Safety and Compliance

How this unique collaborative robot safely manages operational risks

Unlike typical industrial robots that operate behind safeguarding, Baxter™, the collaborative robot from Rethink Robotics, is designed to work effectively directly alongside people in a factory setting, making it possible to deploy in environments which have historically been off-limits to robotic automation. Baxter combines a number of unique technologies designed to allow deployment without some of the traditional safeguarding described in OSHA, ANSI, ISO, or other safety standards, based on the application's risk assessment. Baxter is designed for:

- Physical interaction between a worker and the robot.
- Avoiding accidental contact.
- Minimizing forces and slowing/stopping during human contact.

Baxter meets the applicable parts of ISO 10218-1. In particular, Baxter meets the requirements of a Power and Force Limited Collaborative Robot as described in ISO 10218-1: 2006. The most recent edition of ISO 10218-1 does not include these power and force limiting collaborative requirements, but instead guides readers to an upcoming, unreleased, Technical Specification (ISO TS 15066). Complying with ISO 10218-2 requires performing a risk assessment of the user application to determine the needed safety performance and safeguarding. ANSI RIA R15.06-2012 is a U.S.-national adoption of ISO 10218-1 & 2.

Baxter's Safety and Compliance Features

- Software Control: Baxter is designed to slow or stop upon inadvertent contact, allowing it to work collaboratively or to be co-located with an operator in close proximity.
- Multiple Redundant Systems: Baxter has a wide array of innovative sensors and an emergency stop function to ensure safety.
- Lightweight, Compliant Materials: Baxter's arms weigh less than 20 kg, are fully covered in compliant plastic, and use protective foam at key joints.
- Dynamic Braking: Baxter will slowly come to rest in the event of a power loss or an E-stop.
- Diverse Motor Enabling System: Two separate "heartbeat" signals are maintained to keep motion enabled.
- Human Awareness: Baxter can recognize human proximity with its 360° sonar system, which signals its awareness of any detected nearby people.

FIVE PRIMARY METHODOLOGIES AND SPECIFICATIONS

1. Safety by Design: Mechanical design and human-like cadence inherently reduces risks and injuries.

- Series Elastic Actuators (SEAs): Springs at all joints provide passive compliance to minimize the force of any contact or impact.
- Fully Back-Drivable Joints: Joints are back-drivable and can easily be rotated by hand, even when the robot is powered off.
- Smooth and Impact-Absorbing Shells: Baxter has padding in key areas, such as the elbows and wrists, and is designed to have reduced pinch-points.
- Moderate velocity: Baxter operates at human-equivalent speeds, which makes it easier for nearby people to avoid any unintended contact with the robot.

2. Machine Safety

- Baxter is designed with many traditional safeguards which govern its operation and protect those working around it.
- Automatic Braking: Baxter's braking system automatically prevents uncontrolled movement.
- Over-Temperature Shutdown: Operating temperatures are internally monitored and Baxter will shut down if overheating is detected.

- Brake Applied at Joints on Power Loss: When experiencing a power loss, Baxter slowly returns to gravity-neutral position.
- E-Stop: When actuated, the emergency stop function directly removes power to actuators and applies brakes.

3. Contact Detection

- Upon detecting contact or unexpected resistance, Baxter minimizes its force by disabling actuators and by joint braking.
- Force Sensing at Every Joint: Baxter detects and responds to contact and impact.
- Clamping Detection: Prevents Baxter from applying continuous or excessive pressure.
- Static Force Detection: The robot keeps impact forces below design limits.

4. Diverse Checking Subsystems

- Diverse subsystems leverage and control the "heartbeat" signals to enable joint brakes, and disable motor power if a control error or failure is detected.
- Heartbeats:
  - Commanded Stop via "Heartbeat" Signal: "Heartbeat" signals, triggered via software or external control, engage brakes and disable motor power.
  - Separate System Communications: A second "heartbeat" shuts down the system in response to detecting issues or control errors.
- Subsystems:
  - Distributed Joint Controllers: Provide local "heartbeat" monitoring, local joint disabling and braking capability.
  - Global Joint Disable/Braking: Implemented by the disruption of the E-stop "heartbeat".
  - Joint Position and Force Sensing Redundancy: Innovative, smart and aware.
  - Joint Controller Watchdog Timer: Self-monitoring disables motors and applies brakes if an internal issue is detected with any joint or sensor

5. Sensing and Behavior

- Baxter has a built-in human detection awareness capability, which can indicate awareness when people are detected in its workspace. This is an awareness and feedback feature which does not change the robot's behavior.
- Defined Space: 360-degree sonar or optional use of guarding, such as a presence-sensing mat, defines the robot's "personal space."
- Head-Mounted Lights: Sonar allows Baxter to signal that it is operational and signal when it knows people are around.
- Head Motion and Screen: Baxter provides feedback on its status and intentions, even confirming if Baxter detects your approach. By a "head nod", Baxter indicates understanding of its task.
- Motion Deactivated: Baxter can be quickly and easily deactivated by touching any button.

Product Approvals

Baxter has been certified for fire and electrical safety to UL 60950-1 by Curtis-Straus, a NRTL accredited by OSHA.

An application risk assessment, performed by the integrator and/or user, is a critical requirement to ensure the proper use of Baxter and the safety of personnel associated with Baxter's application. The end effector and part must be evaluated as part of the application's task-based risk assessment. If either presents a hazard, safeguarding can be required. For example, a risk assessment for an application where Baxter would be handling "knives" or sharp-edged objects would result in excluding collaborative operation and using Baxter as a typical machine that is safeguarded.

rethink robotics®

rethinkrobotics.com

27 Wormwood Street
Boston, MA 02210
Telephone: (617) 500-2487

info@rethinkrobotics.com

MADE IN U.S.A.

Rethink robots are proudly designed and manufactured in the United States of America.