

## Drives deliver safety for food and beverage machinery

**Variable speed drives (VSDs) have successfully replaced many traditional techniques for controlling the machinery used throughout the food and beverage sector. In addition to precise process control and significantly improved energy efficiency, drives also help machinery manufacturers meet the required safety standards and reduce system complexity, explains F&B Market Manager Timo Holttinen from ABB.**

The food and beverage industries employ a wide variety of machinery in processes from raw material handling to pumping and conveying of ingredients; from processing by mixing and cooking; as well as during packing and storage. However diverse the application, they all rely on one common factor – the low-voltage (LV) electric motor in both AC (alternating current) and DC (direct current), and including the latest permanent magnet and synchronous reluctance motors.

Pumps, fans and even decanters can be controlled very successfully by running their LV motors at full speed and adjusting their output by relatively crude mechanical methods, such as gears or throttling. However, in the past 30 years we have seen the adoption of a more elegant and energy efficient approach based on variable speed drives (VSDs).

In simple terms, a drive is a device based on power electronics that can be used to adjust the speed and/or torque of AC motors. This enables the operator to slow down or speed up the motor depending on the demand, resulting in substantial energy savings.

A VSD ensures that a process can achieve the optimum speed and torque while maintaining the required accuracy. Being able to vary the speed and torque also means there is less wear and tear on both the motor and the machinery it drives. For example, being able to bring a process up to speed slowly prevents the sudden shock loading that can cause wear and damage over time.

Overall, the benefits of AC drives are well recognized in terms of considerable improvements in plant productivity and efficiency, energy savings and reduced wear on moving equipment. Yet, because of the precise control they offer, drives can play an equally important role in ensuring safe stopping of machinery. To understand this fully, it is useful to review the most recent legislation in this area.

### **Building drives into a complete certified safety system**

For example, in Europe manufacturers of food and beverage processing machinery have a duty under the Machinery Directive to determine the risk their equipment poses to users, and to reduce those risks as much as they can.

The Machinery Directive 2006/42/EC demands that machinery is safe, being both designed and built so that it can be used, configured and maintained throughout all phases of its life to cause minimal risk to people and the environment. It requires that manufacturers perform risk assessments and take those results into account when designing a machine. Any risk considered to be “high” must be reduced to an acceptable level through design changes or by applying appropriate functional safety measures.

Functional safety is part of an overall safety regime that depends on a system or equipment operating correctly in response to its inputs. In machinery, functional safety usually means systems that safely monitor and, when necessary, take control of the machine applications to return operation to a safe state, or to ensure that the desired action, such as safe stopping, takes place.

Monitoring can cover speed, stopping, direction of rotation, and standstill. When the safety system is executing an active safety function, for example monitoring a crawl speed, and the system behavior

deviates from the expected (for example, the system runs too fast), the safety system detects the deviation and actively returns machine operation to a safe state. One example could be stopping the machine safely and lowering the torque of the motor shaft.

### **Stopping functions**

The product standard EN 61800-5-2 governs the safety-related functions of low voltage AC drives and its main requirements are those governing the safe stopping of machinery, both automatically when sensor inputs indicate that the equipment is moving outside of its correct operating parameters or manually when triggered by safety devices such as the emergency stop button or breaking of the light curtain. Perhaps the most essential of safety functions is safe torque off (STO), which brings the machine safely into a no-torque state and/or prevents it from starting accidentally. This function allows the safe cleaning and mechanical maintenance of food processing machinery. Alternatively, it can allow an operator to reposition product while the drive is paused in standby mode, ready to resume operations with the minimum of interruption to production. The drive's internal diagnostic functions also run during the shutdown, making it possible to analyze such events afterwards, a feature which can be hugely beneficial when optimizing a process.

STO integrated into the drive also offers a more cost-effective system, since the function of making the machine safe can take place using the software solution built into the drive in place of external contactors and complex wiring. Provided a relevant risk assessment is carried out, users can even remove contactors from the safety system, and since contactors and wiring can occupy a lot of space in the control cabinet this offers the possibility to achieve a much more compact installation footprint.

A related function is safe stop 1 (SS1), which brings the machinery to a safe stopped state if certain conditions are detected. When activated it decelerates the motor and initiates the STO function after a time delay.

Safe operating stop (SOS) keeps the motor in a safe standstill while maintaining the motor torque and is related to safe stop 2 (SS2), which stops the motor safely, initiating SOS below a specified speed or after a defined time limit.

A number of other defined safety functions can be incorporated into drives, including functions such as: safely-limited speed (SLS) which prevents the motor from exceeding the defined speed limits; safe direction (SDI) which prevents the motor shaft from moving in an unwanted direction; safe brake control (SBC), which provides a safe output signal to control the motor's mechanical brake, while checking the action has occurred; safe speed monitor (SSM) which provides a safe output indicating that the speed is under the specified speed limit.

### **Typical applications for ABB's new safety related drives**

With STO built in as standard, ABB's new ACS880 drive can be supplied with the most common certified safety features integrated into its optional safety functions module, reducing the need for external safety add-ons such as contactors and safety relays as well as the wiring which these would require. As the drive is already in control of the motor, it is logical to allow it to orchestrate safety functions.

Typical functions for these types of safety related drives are SS1, SBC and SLS. SS1 is particularly important for applications such as large sugar centrifuges. If an operator became entangled in the mechanism, the use of STO alone could leave the centrifuge spinning for up to an hour due to the large inertia. SS1 will bring the centrifuge to rest under control, typically employing active braking from a regenerative drive. STO would then be initiated to remove the torque and make the centrifuge safe.

Safe brake control (SBC) would be employed on a palletizer or vertical conveyor. The mechanical brake can be used to safely stop the movement in cases where the motor cannot provide sufficient

torque to lift the load, or the load moves or accelerates uncontrollably. The brake is activated either with a stopping function, or when the motor movement is not as expected by the safety monitoring. SLS guarantees that a machine will not go above a preset speed, ensuring that, for instance, a liquid oil decanter is not damaged by excessive rotational forces.

With basic drive modules however, it is not cost-effective to incorporate all the possible safety functions specified by the standard, and because of the feedback requirements to confirm that an action has occurred, space also becomes an issue. In these cases, external control of the safety function may be necessary via a more intelligent safety PLC or programmable safety relay, and it is possible to incorporate this extra functionality into cabinet drives, which offer the space to incorporate these extra functions.

### **A practical example of a safe stop function**

In a variety of food and beverage applications a decanter centrifuge uses very high centrifugal forces to separate solids from liquids. One common use is in the manufacturing of olive oil, where olive paste is fed into the decanter centrifuge, which then separates the oil, water and pits from the olive flesh.

The key to the separation is the high centrifugal force. While this delivers the benefit of increasing process throughput, which saves time and money, it also introduces safety concerns that need to be addressed. Using ABB's M3AA motor, rated at up to 90 kW, the g-forces reach 2,000 times normal gravitational force. Due to the heavy weight of the decanter and its high speed it is operating with very high kinetic energy.

Under these conditions, any malfunctions or mechanical problems can present a serious safety hazard. As example a small vibration caused by running the decanter above a certain speed can quickly lead to larger safety issues, not only for the machine but also for plant personnel and the production

Variable speed drives can help the decanter centrifuge manufacturer to fulfill the required safety standards, with the most appropriate safety functions built in to help reduce overall system part count and complexity.

For example, the ABB ACS880 industrial drive features a built-in safe torque off (STO) function that removes the torque from the motor, allowing the decanter centrifuge to coast to a stop. The optional built-in functional safety module can also be added into the drive for the safely limited speed (SLS) function, which monitors and limits the decanter centrifuge's speed, preventing over-speed, which might otherwise result from erroneous inputs or speed reference signals.

### **Conclusion**

The reliability of modern drives has seen them come to be regarded as an integral element of a safety system. With dedicated safety functionality, they are forming an increasingly important element in helping the food and beverage industry improve its safety record while at the same time maximizing its productivity and, therefore, profitability.

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**Box out:**

**Typical safe stop functions:**

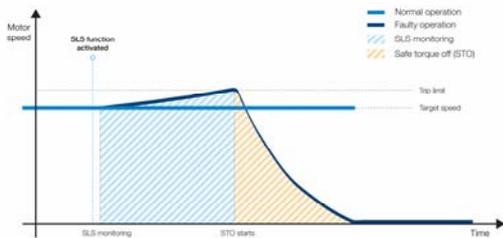
- STO Safe Torque Off – removes torque, preventing accidental start or enabling it to coast to a standstill
- SS1 Safe Stop 1 – decelerates the motor to standstill and initiates STO
- SOS Safe Operating Stop – maintains motor torque while keeping the motor at a standstill
- SS2 Safe Stop 2 – decelerates the motor and initiates SOS
- SLS Safely-Limited Speed – prevents over-speed conditions
- SDI Safe Direction – prevents motor shaft from unwanted reversing
- SBC Safe Brake Control – controls the motor’s mechanical brake
- SSM Safe Speed Motor – an output that indicates the motor speed is operating at a safe speed

**Photos with captions:**



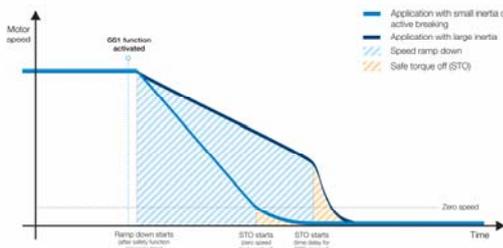
**Full image:** Inside sugar silo.tif

**Caption:** Machine safety is critical in food and beverage industries, including sugar industry where large machinery are being used for various applications.



**Full image:** Safety function graphs\_SS1.tif

**Caption:** Large sugar centrifuge is brought faster to a safe stopped state with combination of SS1 safety function and active braking from a regenerative drive.



**Full image:** Safety function graphs\_SLS.tif

**Caption:** Safely limited speed (SLS) function safely coasts the decanter centrifuge to a stop after detecting over-speed caused by a faulty speed reference.



**Full image:** ABB ACS880-01 with FSO-11.tif

**Caption:** The optional functional safety module can be installed in the ACS880 to provide additional safety functions.