Introduction of Products

Collision Detection Alarm System for Utility Products

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A certain number of disasters that involve fork lifts, which are utilized in a diverse and variety of industries, are occurring each year, which are fatal in some instances. As a means to respond to such situation and reduce the number of collision incidents that involve fork lifts, a "collision detection alarm system", which requires no sensors or tags for targeting and limits erroneous triggering of alarms was developed and introduced to the market. This system is capable of responding to a variety of operating environments, with a combination of a standard millimeter-wave radar that can be used in a wide range of environments and travel trajectory estimation feature, principal features of which are introduced here.

Key Words: *FE, Collision detection alarm system, Radar, Safety, Information and communication technology (ICT), Detection, Alarm, Retrofit*

1. Introduction

Fork lifts are essential industrial machines for the logistics industry, and they are operating in a diverse range of industries and work sites. Unfortunately, however, there is a certain number of disasters in which fork lifts are involved in every year, some of which are fatal.

Safety support devices for avoiding collision accidents and reducing damages are starting to become popular in the automobile industry, and there is a raised level of need for such safety support devices in the fork life field as well.

Fig. 1 FE25/25H/30-1 Collision detection alarm system installed vehicles
(excerpted from Safety Booklet)

Fig. 2 FE25/30-2 Collision detection alarm system installed vehicles
(excerpted from Safety Booklet)

2. Aims of development and means of achievement

The operating work sites of fork lifts consist of people and objects that are mixed in an area, and passages are narrow at some work sites, which makes such work sites environments that are prone to collisions with people and objects.

Vehicle status at the time of fatal accidents involving a traveling vehicle can be classified into forward driving, reversing and others (such as vehicle runaways resulting from the operator getting off the seat or forgetting to engage the parking brake, etc.), and it appears there is no deviation in terms of occurrence frequency to any of these categories and we came to the understanding that accidents are occurring under all circumstances.

When reversing, the operator turns around and looks to the back of the vehicle and drives while directly visually verifying that direction, but the recognition about dangers of collisions with the surrounding tends to be delayed or in some cases the operator remains unaware, which is believed to lead to accidents. The decision was made to first seek reduction of collision damages that arise while reversing, then to work on forward driving and so on, to respond to this need in stages.

Based on this policy, the “collision detection alarm system” safety support device was developed, with the aim of reducing collision accident damages by installing this system on fork lifts.

An overview and features of the “collision detection alarm system” are introduced below.

(1) Alarm triggered by detecting danger of collision while reversing
- Alarm lamp and alarm buzzer alert the operator
- Two-staged alarm according to the risk level of collision

(2) Submillimeter wave radar type
- Detection capable under various environmental conditions
- Detects relative speed and distance with respect to the target
- Tags and sensors not necessary to detect targets

(3) Alarm range linked with advancing direction and traveling speed
- An alarm is triggered when there is danger of collision in the anticipated advancing direction (reduction of false alarms)

(4) Daily inspection mode
- An inspection mode that can be easily implemented by operators

(5) Temporarily Disable switch
- The alarm system can be temporarily disabled

3. Major features

The collision detection alarm system was developed for FE25/25H/30-1, as well as FE25/30-2 respectively as an option for new vehicles but a retrofitting system for vehicles (FE25/30-2 that are already in use by customers is also currently in development).

The system launches automatically simply by turning the key ON, making it possible for anyone to use it easily, and without any special technical skills or knowledge.

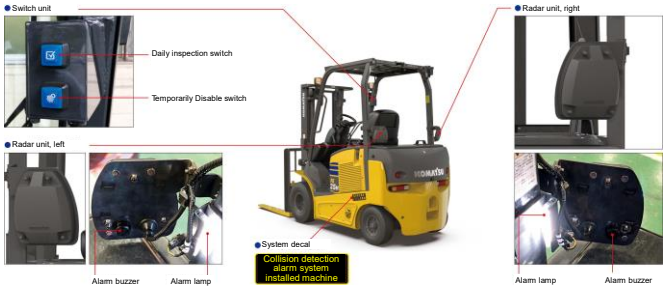


Fig. 3 External appearance of collision detection alarm system (FE25/25H/30-1)
(excerpted from Safety Booklet)

3.1 Alarm triggered by detecting danger of collision while reversing

3.1.1 Alarm lamp and alarm buzzer alert the operator

Two units of submillimeter wave radar units are installed at the rear of a vehicle for this collision detection alarm system, to detect people and obstacles in the rear of the vehicle across a broad range with high precision. In the event there is risk of collision, the alarm lamp and the alarm buzzer are triggered to alert the operator.

Fig. 4 Alarm lamp/alarm buzzer (FE25/30-2)
(excerpted from Safety Booklet)

3.1.2 Two-staged alarm according to the risk level of collision

The range is set up in two stages, namely a caution range and a warning range, depending on the distance of the vehicle from detected objects (risk level of collision). In the event a person or an object is detected within the caution range, the alarm buzzer sounds twice every second intermittently, also the alarm lamp flashes twice every second intermittently. The alarm buzzer sounds four times every second and the alarm lamp also flashes four times every second in the warning range, to convey the operator of a higher degree of danger.

Fig. 5 Caution range
(excerpted from Safety Booklet)

Fig. 6 Warning range
(excerpted from Safety Booklet)

3.2 Submillimeter wave radar

3.2.1 Detection capable under various environmental conditions

An aim for the development of the collision detection alarm system is to create a system with less incidents of false alarms. False alarms, as referred to here, are alarms that are triggered even in a situation where there is no risk of a collision. When there are too many false alarms, it is conceivable that the operator becomes accustomed to hearing the alarm, and the system no longer fulfills the role of alerting the operator.

A submillimeter wave radar, which is less likely to be affected by weather conditions in comparison with sensors that are already in practical implementation, such as conventional cameras and ultrasonic waves, was adopted in order to achieve reduced number of false alarms.

3.2.2 Detects relative speed and distance with respect to the target

A submillimeter wave radar continuously sends radio waves in the frequency range of 24 GHz to detect the relative speed and distance of the target, based on the comparison between the transmitted waves and reflected waves. Its detecting performance and their insusceptibility to external factors make it essential component for the collision detection alarm system.

Fig. 7 Submillimeter wave radar
(excerpted from Safety Booklet)

3.2.3 Tags and sensors not necessary to detect targets

A submillimeter wave radar does not require any special tags or sensors to detect targets, due to the operating principle described above. Since the radar detects humans, cargos, working vehicles and the like, the collision detection alarm system can be used without making any special preparations at the work site where the fork lift is operated.

Fig. 8 Detects proximity of vehicle with people (excerpted from Safety Booklet)

Fig. 9 Detects proximity of vehicle with cargo (excerpted from Safety Booklet)

Fig. 10 Detects proximity of vehicle with another vehicle (excerpted from Safety Booklet)

3.3 Alarm range linked with advancing direction and traveling speed

3.3.1 An alarm is presented when there is danger of collision in the anticipated advancing direction (reduction of false alarms)

The alarm range of the collision detection alarm system is linked with the advancing direction and traveling speed. Furthermore, the alarm is triggered only when the parking brake is in the released position and the directional lever is set to the reverse (R).

When the vehicle is stopped, the distance of approximately 1 m to 3 m directly behind the vehicle becomes the alarm range and the system triggers alarm for the risk of collision if there is risk of collision when the vehicle starts to move. The alarm width is about 2 m, but this can be changed in three stages of about 1.5 m, about 2 m and about 3 m, to suit the circumstances of the work site environment or how the vehicle is being operated (variable alarm width available only with FE25/30-2).

When the vehicle is reversing, depending on the traveling speed, from about 1 m to maximum of 8 m directly behind the vehicle (for FE25/30-2; maximum is 6 m for FE25/25H/30-1) becomes the alarm range. When reversing straight back, the alarm range is at the rear of the vehicle and when turning the alarm range is along the advancing direction of the vehicle. The alarm width is about 2 m just like when the vehicle is stopped, and this can be changed in three stages of about 1.5 m, about 2 m and about 3 m (just as with stopped vehicle, this change is available only with FE25/30-2).

Positions of detected objects and the path, which is estimated based on the vehicle advancing direction, are combined to determine whether or not an alarm is warranted, and an alarm is triggered only when an alert is deemed truly necessary, to reduce unnecessary alarms with no threat of collisions (false alarms) to improve the alarm precision.

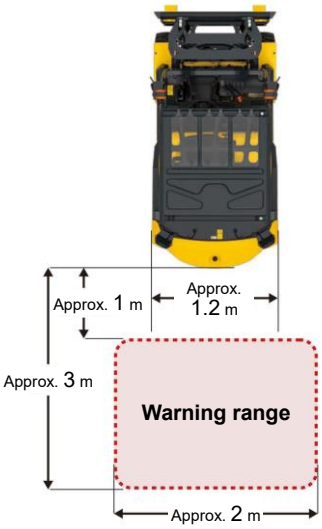


Fig. 11 Alarm range when vehicle is stopped
(excerpted from Safety Booklet)

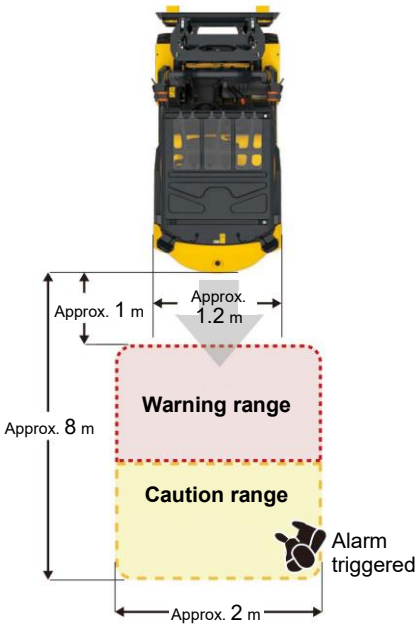


Fig. 12 Alarm range when vehicle is reversing (traveling straight) (FE25/30-2)
(excerpted from Safety Booklet)

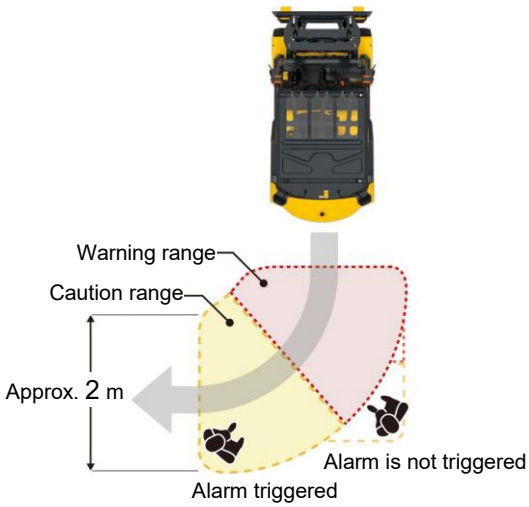


Fig. 13 Alarm range when vehicle is reversing (and turning)
(excerpted from Safety Booklet)

Fig. 14 Alarm range width
(variable in three stages only with FE25/30-2)
(excerpted from Safety Booklet)

3.4 Daily inspection mode

3.4.1 An inspection mode that can be easily implemented by operators

A daily inspection mode is available to verify if the collision detection alarm system is operating normally. The daily inspection mode can be operated from the Daily Inspection switch on the switch unit that is installed on FE25/25H/30-1, or from the multi monitor on FE25/30-2. The operator walks past the rear of the vehicle to verify if the system is detecting the operator.

Once in the daily inspection mode, the alarm lamp on the left and right, as well as the alarm buzzer are triggered intermittently once every second. When the radar detects the operator crossing behind the vehicle, the alarm lamp on the side of the detecting radar changes from flashing to lighting up. When the operator continues to walk across and is detected by the other radar, both alarm buzzers and alarm lamps are triggered for five seconds, then the daily inspection is completed to confirm that there is nothing wrong with the system.

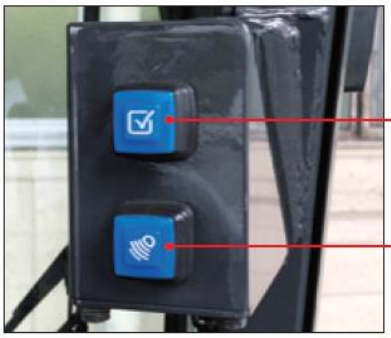


Fig. 15 Switch unit (FE25/25H/30-1)
(excerpted from Safety Booklet)

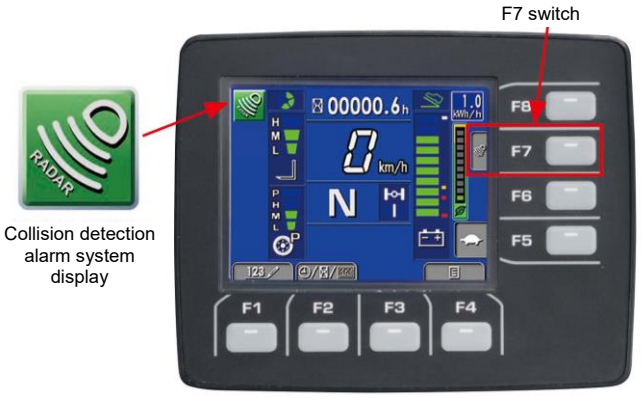
3.5 Temporarily Disable switch

3.5.1 The alarm system can be temporarily disabled

The alarm system can be disabled temporarily in situations where temporarily disabling alarms triggered by collision detection alarm system is desired, such as when working in narrow locations where the vehicle can hardly pass through, or when performing work while remaining in close proximity to a wall.

In case of FE25/25H/30-1, the Temporarily Disable switch on the switch unit is used, while on FE25/30-2, the F7 button on the multi monitor is pressed to temporarily disable the alarm system. In order to enable the system once again, press the same button one more time to restore the alarm system. Furthermore, the mechanism is such that even when the key is turned OFF with the alarm system still disabled, the alarm system starts up when the key is turned ON again, to avoid any problem arising from forgetting to enable the system.

When the alarm system is temporarily disabled, the lamp on the Temporarily Disable switch or the icon at the left upper section of the monitor flashes, while they remain turned on when the alarm system is operating, to facilitate verification on the operating status of the alarm system.



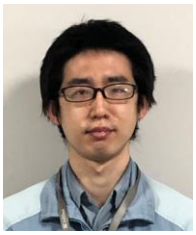
Lit state	Status of collision detection alarm system
Lit	Starting up
Flashes	Temporarily stopped

Fig. 16 Multi monitor (FE25/30-2)
(excerpted from Safety Booklet)

4. Conclusion

This paper introduced the collision detection alarm system for utility products introduced to the domestic market in Japan since 2020. It is hoped that incidents of collision accidents involving fork lifts will decrease, as the installation of this system on FE25/25H/30-1 and FE25/30-2 progresses.

Introduction of the authors



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[A comment from the authors]

During the course of the development for this product, we encountered many aspects for which we had no experience with, yet we achieved market introduction thanks to assistance from a large number of people. We intend to continue with product development in the future, with cooperation of relevant departments.