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NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

GB/T 20867.1-2024

Replacing GB/T 20867-2007

Robotics - Application specification for safety requirements - Part 1: Industrial robot

机器人 安全要求应用规范 第1部分：工业机器人

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3 Terms and definitions

The terms defined in GB 11291.1-2011 apply, together with three terms restated in this part.

3.1 Risk assessment: the overall process comprising risk analysis and risk evaluation. The definition is taken from GB/T 15706-2012, 3.17.

3.2 Collaborative operation: the state in which a purposely designed robot works directly with a person within a defined workspace. The definition is taken from GB 11291.1-2011, 3.4.

3.3 Safeguarded space: the space defined by the perimeter safeguarding. The definition is taken from GB 11291.1-2011, 3.25.4.

4 Risk assessment and risk reduction

4.1 Risk assessment shall be carried out in accordance with GB/T 15706-2012 for setting, commissioning, teaching, operation and maintenance over the whole life cycle of the robot, and the necessary risk reduction measures shall be taken. A worked example is given in Annex A. A note points to Annex B of GB/T 15706-2012 for examples of common machine hazards, hazardous situations and hazardous events.

4.2 Hazard identification shall be performed for any robot and is described as the most important step of the risk assessment: only once hazards have been identified can matching risk reduction measures be taken. Its purpose is to produce a list of hazards,

hazardous situations and/or hazardous events describing the accident scenarios by which a hazardous situation may lead to harm, and when. A list of typical industrial robot hazards is given in Annex B.

4.3 Risk estimation determines the highest risk of each hazardous situation, usually expressed as a grade, an index or a score, and is based on two risk elements: the severity of the harm and the probability of its occurrence. Severity is estimated in accordance with GB/T 15706-2012, 5.5.2.2; the example given divides it into catastrophic harm causing death or permanent disability with no return to work, serious harm causing severe debilitation with return to some jobs only, moderate harm requiring medical attention with return to the same job, and minor harm needing at most first aid. Probability is estimated by considering exposure of persons to the hazard, the probability of occurrence of the hazardous event, and the possibility of avoiding or limiting harm by technical or human means, each with a cross reference to GB/T 15706-2012.

4.3.4 To support the process, one of the risk assessment tools given in GB/T 16856-2015 may be selected: the risk matrix method, the risk graph method or the numerical scoring method. Hybrid tools combining these approaches may also be used.

4.4 The aims of risk evaluation are to determine which hazardous situations, if any, call for further risk reduction, and to determine whether the required risk reduction has been achieved without introducing further hazards or increasing other risks. Where protective and/or risk reduction measures have been adopted, the iterative risk assessment process is repeated to verify that the risk has in fact been reduced.

4.5 On the basis of the risk assessment result, the three-step iterative method of Figure 1 of GB/T 15706-2012 shall be followed, applying the risk reduction measures of Clause 5 to Clause 9 to bring the risk of the robot down to an acceptable level.

5 Design requirements and protective measures

5.1 The design of the general parts of the robot body shall meet the basic safety requirements of GB 11291.1-2011.

5.2.1 Robot motion is produced by power transmission parts such as motor shafts, gears, belts and chains. Where these are guarded individually and/or as a whole by fixed guards, for instance the arm housing, the clearances between guards in relative motion shall meet GB/T 12265. Where interlocking guards are used, for instance a housing carrying a contact sensing device or sensor, the safety control circuit shall reach performance level PL d as defined in GB/T 16855.1-2018 or safety integrity level SIL 2 as defined in GB 28526. Table 1 sets out the application scenarios and typical features of the two guard types: a fixed guard is used where persons are not required to enter the danger zone during normal operation and where body parts must not reach it for operating or maintenance reasons, protects persons near the safeguarded danger zone and can be removed only with a

special tool; an interlocking guard prevents persons from reaching the danger zone during normal operation and, when opened, immediately interrupts or prevents the hazard.

5.2.2 Loss of or change in power covers both electrically and non-electrically supplied power such as mechanical, hydraulic, pneumatic, vacuum and magnetic power. Component selection shall take the failure rate into account and give priority to keeping the safety function of the whole circuit intact. A change in or loss of electrical power shall not cause damage to electrical components through unstable supply, functional defects caused by damaged components, a change in the posture of the arm or in the state of associated items caused by sudden interruption of supply, or any hazardous motion on restoration of supply, whether momentary or normal. Loss of or change in non-electrical power shall not cause movement, motion or tilting of the arm and its related parts, nor the falling of tools, fixtures or workpieces from the end effector. A note refers the safety design of end effectors to GB/Z 43065.1-2023.

5.2.3 All components shall be designed so as to prevent or reduce hazards arising from degradation or sudden failure during assembly, storage, transport, use and maintenance. Power transmission parts such as motors, reducers, timing belts and drive shafts shall be guarded by fixed or movable guards; the example given is an adjustable mechanical stop that prevents an axis from continuing to move in one direction when a brake fails or a drive shaft breaks. Mechanical energy storage parts such as balance cylinders, springs and balance flywheels shall carry conspicuous marking of the hazard class and hazard level together with maintenance instructions. Balance cylinders shall carry a hazard label and a pressure gauge so that the pressure can be observed, shall be maintained promptly when the pressure leaves the normal range, and shall be accompanied by instructions for the controlled release and storage of energy during maintenance.

5.2.4 The design shall prevent or reduce damage to the robot and harm to persons and surrounding equipment when the power source is lost or fails. When a motor brake is selected, its engaged torque in the de-energised state shall be less than the maximum instantaneous torque permitted for the motor and greater than the holding torque at maximum load, so that a sudden loss of supply does not subject the motor and reducer to an excessive instantaneous torque, while still braking effectively.

5.2.5 Warning markings on the robot shall state the location of stored energy devices, the type of stored energy, which may be shown graphically for capacitors, batteries, hydraulic, pneumatic and spring energy, and a text prompt. The instructions for use shall identify the stored energy devices and the measures for controlled release, with matching drawings where necessary.

5.2.6 The robot and its control system shall pass electromagnetic compatibility testing to GB/T 17799.2 and GB/T 17799.4. After passing, the design shall not be modified and shall be kept consistent with the design that was tested, failing which the tests shall be repeated.