The Concept and Study of Initial Exploration of Life-saving Food in Coal Mining

LIU Sai[1], ZHAO Xiao-yin[2] , HAO Chao-yu[3] , LIAN Zhen-shan[4] , LI Gang-gang[5]

[1]*College of Resource and Environments Engineering, Liaoning Technical University, Fuxin, China*
[2]*Civil & Environment Engineering School, University of Science and Technology , Beijing, China*
[3]*College of Safety Science &Engineering, Liaoning Technical University, Fuxin, China*
[4]*College of Resource and Environments Engineering, Liaoning Technical University, Fuxin, China*
[5]*College of Resource and Environments Engineering, Liaoning Technical University, Fuxin, China*
E-mail：lsi_2007@126.com

Abstract: After a coal mining accident, the key to the success of the coal mining emergency rescue is that the trapped miners are still alive before the rescue passage are made through. As new life-saving equipment, life-saving foods are used to maintain the viability and the self-saving ability of the front-line miners when they are trapped in the coal mining accident. The life-saving food will effectively extend the self-save time for the trapped miners and then essentially improve the rescued possibility of the trapped miners. The amount of human metabolism, which was measured under the hot and humid environment, determines salt targets and nutrition indexes of the life-saving food. According to the particularity of underground environment, the passage explores the method to store the life-saving food and how to reasonably select the storage locations. Reviewing the application of the mine life-saving food, we can conclude that the self-saving food will have a better future in the economic and social aspects. But it still needs to be demonstrated whether it is necessary to carry the food with the human body. When the life-saving food is exposed under the hot and humid environment, the deterioration cure is still unclear.

Keywords: Coal Mining; mine disasters; Life-saving food; indexes ; Emergency Rescue

1. Introduction

The safety situation in the coal mine industry is the most serious in China's industrial production. It has always occupied the most percentage of the total production accidents and the total casualties [1] . After the coal mining accident, the basic idea of our coal mine rescue system is to activate contingency plans immediately and do our best to open up a rescue passage from the ground to the down side of the well and then conduct the rescue plans. However, owing to the limit of the natural conditions of coal mines and the high complexity in the technology and engineering of the coal mine rescue, the trapped miners may lose his survival chances because of the rescue passage may not be opened up in time or the food and water for living may not be provided effectively. So if the operations lose its meaning, the emergency rescue plans will be failed. The premise of the mine emergency rescue is that the trapped miners underground are still alive, so it is necessary and urgent to research the self-saving equipment for the trapped miners to survive. The research of the self-saving food is to provide the trapped miners with a reliable supply of food and energy, and then to ensure normal vital signs, so the miners will have a longer time to self-save or being rescued.

2. The Concept and Characteristics of Mine Life-saving Food

2.1. The Concept of Mine Life-saving Food

The coal mine life-saving food is the special food which can maintain the viability and self-help capability of the front-line workers when they are in emergency situations, such as coming across dangerous situations and waiting to be rescued or being trapped underground. The term of life-saving food originally comes from the military. It is defined as a specific food which helps to maintain the survival and self-defense capability for the army when they are facing dangerous or other emergency situations. In china, we do not have the special food to ensure the underground people's living. The self-help devices and equipment being used now mainly are refuge chamber, air pressure self-help devices, and self-rescuer. The main function of them is to protect the breath of mine workers [2] . In recent years, mine rescue systems begin to adopt the drilling method to provide ventilation and food for the trapped miners. For example, a rescued team opened up a life passage which is 30 meters long and 10 centimeters wide in the rescue operation of the Wu mine, Jiahu Town, Jiangxi province. Through this passage, the food such as milk, water, clothing and flashlight are transported to the trapped place and the rescue operations are ultimately successful. This method based on the supply from the ground floor provides new ideas for the mine rescue, but it cannot guarantee adequate food for the trapped miners in time. In March, 2009, a team led by the LiuRensheng and Jinlongzhe successfully developed the "mine rescue

978-1-935068-25-9 © 2010 SciRes.

capsule removable" which can provide space for the underground people. The life-saving capsule provides a good food storage medium for the introduction of the life-saving food.

2.2. Characteristics of Coal Mine Life-saving Food

As an emergency life-saving food, convenience must be reflected in the whole usage process, especially in the following aspects.

1) Small Size, Light Weight, Rugged Packaging

The cost on roadway excavation and maintenance is very high, space is small and the transport is heavy in The mine underground, transport and storage are very limited. After a mining accident, it must be ensured that The life-saving food is convenient to get and use and not damaged. This determines the life-saving food should have small size, light weight and rugged package. Military food mainly adopt the compressed or condensed way to increase the proportion of heat production in per unit volume and then control the food packaging size, packaging and weight. For instance, the heat of the military life-saving food which is equipped to our land army is up to 10.9 ~ 16.7KJ/m^3, while the heat of the U.S. military's compressed food is up to 29.3 KJ/m^3.

2) Be Convenient to Eat

In the food research and development phase, the convenience should be fully taken into consideration. At Present, the canned food and tin food which can keep for a long time have general problems on the inconvenience of opening and eating. The food in cooking (aluminum foil) bags and vacuum packaging is easy to eat, but it's also easy to turn bad. Therefore, all kinds of factors should fully taken into consideration on the premise of the convenience.

3. The Major Technical Indicators of the Mine Life-saving Food

Modern medical science shows that body in the state of hunger or incomplete hunger will result in a series of changes in the performance, such as weight loss, low blood sugar, high urine ketosis, dehydration, decreased immunity, lack of energy and ultimately lead to death because of complications or depletion [3]. Some data show that minerals and vitamins will exhaust when the body in a hunger state for a few days [4, 5].

3.1. Water and Salt Index in Coal Mine Life-saving Food

Water is the source of life. The mine work environment is relatively fixed and the water is easy to find. The special conditions of the coal mine determine that water can be configured as an independent part of the life-saving food, which is different from the military life-saving food. In hot and humid environment, daily water demand under different temperature and different labor intensity are showed bellow (Table 1), the requirements of daily sodium and potassium of different labor intensity are also showed bellow (Table 2) [6].

Table1. Daily water demand of labor under different conditions of temperature and intensity （L/d）

Air Temperature (℃)	Slight Work	Moderate Work	Severe Labor	Very Severe Labor
36~40	3.5	9.2~10.1	9.8~10.9	10.5~11.9
31~35	3.4	7.9~8.8	8.2~9.4	8.8~10.1
25~30	3.3	6.3~7.5	6.3~7.8	6.7~8.3

Table2. Daily sodium and potassium requirements under different working intensity （L/d）

labor Intensity	Sodium Requirements	Potassium Requirement
Slight	9.2～10.1g（Converted into consumption of sodium chloride）	9.8～10.9g（Converted into consumption of sodium chloride）
Moderate or Severe	7.9～8.8g	8.2～9.4g

Under the high temperature and humidity environment, people often have a thermal stress response when they are in the state of semi-starvation. In order to resist the response, life-saving food should contain a certain amount of electrolytes vitamins. The formula is based on the composite electrolyte formula recommended by the GJB1637-93, and a certain amount of Vitamin A、B_1、B_2、B_6、E is put into it [7].

Different individuals have different physical conditions, so the underground self-help may face extreme situations. The water and salt index in the life-saving food is determined according to the amount that the very severe workers need on the temperature of 36~40℃.

3.2. Nutrition Indicators of the Coal Mine Life-saving Food

The emergency food should be able to prevent protein degradation because of ketosis, maintain fluid balance, reduce electrolyte row exchange, and maintain certain work ability in a week. Some people suppose that in order to maintain the greatest work ability in 10 to 12 days, one has to take in 5880KJ calories everyday which contain carbohydrate 100g, protein0.8g per kg of body weight and supply with vitamins and inorganic salts as necessary. And someone suggest that the ideal emergency food should be like that every 2g of salt should also be supplied when 4200KJ calories are provided. It can compensate for the lost water and save some water

in the body. If 5~10% of the total energy is supplied by protein, the loss of tissue proteins is at least and the water in body can be saved. But more protein will produce more urea and then it will increase water requirements.
If the heat supply is less than 2100KJ per day in short terms, the main supply is carbohydrate. This can make the weight and blood sugar drop less. When the heat supply is 6300KJ calories, carbohydrate will occupy 60%, protein 15%, fat 25%, but when it is compared with the same calories fat will make up 57~60%, protein 15%, fat 25%, and when it is compared with the same calories fat make up 57~60%, protein 8.5%, carbohydrate 31.5~34.5. This can reduce the negative nitrogen of the body. Apart from a comprehensive nutrition, the food should also need to meet the high energy density, good taste, have higher reception, and even meet the requirements of diet and endurance of hunger.

3.3. Storage Technology of the Coal Mine Life-saving Food

Mine life-saving food as a reserve food should have a certain shelf-life period. A special storage box should be made to adapt the mine's hot and humid environment and meet the requirements on avoiding insect pest and rodents and explosion-proof technology in the mine.

1) Shape Design Requirements of the Storage Device

The storage device as a life-saving food container should be convenient to open, its shape and size should be suitable to place in the roadway and it should not obstruct pedestrians and transport materials. The storage device should also have certain strength in order to take out the life-saving food normally when the device suffers a gravel impact and certain damage.

2) Explosion-proof Measures of the Storage Device

Refrigerators ordinarily do not have explosion-proof functions, so it is necessary to research the underground refrigeration equipment. The design can adopt the explosion-proof design or the flameproof design. The design idea of mine explosion-proof electrical in low-voltage is to use explosion-proof enclosure, intrinsically safe circuit and auxiliary protection devices. The explosion-proof device in low-voltage can also adopt the lockout technology to the overall design.

3) Choices of the Storage Location

The storage sites of the coal mine life-saving food are chosen on the basis of statistics and features of different types of coal mine accident. The main disaster of China's coal mines are gas disaster, roof, burst, fire, water damage, dust damage, heat damage and so on.
According to the characteristics of various types of disasters, the storage location are mainly targeted by the coal mine flooding accident, coal and gas outburst, burst and the roof accidents.
The key nodes such as nearby working surface and the refuge chambers are also taken into consideration.

4. The Prospects and the Applications of the Coal Mine Life-saving Food

4.1. The Safety Situation in the Coal Mine Production [8]

Table3. China coal mine accident statistics in recent years

Year	Casualty Accidents	Death Toll	Death Rate per Million-ton
1999	3817	6399	6.077
2000	2863	5768	6.040
2001	3082	5670	5.850
2002	4344	6995	5.000
2003	4143	6424	4.170
2004	3853	6009	3.100
2005	3341	5986	2.836
2006	2945	4746	2.040
2007	2365	3786	1.485
2008	1954	3215	1.182
2009	1616	2630	0.892

Though the safety situations in China have greatly improved this years, the number of deaths in coal mine accidents has decreased from 5986 in 2005 to only 2630 in 2009, particularly the number of deaths dropped greatly by 18% in 2009 compared with it in 2008. However, the coal industry still can not get rid of "blood coal" public opinion because of the heavy casualties caused in major accidents. The root is that the major mining accidents caused massive deaths. For example, on November 21, 2009, an explosion occurred in Xinxing coal mine, Heilongjiang province. The mine confirmed that 108 people were killed; Tonghua coal mine have a serious gas accident, 30 miners were killed and 77 wounded in the accident; a gas explosion occurred in Tunlan coal mine and 77 people were killed on February 22.
News of mine accident flooded in the news page all the year, the media enlarge the danger in coal mine production. The staff especially the safety staff in coal mine endures great pressure, college graduates do not want to engage in the work related to the coal industry. The research on the intrinsically safe of coal mine industry has a slow progress.

4.2. Application

After the mine accident, the trapped miners can not find basic food to survive for a long time. From some domestic success stories, we can find that except for those who have a strong will, the chance to find some food, such as bark, coal, urine fluid, is also a key factor in the successful rescue. For instance, three trapped miners from Shenmu mine insisted for six days by eating apples taken with them and drinking water from two water box. Miners of Bridge coal mine persisted for 25 days by eating cinder and drinking sewage. The rescued miners of Wangjialing mine spend a difficult nine days and nights by feeding on the pine bark of wood pole in con-

978-1-935068-25-9 © 2010 SciRes.

struction and cold water. We can conclude that if the trapped miners can get food supplies or energy supply, which will provide effective guarantees for their physical preservation, they will have longer time to wait for rescue. And the right rescue measures can improve the success rate of mine rescue.

4.3. The Applications of Coal Mine Life-saving Food in Economic and Social Aspects

The wide application of life-saving food and the successful rescue of the coal miners can not only restore some economic loss for the coal mines, the more significant influence is the social benefits. From the social perception of the coal industry, we can see that if the "blood coal" situation could be got rid of, China's human rights situation will be improved, the whole society will eliminate the negative impression of the coal industry, more high-quality people will be attracted into the coal industry to further improve the technological and safety level of coal production. More important is that the life-saving food will not only save miners' lives, but also save a well-being family. It consists with the fundamental requirements of the concept of scientific development.

5. Questions and Discussions

1) If the miners are equipped with the portable life-saving food, it will increase the load on miners. And the food would inevitably suffer regular vibration and bump in progress, we have to solve a series of problems to ensure food quality. So it need be discussed that whether the food will be equipped or not.

2) The deterioration curve of the life-saving food is not clear when they are completely exposed to hot and humid environment. This will need more experimental research.

6. Conclusions

Mine emergency rescue is the last bulwark to save the life of trapped miners. The passage defined the concept of the life-saving food, introduced the main content and the application and prospects of the life-saving food. It suggests the main research direction for the mine rescue from a new aspect. The application of life-saving food will win a longer time for the trapped miners to be rescued, enhance the chances of successful rescue, and save more miners' lives. From the social aspect, the food will significantly change the negative perception of people's minds, improve the security sense of the workers, and then improve the status of coal industry practitioners. Mine life-saving food will have a very bright future!

7. Acknowledgment

In the writing process of this thesis, my tutor Professor WangJiren gave me careful instruction. As a PhD supervisor Professor, Wang Jiren serves as Vice President of Liaoning Technical University, he is one of the winners of special government allowance, he is a number of experts group on safety production an effective candidate for National Academy of Engineering. He is an National Teaching Higher safety engineering, vice chairman of the Steering Committee, outstanding contributions to mine safety expert technical consultation. His profound professional knowledge and rigorous academic style of great inspiration to me, hereby express my sincere thanks.

References

[1] NING Yv. China Coal Mine Hazard and safety measures . China, Labour Protection. vol. 8, pp. 12-14, 2009.
[2] ZHANG Guo-shu, etc. Ventilation safety. Xuzhou, China, University of Mining Publishing House, pp. 312-313, 2007.
[3] GUO Chang-jiang, YANG Ji-jun. Starvation and survival. China, Journal of Preventive Medicine of Chinese People's Liberation Army. Vol. 21(2), pp. 155-156, 2003.
[4] Phillips WJ. Starvation and survival: some military considerations.Mil med, vol. 159(7), pp. 513-516, 1994.
[5] LIU Bing-li, BAI Jun-qing, CHENG Ai-guo. Starved of energy supply and physiological changes. China, Chinese Journal of Coal Industry Medicine, vol.8 (6), pp. 547-548, 2005.
[6] HE Zi-an, CHENG Su-qi, etc. Water and salt supplementation for soldiers during military labour in hot environments. China, Journal of Preventive Medicine of Chinese People's Liberation Army, vol.14 (5), pp.313-316, 1996.
[7] GUO Chang-jiang, YANG Ji-jun, etc. Intervention of experimental heat stress by a compound of minerals and vitamins in semi-starvation. China, Journal of Preventive Medicine of Chinese People's Liberation Army, vol.20(2), pp.86-89, 2002.
[8] PENG Xiao-ya, MIU Yong-zheng, LU Xiao-yan. Frequent mining accidents in China and countermeasures of the reasons. China, Mining Technology, vol.8 (5), pp.59-61, 2008.