Collaborative Cyborg Backpack Platform (CoBorg)

Standards Presentation

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Robots and robotic devices — Safety requirements for personal care robots:
https://www.iso.org/standard/53820.html

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What products/markets is the standard applicable to?

- Personal Care Robots: one of the service robot
  - "performs actions contributing directly towards improvement in the quality of life of humans, **excluding medical applications**"

- 3 types of personal care robots:
  - Mobile autonomous person carrier (person carrier robot)
  - A manipulator-type personal care robot (mobile servant robot)
  - **Exoskeleton (physical assistant robot)**

Overview of Topics

Safety requirements for personal care robot

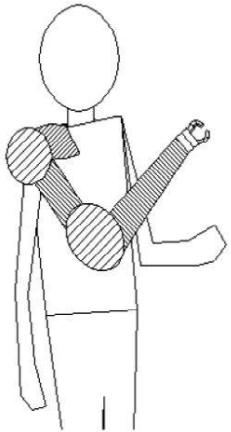
- Electrical Hazards
  - Charging stations
  - Energy storage/supply
- Operational Hazards
  - Unexpected/uncontrolled startup and shutdown
  - Robot shape (pinch points, crushing, severing, etc.)
  - Motion - breaking, loosening, instability, collisions, and speed/force control
  - Noise, vibrations, and hazardous substances emissions
- Human-Related Risks
  - Physical stress and posture
  - Mental stress
- Software Risks
  - Incorrect decision making

What are the standards main prescriptions?

- Electrical Hazards
  - Electronics should be guarded/covered to reduce risk of energy release. The robot shall **prevent overheating**, overloads, and short circuits
- Operational Hazards
  - The robot shall not perform any hazardous action on **start up**
  - **Avoid sharp edges and points**, don't let people stick things in holes, use geometry and/or joint constraints to avoid crushing human limbs
- Human-Related Risks
  - Design the robot to fit ergonomically across many body types
  - Robot shall be **easy to use**
- Software Risks
  - **Algorithms and sensors** will prevent incorrect action

How does the standard apply to Coborg?

- Personal Care Robots: one of the service robot
  - **Exoskeleton (physical assistant robot)**

Wearable robot 	Providing fixture directly to a human without invasion, e.g. straps and clamps to provide direct interaction for dexterous manipulation. Enabling the user to carry loads similar to that of an able bodied person.

Applications - Electrical

Category	Hazard	Recommendation	Coborg Solution
Battery Charging	**Contact with Batteries**	**Design such that live parts can't be touched**	**Anderson connectors**
	Battery Over/Underload	Alert user to battery state	Smart batteries
Energy Storage and Supply	**Contact with Electrical Components**	**<60V DC, insulated housing**	**Vacuum-formed enclosure with insulated connectors**
	Contact with Hot Elements	**Insulated housing, cooling**	**Vacuum-formed enclosure with fan cooling**
	Power Failure or Unintended Shutdown	Passive brakes, stored power	Back-drivable motors, internal power
	Power Overload	<60V DC	PCB safety factor, fuses
	ESD	Ground system	Ground to frame

Applications - Operational

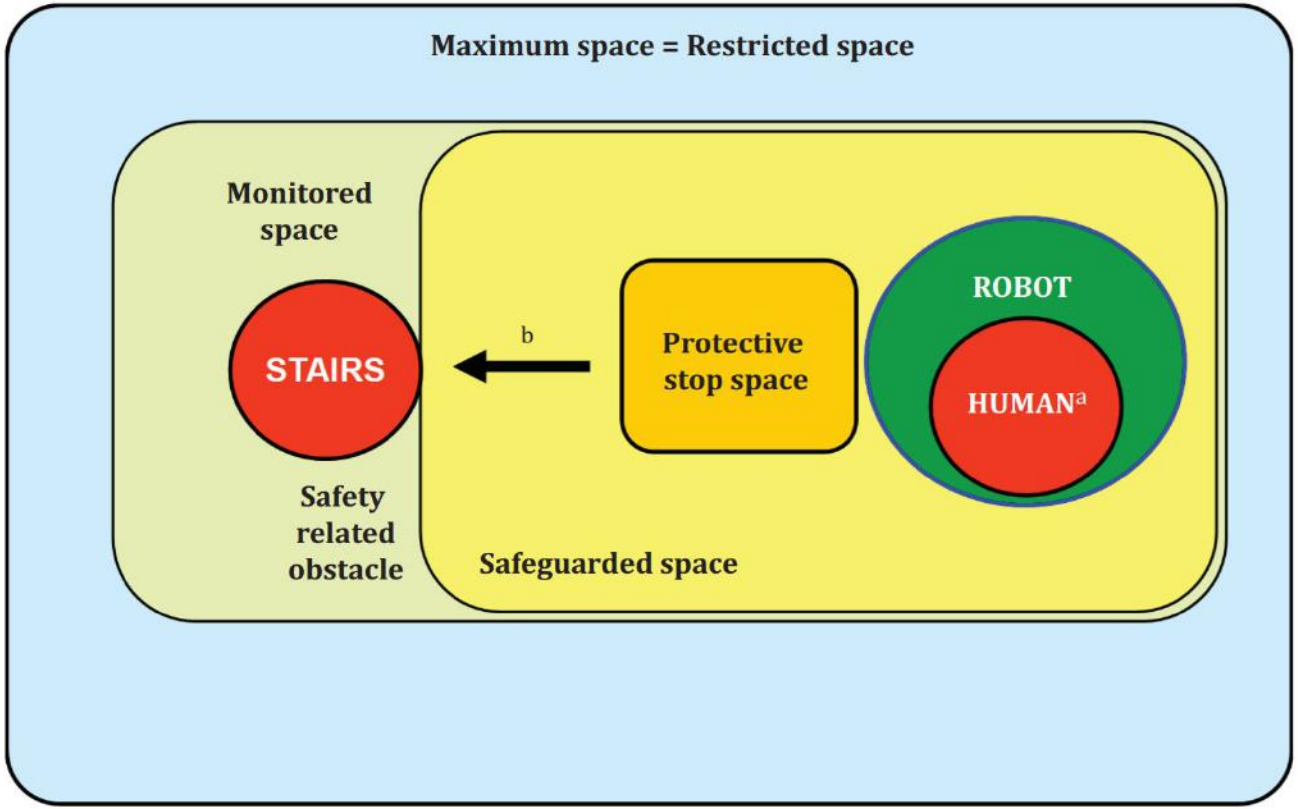
Category	Hazard	Recommendation	Coborg Solution
Robot Startup	**Unintended, Unexpected, or Hazardous Startup**	**Startup should be safe, safety verified first**	**Initialize all systems before moving, controlled move first**
Robot Shape	**Sharp Edges, Holes, Collision**	**Avoid bad geometries, use joint limits**	**SEA's, joint limits, collision detection and bounding boxes**
Noise	Harmful Acoustic Noise	Low noise, damping	System is not loud (HEBI)
Vibrations	Harmful Vibrations	Minimize vibrations (0.5-80 Hz), damping	Low speed maneuvers, padded backpack frame
Hazardous Substances	Harmful fluids, solvents, and allergic reaction	Elimination, avoidance, and containment of fluids	Outsourced motors => HEBI
Hazardous Environment	Sand, Dust, Ice, etc.	Sealing, dust-resistant, coating, etc.	Highly-controlled factory environment (FOD)

Applications - Human Usage

Category	Hazard	Recommendation	Coborg Solution
Stress, Posture, and Usage Hazards	**Stressful Posture Required**	**Ensure properly designed “seat”, place controls in ergonomic locations**	**Built entire Coborg on a hiking backpack frame, entirely voice controlled**
	Incorrect User Body Size Assumptions	Make robot adjustable	Adjustable backpack straps, larger task space
	Mental Stress	Make sure UI is usable	Only two or three commands, voice operated, voice feedback

Applications - Software

Category	Hazard	Recommendation	Coborg Solution
Hazards due to Localization and Navigation Errors	Unexpected Movement	Design navigation and collision detection so that localization is not required	Collision detection does not depend on localization, confidence threshold for vision subsystem
Hazardous Autonomous Action	Harmful Action Taken in Performing Tasks	Constrain operational scenarios, use specific safety identifiers	Only a few specific actions, collision detection, multiple e-stops



Key

a safety-related object

b momentary direction of movement

B.3 Exoskeleton (physical assistant robot)

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Safety of machinery — Emergency stop function — Principles for design:
https://www.iso.org/standard/59970.html

ISO 13850:2015

A type-B2 safety standard (safeguards for generic safety standards) that “specifies functional requirements and design principles for the emergency stop function on machinery, independent of the type of energy used.”

Does not deal with safety functions such as:

- Reversal/Limitations of motion
- Deflection of emissions
- Shielding
- Braking
- Disconnecting

What products/markets is the standard applicable to?

“The requirements for this International Standard apply to all machines, with exception to:

- Machines where an emergency stop would not reduce the risk.
- Hand-held or hand-operated machines.”

Applicable to:

- Industrial equipment (i.e. manufacturing machines)
- Robotic Manipulators
- General machines rooted to non-actuated foundations

ISO 13850:2015 Prescriptions

The E-stop must be…

- initiated by a single human action.
- maintained until it is manually reset.
- disengaged only by intentional human action.
- complementary to protective measures and not interfere with other safety functions.
- designed to stop all operations in a way that does not create additional hazards.
- designed to avoid unintended actuation.

The span of control of the E-stop shall cover the whole machine.*

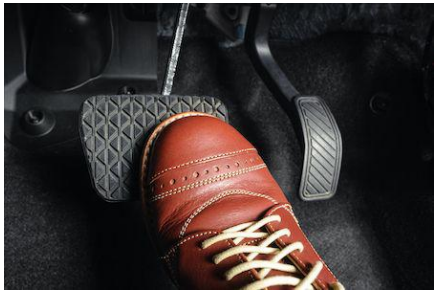
ISO 13850:2015 Prescriptions

Stop Category 0:

Stopping by immediate removal of power to the machine actuators

Stop Category 1:

Stopping movements and operations with power available to the machine actuators to achieve the stop and then removal of power when the stop is achieved.



ISO 13850:2015 Prescriptions

Valid E-stop Devices:

- Pushbuttons
- Wires, Ropes, Bars
- Handles
- Foot-pedals

Location Requirements:

- Directly accessible at each operator control station
- 0.6m - 1.7m above access level
- If detachable, must be accessible in fixed position.

E-stops must be RED in color.

If possible, the background behind the E-stop shall be YELLOW.

The e-stop & background should be free of text and symbols.

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ISO 13850:2015 Prescriptions

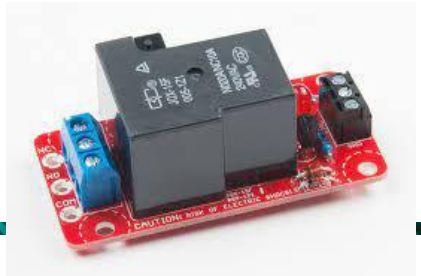
“4.6.2 Emergency stop reset for cableless operator control stations

Restoration of power after an interruption or failure of parts of a cableless control system shall not result in a reset of an emergency stop condition previously initiated by a cableless emergency stop device.

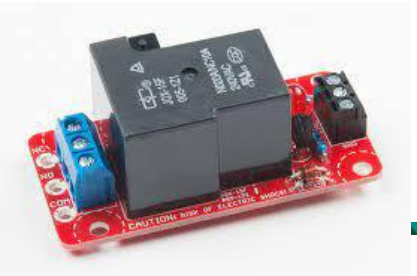
When an emergency stop has been initiated with a cableless control device, reset shall be possible only after the emergency stop device is disengaged from the latched-in position.

Unless the span of control of the emergency stop device can be observed, in addition to the disengaging of the emergency stop actuator on the portable control station, one or more supplementary fixed reset devices on or around the machinery shall be provided to ascertain that the reason for emergency stopping has been cleared.”

Voice Stop



Pull Cord Stop



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How does the standard apply to Coborg?

- We were using an awkward push button E-stop
- Switched to a red treadmill emergency pull cord
- Easy to identify, easy to actuate, user friendly

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Questions?