INDUSTRIAL ROBOTS & ROBOT SYSTEMS

1.0 PURPOSE
The purpose of this procedure is to establish minimum requirements for the rebuild, installation, safeguarding, maintenance, testing, start-up, and employee training as it relates to, or use of, robots or robotic systems. This document augments applicable standards established for the safe construction and operation of robots and robotic systems as referenced below.

2.0 REGULATORY REFERENCE
- Title 29 Code of Federal Regulations 1910

3.0 SCOPE
The design, installation, operation, and service activities for academic and medical robotic equipment at Indiana University and regional campuses.

4.0 ELEMENTS OF THE PROGRAM
Each IU location that utilizes robotic systems shall:
- Establish written work procedures covering the safe operation of robot systems.
- Develop and implement a training program for each person who works on, or has the potential to work around robotic systems.
- Establish a retraining program to be provided whenever necessary to ensure an on-going knowledge of safe robot operation(s). Retraining requirements shall be triggered by, but not limited to the following:
  - Personnel changes
  - Changes or modifications to existing robotic systems
  - Installation of new robotic systems
  - Following an accident, serious incident, or near miss related to robotic systems
- Assure safeguards (i.e. barrier fences, interlocked gates, emergency stops, teach pendants, light curtains, safety mats) are in place and operational at all times.
- Assure employee compliance to safe work practices.
- Assure that each individual needed in the robotic cell for teaching purposes shall be furnished with and use an enabling device consistent with 4.7.3 of ANSI/RIA R15.96-1999.
- Each enabling device or teaching control device shall have a three position switch, which when continuously held in a detented position, permits motion, and when released or compressed past the midpoint detent, shall stop the robot motion using circuitry consistent with 4.5 of the Industrial Robots and Robot Systems ANSI/RIA R15.06-1999.
Note: Tests have shown that human reaction to an emergency may be to release an object, or to hold on tighter, thus compressing an enabling device or releasing it. Design and installation of the enabling device should consider the ergonomic issues of sustained activation. This is a requirement for new robots only. See Section 10.3 of ANSI/RIA R15.06–1999 for information on existing industrial robots and robot systems.

The safeguarding of robotic systems shall:

- Ensure design, construction, and attachment of the barrier guards around a robot work envelope is such that the operator and others are prevented from physical contact to all moving parts of the equipment covering all possible ranges of motion.
- Ensure personal access gates through barrier guards are electronically interlocked to the robot and all other automated parts in the work envelope. (It is recognized that in some continuous operations, stopping of conveyor sections is not practical; however, where the process is not continuous, all moving equipment within the cell shall be stopped by the interlock system.)
- Prevent employee access to non-personnel access openings while equipment is energized. This includes openings such as pass through part openings and thereby this requirement applies to both existing and new equipment.
- Include emergency stops placed at the main control panel, teach pendant, and at all access openings including those mentioned above. Push buttons that activate an emergency stop shall be:
  a) Red in color with a yellow background
  b) Unguarded
  c) Palm or mushroom head type
  d) The type requiring manual resetting
  e) Installed such that resetting the button cannot initiate a restart
- Include actuating controls that are labeled to clearly indicate their function.
- Barrier guards shall be, at a minimum:
  a) Fixed
  b) Interlocked
  c) Prevent access to a point of operation hazard(s)
  d) Constructed to withstand maximum expected operational forces and environmental conditions
  e) Free of sharp edges and projections and shall themselves not create a hazard
  f) Compliant with table 5 of ANSI/RIA R15.06–1999 safety requirements for opening size and distance from hazard
  g) Tools are required to remove any fixed portion
  h) Be tamper resistant
  i) Environmental conditions shall not adversely affect the barrier portion(s)
j) The bottom barrier is to be positioned not more than 0.3 (12 inches) above adjacent walking surfaces, that the top of the barrier be not lower than 1.5 m (60 inches) above adjacent walking surfaces unless additional safeguarding devices are installed to prevent or detect access to the hazard. The area between top and bottom shall be completely filled or comply with table 5 of the ANSI/RIA R15.06-1999.

k) Parts and tooling shall be contained (e.g. loose objects, flying projectiles), where this possibility exists.

Note: Barriers installed around material handling robots need to be high enough to prevent any part from being thrown over the barrier. This precaution may not be necessary if the robot end-effectors are equipped with effective part retention hardware such as locking or over-center closing clamps.

- Interlocking safeguarding devices shall, at a minimum:
  a) Use control reliable circuitry as described in 4.5.1 of ANSI/RIA R15.06-1999. See note below.
  b) have a key, plug or actuating device which is not easily duplicated;
  c) be tamper resistant;
  d) not able to be defeated intentionally without the use of tools;
  e) provide a means for secure attachments;
  f) not be able to be placed in automatic operation until the Interlock barrier is closed;
  g) will result in a shutdown of operations if the Interlock barrier is opened while the hazard is present;
  h) not result in an automatic re-start of operation as a result of only closing the interlocked barrier; and
  i) comply with ANSI/RIA R15.06–1999 until the Interlock barrier is closed;
  j) be capable of being easily unlocked from the inside of the safeguarded space with or without power available, when the possibility of full body access exists
  k) spare keys and actuating devices shall be supervisory controlled and not be readily available.

Note: If spare keys and actuating devices are in demand for the purpose of defeating the safeguard, the design of the overall safety scheme should be reviewed for deficiencies.

Note: Control reliable circuitry must be included in all new installations. Existing installations that do not have control reliable circuitry must follow the monitoring guidelines for single channel circuitry as described in Section 4.3.5 of ANSI/RIA R15.06-1999
• A Risk Assessment shall, at a minimum be:
  a) Performed at the time of final installation and initial startup;
  b) Updated each time the system configuration is changed; and
  c) Documented by the user at the time of the most recent risk assessment.

⚠️ When entering a robot cell for any reason such as maintenance / servicing, un-jamming, or housekeeping, e.g. the lockout/tagout procedures established and required by IU Procedure shall apply.

5.0 ADMINISTRATION / COMPLIANCE / Responsibilities

The senior facility manager or designee in which an installation of robotic system(s) has the responsibility and accountability for communicating and maintaining the requirements for the protection of all persons associated with the use of robots or robotic systems as established by this procedure.

Each employee has the responsibility to learn, understand, and comply with the practices established by this procedure and to request additional supervision and/or training if such practices are not understood.
APPENDIX A: DEFINITIONS

Enabling Device – a manually operated device which when continuously activated permits motion of the equipment under its control.

Envelope – the three dimensional space encompassing the complete movements of all robot parts. (See space definition below.)

Interlock – an arrangement whereby the operation of one control or mechanism allows, or prevents the operation of another.

Multifunctional – capable of performing many tasks.

Pendant – a hand-held device linked to the control system by which a robot can be programmed or operated. Also called a teach pendant.

Robot – a multifunctional, reprogrammable machine that moves material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks.

Reprogrammable – a computer program that can be changed. Having the ability to receive new and/or advanced instructions to perform jobs and to change motions without further human action.

Safeguarding – the act of providing personnel with protection from a hazard.

Space – the three dimensional volume encompassing the movements of all robot parts through their x, y and z axes (previously called envelope).