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## Robotics — Safety requirements for robot systems in an industrial environment —

Part 2:

### Robot systems, robot applications and robot cells integration

ICS: 25.040.30

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## 60 Foreword

61 ISO (the International Organization for Standardization) is a worldwide federation of national standards  
62 bodies (ISO member bodies). The work of preparing International Standards is normally carried out through  
63 ISO technical committees. Each member body interested in a subject for which a technical committee has  
64 been established has the right to be represented on that committee. International organizations,  
65 governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely  
66 with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

67 The procedures used to develop this document and those intended for its further maintenance are described  
68 in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types  
69 of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the  
70 ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

71 Attention is drawn to the possibility that some of the elements of this document may be the subject of patent  
72 rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent  
73 rights identified during the development of the document will be in the Introduction and/or on the ISO list  
74 of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

75 Any trade name used in this document is information given for the convenience of users and does not  
76 constitute an endorsement.

77 For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions  
78 related to conformity assessment, as well as information about ISO's adherence to the World Trade  
79 Organization (WTO) principles in the Technical Barriers to Trade (TBT), see  
80 [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

81 This document was prepared by Technical Committee ISO/TC 299, Robotics.

82 This second edition cancels and replaces the first edition (ISO 10218-2:2011), which has been technically  
83 revised.

84 The main changes compared to the previous edition are as follows:

- 85 — incorporating safety requirements for collaborative applications (formerly, the content of  
86 ISO/TS 15066:2016);
- 87 — clarifying requirements for functional safety;
- 88 — adding requirements for cybersecurity to the extent that it applies.

89 A list of all parts in the ISO 10218 series can be found on the ISO website.

90 Any feedback or questions on this document should be directed to the user's national standards body. A  
91 complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

92

93 **Introduction**

94 This document has been created in recognition of the hazards that are presented by robots when they are  
95 integrated and installed into robot systems, robot applications and robot cells. Part 1 of ISO 10218 addresses  
96 robots as partly completed machines, while this document addresses robots integrated into complete  
97 machines (systems) for specific applications.

98 This document is a type-C standard according to ISO 12100.

99 This document is of relevance for the following stakeholder groups representing the market players  
100 regarding robot safety:

- 101 — robot manufacturers (small, medium and large enterprises);
- 102 — robot system/ application integrators (small, medium and large enterprises);
- 103 — health and safety bodies (regulators, accident prevention organisations, market surveillance, etc).

104 Others can be affected by the level of safety achieved with the means of the document by the above-  
105 mentioned stakeholder groups:

- 106 — robot system users/employers (small, medium and large enterprises);
- 107 — robot system users/employees (e.g. trade unions);
- 108 — service providers, e. g. for maintenance (small, medium and large enterprises);

109 The above-mentioned stakeholder groups have been given the possibility to participate at the drafting  
110 process of this document.

111 Robot systems and robot applications, and the extent to which hazards, hazardous situations and events, are  
112 covered are indicated in the Scope of this document.

113 When provisions of a type-C standard are different from those which are stated in type-A or type-B  
114 standards, the provisions of the type-C standard take precedence over the provisions of the other standards  
115 for machines that have been designed and built in accordance with the provisions of the type-C standard.

116 Hazards associated with robot systems and robot applications are well recognized, but the sources of the  
117 hazards are frequently unique to a robot application. The number and type(s) of hazard(s) are directly  
118 related to the nature of the automation process and the complexity of the application. The risks associated  
119 with these hazards vary with the robot used, its safety functions, and the way in which it is integrated,  
120 installed, programmed, used, and maintained. This document provides requirements for safety in the  
121 integration and installation of robots into robot systems and robot applications. The requirements include  
122 safeguarding of operators during integration, commissioning, functional testing, programming, operation,  
123 maintenance and repair. Requirements for the robot can be found in ISO 10218-1.

124 Both parts of ISO 10218 deal with robotics in an industrial environment, which is comprised of workplaces  
125 where the public is excluded or restricted from access because the people (operators) are working adults.  
126 Other standards cover such topics as coordinate systems and axis motions, general characteristics,  
127 performance criteria and related testing methods, terminology, and mechanical interfaces. It is noted that  
128 these standards are interrelated and related to other International Standards.

129 For ease of reading this part of ISO 10218, the words “robot system” and “robot application” refer to  
 130 “industrial robot system” and “industrial robot application” as defined in ISO 10218-1 and ISO 10218-2.  
 131 “Robot” refers to “industrial robot”.

132 For understanding requirements in this document, a word syntax is used to distinguish requirements from  
 133 guidance or recommendations. The word “shall” is used for mandatory requirements to comply with this  
 134 document. The word “should” is used to identify guidance, suggestions, recommended actions or possible  
 135 solutions for requirements, but alternatives are possible.

136 This document has been updated based on experience gained since the release of ISO 10218-1 and  
 137 ISO 10218-2 in 2011. This document remains aligned with minimum requirements of a harmonized type-C  
 138 standard for robot systems and robot applications in an industrial environment. Providing for a safe robot  
 139 system or application depends on the cooperation of a variety of “stakeholders” – those entities that share  
 140 in a responsibility for the ultimate purpose of providing a safe working environment. Stakeholders may be  
 141 identified as manufacturers, suppliers, integrators, and users (the entity responsible for using robots), but  
 142 all share the common goal of a safe (robot) machine. The requirements in this document can be assigned to  
 143 one of the stakeholders but overlapping responsibilities can involve multiple stakeholders in the same  
 144 requirements. While using this document, the reader is cautioned that all the requirements identified could  
 145 apply to them, even if not specifically addressed by “assigned” stakeholder tasks.

146 It is important to emphasize that the term “collaborative robot” is not used in ISO 10218 as only the  
 147 application can be developed, verified, and validated as a collaborative application. In addition, the term  
 148 “collaborative operation” is not used in this edition.

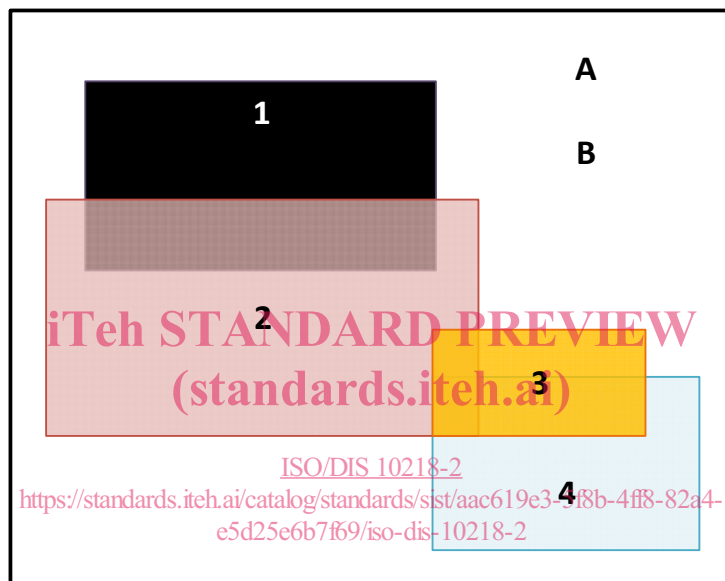
149 Revisions include:

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- 150 — category 2 stopping functions;
  - 151 — cybersecurity; [ISO/DIS 10218-2](https://standards.iteh.ai/catalog/standards/sist/aac619e3-5f8b-4ff8-82a4-e5d25e6b7f69/iso-dis-10218-2)
  - 152 — definitions and abbreviations; <https://standards.iteh.ai/catalog/standards/sist/aac619e3-5f8b-4ff8-82a4-e5d25e6b7f69/iso-dis-10218-2>
  - 153 — details within the information for use clause;
  - 154 — functional safety requirements;
  - 155 — risk estimation parameters and thresholds;
  - 156 — integrating the requirements of
    - 157 ■ ISO/TS 1506:2016 — Robots and robotic devices — Collaborative robots
      - 158 — hand-guided controls (HGC) requirements for collaborative applications;
      - 159 — power and force limiting (PFL) requirements for collaborative applications;
      - 160 — speed and separation monitoring (SSM) requirements for collaborative applications;
    - 161 ■ ISO/TR 20218-1:2018 — Robotics — Safety design for industrial robot systems — Part 1: End-  
 162 effectors
    - 163 ■ ISO/TR 20218-2:2017 — Robotics — Safety design for industrial robot systems — Part 2: Manual  
 164 load/ unload stations
    - 165 ■ RIA TR R15.806:2018 — A Guide to Testing Pressure and Force in Collaborative Robot Applications
  - 166 — marking;
  - 167 — mechanical strength and stability requirements;
  - 168 — mode selection;
  - 169 — power loss requirements;

170 — risk estimation parameters.

171 ISO 10218 deals with safety of robotics in an industrial environment. Other standards cover such topics as  
 172 coordinate systems and axis motions, general characteristics, performance criteria and related testing  
 173 methods, terminology, and mechanical interfaces. It is noted that these standards are interrelated and  
 174 related to other International Standards.

175 Figure 1 is a figurative representation of the relationship of machinery safety standards that can be used to  
 176 support a robot application. The robot (1) is the scope of ISO 10218-1, while the robot system/ application/  
 177 cell (2) is covered by this document. A robot cell can include machines subject to their own type-C standards  
 178 (3). Machines can be integrated into an integrated manufacturing system addressed by ISO 11161 (4).  
 179 Relevant type-A and -B standards are depicted by A and B in Figure 1.



180

181 **Key**

- 182 **1** robots (ISO 10218-1)
- 183 **2** robot systems/ robot applications/ robot cells (ISO 10218-2)
- 184 **3** machine type-C standards, as applicable
- 185 **4** integrated manufacturing systems (ISO 11161)
- 186 **A** type-A standard, i.e. ISO 12100 Risk assessment and risk reduction
- 187 **B** type-B standards, e.g. safety aspects (type-B1) and safety device (type-B2)

188 **Figure 1 — Graphical view of relationships between standards**  
 189 **relating to the robot system, robot application and robot cell**

190



191 **Robotics — Safety requirements for robot systems in an industrial**  
 192 **environment — Part 2: Robot systems, robot applications and robot**  
 193 **cells integration**

194 **1 Scope**

195 This document specifies requirements for the integration of industrial robot systems, industrial robot  
 196 applications and industrial robot cells. The following is addressed:

- 197 — the design, integration, commissioning, operation, maintenance, decommissioning and disposal of the  
 198 industrial robot system, application or cell;
- 199 — integration of machines and components to the industrial robot system, application or cell;
- 200 — information for use for the design, integration, commissioning, operation, maintenance, decommissioning  
 201 and disposal of the industrial robot system, application or cell;

202 This document is not applicable to the following uses and applications:

- 203 — underwater;
- 204 — law enforcement;
- 205 — military (defence);
- 206 — airborne and space, including outer space;
- 207 — medical;
- 208 — healthcare of a person;
- 209 — prosthetics and other aids for the physically impaired;
- 210 — service robots, which provide a service to a person and as such the public can have access;
- 211 — consumer products, as this is household use to which the public can have access;
- 212 — lifting or transporting people;
- 213 — multi-purpose lifting devices or machinery, e.g. cranes, forklift trucks;
- 214 — mobile platforms;
- 215 — tele-operated manipulators.

216 NOTE: Applications for the automation of laboratories are not considered as medical or healthcare of a person.

217 This document deals with the significant hazards, hazardous situations or hazardous events when used as  
 218 intended and under specified conditions of misuse which are reasonably foreseeable by the manufacturer.

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219 Robot systems can be used for a broad range of applications and integrated into robot cell(s). Therefore, it is  
220 not possible to provide a list of all significant hazards, hazardous situations or events into which a robot and  
221 robot application can be integrated. Moreover, same kind of applications can have different levels of risk,  
222 resulting from different designs which correspond to the intended application (e.g. paint spraying on large or  
223 small parts, handling of a small harmful payload like a hot metal bolt or a large harmless payload like a box of  
224 paper tissues).

225 This document also provides basic requirements for industrial robots used in applications as following, but does  
226 not cover the entirely the hazards related to:

- 227 — underground use;
  - 228 — hygienic requirements;
  - 229 — due to the processing of any material, e.g. food, cosmetics, pharmaceutical, metal;
  - 230 — nuclear environments;
  - 231 — potentially explosive environments;
  - 232 — use of robot systems in environments with hazardous ionizing and non-ionizing radiation levels;
  - 233 — hazardous ionizing and non-ionizing radiation;
  - 234 — handling loads the nature of which could lead to dangerous situations (e.g. molten metals, acids/bases,  
235 radiating materials);
  - 236 — when the public or non-working adults have access.
- 237 Acoustic noise has been identified to be a significant hazard with industrial robot systems and is included in the  
238 scope of this document.

239 Other standards can be applicable to associated machinery and equipment in robot applications and robot cells.

## 240 2 Normative references

241 The following documents are referred to in the text in such a way that some or all their content constitutes  
242 requirements of this document. For dated references, only the edition cited applies.

243 ISO 3864-1:2011, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs*  
244 *and safety markings*

245 ISO 3864-2:2016, *Graphical symbols — Safety colours and safety signs — Part 2: Design principles for product*  
246 *safety labels*

247 ISO 3864-3:2012, *Graphical symbols — Safety colours and safety signs — Part 3: Design principles for graphical*  
248 *symbols for use in safety signs*

- 249 ISO 3864-4:2011, *Graphical symbols — Safety colours and safety signs — Part 4: Colorimetric and photometric*  
 250 *properties of safety sign materials*
- 251 ISO 4413:2010, *Hydraulic fluid power — General rules and safety requirements for systems and their components*
- 252 ISO 4414:2010, *Pneumatic fluid power — General rules and safety requirements for systems and their components*
- 253 ISO 7010:2019, *Graphical symbols — Safety colours and safety signs — Registered safety signs*
- 254 ISO 8995-1:2002, *Lighting of work places — Part 1: Indoor*
- 255 ISO/DIS 10218-1:2020, *Robotics — Safety requirements for robotics in an industrial environment — Part 1:*  
 256 *robots*
- 257 ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*
- 258 ISO 13732-1:2006, *Ergonomics of the thermal environment — Methods for the assessment of human responses*  
 259 *to contact with surfaces — Part 1: Hot surfaces*
- 260 ISO 13732-3:2005, *Ergonomics of the thermal environment — Methods for the assessment of human responses*  
 261 *to contact with surfaces — Part 2: Cold surfaces*
- 262 ISO 13849-1:2015, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for*  
 263 *design*
- 264 ISO 13850:2015, *Safety of machinery — (Emergency stop — Principles for design)*
- 265 ISO 13854:2017, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*
- 266 ISO 13855:2010, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of*  
 267 *the human body*
- 268 ISO 13856-1:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 1: General principles for*  
 269 *design and testing of pressure-sensitive mats and pressure-sensitive floors*
- 270 ISO 13856-2:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for*  
 271 *design and testing of pressure-sensitive edges and pressure-sensitive bars*
- 272 ISO 13856-3:2013, *Safety of machinery — Pressure-sensitive protective devices — ISO 13856-2:2013, Safety of*  
 273 *machinery — Pressure-sensitive protective devices — Part 3: General principles for design and testing of pressure-*  
 274 *sensitive bumpers, plates, wires and similar devices*
- 275 ISO 13857:2019, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and*  
 276 *lower limbs*
- 277 ISO 14118:2017, *Safety of machinery — Prevention of unexpected start-up*
- 278 ISO 14119:2013, *Safety of machinery — Interlocking devices associated with guards — Principles for design and*  
 279 *selection*
- 280 ISO 14120:2015, *Safety of machinery — Guards — General requirements for the design and construction of fixed*  
 281 *and movable guards*

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## ISO/DIS 10218-2:2020(E)

- 282 ISO 14122-1:2016, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed*  
283 *means and general requirements of access*
- 284 ISO 14122-2:2016, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms*  
285 *and walkways*
- 286 ISO 14122-3:2016, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders*  
287 *and guard-rails*
- 288 ISO 14122-4:2016, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders*
- 289 ISO 14738:2002, *Safety of machinery — Anthropometric requirements for the design of workstations at machinery*
- 290 ISO 15534-1:2000, *Safety of machinery — Ergonomic design for the safety of machinery — Part 1: Principles for*  
291 *determining the dimensions required for openings for whole-body access into machinery*
- 292 ISO 15534-2:2000, *Safety of machinery — Ergonomic design for the safety of machinery — Part 2: Principles for*  
293 *determining the dimensions required for access openings*
- 294 ISO 19353:2005, *Safety of machinery — Fire prevention and protection*
- 295 ISO 20607:2019, *Safety of machinery — Instruction handbook — General drafting principles*
- 296 ISO 20643:2005, *Mechanical vibration — (Hand-held and hand-guided machinery — Principles for evaluation of*  
297 *vibration emission*
- 298 IEC 60073:2002, *Basic and safety principles for man-machine interface, marking and identification - Coding*  
299 *principles for indication devices and actuators*
- 300 IEC 60204-1:2016, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*
- 301 IEC 60825-1:2014, *Safety of laser products - Part 1: Equipment classification and requirements*
- 302 IEC 61310-1:2007, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual,*  
303 *acoustic and tactile signals*
- 304 IEC 61310-2:2007, *Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*
- 305 IEC 61310-3:2007, *Safety of machinery — Indication, marking and actuation — Part 3: Requirements for location*  
306 *and operation of actuators*
- 307 IEC 61496-1:2012, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements*  
308 *and tests*
- 309 IEC 61496-2:2013, *Safety of machinery — Electro-sensitive protective equipment — Part 2: Particular*  
310 *requirements for equipment using active opto-electronic protective devices (AOPDs)*
- 311 IEC 61496-3:2018, *Safety of machinery — Electro-sensitive protective equipment — Part 3: Particular*  
312 *requirements for active opto-electronic protective devices responsive to diffuse Reflection (AOPDDR)*

313 IEC/TS 61496-4-2:2014, *Safety of machinery — Electro-sensitive protective equipment — Part 4-2: Particular*  
 314 *requirements for equipment using vision based protective devices (VBPD) — Additional requirements when using*  
 315 *reference pattern techniques (VBPDP)*

316 IEC/TS 61496-4-3:2015, *Safety of machinery — Electro-sensitive protective equipment — Part 4-3: Particular*  
 317 *requirements for equipment using vision based protective devices (VBPD) — Additional requirements when using*  
 318 *stereo vision techniques (VBPDPST)*

319 IEC 61508-2:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems —*  
 320 *Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*

321 IEC 62046:2018, *Safety of machinery — Application of protective equipment to detect the presence of persons*

322 IEC 62061:2005 +A1:2012+A2:2015, *Safety of machinery — Functional safety of safety-related electrical,*  
 323 *electronic, and programmable electronic control systems*

324 IEC 62745:2017, *Safety of machinery — Requirements for cableless control systems of machinery*

325 IEC/TS 62998-1:2019, *Safety of machinery — Safety-related sensors used for the protection of persons*

### 326 **3 Terms, definitions and abbreviations**

327 For the purposes of this document, the terms, definitions and abbreviations given in ISO 12100, ISO 10218-1  
 328 and the following apply.

329 ISO and IEC maintain terminological databases for use in standardization at the following addresses:

330 — ISO Online browsing platform: available at [https://www.iso.org/obp](https://www.iso.org/obp/ui/#iso:code:38100:05b-4ff8-82a4-e5d25e6b7f69/iso-dis-10218-2)  
 331 — IEC Electropedia: available at <http://www.electropedia.org/>

#### 332 **3.1 Robot, robot system, robot application, application, collaborative, robot cell**

##### 333 **3.1.1**

##### 334 **industrial environment**

335 workplace where the public is restricted from access or not reasonably expected to be present for the intended  
 336 tasks and robot applications (3.1.4)

337 NOTE 1 to entry: This includes manufacturing, laboratory automation/ production, pharmaceutical automation/  
 338 production, packing, packaging, palletizing, warehousing, logistics, loading/ unloading and more.

##### 339 **3.1.2**

##### 340 **industrial robot**

##### 341 **robot**

342 automatically controlled, reprogrammable multipurpose manipulator(s) (3.2.5), programmable in three or  
 343 more axes (3.2.1), which can be either fixed in place or fixed to a mobile platform (3.2.8) for use in automation  
 344 applications in an industrial environment (3.1.1)

345 NOTE 1 to entry: The industrial robot includes:

346 — the manipulator (3.2.5), including robot actuators (3.2.10) controlled by the robot controller;

347 — the robot controller.

348 NOTE 2 to entry: This includes any auxiliary axes that are integrated into the kinematic solution.

349 NOTE 3 to entry: The following are considered industrial robots:

- 350 — the manipulating portion(s) of mobile robots, where a mobile robot consists of a mobile platform (3.2.8) with an  
351 integrated manipulator (3.2.5) or robot;
- 352 — robots with hand-guided controls (HGC);
- 353 — robots with power and force limited (PFL) capabilities;
- 354 — robots with built-in speed and separation monitoring (SSM) safety functions (3.10.3).

355 **3.1.3**

356 **industrial robot system**

357 **robot system**

358 machine comprising:

- 359 — industrial robot (3.1.2);
- 360 — end-effector(s) (3.2.2);
- 361 — any end-effector sensors and equipment (e.g. vision systems, adhesive dispensing, weld controller) needed  
362 to support the intended task;
- 363 — task program (3.4.1.1)

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

364 **3.1.4**

365 **robot application**

366 **industrial robot application**

367 a machine comprising: <https://standards.iteh.ai/catalog/standards/sist/aac619e3-5f8b-4ff8-82a4-e5d25e6b7f69/iso-dis-10218-2>

- 368 — industrial robot system (3.1.3);
- 369 — workpiece(s);
- 370 — any obstacle or object that has influence on the risk assessment of the intended use

371 **3.1.5**

372 **application**

373 intended use and purpose of the robot (3.1.2) or robot system (3.1.3), i.e. the process, the task(s)

374 EXAMPLE: Manipulating, processing, machining, inspection, spot welding, painting, assembly, palletizing.

375 **3.1.6 3.1.5**

376 **collaborative application**

377 an application (3.1.5) that contains one or more collaborative task(s) (3.1.7)

378 NOTE 1 to entry: Collaborative applications (3.1.6) can include collaborative tasks (3.1.7) and non-collaborative tasks.

379 **3.1.7**

380 **collaborative task**

381 a portion of the robot sequence where both the robot application (3.1.4) and operator(s) (3.9.2) are within the  
382 same safeguarded space (3.11.1.4)

383 **3.1.8**  
 384 **industrial robot cell**  
 385 **robot cell**  
 386 one or more robot applications (3.1.4) including associated:

- 387 — machinery and equipment;
- 388 — safeguarded space(s) (3.11.1.4);
- 389 — safeguards (3.14)

## 390 **3.2 Robot, robot system, robot application – sub-assemblies and components**

### 391 **3.2.1**

#### 392 **axis**

393 actuated (e.g. rotating about a pivot, linear) mechanical joint that provides at least one degree of freedom

### 394 **3.2.2**

#### 395 **end-effector**

396 device specifically designed for attachment to the mechanical interface (3.2.7) to enable the robot (3.1.2) to  
 397 perform its task

398 EXAMPLE: Gripper, welding gun, spray gun.

399 NOTE 1 to entry: End-effectors are sometimes known as end-of-arm tooling (EOAT).

### 400 **3.2.2.1**

#### 401 **grripper**

402 end-effector (3.2.2) designed for seizing and holding workpieces

403 NOTE 1 to entry: Various types of grippers and the terms grip, grasp, grasping and releasing are defined in ISO 14539:2000.

404 [Source: ISO 14539:2000, definition 4.1.2. Modified with addition of the note.]

### 405 **3.2.3**

#### 406 **fixture**

407 device used to hold in position an item as part of the handling or assembling process in a robot application  
 408 (3.1.4), but not as an end-effector (3.2.2)

### 409 **3.2.4**

#### 410 **manual load/unload station**

411 part of the robot application (3.1.4) designed for the direct manual intervention for the placement and removal  
 412 of parts or workpieces for processing by the robot system (3.1.3)

### 413 **3.2.5**

#### 414 **manipulator**

415 mechanism consisting of an arrangement of segments, jointed or sliding relative to one another

416 NOTE 1 to entry: A manipulator (3.2.5) includes robot actuators (3.2.10).

### 417 **3.2.6**

#### 418 **mass per manipulator (*M*)**

419 mass of all moving parts of the robot (3.1.2)