# PROBLEMS IN CONDUCTING RESCUE OPERATIONS UNDER DIFFICULT MICROCLIMATE CONDITIONS

**Z. Kajdasz**
Central Mines Rescue Station
Bytom, Poland

**A. Plata**
Central Mines Rescue Station
Bytom, Poland

ABSTRACT

This paper presents the issues connected with running rescue operations when faced with difficult microclimatic conditions. The authors discuss the main assumptions regarding the tactics of running rescue operations under difficult conditions of microclimate as well as the development of means and methods to protect rescuers from the effects of high temperatures as a result of incidents experienced in recent years. Basing on conclusions resulting from rescue operations conducted under difficult microclimatic conditions they present methods for minimising the hazards to the health of the mine rescuers working under such conditions. On the basis of Polish mine rescue work experiences the authors indicate the directions for conducting further research work on reduction of risks caused by high temperatures to the organisation of rescues and their implementation.

KEYWORDS

Rescue operation, difficult microclimate conditions, climatic hazard minimisation

Apart from the normal operations carried out in underground mines, rescue operations also take place in certain special cases. Such emergency operations are conducted under conditions that are often highly abnormal as regards both the mining work itself and the microclimate in which such operations take place. Therefore, conducting rescue operations under unusual climatic conditions requires a suitable approach to ensure maximal safety for rescuers. To justify this level of safety, one should consider the issue of the potential or likely physiological changes in an the individual's organic system, protecting against overheating and application of technical means facilitating the work of rescuers in the heavy microclimate conditions.

The human body temperature must be maintained at a level of 37°C. At such body temperature the course of biochemical processes and physiological functions in the organism is optimal. Maintaining this body temperature is provided for by the organism by a very efficiently operating thermal regulatory mechanism. Therefore, the individual can stay and work under diversified natural conditions in various climatic zones as well as at work-stands in industry without damage to health, without the deterioration of its physical and mental capabilities as well as productivity.

During resting and manual labour heat generation takes place due to metabolism. This heat is continuously given up by the organism to its environment to maintain its equalised thermal balance. However, it is possible for environmental climatic conditions to be such that the organism cannot loose heat, but even absorb it from the environment (e.g. air temperature, air humidity, heat radiation, air circulation velocity), which causes heat to accumulate in the organism and increases the body temperature, that are very often dangerous for health or even life. Participation in rescue operations, especially under difficult microclimatic conditions, may impose:

great or even extremely intense thermal loads to the organism and therefore rescuers are required to have a high level of physical fitness and adaptability and heat tolerance. For some rescuers the initial increase in body temperature resulting in raising of the pulse-rate, a drop in arterial blood pressure reaches levels threatening personal safety: these are the conditions that stimulate and quicken the appearance of thermal shock (Plata, 1998; Kajdasz, Plata, 1998; Trutwin, 1998).

This is why the protection of rescuers' health and even their lives requires the observance of a safe time limit for their participation in heavy rescue operations as well as the supervision of medical directors during the operations.

Among the most dangerous threats to life and health is thermal shock (heat-stroke) which is caused by overheating due to a build-up of heat accumulation in the organism, cessation of the organic thermo-regulatory mechanisms and an increase in body temperature of between 39,5°C and 41,5°C.

In the past, the difficult microclimate conditions that occurred during rescue operations were the cause of several tragic events. In 1950, a rescuer died in the "Jowisz" Mine due to heat-stroke, during the rescue operation three rescuers suffered from heat-stroke in the "Katowice" Mine, in 1951 three rescuers died from heat-stroke suffered in the "Łagiewniki" Mine, in 1955 two rescuers died due to heat-stroke in the "Pawel" Mine, in 1958 one rescuer died in the "Dimitrow" Mine (Ćwięk, *et al. 1997).* In 1975, during the operation connected with containing the fire-field in the "Mysłowice" Mine the hot air blown out during the penetration of a system of excavations by rescuers, all them suffered heat-stroke and died (Drenda, Wieprzycki 1999). Rescuers who entered the abandoned working as well as those who were running the rescue operation in the "Modrzejów" Mine also died.

Those events occurred over a considerable period of time. Nevertheless, they were caused by underestimation of the effects of the adverse influence of high temperature, humidity and lack of air circulation on the human organism.

The events that took place in the 1960 s and 1970 s contributed to development of regulations for running rescue operations under difficult thermal conditions. They appeared as a result of investigations carried out at that time. The first regulations issued by CMRS in 1975 determined some principles for the rescue activities during rescue operations, they defined the permissible exposure to difficult thermal conditions, defining the limiting dry bulb temperature as 33°C, above which only operations being conducted to save human life or performance of works connected with fire suppression or its isolation are permitted. The regulations also stated that the exposure time of the rescuers in difficult thermal conditions should be shortened, based on measurements of humidity and temperature performed by a team leader, whereas the decision to shorten the work time is to be made by a base manager.

In the succeeding years the term *'difficult thermal conditions'* was defined more precisely and up to the year 2000, difficult thermal conditions where determined by two parameters: temperature and relative humidity. At a temperature (measured by wet bulb thermometers) above 33°C and at a relative humidity above 8,5% rescue operations had to be conducted under laid-down operational principles for 'difficult thermal conditions.' The underground work time was determined by the manager of the operation in consultation with a physician on the basis of relevant tables. These tables determined the maximum exposure times, taking into account the boundary conditions for relative humidities of 50% and 100%. It was stated precisely that due to the special hazard for the safety of rescuers, operations under difficult thermal conditions might only be undertaken when attempting to save endangered persons. In other cases the rescue-operation manager was responsible for making the decision with regard to possible rescue operations, adopting exposure times to the conditions existing at the workplace.

All regulations on the conduct of rescue operations under difficult thermal conditions contained provisions relating to the need to utilise all available means to optimise the rescuers' physical condition comfort whilst they were working.

The issue of the correct conduct of operations under difficult conditions of microclimate can be reduced to three questions. They are as follows:

- proper acclimatisation of the rescuer's organism to the difficult microclimatic conditions,
- providing the rescuers with suitable cooling so that body temperature does not exceed a critical temperature partly caused by additional load imposed by the use of breathing apparatus,
- use of equipment which would improve the microclimatic conditions at the site of operations as far as possible.

The first issue requires solutions consisting in such preparation of rescuers that their organisms are adapted to the difficult conditions of microclimate and are able to tolerate them to a sufficient extent. Such preparation is achieved during everyday work in conditions similar to the difficult conditions of microclimate, which may appear during rescue operations. Also preparation consisting in exercises performed in a chamber in difficult conditions of microclimate. Such exercises are conducted in test chambers at each district station forming part of the Central Mines Rescue Station

The second issue needs some technical solutions. which consist in ensuring the availability of appropriate equipment such as the SAT-2M device in the W-70 apparatus for inlet air cooling or oxygen-type apparatus with an integrated chiller in the BG-4 apparatus as well as the use of cooling jackets. Experience indicates that by the use of the SAT-2M device in the W-70 apparatus and jacket-cooling the rescuer is helped to reduce internal body temperature organically. The extent of the level of body temperature reduction depends on the conditions of the microclimate prevailing at the rescuer's workplace to a large extent (Figs. 1 and 2).

The third issue is resolved by using facilities to improve the microclimatic conditions at the rescuer's place of work. For example, this may consist of a fan with an air duct feeding air of lower temperature and humidity or other type blowers improving local microclimate conditions, the application of water mist or delivering compressed air.

The strategic aims of the second and third issues are aimed at avoiding the appearance of heat-stroke, which takes place as a result of a failure of the internal thermo-regulatory mechanisms of the individual or overheating due to external causes. Hence, the issue of work under difficult conditions of microclimate is always to be seen as a problem of the greatest significance, and one that cannot be ignored. It especially concerns situations where the additional stress connected with expenditure of physical effort exists.

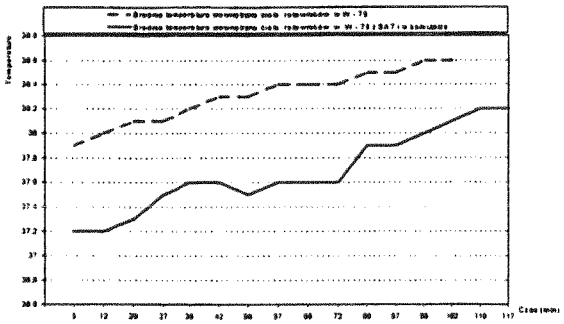

*Figure 1. Conditions of microclimate – temperature of 28°C, relative humidity of 95%*

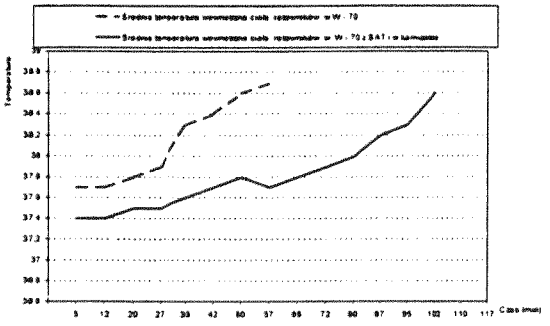

*Figure 2. Conditions of microclimate – temperature of 33°C, relative humidity of 95%*

In 2000, in connection with the revision of regulations on "the organisation, tasks and mine rescue work equipment of the operator and the professional entity dealing with running rescue operations" also the regulations on conducting rescue operations under difficult conditions of microclimate were subject to changes (CMRS directive, 2000). Now, the work time in difficult conditions of microclimate depends not only on the temperature and humidity existing at the workplace but also on the type of clothing the rescuer is equipped with. The conditions for rescue operations are laid out in the directive issued by CMRS.

The additional inspection was introduced, which consists in performing the measurements of the heart rate at each rescuer. Any time the limiting heart rate equal to 140 strokes/minute will be exceeded two times in turn the rescuer must get back to a base and this means the necessity of withdrawing to the base all the rescue team.

At the beginning of June 2000 the tests with the participation of mine rescuers carried on in the co-operation with the Central Institute of Labour Protection in Warsaw have been started in the Central Mines Rescue Station. They were performed within the framework of the target project of the Scientific Committee of Investigations. The title of the project was "The Influence of Microclimate Conditions on Safety of Mine Rescuers during the Rescue Operations Conducted at the Difficult Conditions of Microclimate in Underground Mining Plants. The Physiological Criteria of the Safe Time of the Rescuers Work at Difficult Microclimate Conditions".

The conclusions of the Committee appointed by the President of the State Mining Inspection to investigate the reasons and circumstances of the collected disaster in "Niwka - Modrzejów" Mine in February 1998 (Report of Committee) indicated that the important factors influencing the accidents of rescuers during the rescue operation were the increased temperature (26°C – 31,5°C) at the mining excavation and high humidity of air (from 95% to 98%). Both the heavy climate-ventilation conditions and the influence of hot air in the apparatus W-70, which is used by the rescuers during the operation conducted at the atmosphere not useful for breathing, caused faintness and fatal accidents among the rescuers taking part in that operation. (Trutwin, 1998; Magiera, Kajdasz, 2000).

The influence of those conditions on the state of the rescuer organism load is the subject of the undertaken research and development work. During the investigations carried out in the climatic chamber at CMRS with the participation of mine rescuers the measured factors are the influence of temperature, humidity, work load, breathing apparatus parameters as well as personal cooling means such like cooling jackets, protective clothing or the facilities like SAT2-M on cooling the inhaled air in the breathing apparatus W-70. During the investigations the conditions in which the rescuers execute the exercises are changed within the range of temperatures from 22°C to 43°C and relative humidity from 70% to approximately 98%.

"Assumptions for the investigations of physiological criteria of safe work time of rescuers at the difficult conditions of microclimate" elaborated at the first stage of the target project execution as well as "Methodology of investigations.." which was elaborated at the second stage, caused the necessity to work out and adopt the test stand in a way to make the whole planned investigation programme realisation possible. To this end, the test stand for testing the rescuers in the climatic chamber has been designed and executed. The design of the test stand was consulted with the physicians exercising medical supervision during the tests. The consultations were carried out with the participation of the rescuers appointed to the tests. The remarks of all interested parties were taken into account so that the final effect could meet both the aims of the research design and the possibilities of execution, at the same time warranting safety for tested rescuers.

Information concerning the test stands applied in Great Britain and Germany appeared to be helpful in elaborating the test stand conception. Unfortunately both the descriptions of those stands and the measurement methods contained in available materials were not given in sufficient details.

Practical tests performed on users under the difficult conditions of microclimate and assumed work load are conducted in the Equipment Testing and Evaluating Laboratory of CMRS in the chamber of the type NCZ 2014M (m) manufactured by NEMA Industrietechnik.

The parameters of the chamber within the range of the temperature work mode are:
range of temperature adjustment :
from – 20°C to + 60°C – warranted by the manufacturer – whereas the available real values are:
- 30°C to + 70°C
temperature stability in time : ≤ 0,5K
speed of heating up : ≥ 1, 0K / min
speed of cooling down: ≥ 1.0 K/min

Chamber parameters within the range of the climatic work mode:
relative humidity adjustment range : 10% to 95% (98%)
humidity stability in time : ≤ 3%
Similar tests were carried out in the 1980 s by the Central Mines Rescue Station and by British Rescue Services. Those investigations were executed on the German and British rescuers, who subject to different qualification requirements as well as those investigations were executed on the German and British breathing apparatus of other technical parameters that is of great importance.

The principal aim of the investigations is the improvement in work safety and efficiency of the rescue operations connected with removing the consequences of mining hazards at underground mining plants especially those conducted under the difficult conditions of microclimate. The analysis of the rescue operations carried out in the Polish hard coal mines in several recent years, conclusions of the committees appointed by the president of the State Inspection Office to investigate the reasons and circumstances connected with collective accidents as well as the opinion of the Mine Rescue Work Council, which is an advisory and opinion expressing body, formerly the Minister of Industry and Commerce and currently the Minister of Economy indicate the necessity of elaboration of new protective means for mine rescuers, which would counteract the danger of the organism overheating symptoms at rescuers or appearance of the heat-stroke

Also the analysis of the foreign publications and elaboration concerning this field as well as the preliminary recognition of those issues in the available regulations of the mine rescue services in such countries like Australia, Czech Republic, France, Germany, South Africa, Great Britain or Ukraine make it possible to state that it is necessary to elaborate the aforesaid protective means and principles of the rescuers participation in the rescue operations in which the difficult microclimate conditions can occur.

The investigations performed on a representative group of rescuers shall enable the determination of the conditions in which the rescuers would be able to work safely at the atmosphere unfit for breathing. The figures present the device SAT-2M and cooling jacket's positive influence onto the rescuers organism. Comparing the internal body temperatures in the case of breathing with using the apparatus W-70 equipped and not equipped with the SAT-2M device and with using the cooling jacket one can see the advantages resulting therefrom. The investigations are in progress and the final results along with relevant conclusions will be presented after their completion.

It is planned within the frame of the project to elaborate the new principles of running rescue operations in the underground mining plants, at which the rescuers are exposed to special hazards resulting from the microclimatic conditions existing in mining excavations.

An implementation of the work results shall enable:
- improvement of running the rescue operations undertaken to liquidate consequences of determined mining hazards,
- undertaking the effective and efficient rescue actions,
- increasing the safety of rescue operations

Additional effect of the investigations shall be the verification of the tables of permitted times of rescuers work at the difficult conditions of microclimate.

## LITERATURE

Drenda J., Wieprzycki H., 1999, "Hazard of heat-strokes at miners", International Conference on the newest achievements within the range of mines ventilation as well as fire-fighting, gas and climatic hazard control; Szczyrk, Poland

Magiera W., Kajdasz Z., 2000, "Assessment of Climatic Hazard in Polish Mining Plants in the Aspect of Running Mining Works and Rescue Operations". International Conference on Mining Rescue Work "Kokotek 2000", Poland

Plata A. 1998, Heat Load of Mining Rescuers During the Rescue Action Conducted At Heavy Thermal Conditions, "II-nd Conference "Deep-seated Bed" on mining beds on the great depths and under the difficult geothermal conditions. Karłów, Poland

Ćwięk B., Kajdasz Z., Ofiok J. 1997 Mining Rescue Work in Poland. Edited by: ZG SITG Katowice

Kajdasz Z., Plata A., 1998, "At the difficult thermal conditions – hazards of mining rescuers" quarterly issued Mining Rescue Work No 2 June.

Trutwin W. 1998, "At the difficult thermal conditions – remarks on rescue operations" quarterly issued Mining Rescue Work No 4 December

Committee appointed by the President of the State Mining Inspection to investigate the reasons and circumstances associated with the accident in the mine Niwka-Modrzejów, 1998 Report

Director of Central Mines Rescue Station, 2000 "Directive in the scope of running the rescue operation at the difficult microclimate conditions