



1 Crash protector with integrated sensor.

## CRASH SENSOR FOR MORE SAFETY IN WAREHOUSES

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### Application

According to the safety-at-work regulations storage racks in warehouses must be regularly inspected as the standard EN 15635 specifies. But these inspections are time-consuming and provide only a snapshot of the current state. A more effective and reliable security will be achieved by a new monitoring system that has been developed by researchers of the Fraunhofer IMS in cooperation with the company IWS Handling GmbH. Using a wireless sensor network the state of each pillar of a rack can be monitored continuously.

Typically the pillars of a rack are equipped with a kind of air cushion as a crash protection, so that collisions are partially absorbed. In the new developed system sensors are integrated that measure the air pressure within the cushion. If a protector is compressed by a collision, the sensor will take notice of the event and report it to a central monitoring unit. In case of large areas so called repeaters, that are located at several locations within a warehouse, receive the

messages generated by the sensor nodes and forward them to the central unit.

For surveillance only a view on the display of the central unit is necessary in order to get information if and where collisions in the warehouse have occurred. Additionally the system indicates whether a collision has been harmless, medium-heavy or serious.

A central item of the development was the energy management of the system. The use of a monitoring system like this will only be reasonable, if batteries are not to be necessarily replaced after a short period of operation. Therefore the system has been designed in that way, that the sensor nodes are in »sleep mode« most of the time. Any pressure variation wakes up the electronics inside. Additionally after specified time intervals, which can be individually configured, every sensor node transmits a »sign of life« message containing its current state to a repeater. Using this mechanism it can be assured that a deficiency of a sensor node will be indicated at the central unit and cannot be kept unnoticed.





## Technical Implementation

The system is composed of three types of components that communicate using the UHF ISM frequency band:

- The electronic unit for the pressure measurement integrated in the crash protector, also called »sensor-box«
- A base station consisting of a hand-held computer supplemented by an application specific hardware
- Repeater which ensures the information routing between sensor-boxes and the base station

### Sensor-Box

For monitoring purposes within the air cushion a special electronic solution has been developed which has the task to detect crash events using a minimum of energy. Internally each sensor-box has a pressure sensor that can measure pressure variations up to 200 kPa (2 bar). The sensor-box is activated in case of a pressure modification and determines the maximum pressure value of this event. It transmits the related data via UHF message and returns to the sleep-mode afterwards. For configuration purposes the sensor-box has an additional wireless interface (low-frequency) to enter a dedicated configuration mode.

### Base Station

The complete system is managed by a hand-held computer. It is provided with an UHF wireless interface and an additional LF transmitter as well for the configuration of sensor-boxes. If data messages initiated by

crash events or sign-of-life messages are received, the analysis of the information will be done by the software of the base station. Typically there is a fixed location for the base station, for example in the warehouse manager's office. But for configuration purposes the base station can also be used in a mobile way.

### Repeater

Repeaters are used to increase the operating distance between sensor-boxes and the base station. A Repeater consists of an UHF transceiver module, a microcontroller and sufficient memory for the intermediate storage of messages. Repeaters have fixed positions and are therefore power supplied by mains adapters.

### Wireless Communication Protocol

The typical site of operation for the crash sensor system is a large warehouse that has a many rack pillars, which have to be monitored continuously. If all pillars are equipped with air cushions, hundreds or even thousands of sensor-boxes can be used for the system. Therefore the wireless communication protocol has been designed for a reliable operation with a large number of sensors.

## Technical Data

### Sensor-box

Wireless range	approx. 100 m
Frequency band	UHF ISM Band Europe & USA
Transmission power	max. +10 dBm
LF wake-up range	max. 50 cm
Pressure sensor	max. 200 kPa
Power supply	2 AA batteries
Battery lifetime	min. 3 years
Operation temperature	0 °C – +55 °C

### Repeater

Frequency band	UHF ISM Band Europa & USA
Transmission power	max. +10 dBm
Wireless range	approx. 100 m
Operation temperature	0 °C – +55 °C
Power supply	230/110 V, 50/60 Hz

### Base Station

Type	PSION Teklogix »WORKABOUT PRO« with add-on PCB by Fraunhofer IMS
Frequency band	UHF ISM Band Europe & USA
LF wireless module	133 kHz
Power supply	Li-ion recharge- able battery
Interface	USB
Operation temperature	0 °C – +50 °C

2 Base station.

3 Crash situation.