
SUPPLEMENT TO MACHINE DESIGN
Periodicals
USPS 100
Approved Poly
NOVEMBER 6, 2003
www.machinedesign.com
A PENTON PUBLICATION
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BUMP and GRIND

Robotic crash-protection devices take their lumps and come back for more.

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During the training phase, most robots encounter a few minor crashes. Robots can get pretty banged up during these training sessions, leading to costly tooling damage and lost training and production time. Similarly, in an automated production environment where workers manually load parts and robots perform assembly operations, crashes often result in total process shutdown.

In either case, expensive tooling may be damaged beyond repair while valuable time is lost waiting for new tooling. A new crash protection device can absorb the crash and reset itself with minimal downtime.

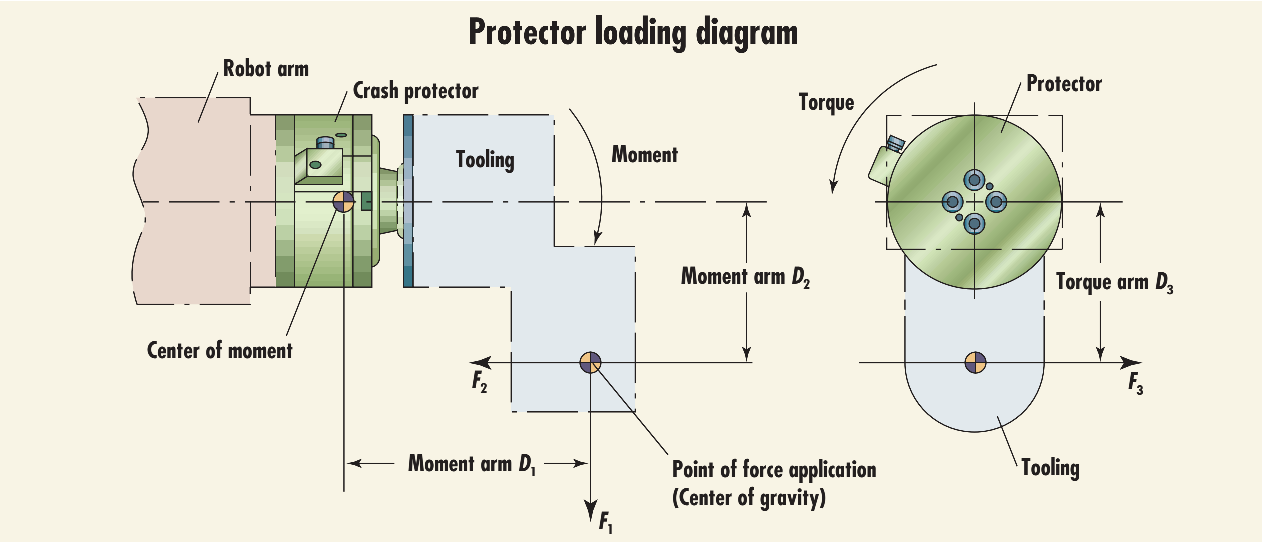
The Protector from **ATI Industrial Automation,** Apex, N.C., prevents costly damage to robotic end-effectors. The device fits between the robot arm and the tooling. It adjusts to support typical loads the robot arm experiences in all directions including angular, compression, and torsional. Should the arm exceed these preset limits, the compliant device absorbs the impact energy through a pneumatic chamber and redirects the energy to reset the device. Key features include automatic reset, adjustable breakaway point settings, and dynamically variable trip points, among others.

During training, the operator walks the robot arm through its operations to map out the desired path and function. Most of the time this is done manually resulting in a few minor crashes. After a crash, the robot is di-

Crash-protection devices minimize damage to robot tooling from angular, compressive axial, and torsional crashes.

rected to back the tooling away from the impact point. The protector automatically resets, letting the programmer continue training with minimal downtime.

Once trained, the robot will repeat desired operations as quickly and as accurately as needed — typical repeatability is within ±0.001 in. How-



Three steps to optimize crash protection

Matching a crash-protection device to an application is critical for successful performance. Loads produced by the static weight of the tooling, inertial loads imposed by robot motion, and the loads produced by the end-effector must all be considered. After calculating loads, and choosing a specific model, the operator can set the required air-supply pressure accordingly. Also, the required pressure must fall within an adjustable pressure range, for instance, a pressure setting of 50 psi should have a range of 25 to 75 psi.

1. Calculate applied loads (static, dynamic, and working). Typically, crash-protection manufacturers provide tables that convert forces applied to the end-effector tooling into moment, torque, and axial forces. Consider all three-load cases.

Static load is the load applied by tooling weight when the robot arm is idle. This includes weight of all parts attached to the Protector, acting at the assembly center of gravity along the direction of gravity.

Dynamic load is the inertial force imposed at the center of gravity due to acceleration of the robot arm. The force acts in the opposite direction of motion. Total load is the sum of the static and dynamic loads. Dynamic loads are only considered with robot accelerations.

The working load is a variety of forces generated at the tool tip while the robot is working. When the forces and their locations are known, they can be easily converted into loads on the Protector. Working-robot accelerations are minimal and can often be neglected. The total load on the Protector is the sum of static and working loads.

The following equations use static, dynamic, and working load specifications provided by the Protector manufacturer to calculate the applied loads:

$$\text{Axial load } (F) = F_2$$

$$\text{Torque } (T) = F_3 \times D_3$$

$$\text{Moment } (M) = \sqrt{(F_1 \times D_1)^2 + (F_2 \times D_2)}^2$$

2. Choose a protector: After calculating loads, select a model from the manufacturer's catalog that has a nominal moment rating higher than loads under both dynamic and working conditions.

3. Obtain required pressure setting: With the model set, approximate the pressure setting: $P = K_1 + K_2 + K_3$, where K_1, K_2, and K_3 are values determined from the equations. P = pressure, M = moment, T = torque, and F = axial load.

For example, calculating the pressure setting for an SR-80A crash protector with a moment of 200 lb-in., a torque of 150 lb-in., and an axial load of 20 lb, is as follows:

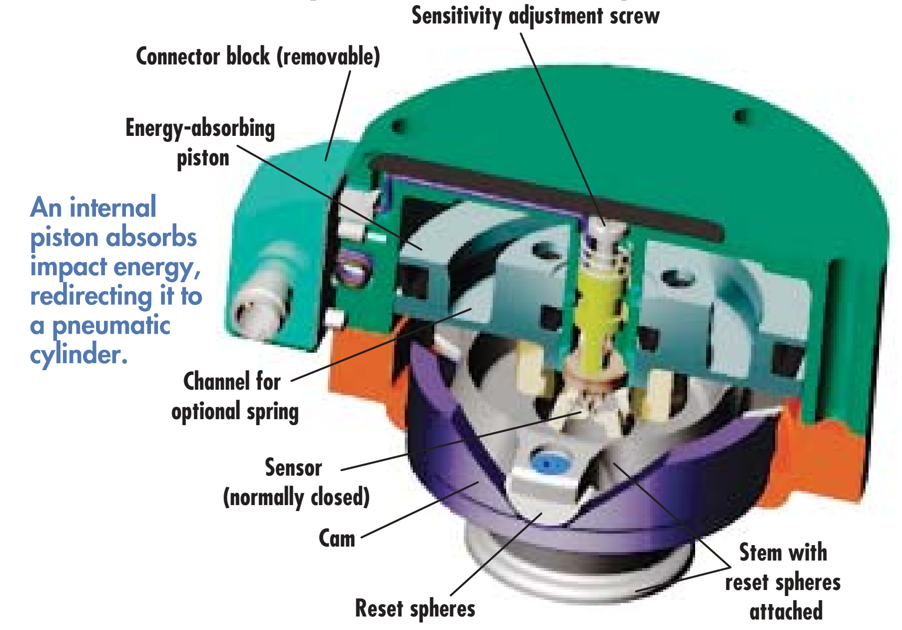
$$P = (200 - 7.9) \times (0.168) + (150 - 24.2) \times (0.183) + (20 \times 0.228)$$

$$P = 32.27 + 23.02 + 4.56$$

$$P = 59.85$$

Therefore, the application requires a nominal air-pressure setting of 60 psi.

Cutaway view of robotic crash protector



ever, most applications rely on proper alignment of components or subassemblies placed in the robot cell. Often, work pieces are either manually or semimanually loaded which could result in misaligned work. Misaligned parts can lead to crashes that damage tooling and halt production.

In a production setting, the protection device will reset after the crash and let the operator clear the obstruction and restart the robot. The operator can move the robot to a safe location while the obstruction is cleared, increasing safety and minimizing downtime.

At **National Manufacturing Co. Inc.,** in Chatham, N.J., crash protectors protect robots on automated machinery for manufacturing deep-drawn enclosures for the medical, electronic, and aerospace/satellite industry. Industrial robots load and unload on a 10-station, 45-ton press. Prior to installing protectors, a major crash resulted in significant robot damage. While waiting for replacement parts from Japan, loading and unloading tasks were done by hand, a time-consuming process considering an average part run of 250,000 pieces. Daniel DiAndrea, project engineer, says "Since installing the crash protector, we've realized such a significant cost savings on downtime and repairs that the protector is now a standard part on our automated machinery."

More than 20 robots at **Guide Corporation,** in Monroe, La., also use the crash-protection device. The robots perform adhesive trace operations on assembly lines for automobile lighting systems.

Subassemblies are manually loaded into trays that are fed into the robot cell. Robots dispense adhesive into a channel at the rate of one part every 24 sec. In the past, if a part was loaded incorrectly, the robot arm would crash, shutting down the line and damaging the adhesive dispensing nozzle. Each incident resulted in a shutdown of at least 30 min.

With the crash protectors, predetermined angular and axial displacement and torsional rotation limits allow the robot controller time for corrective action. The controller returns to home and reindexes after a crash. The system identifies the misloaded part location so the operator can correct the situation and continue production in a matter of minutes. The protector/controller interface also provides auxiliary functions such as turning off adhesive flow during application changeovers and notifying downstream assembly operators of potential mistakes made on certain parts.

Benefits and features of the Protector include:

- Repeatability: Following a crash, the protector resets to within 0.001 in. of its original position.
- Rotational and axial motion: Angular, axial displacements and unlimited torsional rotation give the robot controller ample time to take corrective action after a crash.
- Energy absorption: A pneumatic chamber within the Protector absorbs impact energy during the crash and redirects the energy to automatically reset the device to its original position. This protects the tooling and Protector from damage.
- Consistent breakaway points: Breakaway points are set at a given pressure independent of whether the crash resulted from a moment or torque load.
- Flexible mounting surfaces: Threaded and through-hole mounting patterns maximize flexibility and reduce stack height of the tooling and Protector assembly.
- Automatic reset: The Protector self-resets so operators don't need to enter the robot cell to reset the robot arm.
- Dynamically variable trip points: If needed, trip points can be set using variable air pressure supplemented by auxiliary springs for low breakaway.
- Quick-response crash detection: Setting the switch to actuate within 0.7° of angular or 0.005 in. of axial motion eliminates nuisance tripping. ■