TwinSAFE SC I/O terminals and analog sensors monitor transport of stacked wooden workpieces

# Simple, flexible and cost-effective machine safety implementation

IMA Klessmann GmbH of Lübbecke, Germany is an international manufacturer of trend-setting manufacturing machines for the woodworking and craft furniture industries. In 2017 the company modernized a complex, multi-track transport system for wooden workpieces for one of France's largest kitchen cabinetry manufacturers, Fournier SA of Thônes. In the process, a reliable monitoring system that prevents unauthorized entry was implemented in an extremely simple, flexible and cost-effective way using analog sensors and TwinSAFE SC safety technology (TwinSAFE Single Channel) from Beckhoff.

In the plant area concerned, board-shaped workpieces for kitchen furniture are removed from a sorting warehouse and stacked on pallets in two picking stations according to job lists. The finished stacks are subsequently transported out of the order-picking areas via appropriate conveying equipment to the downstream machines. Following destacking, these machines then receive the necessary parts in precisely the right order to assemble a kitchen cabinet as efficiently as possible. The two picking stations, which are among the safety risk areas due to their operating principle, each have six gates to discharge the workpiece stacks.

According to Michael Gube, software developer at IMA and responsible for the startup of this project, the requirement for this kind of application is that it must never be possible for a human to enter the risk area. There is a high safety risk involved on account of the high dynamics of the transport portals located in this area and the large masses that are moved. The conventional method to control access to such plant areas is to use safety light barriers and muting functions. However, such measures alone were deemed insufficient in this case. For structural reasons the safety light barriers could only be installed immediately before the risk area. Unauthorized entry would be reliably detected by the light barriers, but there would not be sufficient time to stop hazardous movements quickly

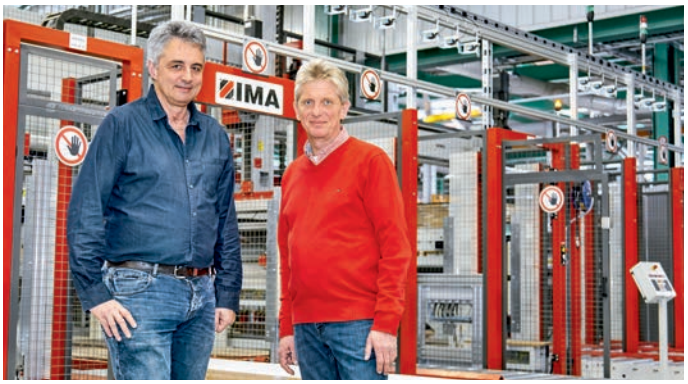

The stacks of wooden workpieces for kitchen furniture from Fournier are supplied by two systems, each with six roller conveyors.

enough, even if the maximum possible braking ramps were activated. Other measures, for example the use of safe service brakes, would place an extreme load on the mechanical system and in the long term once again represent a safety risk while endangering the process safety.

**Two-stage safety concept provides solution**

One of the requirements, therefore, was to guarantee personal and process safety through a second safety device: If anyone attempts to gain unauthorized access to the picking area, they must pass through two devices: as soon as they pass the first, the portal switches to the Safely Limited Speed (SLS) mode. As the person approaches the second device, the machine is stopped from the safe speed.

The first safety device consists of three standard transit time sensors. There is always a safety risk when there is either no material stacked in the area of these sensors or when the material stack is not moving in this area. The entry risk during this phase is reliably avoided the following way: As soon as a board stack moves underneath the transit time sensor area and is subsequently stopped, the transit time sensors measure the current stack height once (latch). If the stack moves completely out of the area, the stack height is given the value 0.




**Pierre Favre (left), project manager at Fournier and Michael Gube (right), software developer from IMA Klessmann and commissioning manager for this project**


**The analog signals from a total of 36 transit time sensors are acquired via the TwinSAFE SC terminals.**

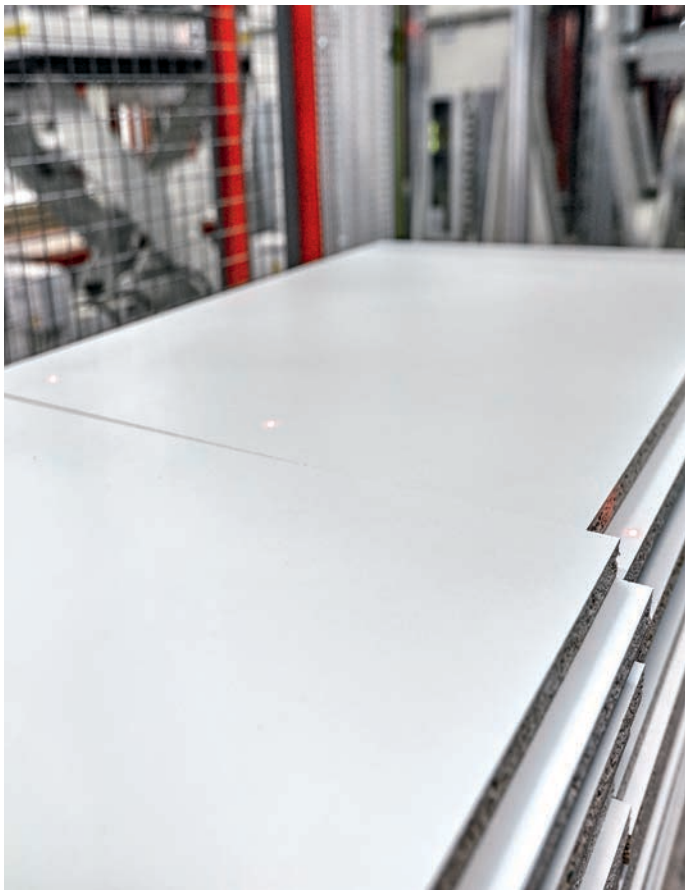
The values of the three sensors determined at a standstill are transmitted to the safety controller and continually compared to the actual values of the transit time sensors. Now if someone attempts to gain entry when no stack is present or by climbing over a stationary stack, at least one of the three actual values deviates from the latched position. This immediately causes the portals to switch to Safely Limited Speed (SLS) mode.

Once a person has overcome the first safety device, he or she must additionally overcome the second set of devices, safety light barriers placed immediately in front of the picking area. If they detect entry, then the axes which are already moving at a safely limited speed are finally brought to a standstill.

### Analog value processing saves considerable costs

For Michael Gube, the prerequisite for an efficient safety solution was the analog signal processing capability of the EL6910 TwinSAFE Logic terminal: "Previously there was a safety deficit on this machine, even though the roller conveyors were manufactured to be inaccessible. However, access was still possible in individual cases, for example if only a base plate normally used underneath a stack was transported. The safety light barriers used for protection were too close to the moving portal, which meant it couldn't be stopped fast enough in case of imminent danger. The initial solutions considered, such as safety doors or the use of radar scanners, would only have been possible with considerable


**The safety enhancement – a subsystem equipped with a CX9020 Embedded PC – was simple to retrofit and integrate optimally into the control system of the entire production facility, which is implemented using PC-based control from Beckhoff.**



**The three transit time sensors (shown by the three points of light) on each roller conveyor monitor the heights of the workpiece stacks.**

mechanical rework and cost expense. The alternative with TwinSAFE SC and transit time sensors proved considerably simpler and more flexible for us, while being much more cost-effective."

### Safety function blocks for analog sensor signals

According to Michael Gube, the safety functions based on the analog signals from the transit time sensors can be implemented very conveniently in TwinCAT 3 software with the appropriate safety function blocks which are above all extremely scalable. The complexity of the system is also not a problem. It consists of two machines with identical hardware and software, each of which makes use of a Beckhoff CX9020 Embedded PC, an EL6910 TwinSAFE Logic terminal and six EL3124-0090 TwinSAFE SC analog input terminals (one for each roller conveyor). Bettina Keller, application/support from Beckhoff, adds: "In addition, each machine uses four EL1904 TwinSAFE digital input terminals for the safety acknowledgement and dual-channel muting inputs and one EL2904 TwinSAFE digital output terminal to control the safety contactors. All necessary functions such as the maximum permitted duration of a muting procedure can be configured conveniently with TwinSAFE function blocks in TwinCAT." That is also confirmed by Michael Gube: "The most diverse safety functions can be realized simply and quickly with the safety function blocks. A particular advantage of this is that it applies universally, even to the more complex analog input signals."

With the help of the TwinSAFE SC terminals, the EL6910 TwinSAFE Logic terminal can also evaluate standard signals for safety tasks.

Bettina Keller explains the building blocks for such a streamlined safety implementation: "The core is the EL6910 TwinSAFE Logic terminal with its extended safety functionality. In addition to the safety function blocks from the EL6900, it offers certified safety function blocks to process analog signals, among other things. These also include more complex functions such as counters, limit value and comparison. In addition, the EL6910 supports the TwinSAFE SC technology, and only this technology makes it possible to securely transmit data from standard EtherCAT I/Os via their TwinSAFE SC extension to the EL6910. As a result, analog signals can now be analyzed, checked for plausibility and evaluated within the logic, although for safety reasons at least one of the data sources must be a TwinSAFE SC component."

**Demand-based solution is scalable, yet integrated**

The fine scalability of PC-based control technology from Beckhoff resulted in one of the biggest advantages in the installation of the new safety solution, as Michael Gube explains: "The entire production facility is controlled by TwinCAT 2 software. However, the TwinCAT 3 software generation is required to directly connect the analog sensors via the EL6910 TwinSAFE Logic terminal. The modular Beckhoff control technology is scalable to suit the application demands and it allowed this by simply and cost-effectively realizing new safety functions via a subsystem that consists of the CX9020 Embedded PC with TwinCAT 3 as well as the TwinSAFE and TwinSAFE SC terminals."

This solution has proven to be extremely flexible in a further regard for Michael Gube: "According to the applicable safety regulations, the hazardous area must be monitored over its entire width in 250 mm intervals. Therefore, we use three transit time sensors on each of the 700 mm-wide roller conveyors. If it should prove necessary in the future to use wider roller conveyors due to larger workpieces, we only need to increase the number of sensors accordingly. The adaptation of the safety functionality can then be configured with little effort via TwinCAT software, especially since safety engineering under TwinCAT 3 is very convenient and efficient."

## TwinSAFE SC integrates standard signals into safety technology

TwinSAFE SC technology (TwinSAFE Single Channel) permits the use of standard signals for safety tasks in any network or fieldbus. To do this the data from the EtherCAT Terminals, extended by the TwinSAFE SC function, are fed to the EL6910 TwinSAFE Logic terminal, where they undergo safety-related multi-channel processing.

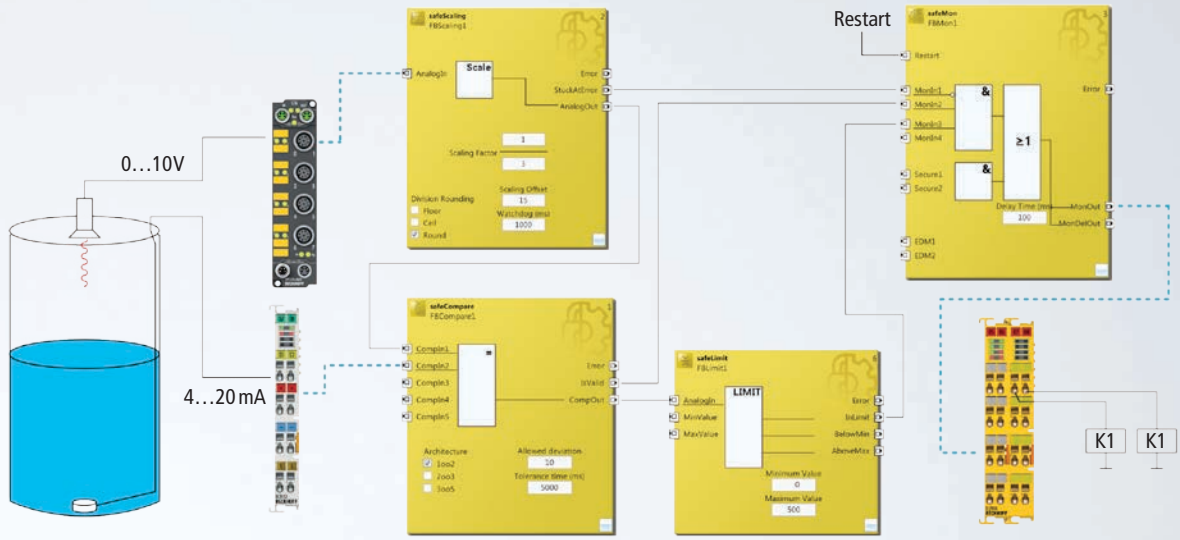
Data from various sources are analyzed, checked for plausibility and evaluated in the TwinSAFE Logic. Certified function blocks are available for this, such as e.g. scaling, comparison/evaluation (1oo2, 2oo3, 3oo5) and limiting. For safety reasons one of the data sources must be a TwinSAFE SC component. The remainder of the data can originate from standard I/Os, drive controllers or measuring transducers. As a result all of the process data present in the system can be used for safety technology. In this way TwinSAFE SC technology opens up completely new possibilities in the world of Beckhoff systems and offers a simple, efficient and inexpensive means to fully integrate all safety tasks into existing infrastructures.

With the aid of the TwinSAFE SC technology it is typically possible to achieve a safety level equivalent to PL d/Cat. 3 in accordance with EN ISO 13849-1 or SIL 2 in accordance with EN 62061. The following TwinSAFE-SC-EtherCAT Terminals from the fields of analog input, position (angle/displacement) measurement and communication are currently available to achieve this:

- EL3124-0090: 4-channel analog input terminal 4…20 mA, differential input, 16-bit
- EL3214-0090: 4-channel analog input terminal, PT100 (RTD) for 3-wire connection
- EL3314-0090: 4-channel analog input terminal, thermocouple with open-circuit recognition
- EL5021-0090: 1-channel sin/cos encoder interface, 1 $V_{pp}$
- EL5101-0090: Incremental encoder interface
- EL6224-0090: IO-Link terminal

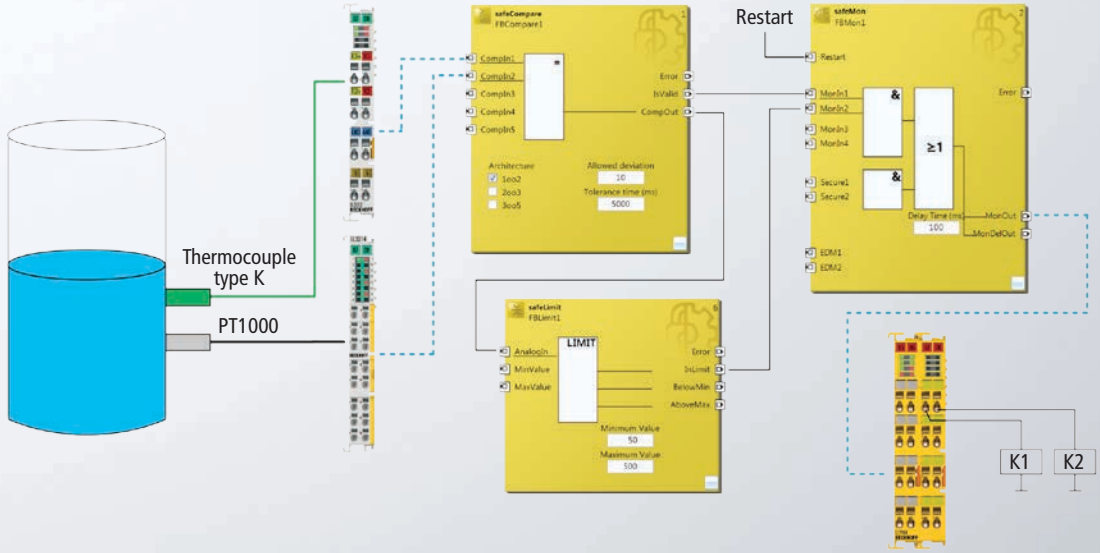
In addition to these there is the EP3174-0092 EtherCAT Box, which is a 4-channel analog input (±10 V or 0/4…20 mA, differential input, 16-bit) with IP 67 protection for decentralized installation directly on the machine.

## Example application for safe level measurement




Example application for safe level measurement with TwinSAFE SC (category 3, PL d): This shows how the level measurement in a container can be implemented with TwinSAFE SC technology. Two different measurement methods are used for this. First, an ultrasound sensor with a 0…10 V interface wired to an EP3174-0092 TwinSAFE SC EtherCAT Box and second, a level probe with a 4…20 mA interface wired to a standard EL3152 EtherCAT Terminal. These two signals are compared or checked for plausibility by means of a Compare function block within the safe EL6910 TwinSAFE Logic terminal. The signal from the EP3174-0092 EtherCAT Box is scaled by the Scale function block first so that both signals have an identical value range. Subsequently, the signal is checked by the Limit function block. The results of the Limit function block and the IsValid output of the Compare function block are used via the Mon function block to switch off the contactors K1 and K2. In addition, the StuckAtError output of the Scale function block can be connected to a Mon input. Therefore, unwanted freezing of the signal can be detected. To keep things clear the contactor control is not shown in this overview, but the user should keep it in mind.

## Example application for safe temperature monitoring




Example application for safe temperature monitoring with TwinSAFE SC (category 3, PL d): Here, two measuring points are equipped with temperature sensors, one with a type K thermocouple (wired to a standard EL3312 EtherCAT terminal) and the other with a PT1000 measuring resistance (wired to an EL3214-0090 TwinSAFE-SC-EtherCAT Terminal). These two signals are compared or checked for plausibility by means of a Compare function block within the safe EL6910 TwinSAFE Logic terminal. Subsequently, the signal is checked by means of the Limit function block. The results of the Limit function block and the IsValid output of the Compare function block are used via the Mon function block to switch off the contactors K1 and K2. To keep things clear the contactor control is not shown in this overview, but the user should keep it in mind.

Further information:

www.ima.de/en/

www.beckhoff.com/twinsafe-sc