force limiting

These four principles of protection in HRC are described in detail in the standard EN ISO 13850 "Robots and robotic devices – Safety requirements for industrial robots" (Parts 1-3) as well as EN ISO 13849-1 “Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design” and EN ISO 13849-2 “Safety of machinery – Safety-related parts of control systems – Part 2: General principles for design”.

In all cases involving HRC, protection of the human must be ensured by safety measures. The technology used must meet certain safety requirements. According to these requirements the essential safety and health requirements are determined and corresponding measures are taken.

3 Machinery Directive
The Machinery Directive (2006/42/EC) issued by the European Parliament provides for a uniform level of safety and health protection for machinery that is brought into circulation within the European Economic Area (EEA). Each EU member must transpose the Machinery Directive into national law. In Germany, this is done by the "Produktsicherheitsgesetz" ("product safety law").

The following concentrates on power and force limiting.

4 Risk Assessment
The first step is always to specify precisely the application using all boundary conditions and components. Risk assessment must then define the necessary measures to reduce risk. It determines whether a risk reduction is required and whether hazards must be eliminated or reduced by protective measures. An example for such a measure in the context of a robot system would be a safe reduced speed in combination with safe collision detection. Only when the final risk assessment confirms that an acceptable safety level has been reached can a CE mark be issued.

Risk assessment must take into account the various aspects of HRC. This include so-called "intended use" as well as "permissible misuse" by persons within each of collaborative robot systems.

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2.1 Safety-rated monitored stop

Robot stops when the operator enters the collaborative workplace and continues when the operator leaves the collaborative workplace.

2.2 Hand guiding
Robot movements are controlled actively by the operator through suitable means. Robot movements are controlled actively by the operator and are technically limited to a safe level.

2.3 Speed and separation monitoring
Contact between operator and moving robot is prevented by the robot.

2.4 Power and force limiting
Contact forces between operator and robot are technically limited to a safe level.

4.1 Centralized risk assessment
The overall application must always be considered (process, fixtures, gripper system, robot), i.e. not only the robot.

4.2 Safety functions must be implemented using suitable components in accordance to determined requirements.
Standards must be applied in their current versions. Thus, for example, a maximum power of 80 W or a contact force of 150 N as stated in EN ISO 10218-1:2006 are no longer valid.

As harmonised European standards are frequently based on the international standards of ISO or IEC or are direct adaptations of these, the advantage of compliance to these standards when constructing robots or designing applications is that performing solutions can also be offered beyond European borders.

6 Technical Safety Requirements

To avoid hazards to persons also in the event of a fault in the system, control-related measures for maintaining limit values must be implemented in a safety-rated manner. The term “safety-rated” is defined in EN ISO 13849-1 [6] by means of categories and performance levels and must be applied to all safety-relevant components.

In the robot safety standard EN ISO 10218-1 [1], the safety functions of the robot controller are determined to be implemented in category “3” with performance level “d” unless risk assessment indicates a higher or lower level. Category 3 means a cross-monitoring, dual-channel system. It is not sufficient, however, e.g. to use two identical components. The safety performance level (PL) determines the required residual probability of dangerous failure.

Risk assessment of a specific complete application results in the required performance level. The system-integrator is responsible that all applied safety functions (e.g. monitoring of the robot speed and contact forces) meet this required performance level before the application is put into operation. When selecting the robot and other components, it must be confirmed that the required safety functions are provided with the required performance level.

It should be noted explicitly that the manufacturer of a particular system or application is responsible for compliance to safety requirements (self-certification). We can seek consultation or support by external experts. Robot manufacturers, by analogy, can self-certify the safety functions of their robots.

7 References


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