

Scientific Exploration and Practice of Safe Production Management of Non-Ferrous Metal Mines under the New Situation

—Taking Dahongshan Copper Mine as an Example

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Abstract

Although Dahongshan Copper Mine, a subsidiary of Chinalco Co., Ltd., has a large production scale, it is still a non-ferrous metal underground mine with low mechanization and labor efficiency due to its early production. In recent years, mines have carried out a large number of beneficial scientific explorations and practices on production safety management. According to their own actuality, they have combined production safety with scientific management. They have done meticulously and solidly, ensuring that the safety situation continues to be good. There have been no serious injury accidents, let alone work-related accidents for two consecutive years. The injury rate of thousands of people is in the good results within the control index have also made it a benchmark for safety management in the nonferrous mines of Chinalco. This paper analyzes and discusses the scientific methods and good experiences of the production safety of Dahongshan Copper Mine from six aspects: explosion management, organizational security, infrastructure, safety inspection and quantitative mechanism, safety training, safety science and technology, etc. Finally, it gives suggestions for the next production safety of Dahongshan Copper Mine.

Keywords

Safety Management, Standardized Construction, Safety Inspection

1. Introduction

There are about 5500 metallic non-metallic mines in Yunnan Province, ranking first in China [1]. In addition, there are many small mines and a weak safety

foundation, Yunnan Province has always been a major accident province [2]. For example, in 2018, there were 98 accidents, 120 deaths, 6 major accidents and 19 deaths; in 2019, there were 77 accidents and 95 deaths, ranking first in the number of major accidents and deaths in the country [3]. Among the 50 key counties for safe production of metal non-metallic mines announced by the State Administration of State Security in 2018, Yunnan Province also ranked first in the country [1]. Dahongshan Copper Mine, a subsidiary of Chinalco Co., Ltd., suffered a minor injury accident in 2014 and two minor injuries in 2015. There were no serious injury accidents for seven consecutive years, let alone work-related accidents [3]. The injury rate of 1000 people is within the control index. Considering that such achievements are based on the background of the frequent occurrence of mine production safety accidents in the province, and on the basis of the huge pressure on safe production that mines have been facing, which is really hard-won.

2. The Distinctive Characteristics and Benchmarking of Dahongshan Copper Mine

Dahongshan Copper Mine is one of the non-ferrous mines built and put into operation at the end of the last century [3]. It is located in Gasa Town, Xiping County, Yuxi City, Yunnan Province. At present, it has a mining capacity of 15,000 t/d (4.95 million tons/year). The annual production of concentrate contains more than 20,000 tons of copper and 600,000 tons of iron concentrate [1]. It is a cloud copper collection under the jurisdiction of Chinalco. The main mine of the regiment. Dahongshan Copper Mine passed the second-level safety standardization acceptance and the three-standard (occupational health and safety, environment, quality management) system certification in 2011, and was certified as a national green mine pilot unit by the Ministry of Land and Resources in 2012 [3]. Dahongshan Copper Mine has distinct characteristics and attributes in the non-ferrous metal mining industry. From the actual scale, Dahongshan Copper Mine is currently the third largest metal underground mine in Yunnan Province, and it is also an ex-large metal underground mine in China. In terms of mining depth, the current mining depth of Dahongshan Copper Mine is about 500 meters, mining depth Generally speaking, but the problems of geothermal and rock explosions have emerged. In terms of mine grade and number of operators, the copper grade of Dahongshan Copper Mine is relatively low. At present, the original mining grade is only 0.4%, and there are 3000 underground workers, which is still labor-intensive, and the degree of mechanization and labor efficiency are not high [3].

In terms of safe production, the safety production pressure in mines, especially underground mines, is the greatest compared with concentrators and smelters [4] [5]. According to statistics, Yuntong Group currently produces 25 mines, of which 22 are underground mines. Considering that most of the bauxite mines mainly operated by Chinalco have also entered the peak period from open air to

underground, the pressure of safe production in Chinalco's underground mines will face serious challenges in the future. As an underground mine with large production scale, long operation time and mature production safety management under Yuntong Group, Dahongshan Copper Mine has carried out a lot of scientific exploration and practice in production safety management over the years, including the standardization of large blasting operation, the summary evaluation mechanism of production safety, and adherence to the mine chief's down the well. Unique safety management work such as the shift system and the standardization construction of team safety production based on pragmatic training have achieved good results, and its experience is worth summarizing and promoting within the company and the industry.

3. Scientific Concept and Practice of Safety Management of Dahongshan Copper Mine

3.1. Standardized Management of Large Blasting Operations

Dahongshan Copper Mine calls the mining and collapse operation of the mining site a large blasting operation, which is named after the large amount of explosives consumed each time. When the amount is large, 30 to 40 tons of explosives are consumed at a time. Dahongshan Copper Mine has been blasted more than 140 times a year, collapsing about 4 million tons. Because of its large amount of explosives, many times, many operators involved, and huge safety risks, it is directly related to the completion of mine output and profit assessment. It can be said that the big blasting operation is the most important and important work of the mine, focusing on the level of on-site production management. The safety management standard of blasting in Dahongshan Copper Mine is highly standardized and worth learning from. The typical practice of safety management of blasting operations is:

3.1.1. Formulate Measures to Regulate Behavior

Combined with the actual situation of the mine, the Measures for the Safety Management of Large Blasting in Dahongshan Copper Mine have been formulated. First of all, the functions and powers of the leaders of the mine and departments are stipulated; secondly, the safety conditions that should be achieved in each process of blasting operation and the protection measures that should be taken are carefully and clearly stipulated. Most of these learily stipulated. Most of these regulations are expressed in specific numbers, which are not only operational, but also simple and clear.

3.1.2. Comprehensive Acceptance to Ensure Implementation

According to the blasting start time, the Ministry of Mine Safety and Environmental Protection takes the lead in organizing the comprehensive acceptance of the blasting mining site by various departments that organize blasting design, construction and auxiliary operations at least one day in advance to ensure that all safety requirements and measures are implemented. During the acceptance

process, first of all, the unit of the construction area explains the mining site and blasting situation. Secondly, the acceptance members enter the mining site to carry out on-site verification of safety conditions and preventive measures in accordance with the acceptance standards. Finally, the Ministry of Safety and Environmental Protection shall make a decision on whether to pass the acceptance and relevant rectification opinions.

3.1.3. Pay Attention to Details and Standard Operation

Before each blasting site, a notice is issued in the form of an important mine document to make detailed arrangements for the blasting organization, blasting scope, main technical parameters, safety measures, etc. A temporary headquarters is set up for each blasting site, which ensures that all blasting production operations are carried out in accordance with the safety operation rules.

3.1.4. Clear Rewards and Penalties to Strengthen Responsibility

If the blasting process is carried out in full accordance with the safety operation procedures, and the blasting effect meets the design requirements, the blasting safety reward will be issued in accordance with the standards; if there are potential safety hazards and problems in the blasting organization, the implementation process, or the blasting effect does not meet the design requirements, the relevant responsible person will be severely punished.

3.2. Build an Organizational Guarantee System for Production Safety

Firstly, establish production safety management agencies at all levels. The mine has established an Occupational Health and Safety Environment Committee composed of the Director as the Director, the Deputy Director of Production Safety as the Executive Deputy Director, the Secretary of the Party Committee, the Deputy Director of Equipment, Operations and Deputy Director Wei, the Chief Engineer, the heads of various government departments and grassroots units, and staff representatives. The committee meets once a month, which mainly includes the communication of important production safety documents and the spirit of the meeting, major safety decisions, the formulation of major accident hidden hazard rectification measures, and the production safety debriefing of heads of various government departments and grassroots units. Set up a security department to independently perform safety and environmental protection supervision functions. The Ministry of Security and Environmental Security is the largest department in the Mining Department, with four groups with a total of more than 70 people. In addition to conventional production work such as mass blasting safety organization, safety inspection, safety assessment and drafting of rules and regulations, it also undertakes personnel and vehicle dispatching. Each grassroots unit shall set up a safety management leading group, and the team leader is the district head, who is responsible for leading the team leader and full-time safety administrator to carry out the safety work of the

unit.

Secondly, implement the responsibility of production safety layer by layer. At the beginning of each year, the mine chief, on behalf of Dahongshan Copper Mine, signs a letter of responsibility for the occupational health and safety environment with the superior company. The mine chief decomposes the responsibility layer by layer and signs the target responsibility letter with the person in charge of each government department and the person in charge of the grassroots unit. In order to promote the realization of the goal, Dahongshan Copper Mine has also established a safety risk mortgage system. The safety production targets in the 2019 target statement of responsibility are 0 for work-related deaths and serious injuries; the negative injury rate of thousands of people in two thousand; the pass rate of respiratory dust is 90%; the effective air volume rate is 65%; the wind speed pass rate is 70%; mines, tailings depots and concentrators have reached secondary safety production standardization and the three-standard system. After reviewing and replacing the certificate. In addition, the local county people's government has also signed a certificate of responsibility for the safety of non-coal mining enterprises.

Thirdly, adhere to the mining director's system of going down to the well and leading the shift. Combined with the requirements and actual needs of the State Administration of Safety Supervision, Dahongshan Copper Mine formulated and promulgated the Management System for the Leaders of Dahongshan Copper Mine. Among them, the leaders lead the class down the well into three levels: the first level is the mining leader. The mine chief and the secretary of the party committee go to the well at least 8 times a month, the deputy director of production safety, the deputy director of equipment and the chief engineer go to the well at least 12 times a month, and the deputy secretary of the Party committee and other mining leaders go down at least 6 times a month. At the beginning of each month, the implementation of the leader's shift schedule last month and the schedule for the current month will be announced in the office building and the wellhead and accepted for supervision and inspection. The second level is the leader of the production area to lead the shift. The district head and the secretary of the party branch will go to the well at least 8 times a month, and other deputy district chiefs will go to the well at least 12 times a month, and the implementation of the leader will be carried out by the Safety and Environmental Department. Assessment, reward and punishment; the third level is led by the person in charge of the mining project department, and the implementation of the leading class shall be assessed and punished by the direct management area.

In the process of leading the shift, leaders and supervisors at all levels of Dahongshan Copper Mine have the following responsibilities: first, to find and eliminate hidden dangers of accidents, inspect and stop the "three violations" phenomenon, and confirm the safety of the site; second, to guide and organize pre-shift meetings and handover shifts; third, coordinate and deal with unexpected problems arising in the production process.

3.3. Various Forms of Safety Inspection and Scientific Quantitative Assessment Mechanism

There are various forms of safety inspection in Dahongshan Copper Mine, which are mainly divided into: First, special safety spot checks deployed by superior units and government departments. After the inspection, the mine chief and the secretary of the party committee held and attended the summary and analysis meeting of the safety inspection, and made arrangements for the required rectification time limit, plan, etc., reflecting the great importance attached to production safety. The second is the comprehensive safety inspection at the mine level, led by the mining leader, the head of the department and the construction area, the person in charge of the project unit and the full-time safety management personnel, and implemented once every month at the end of each month. Third, the business security inspection of each functional department. Fourth, the safety inspection of the construction area. Fifth, the daily safety inspection of the team (room). The Safety and Environmental Department is responsible for sorting out and evaluating the hidden dangers detected by the monthly comprehensive security inspection and operational security inspection. In addition to issuing rectification notices and tracking rectification, monthly safety assessment reports are also formed respectively. The monthly evaluation report carefully summarizes and analyzes the number and distribution of hidden dangers detected, the main problems and the next steps.

It is also important to trigger the punishment mechanism by finding major problems in safety inspections or accidents in production, but before that, it is necessary to figure out who to punish, how to punish, and how much to punish. This requires a scientific quantitative assessment system. Taking Dahongshan Copper Mine as an example, the first is to clarify the technical disclosure work that should be undertaken within the scope of professional responsibilities such as mining, geology, surveying, electromechanical, ventilation, filling, etc. For example, in the basic hole design, the mining profession should clearly describe the relationship between the upper and lower left and right of the outlet area, mining methods, hole depth and number of holes, spacing and displacement; the geological major should give lithology and ore quantity, ore body direction and tendency, grade and thickness; the ventilation major should give the ventilation order and local ventilation requirements; safety major should give Safety exit settings, safety measures suggestions, etc. At last, each major signs the drawings to confirm and control the security risks from the source. The second is to sign and decompose the “Annual Occupational Health and Safety Environment Target Responsibility Letter” layer by layer. Whether the target responsibility statement of responsibility for work-related death, serious injury, 1000 people’s negative injury rate, respiratory dust pass rate, effective air volume rate, wind speed pass rate, whether the mining site, concentrator and tailings reservoir have reached the standardization of secondary safety production, and whether the three-standard system The conditions, standards and corresponding rewards

and penalties are clearly defined through the review and replacement of certificates. Thirdly, form a complete summary and evaluation mechanism for production safety, which should integrate inspection, assessment, summary and evaluation. That is to say, the summary evaluation of production safety is to divide the mine system into several units. Through safety inspection, compare the evaluation standards of each unit, find the source of danger, evaluate its risks, and finally quantify the current situation of safety management of the mine system, and carry out the process of assessment and risk control accordingly. For the problems and hidden dangers detected in the process of systematic state evaluation, the higher company shall issue a rectification notice. The rectification time limit, responsible person, measures and funds shall be implemented one by one in the mine. If the rectification cannot be rectified immediately, a report shall be formed and reported to the company. Fourth, according to the comprehensive safety inspection and business security inspection of Dahongshan Copper Mine, the superior company forms a monthly or quarterly systematic safety evaluation notice for Dahongshan Copper Mine, which is issued in the form of a document to guide the mine to adjust the safety management plan in a timely manner to achieve the annual risk control goal.

The ultimate goal of the quantitative assessment system is to ensure that everyone involved in safety and environmental protection has a sense of responsibility, a sense of awe and understanding.

3.4. Actively Carry out the Standardization of Teams

The team is the cell of the mine. It is the forefront of investigating and controlling hidden dangers and preventing safety accidents. It is also the key link in strengthening on-site management. Dahongshan Copper Mine has made many beneficial explorations and attempts in the standardization construction of the team in recent years, which has greatly improved the level of on-site safety management. First, an operation guide for major risk positions has been formulated. These include job operation instructions such as rock drilling, blasting, lifting, transportation, ventilation, support, etc. Familiarize the operators with it through education and training, assessment competitions and other means. Second, establish a complete ledger record. Each team must fill in the pre-shift meeting and handover, hidden danger investigation and control, hazard prediction and other recording forms. The form style is stipulated in the Mine Team Safety Management Standards and Assessment Measures, and is uniformly used in the whole mine. Security check ledger management is one of the key points of each security check. Third, make a Kanban for the standardized production safety team and hang it on the work site. Kanban describes the job responsibilities, on-site standards, accident types, preventive measures and emergency response measures in detail, so that the team leader will re-educate the team members before the class. Fourth, be equipped with the necessary testing and inspection equipment. The mine is equipped with a portable gas detector for

each excavation team, which requires operators to detect and record the concentration of carbon monoxide before entering the site. Fifth, enforce the on-site security confirmation system. As a kind of team ledger, the confirmation content is pumice, debris, lighting, ventilation and support. The main purpose is to put the leader to the shift into practice and whoever confirms who signs is responsible. Sixth, give full play to the role of full-time on-site security administrators. Each work area (workshop) is equipped with full-time safety administrators. These full-time safety administrators are distributed at various operation sites to investigate and deal with the “three violations” phenomenon and strengthen on-site safety management.

3.5. Strengthen Safety and Environmental Protection Education and Training

The purpose of safety and environmental protection education and training is to teach safety knowledge and develop safety awareness. The criterion for evaluating the success of training is that employees have changed from the idea of “I want me to be safe” before the training to “I want to be safe” and “I will be safe” after the training. From the analysis of casualties in mines in Yunnan Province in the past few years, most of them are caused by “three violations”, which shows that there are weak links in the training work and the training effect is not good. The experience of Dahongshan Copper Mine is to strengthen the training of new front-line employees. For example, most of the front-line mine employees who bear all the processes with the highest safety risks, such as rock drilling, prying, support, backing, charge, connection, mining, mining transportation, etc., are employees of outsourced units or labor dispatch operators. Most of them are farmers with a low level of education, and statistics show that in Yunnan Province in recent years, almost all accidents in the mine come from outsourcing units or front-line labor dispatch teams. Some front-line employees have poor safety awareness and insufficient operational skills. In addition, due to heavy production tasks, the flow of workers has accelerated, it is difficult to concentrate energy, people’s insecurity has soared, and the problem of education and training has been highlighted.

Secondly, strengthen the research and analysis of education and training needs, pay attention to practical training and on-site safety training; select and improve the content and methods of training in a targeted manner, and innovate training methods. For example, front-line employees will be trained in third-level safety education and training for new employees, safety training for special operators, safety training for job transfer operators, safety training for illegal operators and other targeted safety training. Among them, the third-level safety training for new employees is the most valued by mines, including comprehensive safety management knowledge, production safety laws and regulations, and typical accident cases. Some of the content adopts a one-to-one model to enhance effectiveness. Dahongshan Copper Mine also has a special safety training

classroom. Training teachers select or hire experienced practitioners from various majors and hold a registered safety engineer qualification certificate at the same time.

Thirdly, the mine has set up special funds to guide production units to improve the practical skills and safety literacy of employees by formulating training plans, building literacy teams, compiling training materials, and integrating training into safety inspection.

3.6. Continue to Increase Investment in Production Safety Science and Technology

Dahongshan Copper Mine has continued to increase investment in personnel and funds in recent years, and has cooperated with universities and research institutes to carry out scientific research on safety technologies such as ventilation, filling and roof support. For example, the scientific and technological projects currently underway include “Research on the Optimization of Mine Ventilation System”, “Research on Mine Tailings Glue Filling Technology”, “Research on the Stability Classification of Mine Rock Bodies and Optimization of Anchor Support Parameters”, etc. The implementation of these safety science and technology projects can effectively reduce and eliminate the safety hazards of ventilation and goaf caused by historical reasons, and improve the safety production security capacity of mines. At the same time, according to the different production needs of mines, digital mining software and goaf scanners are introduced to accurately detect the distribution, shape and scale of goaf to formulate a database of goaf, and guide mine filling and safety monitoring.

4. Suggestions for the Next Step in Production Safety

Incomplete or illegal and major production safety hazards and casualty accidents of licenses (procedures) are three sharp edges hanging over the mine production safety work, and any occurrence or unresolved can cost us a huge price. Although the production safety department of Dahongshan Copper Mine continues to make great efforts to prevent and reduce casualties, some major production safety hazards that exist objectively for historical reasons have not been fundamentally addressed. For example, because Dahongshan Copper Mine undertakes heavy production tasks, there are many underground operations and wide, distributed in different middle sections, so there are more people underground operations at the same time. For example, the number of underground operations in the morning shift is more than 1000, which brings potential dangers to on-site safety management. For example, due to the early commissioning time, Dahongshan Copper Mine At present, a variety of underground mining methods coexist, including the backward cutting trench bottom structure upward fan-shaped middle and deep-hole space mining method, with narrow working space and high labor intensity. It is recommended that the safety department of Dahongshan Copper Mine continue to strengthen the protection and treatment of these major hidden dangers.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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