american national standard

for Industrial Robots and Robot Systems — Safety Requirements

ANSI/RIA R15.06-2012

ANSI/RIA R15.06-2012
Revision of
ANSI/RIA R15.06-1999

Incorporating
ISO 10218-1:2011
ISO 10218-2:2011

American National Standard
for Industrial Robots and Robot Systems —

Safety Requirements

Secretariat
Robotic Industries Association

Approved March 28, 2013
American National Standards Institute, Inc.

American National Standard

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria for approval have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether he has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

CAUTION NOTICE: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this standard. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Published by

Robotic Industries Association
900 Victors Way, Suite 140, Ann Arbor, MI 48108

ISBN 978-0-578-12360-8

Printed in the United States of America

1P 1M 5/13

Table of Contents

Foreword to R15.06 v
Introduction to R15.06-2012 vii
Foreword [ISO 10218 Part 1] 3
1 Scope 7
2 Normative references 7
3 Terms and definitions 8
4 Hazard identification and risk assessment 12
5 Design requirements and protective measures 13
5.1 General 13
5.2 General requirements 13
5.3 Actuating controls 14
5.4 Safety–related control system performance 14
5.5 Robot stopping functions 16
5.6 Speed control 17
5.7 Operational modes 17
5.8 Pendant controls 19
5.9 Control of simultaneous motion 21
5.10 Collaborative operation requirements 21
5.11 Singularity protection 22
5.12 Axis limiting 23
5.13 Movement without drive power 24
5.14 Provisions for lifting 25
5.15 Electrical connectors 25
6 Verification and validation of safety requirements and protective measures 25
6.1 General 25
6.2 Verification and validation methods 25
6.3 Required verification and validation 25
7 Information for use 26
7.1 General 26
Annex A 29
Annex B 35
Annex C 37
Annex D 39
Annex E 41
Annex F 43
Bibliography 55
1 Scope 63
2 Normative references 63
3 Terms and definitions 65
4 Hazard identification and risk assessment 67
4.1 General 67
4.2 Layout design 67
4.3 Risk assessment 69
4.4 Hazard identification 70

4.5 Hazard elimination and risk reduction 71
5 Safety requirements and protective measures 71
5.1 General 71
5.2 Safety-related control system performance 72
5.3 Design and installation 73
5.4 Limiting robot motion 77
5.5 Layout 78
5.6 Robot system operational mode application 80
5.7 Pendants 84
5.8 Maintenance and repair 85
5.9 Integrated manufacturing system (IMS) interface 86
5.10 Safeguarding 87
5.11 Collaborative robot operation 95
5.12 Commissioning of robot systems 98
6 Verification and validation of safety requirements and protective measures 99
6.1 General 99
6.2 Verification and validation methods 99
6.3 Required verification and validation 100
6.4 Verification and validation of protective equipment 100
7 Information for use 101
7.1 General 101
7.2 Instruction handbook 101
7.3 Marking 106
Annex A 107
Annex B 113
Annex C 115
Annex D 119
Annex E 121
Annex F 123
Annex G 127
Bibliography 149
Bibliography for ANSI/RIA R15.06 151

Foreword to R15.06 (not part of American National Standard ANSI/RIA R15.06-2012)

The objective of this standard is to enhance the safety of personnel using industrial robots and industrial robot systems by establishing requirements for the manufacture, integration, installation and safeguarding of industrial robots.

To accomplish this objective, the Robotic Industries Association Subcommittee R15.06 on Safety closely monitored the work of the ISO Working Group responsible for developing the ISO 10218 standard and provided personnel and substantive input to that group. This is a national adoption of ISO 10218-1:2011 and ISO 10218-2:2011 which are presented in their entirety. This total revision of the requirements for personal safety related to Industrial Robots updates and replaces ANSI/RIA/ISO 10218-1-2007 which will be withdrawn.

ISO standards provide requirements for personnel safety in the design, construction and integration of machinery. Specific occupational health and safety requirements for users are not included as these regulations vary from one country or region to another and are subject to local authority. Where local, state or national codes and regulations exist, they take precedence over requirements in this voluntary standard. Additional user requirements will be disseminated during a transition period until ANSI/RIA R15.06-1999 is withdrawn.

Industry standards, including this one, are voluntary. The Robotic Industries Association makes no determination with respect to whether any robot, robot system, associated safety devices, manufacturer, or user is in compliance with this standard.

Suggestions for improvement of the standard are welcome. They should be sent to the:

Robotic Industries Association
Subcommittee on Safety
900 Victors Way, Suite 140
Ann Arbor, MI 48108

Consensus for approval of this standard as an American National Standard was achieved by balloting of the R15 Standards Approval Committee of the Robotic Industries Association (an accredited standards developing organization). Committee approval of this standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the R15 Standards Approval Committee had the following members:

William Drotning, Chairman
Sandia National Laboratories (Retired)

Organization Represented	*Name of Representative*
ABB Inc.	Nick Hunt
Applied Manufacturing Technologies	Roberta Nelson Shea
B11 Standards, Inc.	David Felinski
Boeing Commercial Airplanes	Jerry Fox
Corning, Incorporated	Devin Barber
FANUC Robotics America	Claude Dinsmoor
General Motors	D. Marty Linn
Genesis Systems Group	Charles Keibler
Honda Engineering North America	R. Todd Dickey
John Deere & Co.	Roger Daniels
KUKA Robotics	Michael Gerstenberger
Lehigh University	N. Duke Perreira
Liberty Mutual Group	John Russell

Organization Represented	*Name of Representative*
Mitsubishi Motors North America	Tim Watt
National Institute of Standards and Technology	Nicholas Dagalakis
NIST/Intelligent Systems Division	Fred Proctor
PaR Systems	Richard Weniger
Pilz Automation Safety	Gilbert Dominguez
Safety Solutions, LLC	Jim Howe
SICK, Inc.	Ian Brough
SPI: The Plastics Industry Trade Association	Melissa Hochstad
Toyota Motor Engineering & Manufacturing North America	Troy Uahinui
Underwriters Laboratories	Daniel Posner
University of Southern California	Mansour Rahimi
Yaskawa Motoman Robotics	Wade Hickle

Subcommittee R15.06 on Industrial Robot Safety, was chaired by Roberta Nelson Shea

Administrative services provided by Jeff Fryman of the Robotic Industries Association

Introduction to R15.06-2012

In adopting the International Standard, the R15.06 Subcommittee for Safety considered the variety of tasks necessary for the efficient and productive use of Industrial Robots and Industrial Robot Systems. The operational scope and characteristics of a robot system can be significantly different than other equipment and machines, and certain tasks may require persons to be in the proximity of the robot system while drive power is available. An industrial robot system frequently is not a stand-alone machine, but rather part of a cell or larger system, which interacts with other machines and equipment.

To assist in the understanding of this standard, certain “stakeholders” have been assigned specific responsibilities. The robot manufacturer is addressed in Part 1, while the integrator and installer are addressed in Part 2. The manufacturer, integrator and installer have the requirement to provide “information for use” to the user of the robot and robot system. This information and instructions are intended to ensure that the user has the necessary information to safely use the equipment furnished to them. The user, while not specifically addressed, has the responsibility to use this information in developing training and safe work practices. When the user makes any changes to the robot or robot system as delivered by the original supplier, the user is acting in the capacity of a machine builder or integrator and has the explicit responsibility to comply with applicable portions of this standard.

Safety must be a conscious effort on the part of all parties (manufacturer, integrator, and user) throughout the life cycle of the robot system starting with the initial design and continuing through integration, implementation, use and maintenance, then culminating in disposal. Protective measures are applied, using the hierarchy of risk control, until risk reaches an acceptable level. Necessary components in workplace safety are the maintenance of, and adherence to, the system safety design. Personnel skills, training, and attitude are important factors in the administrative portion of the safety management system. This standard only serves to provide guidelines to a safe operation.

Terms which may be unique to the standard or have specific contextual meaning are defined in clause 3 of each part. The word “shall” is prescriptive, and describes mandatory requirements to comply with this standard. The word “should” is meant to be a recommendation or good practice and can be a very strong recommendation or advisory. The word “may” is permissive, and the word “can” indicates something is possible or a capability. Notes used throughout the document are informative, intended to provide explanations and additional information.

The normative references listed in Clause 2 of each part are necessary for international compliance with ISO requirements for robot installations. The Bibliography for ANSI/RIA R15.06 (at the back of this standard) contains similar references that may be used for domestic North American robot installations. RIA TR R15.406 extracts the relevant information from ISO standards ISO 13850, 13854, 13855, 13856, 13857, 14119 and 14120 and may be used for USA compliance as a suitable alternative to these ISO standards where they are referenced in this standard.

RIA TR R15.306 offers a Risk Assessment methodology complying with the requirements for task-based risk assessment in Part 2, Clause 4.

This standard is a complete revision of ANSI/RIA R15.06-1999(r2009) which may be used until 31 December 2014. This transition period is established by the standards-developing organization and not by the American National Standards Institute. Changes were incorporated based on public comments received and the International Standard which itself was based on the R15.06 standard from 1999. Some of the most significant changes include:

- A total reorganization of the text presenting the ISO 10218-1 and ISO 10218-2 in their entirety. Changes to the ISO documents were limited to page formatting from ISO A4,

spelling changes of words from the traditional British/ISO spelling (i.e. colour, centre) to common American spelling and decimal annotation of numbers. As both parts of the ISO documents are presented in one volume of R15.06, references between parts do not include the annotation of ISO 10218. These and other strictly editorial changes are annotated by the use of brackets [ ].

- Changing of selected terminology (e.g. reduced speed for slow speed and protective stop for safety stop), but not changes to functional requirements
- Additional requirements regarding new features offered on robots and the safe integration of the features
- Requirements for detachable and wireless pendants
- Change in requirements for safety control circuitry (functional safety)
- Change in control of robot motion to include safety-rated soft axis and space limiting
- Change in clearance requirements
- Requirements for collaborative robot operation (new feature)
- A Risk Assessment shall be performed and is no longer optional
- The robot does not include the end-effector – the robot system does
- The term “operator” applies to all persons performing tasks including maintenance and repair

The new requirements of this edition are not applicable to robots manufactured, or robot systems installed, prior to the publication of this edition provided such robots, robot systems, and robot cells are compliant with the R15.06 1999 edition.

Existing robot system installations which are physically moved after publication of this standard but are re-installed exactly as they were installed (relative positions, layout, functionality, specification and safeguarding) require a review to determine if any new or revised hazard(s) have been introduced, but need no further action provided they were and remain fully compliant with the requirements of clauses 4 through 11 of the R15.06-1999. Installations changed subsequent to the publication of this edition are subject to the requirements of this edition. This does not preclude the voluntary updating of industrial robot systems and cells to the requirements in this edition. Additional guidance and a table of scenarios on handling existing robot systems and robot cells can be found on the RIA website at *www.robotics.org*.

Part 1 – [Industrial] Robots

Intentionally Blank

Foreword [ISO 10218 Part 1]

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10218-1 was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 2, *Robots and robotic devices*.

This second edition cancels and replaces the first edition (ISO 10218-1:2006), which has been technically revised. It also incorporates Technical Corrigendum ISO 10218-1:2006/Cor.1:2007.

ISO 10218 consists of the following parts, under the general title *Robots and robotic devices — Safety requirements for industrial robots:*

— *Part 1: [Industrial] Robots*

— *Part 2: [Industrial] Robot systems and integration*

Intentionally Blank

Introduction [Part 1]

[This standard] has been created in recognition of the particular hazards that are presented by industrial robots and industrial robot systems.

This part of [the standard] is a type C standard as outlined in ISO 12100.

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

The machinery concerned and the extent to which hazards, hazardous situations and events are covered are indicated in the Scope of this part of [the standard].

Hazards associated with robots are well recognized, but the sources of the hazards are frequently unique to a particular robot system. The number and type(s) of hazard(s) are directly related to the nature of the automation process and the complexity of the installation. The risks associated with these hazards vary with the type of robot used and its purpose, and the way in which it is installed, programmed, operated and maintained.

> NOTE - Not all of the hazards identified by [this standard] apply to every robot, nor will the level of risk associated with a given hazardous situation be the same from robot to robot. Consequently, the safety requirements, or the protective measures, or both, can vary from what is specified in [this standard]. A risk assessment can be conducted to determine what the protective measures should be.

In recognition of the variable nature of hazards with different uses of industrial robots, [this standard] is divided into two parts. This part of [the standard] provides guidance for the assurance of safety in the design and construction of the robot. Since safety in the application of industrial robots is influenced by the design and application of the particular robot system integration, [Part 2 of this standard] provides guidelines for the safeguarding of personnel during robot integration, installation, functional testing, programming, operation, maintenance and repair.

This part of [the standard] has been updated based on experience gained in developing the [Part 2] guidance on system and integration requirements, in order to ensure it remains in line with minimum requirements of a harmonized type-C standard for industrial robots. Revised technical requirements include, but are not limited to, definition and requirements for singularity, safeguarding of transmission hazards, power loss requirements, safety-related control circuit performance, addition of a category 2 stopping function, mode selection, power and force limiting requirements, marking, and updated stopping time and distance metric and features.

This part of [the standard] is not applicable to robots which were manufactured prior to its publication date.

Intentionally Blank

Part 1: [Industrial] Robots

1 Scope

This part of [the standard] specifies requirements and guidelines for the inherent safe design, protective measures and information for use of industrial robots. It describes basic hazards associated with robots and provides requirements to eliminate, or adequately reduce, the risks associated with these hazards.

This part of [the standard] does not address the robot as a complete machine. Noise emission is generally not considered a significant hazard of the robot alone, and consequently noise is excluded from the scope of this part of [the standard].

This part of [the standard] does not apply to non-industrial robots, although the safety principles established in [the standard] can be utilized for these other robots.

NOTE 1 – Examples of non-industrial robot applications include, but are not limited to, undersea, military and space robots, tele-operated manipulators, prosthetics and other aids for the physically impaired, micro-robots (displacement less than 1 mm), surgery or healthcare, and service or consumer products.

NOTE 2 – Requirements for robot systems, integration, and installation are covered in [Part 2].

NOTE 3 – Additional hazards can be created by specific applications (e.g. welding, laser cutting, machining). These system-related hazards need to be considered during robot design.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9283:1998, *Manipulating industrial robots — Performance criteria and related test methods*

ISO 10218-2, *Robots and robotic devices – Safety requirements for industrial robots – Part 2: Robot systems and integration*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13849-1:2006, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13850, *Safety of machinery — Emergency stop — Principles for design*

IEC 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*[1]

IEC 62061:2005, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems*

[1] NFPA 79, *Electrical Standard for Industrial Machinery*, contains the identical requirements as IEC 60204-1 for the purposes of this standard