

Study on WD Petrochemical Company Safety Management Improvement

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Abstract: *The study takes the safety management of a domestic petrochemical company as the research object, collects and summarizes relevant information, and analyses the current situation in four aspects, including its organizational structure, safety management system, safety culture construction and behavioral control, so as to identify the problems that exist, such as the adverse impact of management changes, the lack of depth in the construction of safety management system, and the lack of strength in the construction of safety culture. The study also compares and draws on the safety management concepts and systems of well-known domestic and international chemical companies such as DuPont, Toyota and Sinopec, for example, establishing the concept that safety investment is efficiency and extending production safety to the lives of employees, and proposes measures to absorb and apply these achievements in the context of the actual situation of the company. The study proposes a "1-2-4 model" based on the existing "2-4 model" of accident causation: a safety information platform, two levels of organization and individual, the root cause of culture, the fundamental cause of system, the indirect cause of employee awareness and knowledge, and the direct cause of employee behavior. In view of the problems of enterprise safety management, based on the model, this paper proposes measures to improve WD's safety management, including planning, creating a safety information platform, establishing a safety management organization and employing professional staff, introducing solid system construction and benchmarking activities, cultivating a progressive corporate culture, creating a good working atmosphere, truly putting people first, putting strong training and education in place, raising staff safety awareness, teaching employees about safety, adopting effective motivational methods, etc. This will promote the continuous updating and improvement of WD's safety management and ensure a healthy and sustainable development of the company as well as a harmonious community business relationship.*

Keywords: *safety management; safety culture construction; behavioral control; safety management system*

1. Introduction

The topic of safety is everywhere and all activities must be done with safety in mind. "Safety first" is fundamental for any company to achieve economic and social benefits. The petrochemical industry is an artery of industry and a pillar of the national economy, and its ability to produce safely has far-reaching consequences and is closely linked to the daily lives of people. The petrochemical industry itself is high-risk. Most of the media are flammable and dangerous, which can easily lead to fires and even explosions. The installations are large, with complicated process routes and harsh operating conditions, and most of them are high-temperature and high-pressure while running continuously. Once an accident occurs, it can easily spread and cause secondary accidents, resulting in huge losses and hazards to property, people and the environment, threatening the safety of nearby communities. To promote industrial clustering, the Development and Reform Commission released the 13th Five-Year Plan Layout of the Petrochemical Industry in June 2015, which was further deployed, aiming at scientific and rational planning from the source of petrochemical industry development. Seven world-class large-scale petrochemical industrial parks are planned to form economies of scale, including Dalian Changxing Island, Shanghai Caojing, Jiangsu Lianyungang, Guangdong Huizhou, Zhejiang Ningbo, Hebei CaoFeiDian, Fujian Gulai Peninsula, etc. At the same time, domestic crude oil import quotas were released and more private enterprises were given the right to import crude oil. Private enterprises, from downstream industries such as printing, dyeing and textile, moved into the upstream refining industry and participated in the restructuring and base construction of the petrochemical industry in accordance with industry requirements. This will lead to a further increase in the level of intensification, scale and integration of the petrochemical industry, and at the same time

will place higher demands on safety management. The concept of production safety and development is also changing, and the level has been significantly raised. Safety production is no longer just for the pursuit of enterprise efficiency or the improvement of the gross national product, but has been incorporated into the overall pattern of national economic and social development and the construction of the rule of law, and is the scope of social management.

2. Theoretical Overview

2.1 Overview of Safety Management

Article 19 of the Work Safety Law sets up corresponding institutions and personnel according to the different sizes of enterprises, "Enterprises employing more than 300 persons shall set up work safety management institutions or equip them with full-time work safety management personnel; those with less than 300 persons shall equip them with full-time or part-time work safety management personnel or employ engineering and technical personnel with corresponding technical qualifications".^[1] The form of safety management departments in domestic enterprises still mainly follows a centralized organizational model, with relatively inefficient communication channels, overly centralized decision-making, neglecting the importance of effective assistance from parallel departments and grassroots staff participation, and less than ideal efficiency and effectiveness in the implementation of safety instructions and measures to effectively stifle accidents.^[2] With the improvement in safety performance caused by DuPont's change from a centralized to a combination approach, the functional shortcomings of a centralized safety organization have received increasing attention, and DuPont's transformation has inspired many enterprises at home and abroad to follow DuPont's example in re-planning their safety management structures and optimizing the functional design of their organizations. The safety management body is an independent functional department, whose duties include familiarizing itself with and implementing relevant safety regulations, coordinating the overall work of the company's safety production, disseminating safety provisions, publicizing corporate rules and regulations, organizing regular safety meetings, drawing up annual work plans, implementing the division of responsibilities and targets, preparing and reviewing safety operating procedures, organizing various skills training, education and competitions such as fire drills, etc.^[3] Regular safety inspections are carried out in different disciplines and installations, correcting irregularities and behavior, leading the investigation of hidden dangers, attempted accidents and accident analysis, planning safety budgets, ensuring continuous investment to maintain the essential safety of equipment, guiding the construction of a safety culture, strengthening staff safety awareness, assessing the state of safety production and strengthening the exchange of experience in the industry.^[4]

2.2 Safety Management and Safety Culture

The concept of safety culture first originated in the US, and its core lies in making people as concerned about their own safety and health as they are about the need and importance of regulating their own behavior, which in the case of individuals is personal safety cultivation and the safety atmosphere of a company.^[5] Its essence lies in the creation of a good working atmosphere, through effective positive incentives to guide and improve the behavioral cultivation of employees, so as to prevent accidents. Safety culture is a common way of behavior and unwritten guidelines accepted by all employees, and is a kind of work synergy and interpersonal relationship magnetic atmosphere that we all care for and cultivate in the process of establishing, growing and developing the enterprise, and is rooted in the conceptual awareness of all personnel.^[6] Safety education and publicity as a carrier of culture, is the basis of the construction of safety culture. Regardless of the development of science and technology, how high the degree of intelligence, equipment cannot really achieve the absolute essence of safety, which requires effective management system to make up. Management mode is diverse and is no right or wrong, only whether it is suitable for the enterprise's own situation.^[7] The applicable effective management method helps to make up for the lack of equipment technology; and the construction of safety culture can ensure that the enterprise management system is effectively and correctly understood and implemented, truly helping the enterprise to achieve essential safety. The root of safety culture construction lies in the cultivation and improvement of human quality, and the most fundamental lies in changing the invisible and untouchable "safety awareness" in the minds of employees. The most effective way of achieving this change is through top-down change, the leadership of the company, and the absence of privileges in front of safety.^[8] The safety culture guides and inspires employees to think about safety-related issues, to find the answers to their own questions

and to improve their professional skills through internal and external education and training, to give them the ability to solve faults and even to improve and transform equipment, and to enhance their sense of achievement at work. By attaching importance to humanistic qualities such as character and conduct, taking the implementation of rules and regulations seriously and creating a harmonious working atmosphere, employees can change from passive to active. The invisible hand is used to guide the way employees behave. A modern corporate culture of safety concepts includes: "Safety first".^[9] The phrase cannot just be used as a slogan, but should be taken seriously at all times in work. Safety is not a trivial matter, and should be given priority, both in terms of progress and efficiency. Valuing life and health is a prerequisite for all production and life activities. Safety management should use passionate publicity and education to stimulate education staff, with heartfelt service to support them, deep concern to protect and warm them, tender initiatives to regulate their safety behavior, absolute management to restrain them, ruthless accidents to inspire them. Some research data show that accident losses account for 2.5% of GNP, and safety investment in Western countries accounts for 3.3% of GNP, and the current safety investment in China is about 1.2% of GNP. The value of the safety input-output ratio is 1:6, in the design and construction phase of safety equipment and facilities can be ten times, a hundred times, or even a thousand times in return. In front of many shocking cases, this view is also getting more and more attention from enterprises, and the accident treatment, rectification costs, the first prevention of investment can bring long-term sustainable economic benefits for enterprises. The intelligence and automation of production equipment cannot be separated from the design and operation of people; therefore, all accidents can be prevented at source.

2.3 Behavioral control of safety management

The four factors that cause accidents are people, machines, environment and management. Unsafe human behavior is the most difficult to monitor and change, and is the most important cause. DuPont statistics show that 96% of accidents are caused by "unsafe behavior", so the direct way to prevent accidents is to do a good job of managing the behavior of the people working on site. Human behavior can be observed and measured. On the contrary, human consciousness and attitude in minds can neither be observed nor measured, so human behavior can be managed while attitude and consciousness can be changed by changing behavior which is of great importance. Human behavior is influenced by psychology, physiology and the surrounding environment and behavioral change should start from both individual and group dimensions. Individual changes should be made from awareness, knowledge and habits at the same time, strengthening training and the knowledge of staff, encouraging staff to correct each other's bad habits, and reversing awareness through behavioral changes.^[10] Through the change of consciousness, employees can consciously change their behavior, and finally realize a virtuous long-cycle cycle.

3. Analysis of the Current Situation, Problems and Causes of WD's Safety Management

3.1 Corporate Safety Management Fact Sheet

WD was established on December 19, 2003 as a Sino-foreign joint venture between GS-Caltex Group, Oman National Oil Company and Red Star Organic Chemicals, the 230th largest chemical company in China. With a registered capital of US\$231.67 million, the company's legal representative is Xu Jinxiu and the total area of the plant is 111 hectares. The company employs approximately 350 people and produces and sells paraxylene and related petrochemical products (according to the scope of the production license), as well as import and export distribution of similar products. In 2014, the company merged with Lixing Storage and Glaxo Chemicals to form a group company. The Company's main production facilities are aromatics plants (including naphtha hydrotreating plant, continuous reforming plant, aromatics extraction plant, disproportionation and alkyl transfer plant, paraffin separation and acid water stripping plant, Parex adsorption and separation plant, xylene isomerization plant, xylene fractionation plant, reforming gas deep cooling recovery plant and residual oil extraction and olefin refining plant). The production scale is 1.671 million tons per annum of imported C4-C11 reforming feedstock and 140,000 tons of mixed xylene feedstock, with 800,000 tons per annum of paraxylene as the main product and toluene, residual oil, benzene, LPG, paraffin, heavy aromatics, fuel gas and SA-1000, a high boiling point aromatic solvent, as by-products. The company is located in the Qingdao Economic and Technological Development Zone and its surroundings are as follows: One wall away to the east is Qingdao Yijia Yanghong Fuel Oil Co. The distance between the nearest LPG spherical tank (Class A) and the fuel oil storage tank (Class C) of Tianan Heavy Traffic Asphalt Co.

South: Qinhuangdao Road and 35KV overhead line (Haifu A line and Haifu B line), the distance between the fence of the plant and the roadside of Qinhuangdao Road is 28m, and the fence of the plant is 2m from the 35KV overhead line; south of Qinhuangdao Road, there are enterprises and residential areas (enterprises such as Yihe Electric Company, Qingdao Jilongda Company, Yitian Electrical Parts Manufacturing Co. The distance between the company's LPG spherical tank wall and Qingdao Jilongda Company is 206 m. The distance between the pipe wall of heavy naphtha storage tank and Yitian Electrical Parts Manufacturing Co. To the north of Liaohe Road are Qingdao Hongxing Logistics Industry Co. The fence of the company's factory is 60m away from the transportation corridor of the chemical zone; outside the fence of the company's factory is adjacent to the abandoned transportation corridor of the chemical zone (the corridor mainly transports steam and is now abandoned and ready to be dismantled). The company has two Sinopec buried oil pipelines on the north side of the plant, which are 37m and 40m away from the company's plant fence. There are vehicle injuries, drowning, toxic hazards, noise hazards, dust hazards, high and low temperature hazards, etc. while fire, explosion, poisoning and asphyxiation is the greatest risk.

3.2 Current Status and Problems of the Enterprise Safety Organization

The new Work Safety Law promulgated on 1 December 2014 stipulates that enterprises with more than 100 employees should establish a "safety management agency or have a full-time work safety manager". The 2002 edition of the Work Safety Law requires an enterprise to have more than 300 employees, which shows that the national mandatory requirements for the establishment of safety agencies in enterprises are gradually increasing. The safety management agency of an enterprise is fully responsible for the safety management and supervision of the production and operation of the organizational structure, the implementation and enforcement of national safety and health laws, local rules and regulations, national and industry standards. In addition to ensuring normal production and business efficiency, it should respond to the higher and stricter national requirements for safety and environmental protection, and continuously increase the investment in the infrastructure equipment and facilities of the enterprise. Although safety investment does not directly bring benefits to the enterprise, it is the basis for the survival of the enterprise, the guarantee of benefits, and the basis for the sustainable and healthy development of the enterprise. The main responsibilities of an enterprise's safety management organization include guiding and building the safety culture of the enterprise, preparing and improving the enterprise's safety management system.

3.2.1 Current Status of the Corporate Security Apparatus

WD has a linear structure, with parallel departments such as Production, Planning, Finance and Human Resources under the leadership of the General Manager, and parallel departments such as EHS (Safety, Health and Environment), Production and Operation, Process Technology and Mobile Equipment under the Production Department. There are sections under each department, a principal minister for each department and a section manager for each section. Under the safety department, there are three sections: safety, environment and security. Overall, the safety department is at the third level in the company's structure system, and the safety director is under the direct leadership of the production principal.

The company's safety operations are managed in a linear fashion. Three sections are set up under the safety department, namely the environmental section, the safety section and the security section. Each section has a manager, three engineers in the environmental section and a sewage treatment director; the security section has a security manager and sixty security guards, who are responsible for the security of the whole plant; the safety section has three safety engineers, three safety technicians, a health care engineer, a doctor and a nurse, and a professional fire brigade, with some of the first and second line team members working part-time as production operators.

3.2.2 Problems With The Safety Organization

In general, the responsibilities of the safety department should focus on conceptualizing, organizing and guiding the construction of the safety culture and safety management system of the company, and promoting its continuous implementation within the company, organizing regular plant-wide system audits, and regularly inviting external organizations to audit and certify the existing management system of the company; continuously improving the professional knowledge and awareness of safety management personnel, and fully studying laws, regulations and various standards. As one of the few foreign invested petrochemical companies in China, the company should especially strengthen the promotion, education and implementation of safety laws and play the role of internal safety advisor,

organize various internal and external safety trainings, organize safety inspections at different scopes and levels of the company, etc. 1) The safety organization and the production line structure are set up with a clear linear character, where tasks can be communicated and carried out vertically to the end. However, the parallel departments lack horizontal links or the degree of cooperation between them is not close enough. For example, there is no engineer or technician position set up within the on-site production department such as electromechanics and instruments, so the decision support of the production line leaders needs to consult other parallel departments. And the cooperation process is prone to inter-departmental shifting, so the leadership decision lacks multi-directional professional staff and assistance, and the decision-making efficiency is affected to some extent. Similarly, the same problem exists in other sectors. 2) The safety department is too inclined to the role of referee. The security department's role is first and foremost that of an adviser and counsellor, then that of an organizer and coordinator, and finally that of a supervisor and reviewer; as yet it has not consciously weakened its role as a referee. 3) The security sector does not fully play its role as a think tank and counsellor for decision makers. The focus of work is slightly inclined to cooperate with the various safety inspections by external regulatory bodies; the safety inspection and evaluation process is more dependent on other functional departments, and the filing and management of safety-related procedures and technical documents are not meticulous enough; the professional ability of safety management personnel needs to be improved, and they lack understanding of the contents of some professional documents; the mastery of systems and standards by safety professionals has not yet reached a proficient level, and they are not able to be flexible and apply themselves to the management of field operations. (4) The top safety manager (Vice President of the Production Division) and the safety director (Technical Director) are part-time Korean personnel who are appointed by the Group's headquarters for a short period of time and rotate relatively frequently, and need to learn and adapt to the domestic production safety laws and regulations and to understand the factory situation for a long period of time before taking up the post. There is a relative vacuum in security decision-making that prevents the development of long-term, unified and clear strategic security objectives. This is not conducive to the continuous development of specific safety work. From the perspective of safety management of the entire company, this results in a waste of management resources and affects the efficient operation of the entire management system. Furthermore, in view of the importance of safety management and the professional and experience requirements for the post, it is not suitable for the leadership of safety management posts to be taken up by certain positions on a part-time basis, which cannot fully reflect the basic requirement of "leadership commitment" in the system construction. 5) Safety technicians receive little external training or exchange opportunities, and their professional foundation and background are relatively weak. According to the principle that the management of production must be accompanied by the management of safety, the production department is responsible for the specific work of on-site safety and hidden danger investigation, but with regard to on-site hidden danger, hazard identification and risk control, the safety department lacks on-site professional guidance and demonstration for the front-line staff and production technicians, and lacks suggestions for hidden danger rectification measures and assessment of rectification effects.

3.3 Analysis of Safety Culture Building

3.3.1 Safety Culture

Safety culture, like culture in the broadest sense, requires a long-term process to form and is the sum of physical safety and safety awareness that is commonly shared and followed by all members. The vertical analysis of safety culture can be summarized into three levels or stages, from low to high, including the material carrier stage of safety culture, the education and procedures stage, and the spiritual awareness stage. Spiritual awareness is the soft culture which exists in employees' minds. Although abstract and elusive, it can be expressed in the daily chats of employees, their behavioral actions and even their safety habits in life. Enhancing safety awareness is the most direct and effective measure to prevent accidents and injuries. Safety culture does not appear suddenly, it is after a long period of summary and precipitation to form a relatively stable safety culture tradition, is the wealth created in the work of safety production, must be well maintained and constantly carried forward. Once an enterprise has formed a safety culture with its own characteristics, it will be passed on from generation to generation and become a code of conduct and a law of business for employees. The best way to educate an enterprise on the value of safety is to publicize advanced role models in production safety. By establishing advanced figures in safety production, you can make other members understand that it is actually not difficult to be safe. Recognizing and rewarding advanced figures in safety is a vivid and concrete way of motivating the organization, providing a sustained impact in production.

3.3.2 Current Status of WD's Safety Culture

1) In terms of motivation, positive reinforcement is mainly given to individuals, while negative reinforcement is mainly targeted at departments. The importance of execution is stressed. Due to the streamlined organization and relatively smooth departmental cooperation, the company has a strong executive force and there is basically no slackness or laziness among employees.

2) Emphasis is placed on the management of hidden dangers and attempted control of accidents, and prevention is embedded in the daily inspection and operational supervision activities of the team. After an unsafe incident, unless the person concerned deliberately fails to act, severe punishment for the person concerned is not advocated. Instead, the focus is on finding the root cause of the accident and taking corrective and preventive measures. This approach greatly protects the motivation of the staff and encourages them to experiment and innovate actively, without worrying about being tied up by occasional mistakes. Fully trusting the staff and giving them space, from the staff's point of view, they usually do not want to destroy this good atmosphere of trust, and will actively work in accordance with the relevant system norms, and actively put forward various safety improvement suggestions and follow up the results of the improvements.

3) Attach importance to intrinsic safety. The design and selection of process equipment are strict, with a strong investment in safety costs at the beginning of construction. Over the past ten years since the plant was built, the plant has benefited from high quality construction standards and strict procurement control, and the online rate of equipment is significantly higher than that of similar enterprises in the same industry.

4) Construction of safety culture in the work group. Education is used as a bridge to promote the construction of safety culture, including three levels of education, process training, mechanical and electrical instrumentation professional training, pre-operation toolbox meeting, communication skills training, etc. At the same time, the proposal exhibition board activity is implemented, with the team divided into groups that regularly updates the content of the exhibition board to promote mutual learning among the team.

5) Safety culture building by management. Modern safety culture construction is mainly promoted through the promotion of team building, regular inspection system, setting targets and effective incentives, advocating and encouraging source control, inspecting hidden dangers, and organizing the review and rehearsal of emergency plans. Taking the promotion of team building as an example, unlike domestic enterprises, the company attaches importance to effective communication between the upper and lower levels, encourages regular dinners between managers and junior staff, which are reimbursed or subsidized by the company's finance. and requires managers of all departments to conduct team building activities on a regular basis and as a performance appraisal item.

3.3.3 Problems in Building a Safety Culture at WD

1)Lack of strategic planning for cultural construction. Safety culture construction mainly stays in preaching and education, and the incentive method is mainly based on material rewards. Due to the lack of planning support, the development of safety culture is in a free and spontaneous state. The safety department has not set clear goals and designed a feasible roadmap to promote culture building step by step, and the safety management department currently has no directional guidance and specific measures for the process from free and spontaneous progression to dynamic and mutual assistance.

2)Safety culture features are not obvious. The safety culture construction mainly relies on the cultural construction activities of the enterprise, and the main body of the implementation planning is the relevant departments of human resources. The safety management department does not reflect the main position in the safety culture construction, so the cultural characteristics do not highlight "safety".

3)People-oriented is the core of corporate culture and safety culture. A harmonious safety culture is the most important factor in preventing man-made accidents. So far, the construction of corporate and safety culture has mainly revolved around building departmental teams, attaching importance to emotional management, focusing on team harmony. However, there is a lack of guidance and necessary support for the individual career development of employees, which leads to the team forming a synergy but lacking the necessary individual foundation to support the team's ability to improve.

4)Lack of long-term mechanism and assessment of the effect of safety culture construction. The safety management department cannot clearly grasp and control the current situation of safety culture, lacks foresight and planning guidance, and the sustainability of safety culture construction is insufficient, which is not conducive to the long-term progress and enhancement of culture construction.

5) Safety culture inheritance and maintenance face the risk of discontinuity. Firstly, due to the dispatch of foreign senior management and job rotation system, the company culture is easily influenced by the leadership style and some elements of the original culture have been changed to varying degrees, and employees need to constantly adjust to it. Secondly, due to the rapid development of domestic petrochemical enterprises in recent years, the enterprise traditional culture is vulnerable to subversion after the reversal of the ratio of new and old employees because the safety culture has not formed and solidified a system and the company lacks management planning guidance. The problem is highlighted in the production activities of the site team, which is the basic unit and core unit of safety culture.

3.4 Security Management Tools and Technical Methods

3.4.1 Overview of Security Management Tools and Technical Approaches

To sum up the research results of accident causation theory, there are five main points. Firstly, all accidents are the result of unsafe human behavior, unsafe physical conditions and deficiencies in management links. The key to the control and restraint of human unsafe behavior lies in the establishment of safety awareness, the correction of bad habits and the improvement of the technical quality of safe operation. The key to controlling the unsafe state of things is to understand the physical properties and functional roles of things, to operate and use them according to their own laws, and to ensure that they are always in an essentially safe state through regular inspection and maintenance. The key to the control of management deficiencies lies in deepening the understanding of the various aspects of management. Secondly, accidents occur as a result of many causal events occurring one after another, and the events and nodes in the causal chain must be strictly controlled or even cut off. Thirdly, Murphy's Law states that if something is likely to go wrong, it is bound to happen sooner or later. To a possible error of things, it is necessary to establish the principle of prevention in the first and remember that any error can be controlled by management means. Fourthly, accidents are the result of the intersection of people or things with the release trajectory of unexpected energy on a certain spatial and temporal plane. Fifthly, according to Heinrich's law, 1:29:300:1000, for every fatal accident, there are bound to follow 29 serious accidents, and 300 near-miss accidents and 1,000 minor injuries. Attach attention to details. Accidents occur from minor and small potential pitfalls. Safety management tools and techniques are used to identify and determine the immediate causes of accidents, to eradicate them, to avoid them and to prevent them from occurring.

3.4.2 Status of Application of WD Safety Technology Methods and Management Tools

WD's safety assessment is based on a KPI target management system. The company sets key performance indicator every year, and each functional department makes annual safety KPI and makes a safety guarantee for its area or business scope. The safety department assesses at the end of the year in accordance with each functional department's initial plan and the company's regulations. The accident-free campaign was introduced in 2006 to count the total number of accident-free staff hours for the whole plant. A counting board was set up at the entrance of the plant to update the total number of accident-free staff hours on a regular basis to remind and motivate staff to create a higher record; for every million hours of accident-free safety production, the company gave all staff a safety bonus whose amount is gradually increased cumulatively. This approach links the safety of the company to each individual, so that everyone is constantly aware that their actions are safe and that they are an integral part of the collective, thus ensuring the company's safe and accident-free production. NCR (Non-conforming) issuance. This practice is a means of control in the PDCA cycle. Any functional department, according to the provisions of the system, can conduct on-site inspections or document reviews of parallel departments, and if any non-conformities are found, an NCR can be issued to the department concerned. In terms of process, it needs to be signed and confirmed by the manager and director of the issuing department and then submitted to the safety management department, and finally issued by the safety director, who will order the department concerned to complete the rectification within a certain period. Fully implement the hidden danger investigation and rectification system. Encourage the grassroots to discover unsafe factors on site. Afterwards the discoverer prepares a proposal, which is approved by the team leader, director, manager and minister at each level. Then organize a panel of experts to rate all proposals every month, and the Vice President of the Production Department awards the first, second and third prizes to the proposers at the regular monthly safety meeting.

Perform root cause analysis method. The RCA method originated in the US Navy and departments, and has since been widely used in the oil, power and coal industries. The principle is similar to the

Swiss cheese principle, where there are many layers of cheese and each layer may have holes, but because many layers are stacked on top of each other, the cheese as a whole does not have holes, so it is assumed that if light is shone through the cheese, the light cannot pass through. However, if light passes through the cheese, it means that there are holes in the cheese, and each layer has holes, thus indicating that the accident is not caused by a single event, but rather the result of an uncontrolled layer and failure of the chain. In the case of accidents, the department concerned is required to prepare an RCA report, draw a snap chart based on the chronology of the incident, analyze the causes and finally find the root cause and formulate corrective or preventive measures.

The DuPont STOP card method was introduced. This method considers that all unsafe conditions can be traced back to unsafe behavior, so the system concentrates on the observation of human behavior. The observer has to identify the safe and unsafe behavior of the person being observed, and needs to communicate with him/her in person, affirming his/her safe behavior or pointing out unsafe behavior. Whenever any unsafe behavior or typical safety behavior is found, any employee of the company can issue a STOP card. Every employee is a safety manager and a supervisor, which can both strengthen safe behavior and weaken unsafe behavior. 6SIGMA is promoted, introducing the concept of quality management into safety management, allowing staff to master the DMAIC way of thinking and work prevention, studying various abnormal conditions in process operations from the perspective of statistical analysis through fishbone diagrams and Para diagrams, finding the root causes of problems, proposing rectification plans and following up to verify the rectification results.

3.4.3 Problems in the Application of WD Safety Management Tools

1) Safety management tools were introduced largely and quickly, but the promotion and implementation were not well planned and lacked a comprehensive plan, resulting in unsatisfactory results. The safety management department was unable to fully digest various safety management tools and methods, and the training for staff was too haphazard. For example, the STOP card was compulsory for each staff to submit 2-3 cards per week at the early stage of implementation, making the card distribution a mere formality, most of the staff casually filled in the cards and submitted them in the office while there was no effective communication. The safety management department did not have on-site supervision, and only pursued the number of cards. The same problem exists in the implementation of the RCA.

2) The approver of the job ticket corresponds directly to the level of the position. The supervision and management of safety operations is on the whole better, with a complete range of operation tickets and double confirmation of the applicant and approver of the four stars of the operation ticket. At present, the final issuance of operation tickets is issued by the production department itself, and the technical staff of the safety department is notified of the pre-operation inspection before the 5 kinds of special operations. In terms of process, the issuance link of engineers and safety officers of the safety management department is missing. The approval of on-site operations cannot be equated with the approval of other office procedures. The approver of on-site operations must have sufficient professional knowledge and on-site experience; it is not the case that whoever has a high position can finally confirm the signature, thus losing the meaning of double confirmation. The approval should be finally signed by the actual commanding officer of the on-site operation.

3) The update of safety and technical operating procedures is not timely enough. Due to the many renovation and expansion projects of the plant in recent years, the new equipment and new processes have increased the operational relevance of the old plant, and the corresponding updating and refinement of the operating procedures have not been connected in a timely manner.

4) The pre-operational safety analysis JSA is not documented and there is no JCC operational cycle check system in place. Although the pre-operation safety meeting TBM has been implemented, there is no distinction between pre-operation safety analysis for routine and non-routine operations, and no written records and files have been created.

3.5 Analysis of The Causes of WD's Safety Management Problems

3.5.1 Causes of Safety Organization Problems

1) Safety management personnel are appointed and their positions are changed slightly frequently. Although the safety director (expatriate) is experienced in the industry, he still needs to enhance his study and understanding of domestic laws, regulations and other relevant systems and industry standards. Most of the technical safety managers are still not registered, which to a certain extent

weakens the effectiveness of the overall management structure.

2)The company's development strategy and blueprint are not clear enough. For example, in a series of historical events, the employees are aware of it afterwards; senior changes and rotations cause fluctuations in business levels in the short term; the company should do something to make the employees fully feel the company's will and blueprint for long-term development in the country.

3.5.2 Causes of Safety Culture Problems

1)Lack of innovation and change in safety incentives. The implementation of the safety proposal reward system and no disaster time rewards for a considerable period of time did improve the level of safety management. However, with the intensification of fierce competition in the industry, it failed to do a good job of vertical and horizontal comparison within the industry. The lack of follow-up improvements and innovations, the lack of health care, slightly putting the cart before the horse. The province of the enterprise lacks strong, effective health care factors of domestic state-owned enterprises or some private enterprises, such as employee real estate, personnel treatment, welfare protection, etc.

2)By the impact of industry competition, the recruitment threshold for grassroots staff has been lowered, and ideas have gradually deviated from the previous focus on professionalism and skills. There may even be individual nepotism, and failure to stop this phenomenon in time will inevitably affect the culture of the team in the long run.

3.5.3 Causes of Problems with the Application of Security Management Tools

1)Safety investment has not been continuously and systematically increased. The selection of equipment at the beginning of the plant was based on high standards. After so many years of operation, its reliability and stability are indeed ahead of peer enterprises; with the increase of the operation cycle, the company should not be paralyzed and overly pursue economic benefits but pay full attention to safety investment, actively introduce new technologies and equipment, and pay attention to the provisions of the new national safety and environmental protection laws in time.

2)The introduction of safety management tools and technical methods of education has gradually become a formality, which should have been more and more in-depth and extensive with the stability of operation and the growth of the enterprise. As far as the current effect is concerned, the education work has not been continuously enhanced, regardless of the level of lecturers or the effectiveness of grassroots learning. If improvements are not stepped up, it will directly affect the safety awareness and operational behavior of employees.

4. WD Safety Management Improvement Measures

According to the accident causation theory, domestic expert Fu Gui proposed a 2-4 model based on the summary, which analyses the root, underlying, direct and indirect causes of accidents at two levels and in four stages, as summarized in the table below.

Table4-1Accident causation model (safety management system)

Organizational level		Personal level		Behavioral outcomes	
Guiding behavior	Operational behavior	Habitual behavior	One-off acts	Accidents	Losses
Root causes	Underlying causes	Indirect causes	Direct causes		
Organization and Culture	Management System	Safety awareness Safety knowledge Safety habits	Unsafe condition of objects Unsafe movement of people		

Corresponding to the accident causation theory, a complete and effective safety management system must start from the root causes, underlying causes, direct and indirect causes and other aspects

to truly achieve a people-oriented approach and improve the level of enterprise safety management. In the case of WD Petrochemical Company, this includes the following aspects: improving the management functions of the safety organization, continuously building a good corporate culture, optimizing the safety management system and implementing relevant standards, strengthening staff education, training and behavioral management, and creating an efficient safety information platform.

4.1 Measures to Optimize the Organizational Structure

1)The organizational structure of the production line departments should be a combination of linear and functional models. The workshop should be equipped with more engineers of various disciplines, including mechanics, electrical, instrumentation, process and safety, etc. It should be a good advisor and guide for the production operation, reducing the pressure of the current line leaders and reducing the risks of safety production. The safety department should be headed by a full-time and permanent person to ensure the continuous implementation of measures and the long-term effectiveness of safety management.

2)Refine the functional division of the security department. On the institutional setting of the safety department, set up a production safety committee with the main person in charge of the enterprise, the relevant functional departments, and the grassroots units, establish and improve the production safety management network from the production safety committee to the functional departments, workshops and grassroots teams, and clarify the personnel responsible for production safety in each unit of the network. It is suggested that a distinction can be made between setting up safety planning and safety technical sections. The safety planning department is responsible for cultural construction, system improvement and dynamic management, safety investment management, etc. The safety technology department is equipped with engineers and safety technicians, focusing on on-site safety inspection, staff training, etc. The responsibilities of the safety planning staff department are to be a good assistant and advisor to the safety director, to understand, interpret, implement and enforce relevant production safety laws, regulations, policies and red-headed documents; to establish and improve the safety management system of the enterprise; to plan and organize safety education and training and activities for various professions and positions; to draw up the safety production work plan for the whole plant; to plan safety equipment and facilities improvement and investment, and to make the corresponding budget submission; to centralize and organize the safety production operation documents and archival documents of each functional department, to establish and timely update the safety production archives; to understand and master the safety production status and management status of the enterprise, to prepare and release monthly safety technology reports and quarterly safety management reports, to identify management weaknesses, on-site process hazards or hidden dangers, and to propose preventive measures. The safety technology department performs the following duties: conducts or organizes safety production inspections in accordance with the provisions of the enterprise's safety production inspection system, endeavors to detect, stop, correct and deal with irregularities at the first site and at the first time; supervises and tracks the implementation of rectification and improvement of hidden dangers; records the inspection and treatment; supervises the issuance and wearing of qualified labor protection articles; participates in the completion and acceptance of new renovation and expansion facilities and projects; deals with accident investigation, treatment, statistics, reporting and other management work; participates in the monthly plant-wide safety production meeting and organizes regular workshop safety meetings; regularly checks and understands the production workplace equipment, facilities, process technology and other archival materials designed for safety production.

3)Strengthen the safety management responsibilities of parallel departments. Each site function department is equipped with a safety technician, and each site team is equipped with a safety net member to truly achieve "vertical to the top, vertical to the bottom, horizontal to the edge, and everyone is responsible"; following the principle of sub-line responsibility, systematic management; graded management, lower management level; consistent responsibility and authority.

4)Localization of safety qualifications for expatriate managers. Stress understanding of domestic laws and regulations by foreign managers of enterprises, and take examinations and certification for safety managers in accordance with the relevant requirements. This will fully reflect the importance that senior leaders attach to safety work internally, set a good example for employees, which will invariably enhance the safety culture of the enterprise and the safety awareness of employees. Secondly, it will establish a good reputation and image of the enterprise externally.

4.2 Safety Culture Building Measures

1)The safety management department relies on the existing achievements to build and guide a corporate safety culture with obvious "safety" characteristics. A special planning team has been set up to work closely with the human resources department to carry out the construction of a safety culture. With reference to the experience of the TPM management activities that have been successfully implemented by the company, a reasonable safety culture development plan and construction program has been formulated, paying attention to the objective gaps in the quality of departmental personnel and the working atmosphere, and gradually advancing step by step.

2)Safety education is truly people-oriented. The simple propagation of safety concepts, safety values and visions are relatively boring and easy to make employees feel imposed, making it difficult to penetrate the hearts of people. Interactive forms of propaganda and education should be actively explored, making full use of enterprise radio, newspapers and magazines, networks such as WeChat public number, carrying out safety literature and arts, displaying exhibition boards of various types of safety production accident cases, organizing small-scale cultural performances, etc. to enhance interactivity, so that safety awareness is truly integrated into the work and life of each employee.

3)Highlight practical education. Strengthen the joint effect of enterprises in the park and between regions, and establish joint practical training bases to experience various types of safety accidents in various simulated environments, so as to enhance hazard identification and prevention skills. In addition to internal drill competitions, competitions are held to compete with each other and strengthen linkages, fully integrating the emergency response capabilities of the park and enhancing the joint inter-enterprise ability to respond to unexpected accidents.

4)Improve a well-oriented constraint and incentive mechanism. Add goal motivation and competition motivation as tools to encourage employees through competitions in safety knowledge, safety drills, etc. Establish a complete positive incentive mechanism. According to Herzberg's two-factor theory, in addition to means such as material incentive and health care, there should be a gradual shift to the culture of the spiritual level. Widely publicize production safety innovations and technical reform proposals, advanced deeds and exemplary figures, increase efforts to select and establish exemplary models, promote a positive spirit, and guide employees to pursue honor and achievement.

5)Establish a feedback, assessment and rectification mechanism. On the basis of the present safety culture, the enterprise internally organizes relevant personnel to carry out evaluation of production and operation and safety management in the form of visits and talks, questionnaires and surveys; third-party evaluation agencies are regularly invited to assess the cultural construction of the enterprise.

6)In the process of institutional improvement, work is planned to solidify the good parts of the existing culture. The material level of the safety culture needs to be maintained after it has been gradually built up so that it can be used for a long time. The material level is mainly a matter of updating slogans from time to time. The institutional level is more difficult to build and maintain and should be widely publicized to ensure that every employee fully understands the system.

4.3 Safe Behavioral Development Measures

1)Establish a personnel safety information system and a personnel safety ledger. The personnel safety ledger is compiled according to each person's personality characteristics, physical examination records, types of work, violation records, safety assessment, safety education hours, safety skills, educational background, rewards and punishments, etc., and is constantly updated. It is used as an important reference for staff promotion and job rotation.

2)Improve staff safety awareness, skills and knowledge by combining traditional safety education with the internet and vigorously promoting an organizational learning model that encourages individuals to take turns giving lectures on a particular topic to enhance communication within the organization.

3)Refine the equipment safety operating procedures and method, in the preparation process can set up temporary groups of equipment and process professionals to cooperate and complement each other. Encourage front-line staff to prepare, modify or make suggestions on existing regulations and operating methods, and improve existing regulations and operating guidelines from a practical point of view. At the same time, mobilize staff's work enthusiasm and participation, so that front-line staff can implement

the operating regulations they have participated in preparing, thus reducing violations due to improper operating behavior.

4)Performing internal production safety inspections. The purpose of safety production inspection is to detect and eliminate dangerous and harmful factors in production equipment and operating environment; to detect irregularities of operators and to stop and correct them in time to prevent accidents and health hazards. It is recommended that the JCC system be implemented, and that a special team consisting of coordinators, team leaders and operators be set up to check the implementation of standard operating procedures in actual operations on site at least twice a year; for critical tasks and routine operations, the focus should be on checking the applicability of the standard operating procedures, how they are being implemented and whether the actions of the operators are standardized, whether the operating procedures are being followed and whether attention is paid to precautions listed in the pre-operational safety analysis. After the inspection is completed, suggestions for improvements to the operating procedures are discussed and best examples are developed. At present managers carry out regular safety inspections, which can again be based on the inclusion of outstanding frontline staff to carry out safety inspections together with managers, to enhance the sense of honor and achievement of staff, to encourage frontline staff to actively propose, and to realize the three groups of management. The form of inspection should be fully diversified: daily safety inspection system for posts, daily inspection by managers, regular comprehensive safety production inspection, mainly by leaders, organizing special inspection teams to carry out, inspection team members include the person in charge of the enterprise, safety management personnel, the person in charge of the production departments and parallel departments, full-time safety officers; special safety inspection such as fire equipment and facilities, special equipment, electrical equipment, etc.; seasonal safety production inspection. Seasonal changes will bring certain impact on production, for example, the rainy season is easy to trigger electric shock, distillation system operation fluctuations, rain and dirt system oil overflow. While strong wind is easy to cause negative pressure fluctuations in the heating furnace, improper operation can even cause a flash explosion. Summer high temperature is easy to trigger heat stroke, while in winter, some special media pipelines are easy to freeze and condensation, resulting in instrumentation failure.

5. Conclusion

Safety management is the fundamental guarantee of production operation and the basis of all benefits and sustainable development of the enterprise. Through the above analysis, WD has improved its safety management work through "1-2-4 model", "one information platform, two levels of organization and individual, four causes" (including culture, system, indirect causes of staff's awareness and knowledge, and direct causes of unsafe behavior), to effectively manage the safety production of the enterprise and ensure its sustainable development.

1)Build a complete information platform. Firstly, based on the information and data that can be collected by Industry 3.0, build a basic electronic information base. Secondly, keep up with new developments in the industry and keep up with the tide of innovation in Industry 4.0.

2)The root cause of the work at the organizational level lies in the establishment of a sound organizational structure and the cultivation of a good cultural atmosphere. Maintain and continue the excellent people-oriented cultural tradition of the company, continue to maintain a positive incentive policy for employees, and supplement and improve the incentive system at the spiritual level. At the same time, according to the two-factor theory to take into account the solid foundation, do not ignore the vertical and horizontal comparison of health care factors and steady improvement.

3)The fundamental aspect of the work at the organizational level is to improve the management system. Effective digestion and absorption of system elements, organic integration and improvement of various current rules and regulations; good internal review, introduction of external review, continuous improvement.

4)The main work at the individual level is to help employees develop good safety habits and eliminate the indirect causes of accidents. The basis for good staff safety education is to launch inter-professional and multi-level training, and to strive to improve the safety awareness and all-round skill quality of all staff and to eliminate unsafe human behavior.

5)The most direct work at the individual level is to use various safety management tools and technical methods to check and correct the operational behavior of employees on site. To achieve

safety standardization in production operations, and on-site inspection and maintenance, and engineering construction; to refine risk identification and hidden danger management, to enhance employees' ability to judge risks, control dangerous hitches and prevent accidents, to enhance forward-looking awareness, and to improve the essential safety level of the enterprise; to integrate safety management techniques and methods, to strengthen the tracking and feedback during implementation, and to strengthen the applicability and localization of the introduced methods, so that the various safety management tools are effectively put into practice.

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