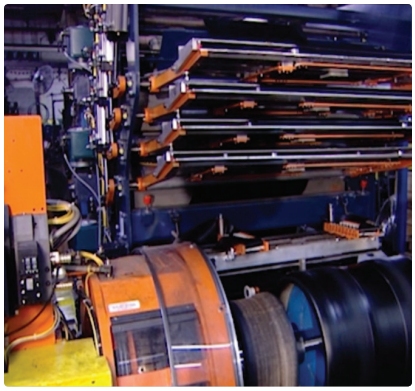
Safety in Drives and Motion

James Grosskreuz, Product Manager



In the past, many applications deployed safety devices that were hardwired and standalone - where safety was managed locally at the device and safety network support was not available. For example, safe drives were equipped with dedicated local safety I/O and supported limited safety functions such as Safe Torque Off, and perhaps Safely-limited Speed monitoring. Drive safety configuration was managed locally using web browsers or dedicated software tools, and the safety function activation was via safety I/O at the drive.

Safety Today

A modern safety solution incorporates a fully programmable, flexible safety implementation using Programmable Automation Controllers (PACs) with safety task support and networked safety devices that integrate with the machine. This safety controller-based architecture has distinct advantages over traditional standalone hardwired safety when:

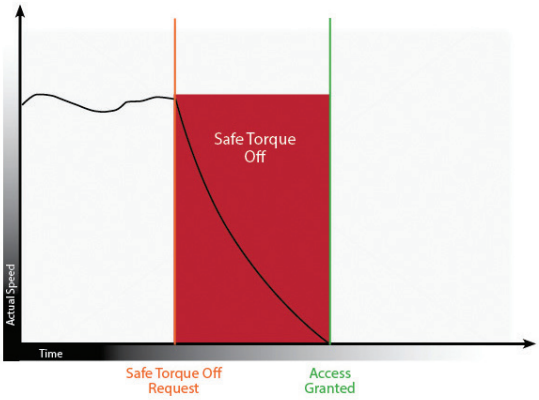
- Multiple safety zones have to be managed
- Large number of safety I/O is required
- A large physical machine area is to be safeguarded
- Machine flexibility, modularity, and scalability is important
- Diagnostic safety information is required
- Safe motion and drive safety control is required
- Application specific or customizable logic to improve machine productivity

Networked safety drives are a critical safety component in a safety controller-based architecture. Networked safety drives can offer basic and advanced safety functions with safety configuration, safety function activation, and safety status monitoring support via network safety connections. Modern safety network technology allows safety control devices to coexist with standard control devices on a common network that supports both safety connections and standard connections. The advantages of network-based safety implementation are clear.

Motion and Drive Safety Functions

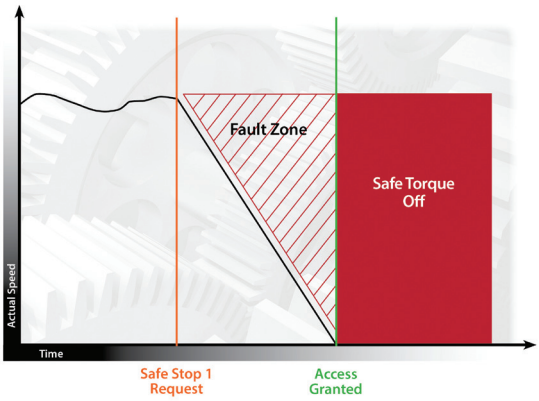
The trend in drive safety capability now allows multiple options for controlling the type of stopping actions. Controlled and monitored ramp profiles can be used to decelerate parts of a machine, a safety zone, or an entire machine. Furthermore, there are multiple options for safely monitoring motion profiles based on position, speed, and/or direction of a machine element. PACs with safety task programming combine these two powerful concepts - allowing for safe machine monitoring capabilities along with the flexibility to perform controlled stopping actions across multi safety zones as needed.

Now, let's review the actual safety functions that are commonly used in safe motion and drives control.



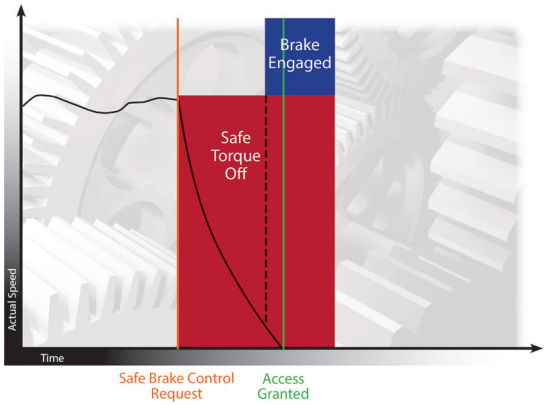
Stop Function - Safe Torque Off (STO)

Power that can cause rotation (or motion in the case of a linear motor) is removed from the motor. The drive will not provide energy to the motor that can generate torque (or force in the case of a linear motor).



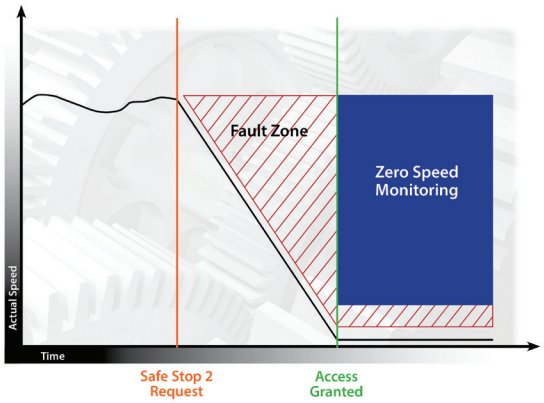
Stop Functions - Safe Stop 1 (SS1)

Initiates and monitors the motor deceleration rate within set limits to stop the motor and initiates the STO function when the motor speed is below a specified limit



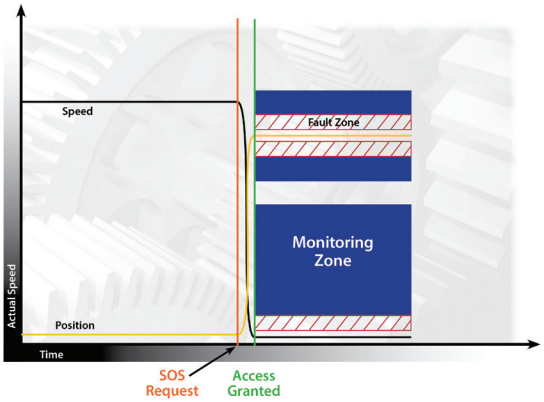
Stop Functions - Safe Brake Control (SBC)

Provides a safe output signal to control an external brake. The SBC function coordinates with the STO function.



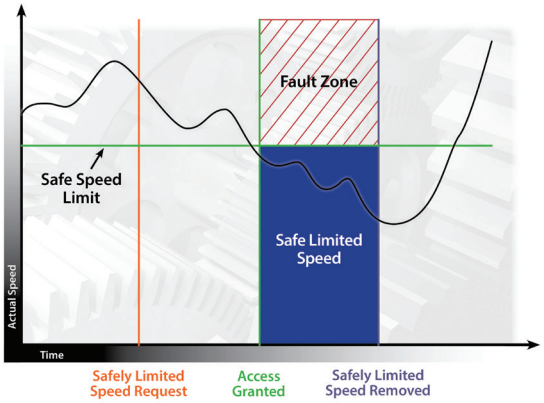
Stop Functions - Safe Stop 2 (SS2)

Initiates and monitors the motor deceleration rate within set limits to stop the motor and initiates the Safe Operating Stop function when the motor speed is below a specified limit



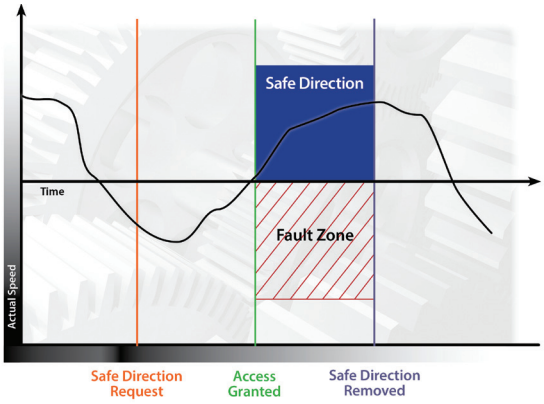
Stop Functions - Safe Operating Stop (SOS)

The SOS function prevents the motor from deviating more than a defined amount from the stopped position. The drive provides energy to the motor to enable it to resist external forces. While stopped, the SOS function can monitor either position or speed of the motor.



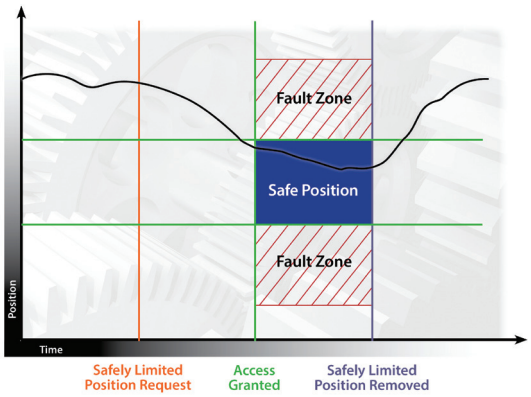
Safely Limited Speed (SLS)

The SLS function prevents the motor from exceeding a specified speed limit.



Safe Directions (SDI)

The SDI function prevents the motor shaft from moving in the unintended direction more than a specified limit.



Safely Limited Position (SLP)

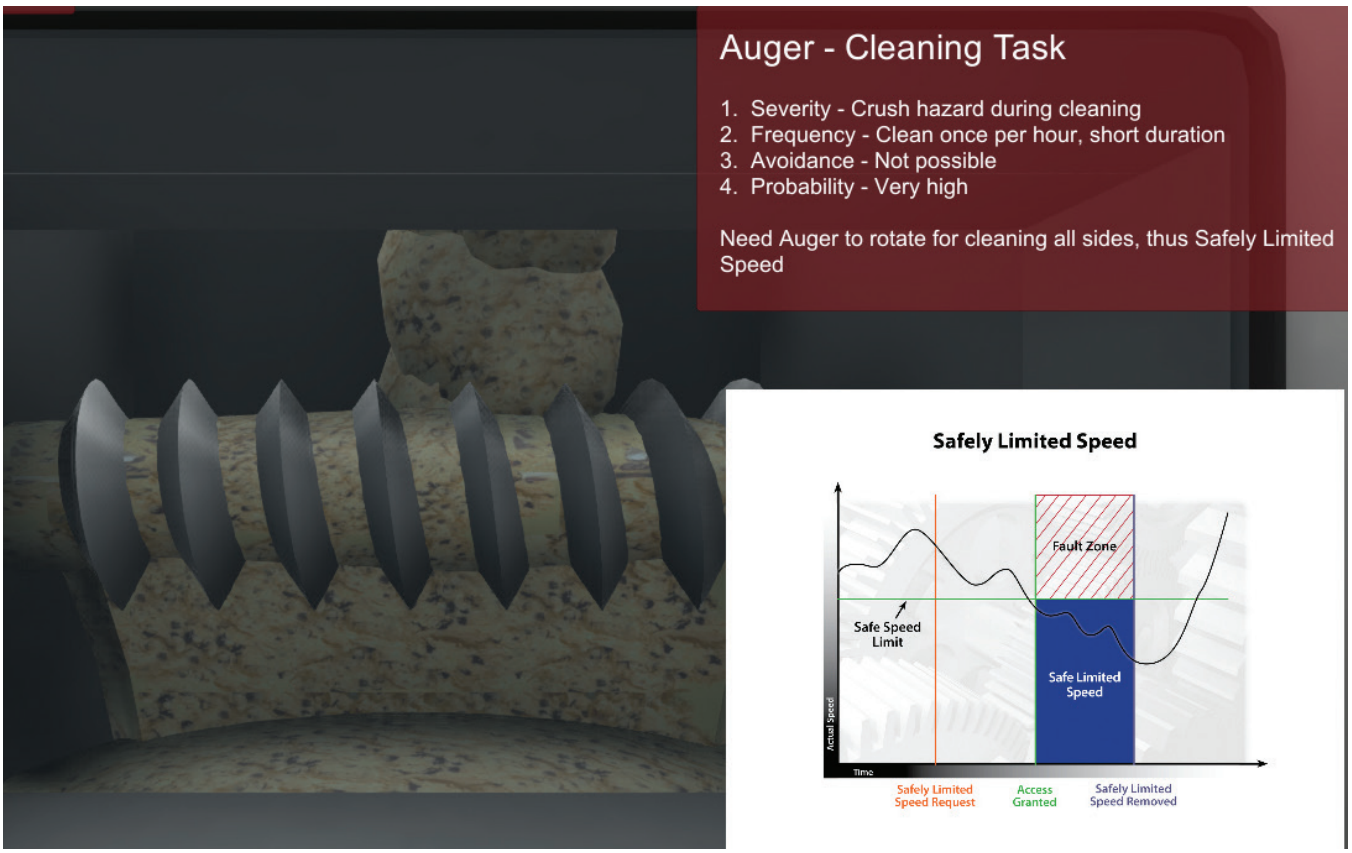
The SLP function prevents the motor shaft from exceeding the specified position limits. There are two limits: a positive position limit and a negative position limit. A safety fault generates when one of the limits is reached.

Application Examples

Material Movement/Conveying Application

Approximately once per hour, the machine requires that the material around the auger be cleaned. Access to this area is not allowed when the machine is operating normally. However, when access is requested the auger is slowed to a safe speed. The safety system actively monitors this speed using the Safely Limited Speed function.

Access is now granted, and the operator is allowed to clean the auger while the machine is active *and* simultaneously being safely monitored. It is no longer necessary to stop the machine to clean the auger. Using the Safely Limited Speed function results in a smarter and more productive machine. This particular application requires PLe integrity with one motor-mounted safety rated encoder and an auxiliary feedback device.



Coordinated safe stop (SS1) of a line

In this application, it is desirable for the machine to stop in a coordinated manner. A coordinated stop will ensure that the affected parts of the machine will not create mechanical interferences while stopping.

In this case, six drives are geared to a line master. When the operator pushes the line-stop safety-switch button, the line will ramp to a coordinated, controlled stop, while SS1 safety monitoring is in place for each of the six drives. Additional flexibility is achieved if the machine is running different materials or products. During machine changeover, based on the materials being processed, the line ramp rate can be changed by the operator using an operator interface. This can be done without changing the underlying program, resulting in faster changeovers and improved efficiency.

Safely-limited Speed (SLS) for variable diameter wind/unwind roll

There are scenarios in which the machine operator has to perform maintenance operations in the vicinity of the unwinder roll with the guard doors open. In this case, SLS monitoring of the surface speed of an unwinder roll is needed.

The SLS monitoring speed slowly and dynamically changes with the roll diameter. The motor drives the unwinder roll at a variable speed to maintain a constant surface foot per minute (SFPM) as the web is unwound off of the unwinder roll. As the web is unwound, the unwinder roll diameter decreases. The instantaneous winder roll diameter is used to derive the required motor speed to maintain the necessary SFPM web speed. There are two analog inputs (not shown) which are used to determine the roll diameter. The monitoring speed for the SLS speed setpoint calculated is based on the instantaneous roll diameter measured by the analog inputs.

This particular solution requires PLd monitoring using one motor that has a built-in SIL CL2/PLd safety rated encoder. The use of motors with safety rated encoders simplifies the implementation of motion based safe monitoring systems by over 80% as compared to using systems with only standard encoders. This results in faster time to implement machine safety.

Modern Safety Solutions

Modern safety solutions incorporate a fully programmable, flexible safety implementation using Programmable Automation Controllers (PACs) with safety task support and networked safety drives that integrate with the machine. Drive safety capabilities now allow for multiple stopping actions and flexible options for safely monitoring speed, direction, and position of machine elements.

There are many examples of modern safety solutions that incorporate one or more of the many safety functions. Contemporary and smart safety solutions help maximize machine efficiency and uptime while conventional safety approaches may hinder productivity. Best-in-class manufacturers can achieve up to 5%-7% higher Overall Equipment Effectiveness (OEE), 2%-4% less unscheduled downtime, and less than half the injuries of average performers by adopting modern and integrated safety solutions as part of their plant automation systems.

Resources

Rockwell Automation

Jim Grosskreuz

1201 South Second Street
Milwaukee, WI 53204

jgrosskreuz@ra.rockwell.com

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe/Middle East/Africa: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

Publication MOTION-WP006A-EN-P – April 2018