

Application of Wristband type wearable sensor MS200 for Occupational safety and health

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Abstract:

Nowadays, the incidence of heat stroke has been increasing, and the fall accident is the most common workplace accident. Under increasing the demand for work environment improvement, we have developed a wristband-type wearable sensor that assesses the risk of heat stress quantitatively and detects and issues alerts for fall accident from high height working site. By utilizing IoT management, we provide a good work environment and an accident response methods.

Keywords:

Wristband type wearable Sensor, Wearable terminal, Heatstroke, Fall detection, Safety, Productivity, Health, ICT, Biological information, Monitoring system

1. INTRODUCTION

Field sensors are used in a wide range of fields, including water supply and sewerage, steel, paper and pulp, and chemicals, and we have previously offered a lineup of devices that measure the physical quantities (flow rate, concentration, pressure, temperature, etc.) of processes in each field. In recent years, there has been an increasing demand for sensing for the purpose of managing the work environment and ensuring safety for each field worker. Based on the technology we have cultivated in industrial field sensors, we have developed a wristband-type wearable sensor, the MS200, which can contribute to control the work environment and the accident prevention. This sensor estimates the heat stress level felt by each worker working in a high-temperature environment from sensing information that takes into account not only temperature and humidity but also pulse rate and body movement. This article describes the current situation of demand for heat stress treatment and fall accident detection, and the MS200's efforts in addressing these issues.

under hot conditions where heatstroke may occur, the employers shall be demanded "establish a system for early detection," "create procedures for implementing measures to prevent the condition from becoming serious," and "inform relevant workers" (3). From such circumstances, the need for heatstroke prevention measures for site workers is increasing.

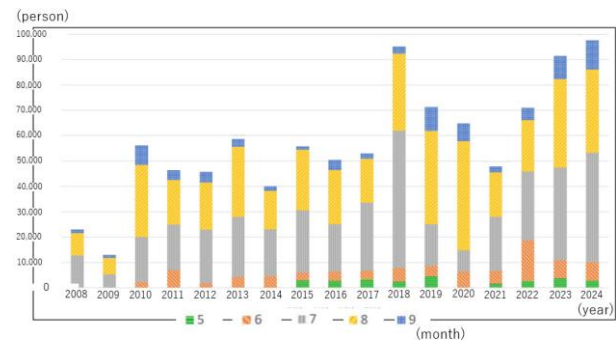


Figure 1. Emergency transport situation due to heat stroke in summer (May. ~ Sep.)

2. FIELD WORK CHALLENGES

2.1 The threat of heatstroke

In Japan, the summer is hot and humid, and in recent years, due to global warming, many deaths and injuries due to heatstroke occur every year. Figure 1 (1) shows the situation of emergency transport due to heatstroke in the summer from 2008 to 2024, and the number of transports is increasing every year. Also, as shown in Figure 2 (2), by industry, the majority of casualty cases occurred in the construction, manufacturing, and transportation industries, and it can be seen that there are many casualties among site workers. The Ministry of Health, Labor and Welfare had issued the revised Industrial Safety and Health Regulations to strengthen measures to prevent fatal accidents due to heatstroke, and it will be activated from June 2025, which is that when working

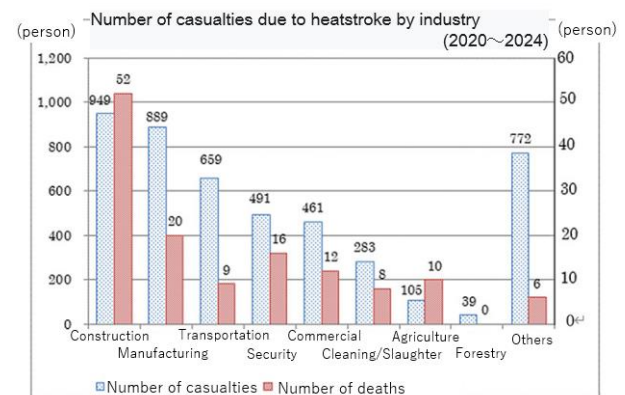


Figure 2. Number of casualties due to heatstroke by industry

2.2 The dangers of working at height

The largest number of fatalities and injuries from industrial accidents is due to falls. Falling accidents are often caused by working at high height site or on unstable scaffolding, and occur frequently in industries such as construction, manufacturing, and transportation. Figure 3⁽⁴⁾ shows the types of accidents and the number of fatalities and injuries by industry.

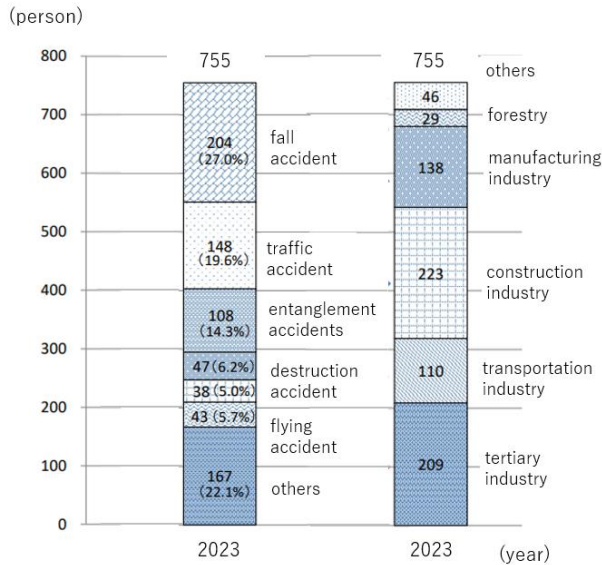


Figure 3. Number of casualties by type of disaster accident and industry in 2023

In order to prevent frequent accidents among on-site workers, it is necessary to make the work environment safe and thoroughly to manage the health of workers.

3. APPROACH TO THE TASK

3.1 Heat stroke measures

There are various countermeasures for heatstroke, and one of these are the items in Table 1 generally.

Table 1. Examples of countermeasure for heatstroke

Classification	Countermeasure
Work environment	Obtaining environment information Measuring and informing WBGT value Reducing WBGT value Maintaining break room
Work Management	Shortening of work hour Water and salt intakes Wearing breathable work clothes
Health care	Checking worker's health Site patrol Using health check sheet
Education	Safety education about heart stroke

On the other hand, the risk of heatstroke varies depending on the individual worker's condition, such as age, physique, lifestyle, etc. It is difficult to estimate the risk of heatstroke for all workers based on the common standards or methods, and it is essential to assess the risk

according to the condition and environment of each worker. Therefore, since the judgment of heatstroke risk differs from person to person with its work condition, a quantitative judgment method and criteria for each worker are required. Namely by monitoring the temperature and humidity around the worker in real time and collecting data such as the body surface (in the wear) temperature and heart rate of individual workers, which make it possible to perform more accurate and quantitative risk assessments based on the amount and intensity of work. MS200 uses the term 'heat stress' which involves more quantitative management (risk assessment).

3.2 Measures to accidents while working at height

When treating a happened fall accident while working at high height site, although it is necessary to take measures to prevent the secondary accident from happening firstly, but it is also important to respond the occurred accident. First of all, speed is important, and it is required to take appropriate treatments as soon as possible. For example, if a worker who has fallen has lost consciousness, it is necessary to immediately call an ambulance and administer first aid. It is also important to quickly inform surrounding workers that an accident has occurred. This will enable other workers to take appropriate action and prevent secondary disasters. Next, it is important to determine in advance the chain of command in the event of an accident.

When dealing with a fall accident from high height work site, three elements are important: preventative measures, rapid response in the event of an accident, and measures to prevent recurrence after the accident. By taking these measures thoroughly, it can enable both the safety of workers and the prevention of industrial accidents.

4. MEASURES AGAINST HEAT STRESS AND FALL ACCIDENTS

To assess each worker's heat stress timely and to detect fall accidents quickly, we provide the wristband-type wearable sensor MS200.



Picture 1. Wristband type wearable sensor MS200

The displaying items from top to bottom are time clock, remaining battery level, fall detection information, heat stress level (0-4) with facial expressions, WBGT equivalent value, and pulse rate. In addition to the functions of heat stress level assessment and its alert functions, this device also has the functions of height detection, fall detection, and fall alert. Figure 4 shows the displaying for the fall detection function status. Blue one will appear after the fall detection function ON, and it will turn Red when the altitude gap between current and the reference (see 4.2) exceeds 1.5m or more.

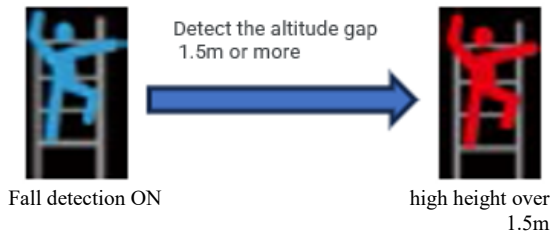


Figure 4. Fall detection function status

4.1 Heat stress level measurement

This product senses not only environmental factors such as temperature and humidity but also pulse waves from a pulse sensor and movement volume from an acceleration sensor, and to assess the workload and physical movement status of each worker. In addition, based on individual data such as height, weight, and lifestyle habits, MS200 calculates and displays the heat stress level (0: normal to 4: extremely high) based on our own unique criteria and algorithm. Namely it is possible to calculate the heat stress level based on quantitative criteria after assessing own status of each worker under current situation.

Japan's summer climate is characterized by high temperature and humidity, which significantly increases the risk of heat-related illness among workers. Conventional management methods based solely on environmental factors such as temperature and humidity often result in frequent "danger" assessments. Figure 5 shows the result of assuming the case which it was managed only by the data of temperature and humidity. The ratio of "Almost safe" is 1% of the whole. Thus, in case that it was managed uniformly only by temperature and humidity in environment of high temperature and high humidity like summer in Japan, since the ratio of "Almost safe" is low, workers need to worry that there is a safety risk and take a break very often. Consequently, in this management, although safety is secured, productivity is decreased. In contrast, field testing of MS100 (predecessor to MS200) demonstrated the effectiveness of individualized heat stress monitoring. As shown in Figure 6, 92% of the data recorded indicated a "heat stress level 0." This suggests that workers were able to take breaks appropriately based on their personal condition, maintaining safety while maximizing productivity. Furthermore, no health issues were reported

during the test period, confirming that the system did not overestimate safety risks. These findings support the conclusion that personalized heat stress management using wearable sensors is a practical and efficient solution for balancing safety and productivity in harsh working environments.

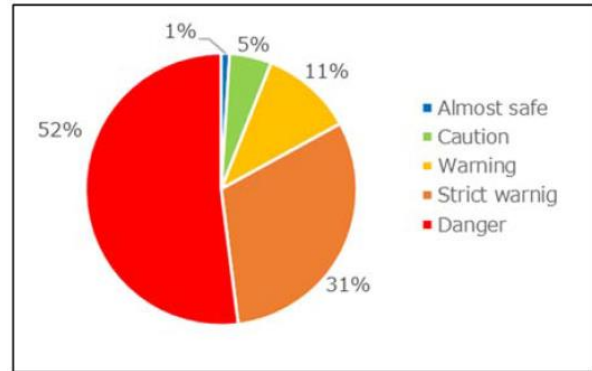


Figure 5. Result of Field test (managed by only temperature and humidity)

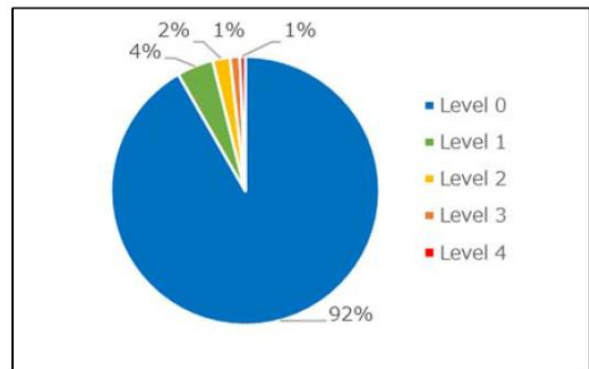


Figure 6. Result of Field test (managed by heat stress level)

MS200 can be available as a standalone usage without System, but Figure 7 indicates System usage. MS200 can transmit many sensing data in real time via wireless communication (Bluetooth® Low Energy 5.0 compliant, hereafter referred to as wireless communication), so the managers (on the remote also) can share each worker's real time heat stress level through the included PC tool or a user-built system.

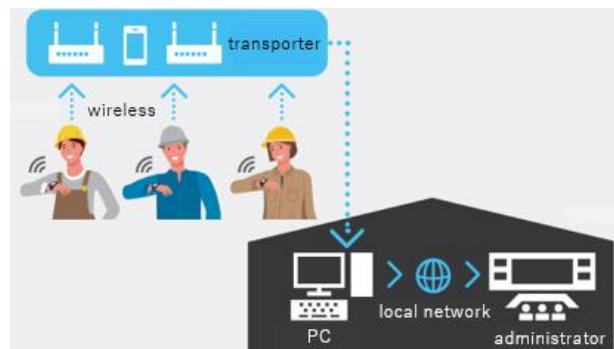


Figure 7. Example of MS200 system usage

In this way, MS200 can quantitatively assess each worker's heat stress level, helping them to decide the timing of taking hydration and breaks.

4.2 Fall detection and alarm

MS200 has the function of detecting falls from work at high height site and of notifying the host system of the detection of a fall using the wireless system mentioned above. The specification is that the notification will be issued to the host system when both "fall detection" and "the worker cannot move from the fall spot" are observed. The value of falling period "time" is not used to determine the fall accident, only the height gap between current point and reference point is used as below explanation. First, the reference point of 0m height is created by using atmospheric pressure value at the point where MS200 height detection function turned on. Normally sine the point of switch ON action will be the chest height, the reference height (=0m) will be here. If the worker falls from high site and lay down or sit down with injured at the point, MS200 position will be below chest height (=0m) which is the reference level at switched on, so we decided to set a fall flag when MS200 detects below the reference height. At this point, MS200 only sets the flag, it does not issue an alert to the system and on display. Fall detected notification spec is that the notification issues in conjunction with the verification of the worker's status described next. The verification of the worker's status after being set the fall flag is done by being assessed using GPS position fluctuation to evaluate whether the worker can walk/move around physical or not. The reason why the fall notification doesn't based on the height level or body movement (movement of the hand with MS200), if the worker is injured and cannot walk but can move one's hand or can stand up, the body movement (MS200 moving) or over 0m height can be observed, so the spec is that the notification signal/displaying are issued in the case of no physical position fluctuation by comparing GPS data. This assessment makes it possible to distinguish an injuries status, whether a worker has jumped intentionally (can move) or fallen inadvertently (keep staying), and to properly assess the worker's physical condition. Figure 5 shows the process flow from a fall detection to an alert issuing. On GPS location data after setting fall flag, if the worker's position fluctuation keeps staying within the threshold in GPS location data in a certain period, it is assessed to be under one's emergency situation in which the worker is unable to move, and a notification signal is issued to the higher-level system. An alert may also be issued if the worker intentionally jumps with no damage after falling and remains in place, but based on the Fail Safe concept, MS200 assessment spec is designed to ensure such situation without being rejection in the case of worker's lost consciousness and being unable to move. At this moment, if there is nothing wrong with the worker, they can cancel the alert by himself.

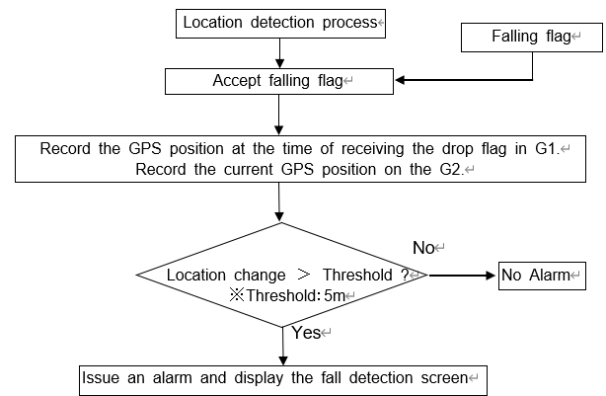


Figure 8. Location detect flow

4.3 Flexible system construction for each site

This product records measurement data such as pulse rate, heat stress level, temperature, humidity, body movement amount, fall flag, altitude, latitude/longitude. These data can be outputting to a higher-level system using wireless communication. Since our company provides this communication protocol public, System developers can build own systems by selecting not only heat stress levels and fall detection flag but also other data. For example, it is possible to link GPS data with a map of the surrounding workplace to display the location of the worker who issued the alert. In this way, it is possible to build a system with a high flexibility and suitable to each site.

5. SUMMARY

We have introduced the need to respond to harsh work site conditions and our corresponding device solution, the MS200, an industrial wristband type wearable sensor. IoT management of the heat stress levels of workers working in high-temperature environments and at height, as well as responses to fall accidents, is expected to become increasingly important in terms of both safety management and work efficiency. We will continue to improve and add functions to the MS200 so that it can meet these IoT demands.

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