Enhanced winter performance ability and winter ergonomics

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Severe weather problems are becoming more common in the world. In the winter of 2009-2010, snow, low temperatures, ice and wind induced many problems for railways all over Europe, resulting in train cancellations and train delays. The problems increased due to a lack of skilled and experienced personnel, as well as a lack of snow and ice removal equipment/vehicles. Therefore, there is a strong need to increase the ability of technical systems to work in good order in extreme winter conditions, as well as to focus on the development of reliable technical and logistical arrangements without eliminating the human contribution to the systems.

It has been proven that exposure to the cold results in a gradual reduction of physical and cognitive performance. Cold weather has a negative effect on aspects of muscular performance such as endurance, strength, power, speed and coordination.

This paper describes the risk areas which are related to the work of maintenance personnel in cold environments and which may result in unavailability and failure. A method for measuring individual cold-sensitivity is presented, as well as different methods for enhancing the personnel's winter performance ability, e.g. insulation of cold surfaces.

1. Introduction

The operation and maintenance of railways in a cold climate are in many respects outdoor activities where high demands are made on the performance of trains, with high safety requirements for electrical installations and railway traffic. A cold climate is defined as a climate where the temperature is equal to or less than +10°C and the duration of the prevailing cold climate in Sweden is 6-8 months in a year [1].

2. Risk areas related to maintenance

A cold climate puts higher demands on the competence and experience of the personnel and, in particular, their knowledge of how environmental factors such as harsh climate conditions, cold surfaces, and heavy and vibrating tools affect the assets/vehicles, the logistics and their own performance. The maintenance work is also affected by the assets' design and construction (near ground level, cold surfaces etc.) and the design of the maintenance equipment, tools and vehicles. Cold weather reduces the functional capacity of the technical systems and humans and induces a gradual reduction of physical and cognitive performance, by deteriorating the short-term and working memory, as well as the long-term memory and the consciousness [2], [3]. You become a danger to yourself and others, without knowing it. The impaired functional capacity and powers of concentration increase the risk of accidents and injuries. Holmgren [4] found that about 80% of the maintenance-related accidents in the Swedish railway system during 1988-2000 happened during the execution phase. The dominant cause of incidents and accidents was human error. The harsh winter of 2009-2010 resulted in an increase in accidents and incidents from 4 to 27 per year for one of the Swedish maintenance contractors. Three track workers were killed and one of the fatal accidents occurred during snow clearance duty [5]. These incidents and accidents might have been possible to avoid if the management and personnel had possessed the right knowledge, skill and winter performance ability; e.g. if they had been aware of the factors which personnel working in a cold climate are exposed to [6]:

- Body cooling due to low temperatures, wind, snow, rain and humidity.
- Contact with cold surfaces of assets, vehicles and tools.

- The wind chill effect; i.e. the cooling effect of wind at low air temperatures, which increases the risk of hypothermia. The wind chill index (WCI) is used to estimate and measure the wind's cooling effect; e.g., if the wind speed is 5 m/s and the temperature is -10°C, the cooling effect is -21°C [1]. Cooling increases the convection, reduces one's discretion and work capacity and results in lower endurance.
- Work wear/protective clothing can be heavy, bulky and thick and therefore difficult to move in.
- Greater psychological stress. In addition to the actual maintenance task, the personnel must also focus on their own personal thermal protection. This means that their concentration, attention and decision making are shared by these tasks.
- Cold, ice and snow can result in poor performance and safety for vehicles.
- Maintenance work in a cold climate coincides largely with short dark days.

The risk of accidents is increased by the fact that no investigations are carried out as to whether the personnel have developed cold-intolerance or cold-induced injuries during their professional life, and by the fact that no individual tests are conducted. Cold-intolerance and cold-induced injuries limit one's endurance and one's ability to perform in the cold.

3. Method for measuring individual cold-sensitivity

A method for measuring individual cold-sensitivity called the "Performance in Cold Method of Linné" has been developed (and patented) by Performance in Cold AB and a research group at Luleå University of Technology (LTU). This method consists of a special survey to identify the root causes of each individual's problems, an automated measurement technique for measurement of the temperature of the hand and finger when they are warm (i.e. have been in room temperature, +20°C, for at least 1 hour), directly after a rapid cold provocation, and during and after the recovery process, see Figure 1.

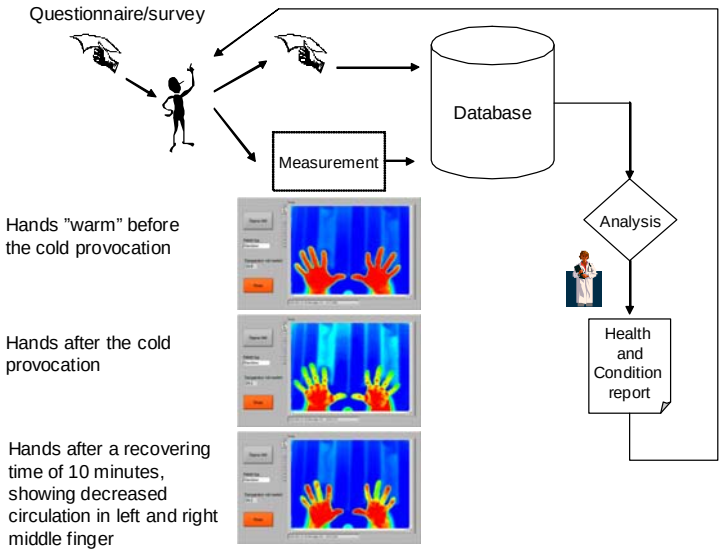

Figure 1: The "Performance in Cold Method of Linné"

The survey methodology was developed in a research project funded by Banverket [7] and is used to collect information about how humans experience the equipment which they work/perform with and their own sensitivity to working/performing in a cold climate.

A total of 190 people (schoolchildren, railway maintenance personnel, military personnel and winter sport athletes) responded to the questionnaire. A few of the respondents had knowledge of the wind chill factor and the effects of the cold and cold surfaces, for example, and many of them wanted to know more and obtain advice on measures that could reduce the cooling effects. The results from the questionnaire show that:

- 42% feel that they have impaired blood circulation in their hands,
- 60% believe that the existing protective clothing against cooling is inadequate or very inadequate,
- 74% believe that protective gloves, head coverings and shoes are inadequate or very inadequate against the cold and
- gloves are too bulky and must be taken off in order to conduct maintenance work in the cold.

The automated measurement technique uses an infrared camera (equipped with software developed by the research team) which automatically detects a number of well-defined metering zones on body parts (hands, feet, face etc.). The automated measurement technique has been tested by personnel at LTU, students and winter sport athletes. The results from the measurements and the analysis have led to several hypotheses which are going to be tested in further research: e.g. the left side of the body tends to be colder than the right side (1 to 4°C); women have colder hands than men; there are different recovery processes for individuals with warm hands compared with individuals with cold hands; and winter-adaption increases the body temperature. It is also possible to detect earlier injuries that may cause reduced blood circulation, such as frostbite, burns and scars.

4. Methods for enhancing the personnel's winter performance ability

There are requirements for protective equipment for workers, but they do not take into account individual differences, e.g. the fact that there are individuals sensitive to the cold, or individuals who have old injuries from working in a cold climate. It is interesting to note, in this connection, that protective clothing for women was introduced just 2 years ago [8]. Accordingly, there is a need to develop better and individual clothing which takes individual differences in winter performance ability and cold-sensitivity into consideration. In the meantime, the existing individual equipment/clothing can be improved by locating areas on the body that need extra insulation.

Today's tools are often designed without consideration of the fact that they could be used in a cold environment (on metallic surfaces). This increases the risk of cold-induced injuries, especially in those situations where the personnel have to work with their bare hands because their gloves are too bulky. The existing tools can be improved in order to reduce the thermal exchange, e.g. by adding insulating tape, Figure 2.

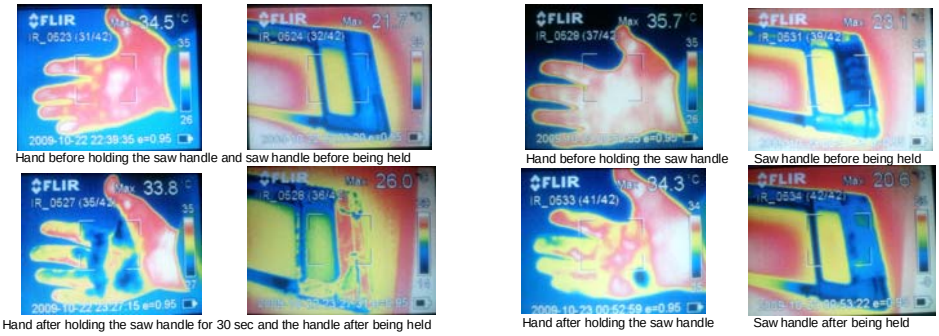

Figure 2: The cold surface of a metallic saw handle absorbs the skin heat (see the 4 thermo-images on the left). If the handle is insulated with a special tape, the heat remains on the hand.

5. Conclusions

The recent winters have had long periods of cold weather, which requires skilled personnel who can perform and work in cold conditions. Work in such conditions takes longer to carry out and it may not be possible to complete the work on time due to the cold-intolerance of staff. Education, training and individual tests increase the possibility of completing the work, even if the personnel are not adapted to the cold. The personnel will know their own abilities and the team will know who might run the risk of encountering problems. There will therefore be no surprise when an old frostbite starts to cause pain. It is better to be wise in advance than wise after the event.

Safe work in a cold climate requires that the personnel have good winter performance ability and are winter-adapted. Winter performance ability is obtained through education and training, while winter-adaptation means that you must have been working outdoors in the cold, for 8 to 10 days and 8 hours a day, and preferably should have frozen a little. With the state of affairs prevailing today, where personnel are sent out without been tested and assessed concerning their individual ability, education and training, the risk of frostbite increases during the period for winter-adaption.

There are currently no health profiles for working in a cold climate. No questions are asked as to whether you have developed cold-intolerance, or have cold-induced injuries which can affect your winter performance ability. There are no demands or examinations concerning injuries or increased sensitivity to working in a cold climate.

The results from the survey indicate that there is a need to develop and improve protective clothing, and to make an inventory for the workplace of the factors which increase the body's heat production, e.g. cold surfaces/liquids, wind, the cold etc. The survey also shows that there is a need to provide education in order to increase working capacity in the winter.

In the future, specifications for equipment to be used outdoors will need to be changed, so that the surfaces to be touched/handled by the human skin will be provided with an insulating layer. Better methods for measuring the heat exchanges constitute another development area, e.g. methods using an infrared camera.

6. References

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