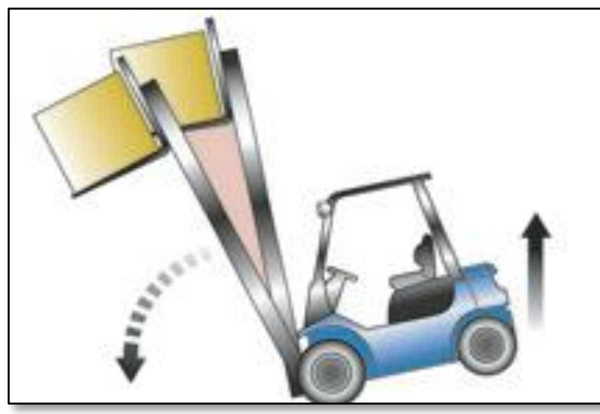
Reduce Accidents on Manned Forklifts with Integrated Stability Control

Preventing tip overs with cost-effective sensor technologies for a safer workplace and reduced product damage costs.

The Industrial Truck Association (ITA) estimates that there are nearly 856,000 forklifts in operation in the U.S. Annually, those vehicles are involved in more than 100,000 accidents—resulting in more than 94,000 injuries and 85 fatalities, according to the U.S. Occupational Health and Safety Administration (OSHA). Of those fatalities, 42% occur when the forklift crushes the driver as he or she attempts to jump off the tipping vehicle.



Forklift tip overs occur in one of two ways: laterally (side-to-side) or longitudinally (front-to-back). Preventing tip overs is a key component of standardized forklift driver training and safety procedures. The ANSI / ITSDF B56.1-2012 Safety Standard for Low Lift and High Lift Trucks place the responsibility for maintaining a vehicle's stability on the operator, with requirements as follows:

Section 4.4.4 - Stability
"…The amount of forward and rearward tilt to be used is governed by the application. The use of maximum rearward tilt is allowable under certain conditions, such as traveling with the load lowered."

Section 4.5.1.4 Exceptions
"… (b) The user may operate the truck without the overhead guard, provided all of the following conditions are met: (1) vertical movement of the lifting mechanism is restricted to 1,825 mm (72 in) or less from the ground…"

Section 5.3.18– Operating Safety Rules and Practices, Traveling
"… (a) An industrial truck, loaded or unloaded, may tip over if an operator fails to slow down to a safe speed before making turns."
"….(b) The likelihood of lateral tip over is increased under any of the following conditions, or combinations of them: (1) overloading, (2) traveling with the load elevated, (3) braking or accelerating sharply while turning, (4) rearward tilt or off-center positioning of the load..(6) traveling at excessive speed."

> "(c) Tipping forward can occur and its likelihood is increased under the following conditions, or combination of them: (1) overloading, (2) traveling with the load tilted forward and/or elevated, (3) hard braking while traveling forward, (4) suddenly accelerating while traveling in reverse."

The costs add up

Of course, no training procedure can completely mitigate the chance of human error. And mistakes can not only be deadly, they can also be costly. Should a forklift tip over cause damage to inventory, the replacement costs can far exceed the value of the damaged items. For example, if the value of a case of goods damaged by a forklift collision is $100, the cost to replace it must come from the margin on future sales. If the company makes a 1% margin on that case of goods, they must sell 100 additional cases to make up for a single damaged case.

To help further reduce the occurrence of forklift tip overs, a variety of sensor technologies can be integrated into several points on a vehicle. This white paper will explain the types of stability control sensors available for installation on manned forklifts, the most common applications, and key considerations when selecting a system.

How do stability control sensors work with forklifts?

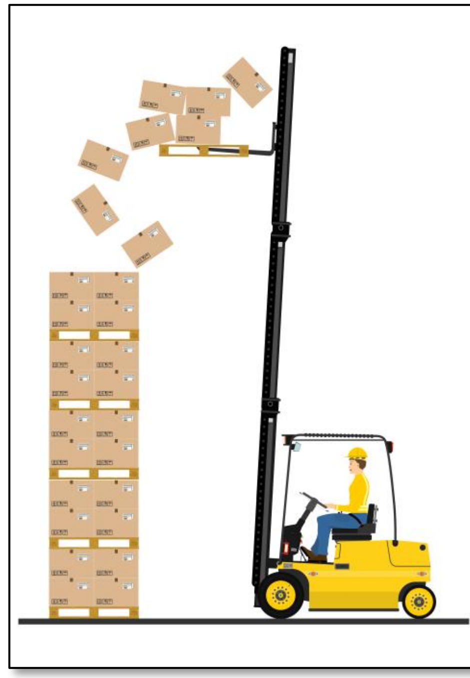
Stability control sensors continuously monitor a forklift's operation (such as speed, turns, and forward or reverse travel) to detect conditions that might lead to instability and increase the potential for the vehicle to tip over. The collected data is routed to an on-vehicle unit that processes and analyzes it in real-time.

When a sensor detects a particular preset trigger point or threshold, the forklift's control system automatically activates a corresponding correction to assist the operator in regaining control. Resulting actions can either limit the operator's control of a certain function (such as restricting the tilt angle of a mast, or limiting the top speed at which the vehicle can travel when loaded) or completely override the operator's action (such as preventing forklift height increases when a vehicle is traveling above certain speeds). Often, information from multiple sensors monitoring a variety of aspects is analyzed simultaneously and interlocked, forming the basis for the control to determine if (and what) automatic stabilizing actions are required.

Because of the resulting safety and product damage reduction benefits, there is growing interest in equipping forklifts with stability control technology. Systems are typically installed as an option offered on a new vehicle by the original equipment manufacturer (OEM) or, in some cases, at forklift dealer locations.

The most common types of sensors detect the following:

Fork Height: Thresholds are set for the maximum height to which forks can be raised for load pickup or placement at elevated heights, such as on racking. In addition to preventing a tip over by restricting the height to which a load can be raised, these sensors also reduce the risk of damage to pallets when picking due to the inherent accuracy of pre-determined fork height limits. Two different types of sensors can be employed to measure the distance of the forks to the ground:



- **Wire draw encoders** can be mounted on the forklift's mast. They utilize a metal measuring cable that is wound around a reel coupled to a rotational sensor. As the forks rise, the end of the cable rises with it while the encoder detects and determines the number of rotations made by the reel as the cable is unspooled. It generates digital signals about the rotations corresponding to the length of the extended cable, and provides an output that relates to the equivalent height of the forks.

- **Distance measurement sensors** project a laser beam spot of light onto the forks or the ground. Mounted at the top of a mast, the light is reflected back to the sensor, which calculates the position of the forks through laser triangulation. This type of measurement is non-contact and therefore low maintenance. It also produces highly accurate measurements, at tolerances within +/- 1 mm.

Travel Speed: Accidents can occur if the fork truck is traveling too fast with a load and turning sharply or if the load is at an improper height or tilt. Utilizing a closed loop feedback sensing system, forklift travel speed can be detected and measured. If the sensor determines that the speed exceeds a certain threshold, the vehicle's control system can automatically impose acceleration limits. **Incremental encoders** detect the mechanical motion of the vehicle's driveshaft. The encoder counts the revolutions the driveshaft makes and relays the information to the vehicle's control system.

Steering Angle: Also using a closed loop feedback sensing system, safe steering angle conditions can be verified. Based on certain conditions, the information detected can trigger turn angle limitations and other means to prevent a tip over. As with travel speed, **incremental encoders** or **absolute encoders** can be used to count the number of turns of the steering wheel then relay the information to the vehicle's control system. These sensors are placed near the steering shaft.

Mast Tilt Angle: To verify that the mast is not tilted past a safe range for optimum load (and forklift) stability, sensors determine either the distance a mast travels away from a set point (using a **distance measurement sensor** or **wire draw encoder**), or the absence of the mast via an **inductive sensor**, which detects the proximity of metal objects without touching them. When the metal mast is within the range of the inductive sensor, the sensor detects that its electromagnetic field has been interrupted. Should the mast pass out of the sensor's detection range, the information is relayed to the forklift's control system to trigger the corresponding stabilizing action.

Load Presence: Sometimes, the driver cannot see if a load is present in the racking. Beyond just load pickup verification within out-of-view racking slots, sensors that indicate whether or not a pallet or load is present on the forks can trigger the activation of automatic stability functions, such as limiting speed or steering angle. Two types of sensors, typically mounted near the base of the forks or on the mast within view of the load, are most commonly used for load presence detection:

- **Photoelectric sensors** utilize a photo eye to detect the absence or presence of the load by emitting a beam of light. The beam of light must reflect off the load (or pallet) back to the receiver to be detected.

- **Ultrasonic sensors** generate high frequency sound waves that bounce off a load on the forks back to the sensor, indicating the presence of the load. Once the load is detected, the driver can safely load it onto the forks.

Load Weight: By measuring the amount of hydraulic pressure exerted by a load on the vehicle's forks, **pressure sensors** provide either a primary determination of the load's weight, or a secondary verification of the weight recorded by an on-board forklift scale. The information transmitted by the sensor to the vehicle's control system can trigger stabilizing actions that may be required for heavier loads.

Vehicle Location: Forklift tip overs can also occur when a vehicle comes in contact with overhead obstacles, such as structural beams, fire protection sprinkler heads and doorways. To restrict access to, or trigger vehicle limits such as speed or mast height elevation in, certain areas of a facility, ultra-high frequency (UHF) **radio frequency identification (RFID) system** can be deployed. Tags are placed on the walls, floor, and structural uprights or ceiling of the building; readers are installed on the forklifts. The readers transmit an electromagnetic field to capture tag data. Based on the information the reader detects from the tag, it can transmit a message to the forklift's control system to implement the appropriate vehicle stability measures.

Summary
When considering forklift stability control systems, consider the following points:

- Method of detection used and its ability to function reliability in your facility (facility noise level, color variability of sensing targets, dusty or dirty environment, hot and cold temperatures, resilience vs. ambient light or reflective vests, etc.)
- Sensing distance and accuracy
- Sensor data and diagnostics, e.g., dirty lens output, analog output
- Sensing device size and its position on the vehicle
- Power requirements of the system and how it may (or may not) impact forklift battery draw and run time
- The action that the sensing device should trigger (either limiting or overriding an operator's actions)

Need more insights into how to select the right stability control technology for your manned forklift fleet? Contact Jeff Wuendry at SICK. Email jeff.wuendry@sick.com or call us at 800-325-7425.