7TH INTERNATIONAL CONFERENCE ON SUSTAINABLE SOLID WASTE MANAGEMENT



INCLEASICURAZIONE ISTITUTO NAZIONALE PER L'ASSICURAZIONE CONTRO GLI INFORTUNI SUL LAVORO

Using smart PPE in waste management: advantages and disadvantages

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Index Using smart PPE in waste management: advantages and disadvantages



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Introduction

INAIL is the only Italian authority able to operate for health and safety protection in workplaces, also undertaking several **scientific research** and **prevention projects**.





Introduction: risks for workers in Waste management



Road accider

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extreme climatic conditions





Cuts and abra sions





waste landsli

> Chemical burr



Entrapment in moving parts of machinery

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Introduction: Personal Protective Equipment

Risk controls to be adopted



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Workers in SWM are required to use PPE including: *Respiratory* Protective Equipment (RPE), protective *clothing* with high visibility features and/or rain, heat or cold protection, *gloves*, *safety helmet*, safety footwear, ear and eye protection.

SMART Personal Protective Equipment

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solutions to enhance product multi-functionality".

SMART Personal Protective Equipment: Introduction

In other words, smart PPE are designed using industry 4.0 technologies.

The <u>aim</u> of the use of smart PPE is to:



 provide better safety;
increase PPE's performances/functions;
reduces long term cost,
improves workers productivity/efficiency.

Smart PPE can be defined as "Advanced Personal Protective Equipment, integrating materials (e.g.

technical textiles and smart materials), components and Information Communication Technology



Some EU programmes underline that <u>Industry</u> <u>4.0</u> devices <u>can be used to improve</u> health and safety <u>protection for workers</u> and population.

Overview of SMART PPE: Smart Wearable

- 1. Worker's GPS location,
- 2. Communication with the worker,
- 3. Monitoring worker's physical conditions
- 4. Monitoring environmental workplace conditions
- 5. PPE heating/cooling according to the environmental temperature
- 6. PPE operating as an emergency stop nearby hazardous equipment
- 7. Luminescent materials or lighting signals as notice or help request.



Smart

phone

Sensors

Situatio

room

Overview of SMART PPE: Communicating wearable to device

The system bases on a smartphone to transmit data and on Bluetooth TAGs applied to PPE as sensors. These are the most used.

- 1. Check of the PPE foreseen and inhibition of the beginning of work
- 2. Sound alarm in the case of non-detection of PPE
- 3. Possibility to exclude or add particular PPE
- 4. Emergency key for the operator (with infos on worker's GPS position)
- 5. Sending events/alarms in real time to a central office.

Overview of SMART PPE: RFId access control or inhibition

- 1. authorizes the worker to access.
- APPLICATIONS 2. verifies and certifies the correct use of PPE by the worker,
- 3. defines "insurmountable" areas (after which it blocks the machinery, signals the alarm etc.) to protect the worker.

Overview of SMART PPE: RFId/Bluetooth interaction with hazardous equipment



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Overview of SMART PPE: Face recognition and optical area control

- 1.Check entry into a "restricted access" area;
- 2.verify workers' identity;
- 3.authorize the worker to pass;
- 4. activate specific functions if interfaced with PPE.





Overview of SMART PPE: Physical Safety Information Management (PSIM)

These systems provide, due to the data collection coming from Smart PPE and Smart Collective Protective Measures, to analyse situations for preventing *near miss* or *abnormal situations*.



Overview of SMART PPE: Smart Textile with printed circuit boards/conductive ink

With these textiles is possible to integrate directly into the protective clothing electric circuits composed of conductive sections, resistances and capacitors.

Equipped with sensors, these circuits:

- 1.collect biometric informations (heart rate, body temperature, etc.);
- 2.detect tissue tension;
- 3.detect localized muscular effort;
- 4.detect breathing.







Overview of SMART PPE: collect data through the wearable

Beingoes of protective clothing were developed which, thanks to a smart textile with electrical circuits combined with sensors, <u>collect data and store</u> <u>it on an external device</u>. The aim is to:

1.prevent possible accidents,

- 2.highlight worker's unfavourable physical condition
- 3.study the state of health



Overview of SMART PPE: Smart wearable to "feel" the hazards

Some smart wearables help workers with sensory problems (deafness, blindness, cognitive difficulties, ...) or in places where it is difficult to perceive optical or acoustic signals:

- 1. "feel" the hazard approaching by vibrating/lightning;
- 2. hear an alarm signal;

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3. "feel" the intensity of a risk not perceptible to the senses (electromagnetic fields, ionizing radiations, odorless gas, absence of oxygen, ...)



Overview of SMART PPE: Smart wearable to "wear" virtual reality

Some smart protective clothing have **integrated various movement sensors**, to assess the position of the wearer and communicate it to a SW **to provide physical feedback of what happens in virtual reality** through miniaturized actuators.

E.g. The wearer could feel vibrations or hurts on one arm if struck.

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Overview of SMART PPE: Augmented Reality

TOP

- The AR provides useful information:
- 1.to reduce risks during the field training;
- 2.for the worker who has to perform complex tasks on dangerous machinery;
- 3. To help during training course.

Overview of SMART PPE: Virtual reality

- The VR is fundamental for a:
- 1.Simulate hazardous situations;
- 2.Zero-risks training in hazardous conditions;
- 3.Check reactions in extreme conditions.



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Advantages and Disadvantages

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Advantages linked to the introduction of smart PPE in SWM 1/2

- •<u>Real time health monitoring</u> through sensors. Useful in contexts where workers are alone, isolated or in confined spaces;
- •<u>Real time environmental monitoring</u> through sensors. If an hazardous situation is detected, the worker will be alerted or countermeasures will be activated;
- •<u>Wireless</u> Bluetooth, Wi-Fi or RFid based <u>communication</u> technologies allow smart PPE <u>to</u> <u>exchange information detected</u>: Device to Device (D2D), Device to Human (D2H) or Human to human.
- •Smart DPI can prevent workers from accidents by <u>communicating wireless to systems and</u> <u>machinery [Device to Other (D2X)]</u> for emergency stop.
- •<u>Checking correct use of PPE</u>. Sensors installed on PPE allow to check whether the PPE is worn and it is worn correctly.
- •<u>Real time positioning in case of emergency</u>, useful when the workers are alone or in emergency situations;
- •<u>Easy authorization for access basing on GPS/wireless technology</u> to specific areas or control which read how many workers are present in the area for safety reasons.

Advantages linked to the introduction of smart PPE in SWM 2/2

- •smart PPE can ensure greater climatic comfort to worker by reacting to adverse climate conditions, basing on data from climatic sensors (usually heating or freezing protective clothing).
- •Smart PPE can <u>actively react to some hazards</u> detected by sensors to protect the worker or to give a warning signal in proximity to a hazard;
- •Some protective clothing provide <u>additional features or higher levels of protection due</u> to the <u>innovative features of smart textile</u>.
- •Smart PPE and Physical Safety Information Management can give <u>hazards awareness</u>, forecast and <u>warning</u> to prevent accidents at work;
- •The technologies associated with Augmented Reality (AR) can provide <u>additional information on the</u> <u>risks</u>, <u>on work activities and workplaces</u> and <u>help during training courses</u>.
- •The technologies associated with Virtual Reality (VR) allow to <u>perform a Zero-risks training</u> or <u>to</u> <u>simulate highly risky situations</u> or <u>to check reactions in extreme conditions</u>.

Disadvantages linked to the introduction of smart PPE in SWM 1/2

- •For some workers <u>training and use</u> of smart PPE <u>could be problematic or longer because of</u> <u>their complex functions</u>.
- •<u>The respect of workers' privacy</u> is a crucial point in smart PPE assessment. Data provided by these objects may relate to the worker's health, physical and mental state and position during the working time (when using Smart PPE). These are private information according to EU Privacy Regulation;
- •Smart PPE can be affected by <u>failures because of their</u> electronic components which allow <u>complex systems</u> with many functions;
- •<u>extreme environmental conditions in workplaces can lead to failures or malfunctions</u> of Smart PPE being these electronic devices/complex systems.
- •<u>Smart sensors</u>, being measurement systems, are affected by <u>precision errors and uncertainty</u> of environmental and health measures.
- •<u>wireless communication/functionality depending on 3G/4G network</u>. Functionality of Smart PPE using GSM network depend on signal reception.

Disadvantages linked to the introduction of smart PPE in SWM 2/2

- •Every equipment that use <u>radio signals produces electromagnetic fields</u> that could interfere with the worker (medical devices). Consider that PPE is generally in strict contact with the worker body.
- •The variability of <u>wireless communications are affected by interferences and distance</u>. Therefore, the system should be required to verify the correctness of the signal.
- •The position of workers, based on the <u>GPS signal, has a low resolution</u> with an error of even some meters. The EU "Galileo" system and 5G communication technology will allow greater precision.
- •The presence of electronic circuits, complex systems and additional features <u>increase the costs</u> of PPE compared to the standard ones. Over time, these costs are likely to reduce.

Comparison between advantages and disadvantages of using smart PPE in each phase of SWM

Advantages	Collection	Transport	Recovery	Disposal	Monitoring
Health monitoring;	Х	Х			
Real time environmental monitoring;			Х	Х	
Wireless communication Device to Device (D2D);	Х		Х	Х	
Wireless communication Device to Other (D2X);	Х	Х	Х	Х	
Checking correct use of PPE;	Х		Х	Х	
Real time positioning in case of emergency;	Х	Х			Х
Authorized access based on GPS/wireless technology;	Х	Х			Х
Reacting to adverse climate conditions;	Х	Х		Х	
Disadvantages	Collection	Transport	Recovery	Disposal	Monitoring
Complex training and use;	Х	Х	Х	Х	Х
Respect of privacy rules;	Х	Х			Х
Failures of complex technological devices;	Х	Х	Х	Х	Х
Failures due to extreme environmental conditions;	Х	Х			
Uncertainty of environmental and health measures;	Х	Х			Х
Wireless communication depending on 3G/4G network;	Х	Х			Х
Production of electromagnetic fields;			Х	Х	Х
Reliability on wireless communication;	Х	Х			Х
Low resolution of positioning GPS based;					X
High costs.	X	Х	X	Х	Х

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Inail's project

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Industry 4.0 should be an equal opportunity for innovation; however, it often creates differences among companies for resources and experience.

Inail is developing <u>a new Smart PPE</u>:

- 1. With few and relatively cheap components;
- 2. Uses a specific software and hardware;
- 3. Able to transform any standard PPE into a "Smart PPE";
- 4. Able to detect a large number of hazards;
- 5. With many changeable sensors;
- 6. Able to "react" to the hazard.

The system is still under patenting, so cannot be provided the details of the project. The idea is to give it free for everyone in the future.



Conclusions

Improve safety in SWM through the use of Industry 4.0 technologies means:



- 1. Improving workers' efficiency;
- 2. time savings;

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- 3. long term costs saving for companies;
- 4. Reduction of accidents and diseases;
- 5. More safety for workers;
- 6. A <u>360° sustainable policy</u> in SWM

Why do not choose a safer way?



Thank you for ...

... your kind attention!

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