

Introduction to Safety for Collaborative Robotics

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Robotic Industries Association

Collaborative Robotics

What is it ??



Collaborative Robotics

What is it ??

- Aren't "Collaborative" Robots safe "right out of the box"?
- It's "Collaborative" and that means "inherently safe" – right?
- Because it's "Collaborative" I won't need any of those safety fences and light curtains – right?



Safety For Collaborative Robotics

Why do we need this presentation?



Safety For Collaborative Robotics

Why do we need this presentation?

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MYTHS
(OR AT LEAST, MISUNDERSTANDINGS)



Safety For Collaborative Robotics

Today's Topics:

- About Standards
- RIA's Foundational Standard: Safety Requirements for Industrial Robots and Robot Systems
- New Guidance on Collaborative Robot System Safety
- Resources



Safety For Collaborative Robotics

Today's Topics:

- **About Standards**

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What Is A Standard?

Voluntary Industry Consensus Standards

- National and International Standards Organizations
- **ANSI, ISO**, IEC, ASTM, etc.
- Standards help create, grow, and stabilize markets



Safety For Collaborative Robotics

Today's Topics:

- About Standards

- **RIA's Foundational Standard:**

Safety Requirements for Industrial Robots and Robot Systems

- Additional Guidance on Collaborative Robot System Safety

- Resources



RIA's Standard: Industrial Robot Safety



ANSI/RIA R15.06-2012, Industrial Robots & Robot Systems – Safety Requirements

- U.S. National Adoption of ISO 10218-1,2:2011
- **10218 Part 1:** Safety Requirements for Industrial **ROBOTS**
- **10218 Part 2:** Safety Requirements for Industrial **ROBOT SYSTEMS** and Systems Integration



RIA's Standard: Industrial Robot Safety

R15.06 = 10218

**= CSA Z434
etc.**



Safety For Collaborative Robotics

Why do we need this presentation?

Why do I need to know about the basic standard?

- Aren't "Collaborative" Robots safe "right out of the box"?
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...Because Collaborative Safety = TS 15066

- **ISO/TS 15066:2016** – an ISO Technical Specification
 - RIA TR R15.606-2016 – An ANSI-registered Technical Report
 - Shorthand: “15066” or “TR 606”
- Order & download PDF from RIA Webstore
- **Important! Supplemental to ISO 10218 / R15.06**
 - “Industrial Robots and Robot Systems – Safety Requirements”

“This Technical Specification is relevant only in conjunction with the safety requirements for collaborative industrial robot operation described in ISO 10218-1 and ISO 10218-2. ”



Robot Definition from ISO 10218 / R15.06

- **Industrial Robot:** Automatically controlled, reprogrammable multipurpose manipulator, programmable in three or more axes, which can be **either** fixed in place or mobile for use in industrial automation applications
 - NOTE 1: The industrial robot **includes:** the manipulator, including actuators; the controller, including teach pendant and any communication interface (hardware and software).
- **Industrial Robot System:** System comprising: Industrial robot; end-effector(s); any machinery, equipment, devices, external auxiliary axes or sensors supporting the robot performing its task

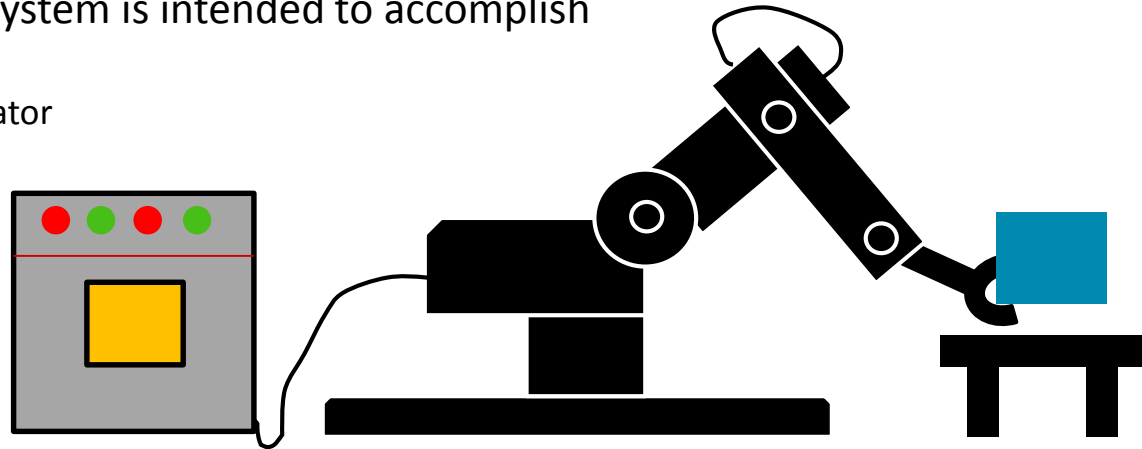


Robot Definition from ISO 10218 / R15.06

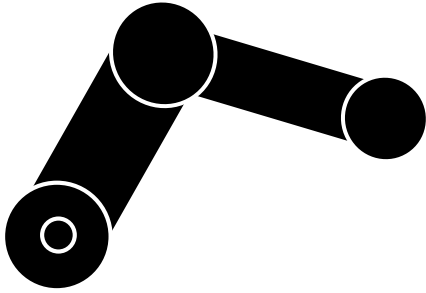
- **Industrial Robot** = Robot Arm + Robot Controller
- **Industrial Robot System** = Robot + End-Effector + Workpiece
+ Ancillary Equipment

That make up a complete Robot *System*

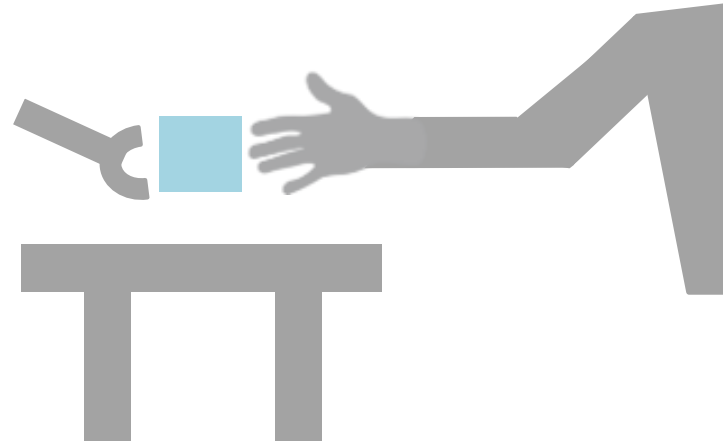
- The End-effector and Workpiece are determined based on the **Application** – or, what the robot system is intended to accomplish
- Might be a... ?
 - Sealant applicator
 - Gripper
 - Cutter
 - Welder
 - ...
 - ...



Definitions: Robot



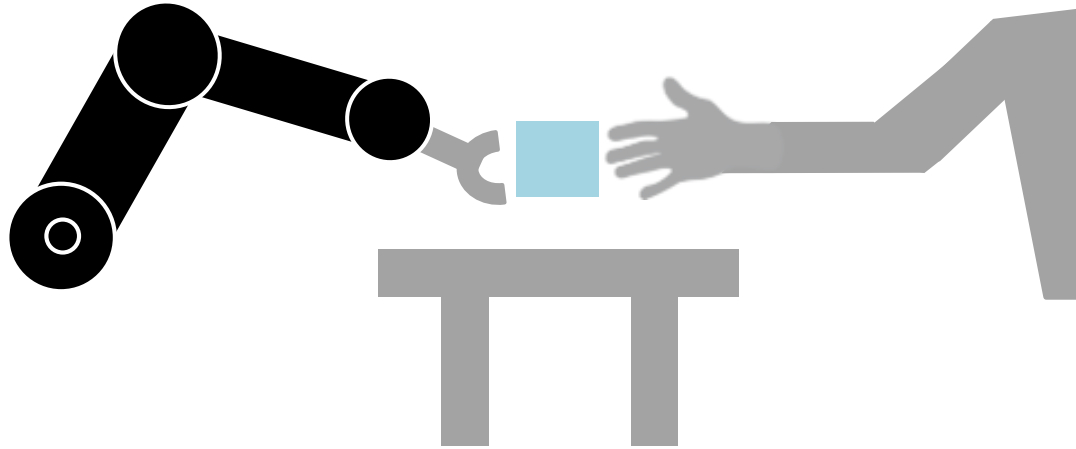
“Collaborative” Robot
(PFL, “Inherently Safe,” etc.)



End-Effector, workpiece,
ancillary equipment, etc.



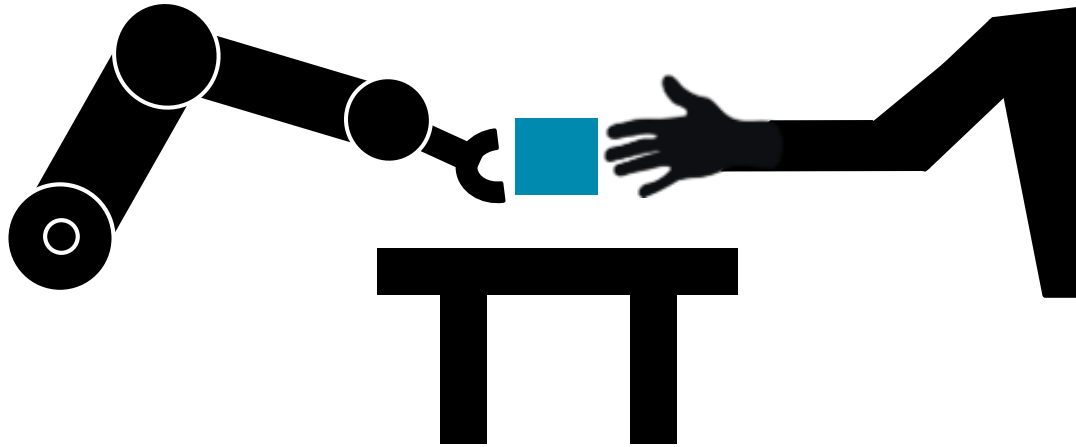
Definitions: Robot System



Collaborative Robot SYSTEM



Definitions: Robot System



Collaborative Robot SYSTEM



Safety For Collaborative Robotics

MYTH Aren't "Collaborative" Robots safe "right out of the box"?

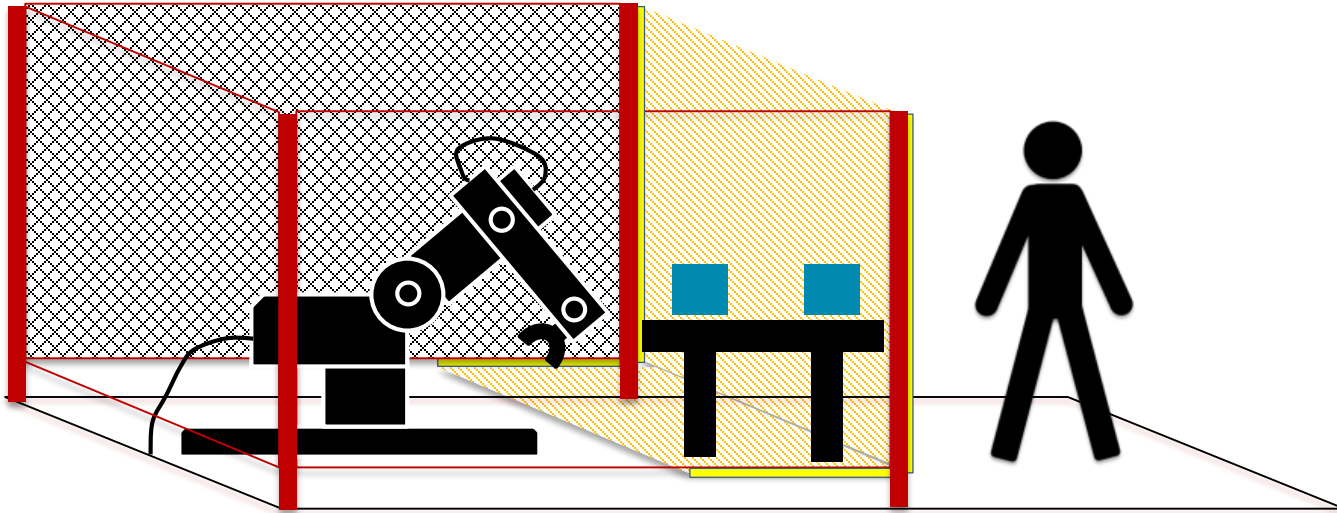
REALITY

The "Collaborative" robot arm cannot do any work until it is integrated into a complete robot system – and it is the **ROBOT SYSTEM** that is (or is not) **COLLABORATIVE**



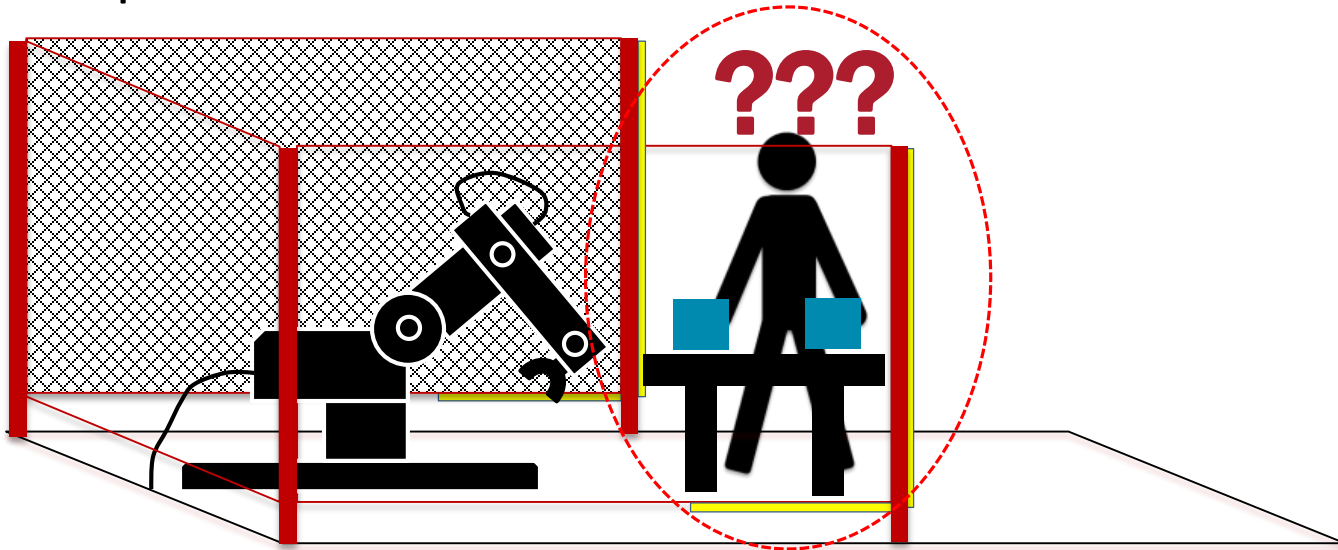
Traditional Safety Paradigm

- **Old:** Primary means of protecting people was to separate them from the robotic equipment
- Physical safeguards and protective devices

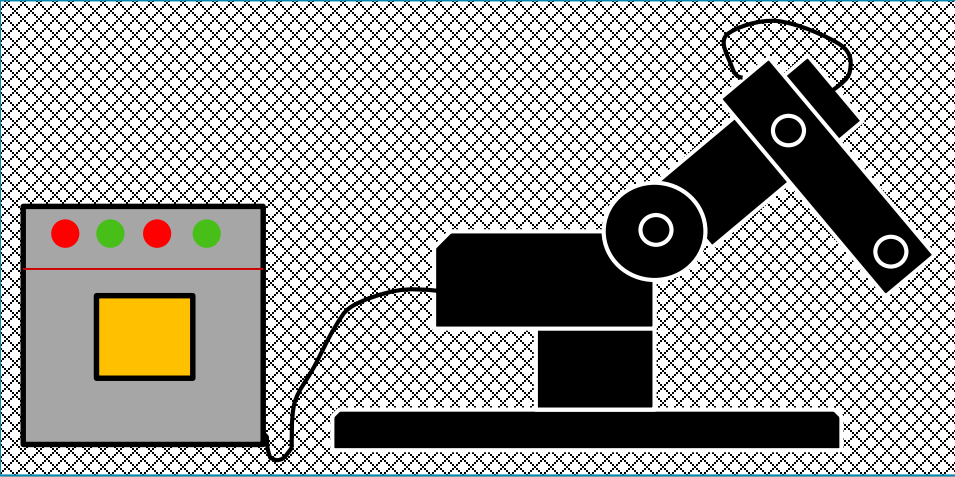


Paradigm Shift

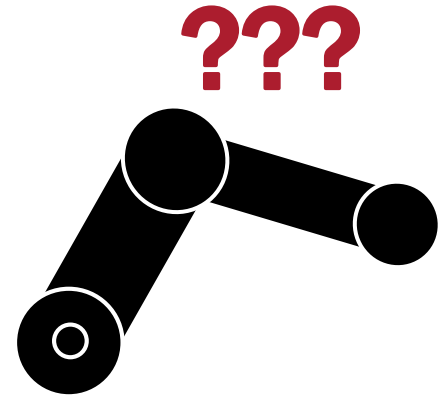
- **New:** With the advent of Collaborative Robot Systems, now the human and robot system can interact safely in the shared workspace



Paradigm Shift



“Traditional” Robot
(Safeguarded)



“Collaborative” Robot
(PFL, “Inherently Safe,” etc.)



Safety For Collaborative Robotics

MYTH

It's "Collaborative" and that means
"inherently safe" –

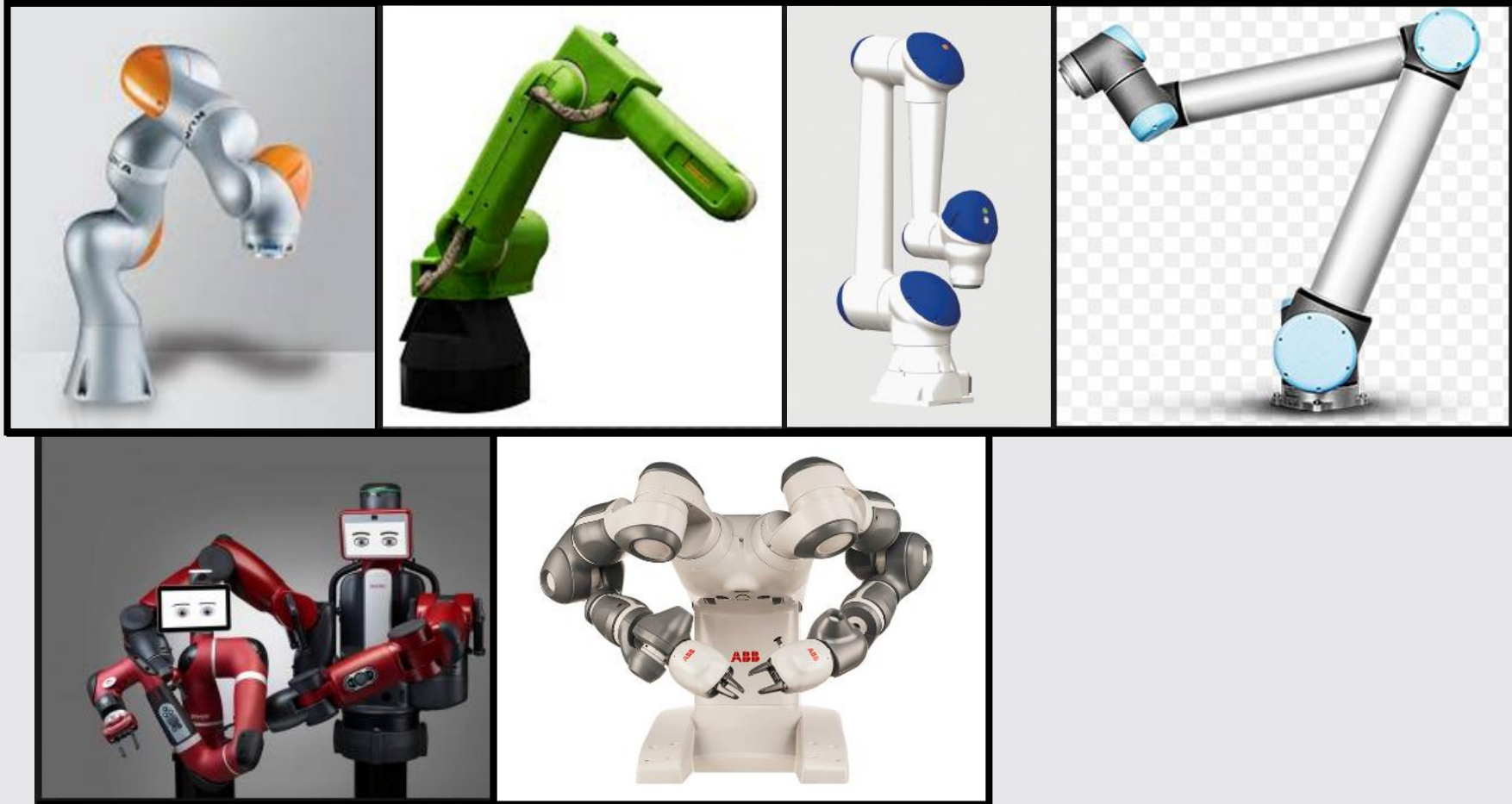
Right?

REALITY

"Inherently safe" describes some specific design factors that help the robot arm be **safER** for human contact.



“Inherently Safe” Design Factors



Safety For Collaborative Robotics

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- **Additional Guidance on Collaborative Robot System Safety**
- Resources

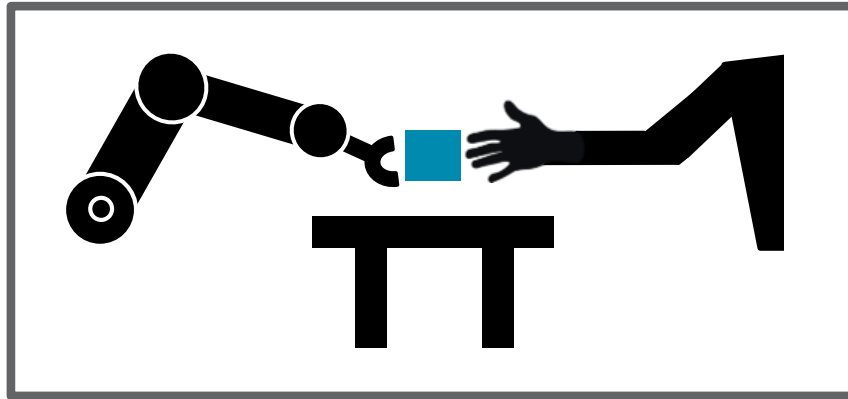


Why is TS 15066 / TR 606 Important?

Unique strengths of humans (*creative problem-solving*)

+ Unique strengths of robot systems (*power and precision in repetitive tasks*)

Increased productivity



Why is TS 15066 / TR 606 Important?

- Integrates **key information together** in one document:
 - Definition of collaborative robotic operation
 - Characteristics of safety-related control systems for collaborative operation
 - **Factors for the design of a collaborative robot system***
 - Built-in safety-related systems for collaborative operation, and requirements for their use;
- How to implement a collaborative application using the following techniques:
 - Safety-rated monitored stop
 - Hand guiding
 - Speed and Separation Monitoring
 - **Guidance on speeds, protective distances, formula for protective separation distance***
 - Power and Force Limiting
 - **Threshold limit values for power and force to avoid pain***

* *New Information in 15066/ TR 606!*



Why is TS 15066 / TR 606 Important?

New information:

- **Annex A:** “The Body Model” incorporates important data from a study of pain thresholds for Power and Force Limiting applications
- Study conducted at the University of Mainz in Germany
- 100 human test subjects; both sexes and wide range of ages and body dimensions
- Maximum permissible pressure values shown in Annex A represent the 75th percentile



Why is TS 15066 / TR 606 Important?

- New information:
 - **Annex A:** “The Body Model”

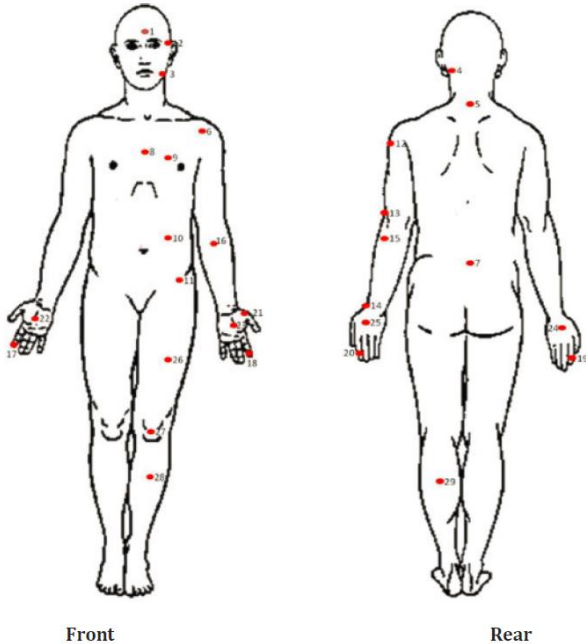


Figure A.1 — Body model

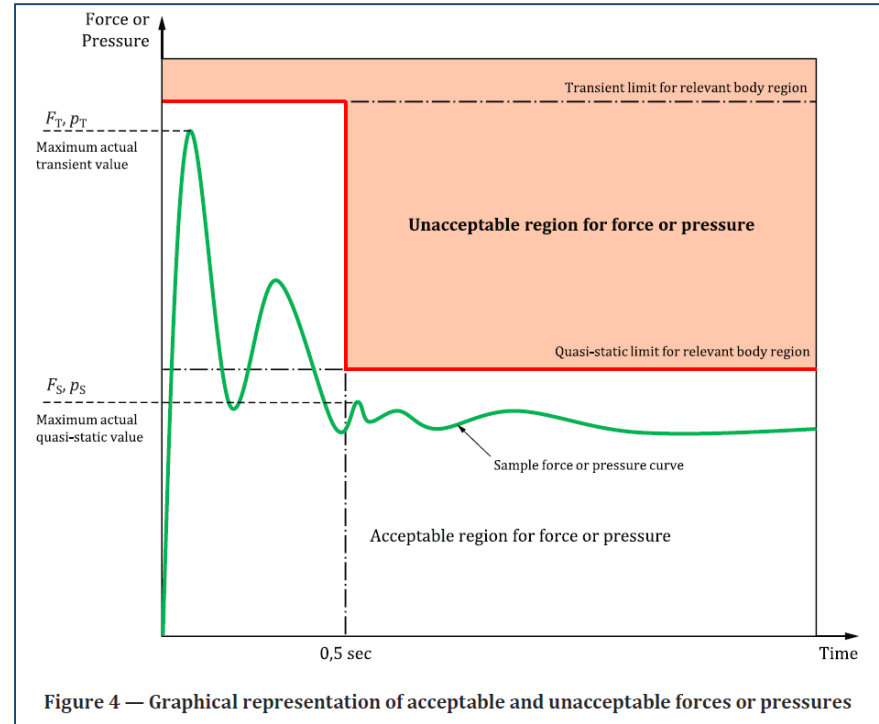
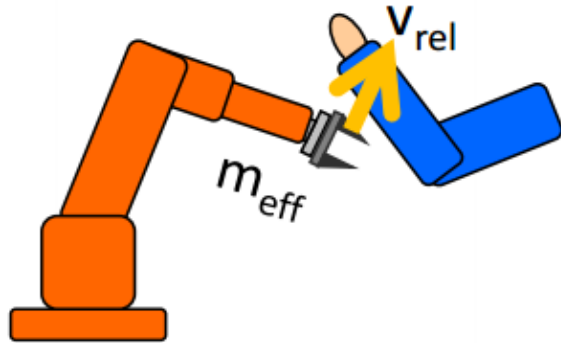


Figure 4 — Graphical representation of acceptable and unacceptable forces or pressures

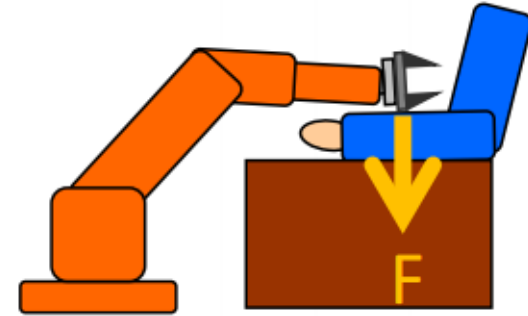


Transient and Quasi-Static Contact



Transient Contact:

Human body part is capable of recoiling from impact



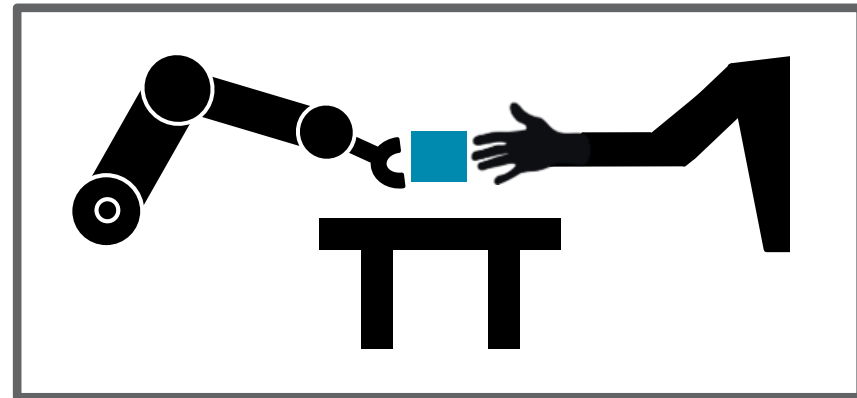
Quasi-Static Contact:

Human body part is at risk of being clamped or entrapped



How Can TS 15066 / TR 606 Help You?

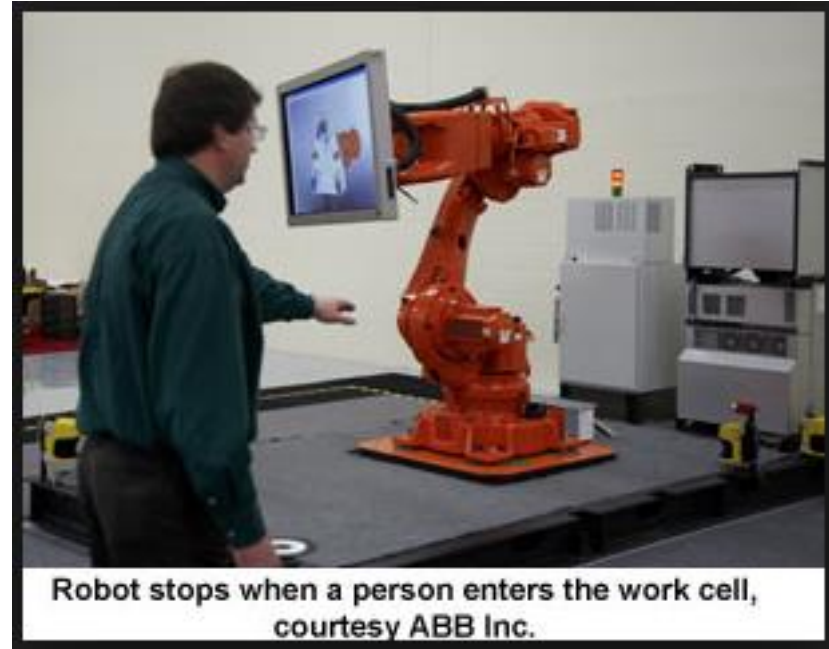
- Guidance primarily for suppliers and integrators for the safe design and operation of collaborative robot systems.
- Four types of collaborative operation:
 - Safety-rated monitored stop
 - Hand guiding
 - Speed and separation monitoring
 - Power and force limiting



Four Types of Collaborative Operation (1)

Safety-Rated Monitored Stop

- A stop is assured while maintaining power to the robot
- Operator may interact with robot
- Automatic operation may resume when the human leaves the collaborative workspace (requires safeguarding)
- Either the person OR the robot system may move, but NOT at the same time.



Four Types of Collaborative Operation (2)

Hand guiding

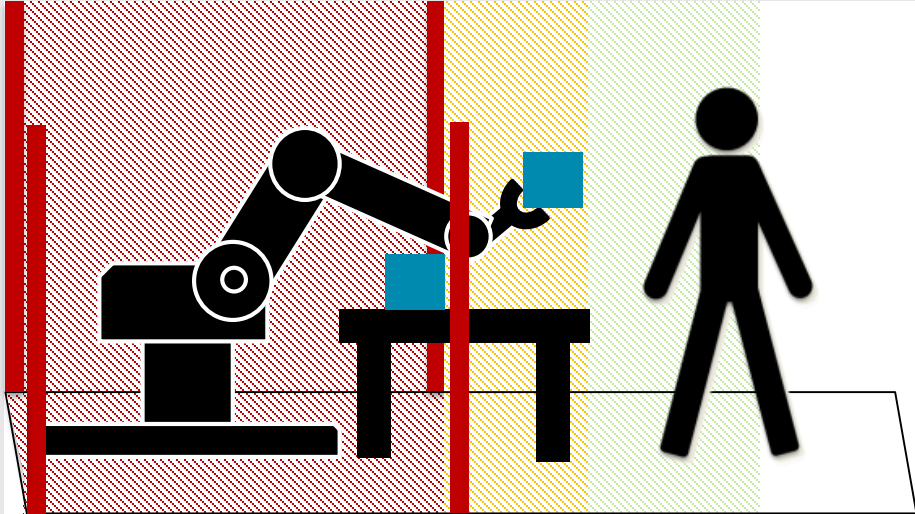
- Operator is in direct contact with the robot and is using hand controls to direct the robot where to go and what to do
- Robot system under manual control
- Both the person and the robot may move at the same time; motion controlled by the person



Four Types of Collaborative Operation (3)

Speed and separation monitoring

- Robot/hazard speed is reduced the closer an operator is to the hazard area
- Protective stop is issued when operator is in potential contact
- Person and robot may move at the same time



Four Types of Collaborative Operation (4)

Power and force limiting

- Speed, torque, motion of the robot is controlled so that incidental contact between robot and operator will not cause harm
 - **Since contact is permitted, it must be controlled and its risks understood**
- Person and robot can move at the same time
- Possible risk reduction measures:
 - Robot design factors (e.g., rounded shape, compliant materials)
 - Appropriate application selection & robot cell design (e.g., end-effector, workpiece, motion path, etc.)
 - Consult biomechanical power and force guidance (Annex A)
 - Transient Contact (human body part can usually recoil or “bounce away”)
 - Quasi-Static Contact (clamping; entrapment risk)

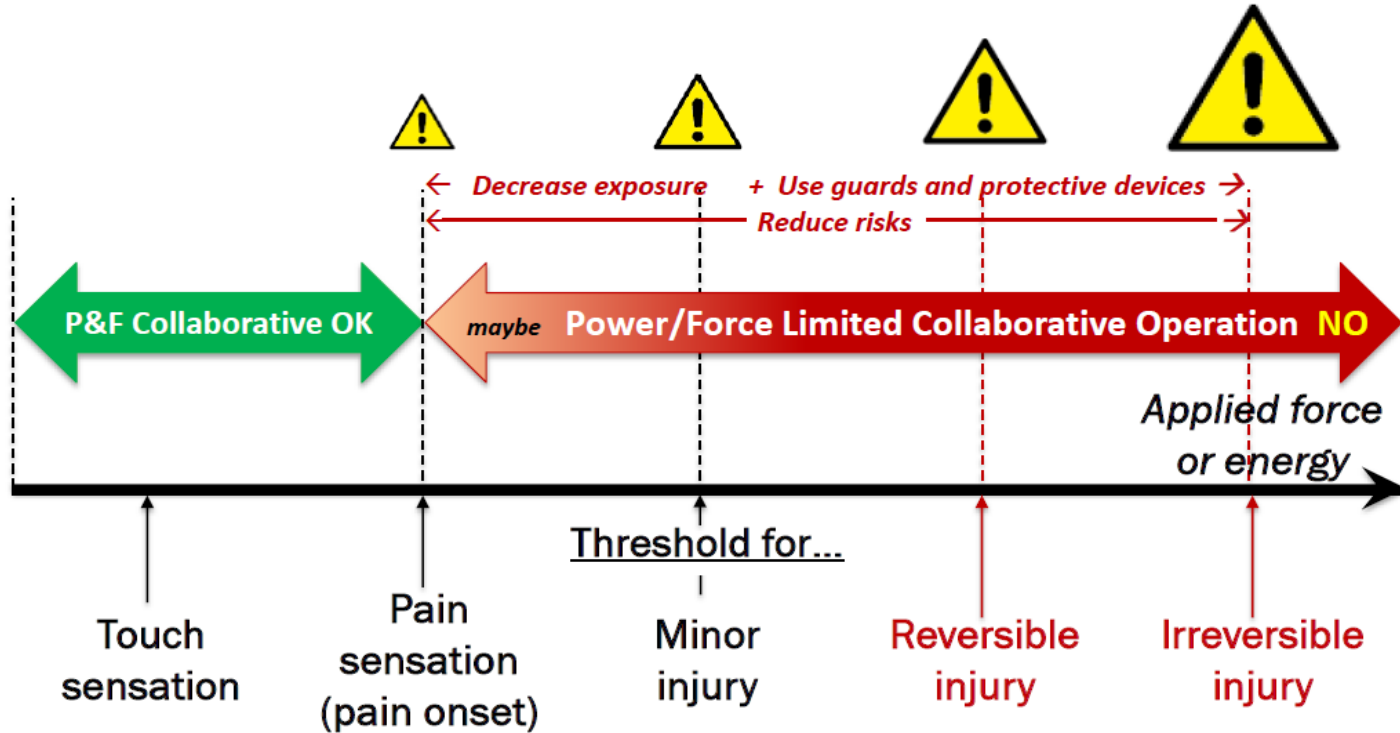


Four Types of Collaborative Operation

Collaborative type	Benefit	High Risk Applications?	Low Risk Applications
Safety-rated monitored stop	Quicker resumption of operation (power retained)	Yes safeguarding required	Yes
Hand-guided	Personal control & responsibility by operator; high variability of programs & quick changes	Yes	Yes
Speed & Separation Monitoring	Reduced space for application; Immediate resumption of higher speeds	Yes safeguarding required for intrusion/ approach	Yes safeguarding required for intrusion/ approach
Power & Force Limiting (<i>without protective devices</i>)	Reduced space for application; if easy to program, then personal control by operator	Yes, but LOW speed (might be <u>VERY</u> SLOW)	Yes



Four Types of Collaborative Operation



Safety For Collaborative Robotics

MYTH Because it's "Collaborative" I won't need any of those safety fences and light curtains –

Right?

REALITY

Depending on your risk assessment (and yes, the RA is still required), you might find you do need **safeguarding**



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- **Resources**



Practical Steps for Collaborative Safety

1. Get to know your Standards

- R15.06 / 10218; TR 606 / TS 15066

2. Think in terms of the Robot SYSTEM

- Not just the robot arm!

3. Select Other Equipment with Care

- Avoid end-effectors (etc.) that are sharp, pointed, jagged, hot...

4. Do your Risk Assessment

- TR 306

5. Watch your Poses and Paths

- Avoid those that might cause contact with face/ head/ neck, or clamping/ pinching (quasi-static contact)



Resources: Robotics.org

The screenshot shows the Robotics.org website homepage. At the top, there is a navigation bar with the RIA logo, the text "ROBOTICS ONLINE", and a search bar. Below the navigation bar is a dark blue menu with various categories like "RIA & YOU", "ROBOTIC RESOURCES", "UPCOMING EVENTS", "WEBINARS", "SAFETY & STANDARDS", "INTEGRATOR CERTIFICATION", "BECOME A MEMBER", and "BLOG". The main content area features a large banner for the "ROBOTICS ONLINE WEBINAR SERIES" with a call to action "Watch live or archived at no cost. REGISTER NOW". Below this is a featured product section for "Honeywell Intelligent" Robotic Palletizing, showing a blue robotic arm. At the bottom, there is a section for "Collaborative Robotics End User Applications Whitepaper" with a call to action "Download this free whitepaper today!".

- Feature Articles
- Safety Resources
- Webinars
- Supplier Information
- Certified Integrators Program
- Industry Event Schedule
- More!



Resources: [Robotics.org/](https://robotics.org/) [CRAV.ai](https://craai.org/)



COLLABORATIVE ROBOTS, ADVANCED VISION & AI CONFERENCE

Presented By:



OCTOBER 24-25, 2018
HYATT REGENCY SANTA CLARA
SANTA CLARA, CA



Resources: Robotics.org/ Safety Page

The screenshot shows the Robotics.org website's Safety Resources page. The browser address bar displays the URL <https://www.robotics.org/robot-safety-resources>. The page header includes the RIA logo (Robotic Industries Association) and the text 'ROBOTICS ONLINE'. A search bar and a 'BROWSE BY' dropdown menu are also visible. The main navigation bar contains the following items: RIA & YOU, ROBOTIC RESOURCES, UPCOMING EVENTS, WEBINARS, SAFETY & STANDARDS, INTEGRATOR CERTIFICATION, BECOME A MEMBER, and BLOG. The main content area is titled 'SAFETY RESOURCES' and features three columns of information:

- ROBOT SAFETY STANDARDS DOCUMENTS**: ANSI Standards and RIA Technical Reports. [LEARN MORE](#)
- ROBOT SAFETY TRAINING SEMINARS**: Join our experts at any of these upcoming training seminars! [PUBLIC TRAINING OPPORTUNITIES](#) [IN-HOUSE SAFETY TRAINING](#)
- SAFETY ESSENTIALS FOR COLLABORATIVE APPLICATION DESIGN**: Ensure that your workers are trained on the latest in collaborative application safety. [LEARN MORE](#)

- Standards Documents
- Safety Seminars
- Webinars
- Risk Assessment Software



Resources: Robotics.org/ Standards

RIA & YOU ROBOTIC RESOURCES UPCOMING EVENTS WEBINARS SAFETY & STANDARDS INTEGRATOR CERTIFICATION BECOME A MEMBER BLOG

GLOBAL ROBOTIC STANDARDS

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What Are Standards?

An Industry Consensus Standard...

- Provides normative and informative guidance
- Is typically developed through a consensus process
- Is drafted by a volunteer committee of representatives of concerned interests such as manufacturers, users, regulators, suppliers, integrators, consultants, and academia
- Provides a voluntary means to achieve a desired outcome
- Can become law when adopted by a regulatory agency

Participate in a Committee!

The Robotic Industries Association sponsors development of ANSI and ISO standards applicable to the robotic industry. Drafting committees are formed for various topics of interest. Participation is open to "anyone with a direct and material interest" in the work being done. Participation is divided into Voting and Associate memberships. Voting members representing companies must have the

Upcoming Standards Meetings

A list of all known robotics standards meetings scheduled for 2017.

[View Meetings](#)

Why Standards?

Voluntary standards are important and beneficial

- Standards Newsletter
- Upcoming Standards Meetings Schedule
- Committee Application

Questions About Standards?



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