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# System Safety Management of Whole Life Cycle of Chemical Process Unit

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**Abstract**: Guaranteeing the safety performance of chemical process units is the premise for the safety production of chemical enterprises. Only to have the system safety management of the whole life cycle of the process units can operate the process systems under the state of controllable risk.

**Keywords**: whole life cycle of process unit; safety; management

## 1 Life cycle safety management of process units

The life cycle of chemical process unit includes research and development (R & D), project approval, design, construction, operation, transformation, repair and demolition. The enterprise′s safety management should run through the above mentioned stages. Through the management system, the tasks that should be completed in each stage should be clarified, and then the tasks should be completed in a down-to-earth manner, and then the actual results can

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be achieved.

### 1.1 Research and development

Many enterprises have their own R & D departments. For safety, they should focus on two aspects in the process R & D stage. The first one is to identify the hazards of chemicals (such as whether there is abnormal toxicity and instability in raw materials, intermediate products and products) and avoid selecting chemicals with great hazards. The other is to master the hazards of chemical reactions, especially the exothermic characteristics of reactions. In the research and development stage, if we can apply the strategy of intrinsic safety as much as possible and take some measures as early as possible to eliminate the hazards, it will be very positive help for the safety of the actual industrial production process. These are all specific technical work. In order to ensure the proper implementation of these work, the enterprise can establish a process safety evaluation mechanism during the R & D period from the perspective of management, including how to select chemicals and process plans, how to assess risks, and how to transfer the safety information mastered in the R & D stage to subsequent designers and producers[1].

### 1.2 Design

For safety, the most important work in the design stage is to carry out in-depth process hazard analysis and implement the measures proposed in the analysis process to improve the design. Generally, the preliminary process hazard analysis can be carried out by using the analysis method of what if in the preliminary design stage, and then the detailed process hazard analysis can be carried out in the detailed design stage to ensure that every potential accident scenario has sufficient safety measures to reduce the risk to an acceptable level. For example, the risk analysis of plant facilities layout shall be completed, especially the risk of densely populated areas (such as central control room and administrative office area) shall be fully

considered in the design, so as to ensure that the densely populated areas will not be seriously damaged in the event of explosion, so that the people inside have the opportunity to escape. If these dense areas are too close to the hazard sources (measured by the blast wave pressure), they need to be rearranged. If the location cannot be changed, the necessary anti explosion design is needed to reduce the consequences.

In the design stage, more work can be done, such as: review the alarm and interlock of process units, carry out human factor analysis (make the layout and design convenient for operation and reduce operation errors as much as possible), complete the calculation of the release capacity of pressure relief devices such as safety valves, and calculate the thermal radiation of the flare by the devices with the flare (move the operation platform affected by the thermal radiation to the safety area). conduct ventilation calculation review for areas involving toxic substances and special review for dust explosion prevention for process systems involving combustible dust. In addition, if there are other factories nearby, it is necessary to know what facilities there are in neighboring factories and what impact will be caused to the factory in case of accidents. Enterprises should establish management elements of process hazard analysis, and clarify the specific requirements of process hazard analysis and review for the process system in the design and operation stages[2]. In the production process equipment, any special equipment involved must be designed by the unit with corresponding special equipment design qualification.

### 1.3 Construction

In addition to the construction related work safety, the key point in the construction phase is to control the manufacturing and construction quality of key equipment and pipelines (this work is to ensure the integrity of mechanical equipment), including the supervision and quality control of the manufacturing process (NDT, hydrostatic test, etc.). In addition, the function

test of instrument automatic control system and safety instrument interlocking loop needs to be completed. Before the transition from the construction stage to the production and operation stage, carry out the pre start-up safety review, systematically check to ensure that the construction and installation of the process system meet the requirements of the design specifications, and start-up is allowed only after the conditions for safe start-up are met. Enterprises need to establish the management element of pre start-up safety review. During the construction period, if the design changes, it is also necessary to carry out hazard analysis on the changed part to prevent the introduction of new hazards[3]. In principle, during the design and construction phase, these safety related tasks are under the overall responsibility of the project leader (project director or project manager). In the process of construction, the manufacturing and installation of special equipment must be manufactured and installed by units with corresponding qualifications, and be supervised and inspected by local inspection organizations with corresponding inspection qualifications.

### 1.4 Management

This is the daily management stage of the plant, with a long duration. A lot of hazard identification and risk control work needs to be done, and a continuous improvement mechanism needs to be established. The elements involved in the operation phase are mainly people, equipment and work activities. The factory can ensure the safety and sustainable operation of operation by implementing several safety management elements (systems). There are management and control mechanisms (such as change management) for newly generated hazards, and measures to eliminate and control hazards are all implemented. Many of our enterprises are trying to manage safety and are busy, but they are not efficient. One of the most important reasons is that they do not pay attention to the key points. In our current development

stage, the key is to prevent catastrophic accidents (accidents that may cause one or more deaths), so we must focus on the key, especially the process safety management as the core! In the past (including at present), we still treat safety as a whole concept. In the industry, there is a common way to manage process safety in the way of operation safety management, which makes it difficult to really manage process safety despite its many efforts, but the consequences of process safety accidents are often more serious (fire, explosion or toxic substance leakage). The management of operation safety emphasizes the control of human behavior, while the process safety relies more on engineering measures to eliminate hazards and reduce risks. There are great differences between the two management ideas and objects of concern. More attention should be paid to the process safety management to completely eliminate catastrophic accidents. In the operation stage, some elements must be grasped with great effort[4]. Many of our enterprises have made a lot of management elements, but failed to focus on those particularly important management links, resulting in half the effort. For some key elements, if there is a system but the implementation process is not solid, it will leave a path for the accident.

Let me pick out these key elements to discuss:

1) Hazard analysis, During operation, hazard analysis covers a wide range, including process hazard analysis and review every several years, as well as hazard analysis related to operation safety, as well as general hazard identification of operation area, such as various hazards in operation environment, chemical hazards, etc. Process hazard analysis is very important to eliminate hidden hazards in the process system, which can not be identified by a quick look. It is more than a thousand times of patrolling around the factory. Change management. Now domestic enterprises begin to attach importance to change management, and pharmaceutical enterprises are the first to accept and carry out this work because of GMP. But in

some enterprises, change management is the same as going through the process, forgetting why we need to carry out change management. Its original intention is to avoid introducing new hazards due to changes through this workflow, and eliminating hazards is the core of change management. In some enterprises, change documents and signatures are available, but hazard analysis is the only place where there is little in-depth work, which is also related to the failure of plant management and technical personnel to master the tools and methods of hazard analysis[5]. There may be many changes in enterprises, so they can be classified according to the risk. For changes with high risk, detailed hazard analysis should be carried out.

2) Mechanical integrity. The integrity of mechanical equipment (including the reliability of important instruments) is the material basis for the realization of safety in chemical enterprises.

In 2018, the vinyl chloride leakage accident of Hebei Shenghua Chemical Co., Ltd. was caused by the integrity failure of mechanical equipment. Many of factories treat all the equipment and meters equally and are still in the primary management stage of repairing when they are broken. To do this work well, we can introduce the concept of risk-based preventive or predictive management to manage the equipment according to different risk levels (many factories have equipment classification, but basically according to the asset value of the equipment itself, rather than according to the risk that equipment failure can bring), make preventive maintenance plans for key equipment and implement them on schedule. In this way, we can use limited resources to achieve the goal of ensuring the integrity of key equipment. In particular, the special equipment in the process unit shall be registered as required and inspected regularly on time. The integrity management of mechanical equipment is a very important but challenging management element, which requires coordination of equipment, maintenance, technology and production departments. Operating procedures and training.

Operators and maintenance personnel are an important part to ensure safety. Many accidents are caused by people's unsafe behaviors. The enterprise must formulate the post responsibilities and equipment operation procedures, so that each on-the-job employee can understand his/her post responsibilities, equipment performance and operation essentials. In particular, basic safety training for new employees is essential. High risk operation risk management. Hot work has led to many accidents. Some of our enterprises do not even conduct combustible gas detection when issuing hot work permit (some enterprises do not even have combustible gas detector), or the person in charge of gas detection has not received enough training at all[6]. In addition, most of our enterprises have not established the permit system for open work, and attach importance to energy isolation, but it is not enough. The core of risk control of high-risk operation is to put in place the key hazard control measures of combustible gas detection, cleaning and isolation.

3) Emergency response plan. The emergency response is not only to solve the current problems when the accident occurs (such as removing the newly leaked chemicals), but also to prevent the accident from escalating into a worse situation. To maintain an efficient emergency response capability for potential accident scenarios, feasible plans, required emergency materials and competent personnel are required (relying on sufficient drills to improve the response capability). Some of our factories have emergency plans, but they are too general. For example, a disposal plan for leakage of hazardous chemicals should be used to deal with various leakage accidents in the factory, toluene leakage in the tank farm and liquid chlorine cylinder leakage in the workshop. The measures to be taken are far from each other. The practicality of such a disposal plan is questionable. A good way is to identify the credible accident scenarios that may lead to serious consequences in the process system, and then establish targeted emergency response plans (part of the emergency plan). On the basis of these solutions, we can

know what main emergency scenarios, tools and equipment and protective equipment (where to put them). It can also be used to carry out emergency drills and deal with potential accidents and contractor. The contractor here mainly refers to the contractor who provides production, maintenance and construction services for the factory, and they often undertake more difficult or dangerous tasks. In the process of contractor's operation, fire or explosion and other accidents are caused by the enterprise. The management of contractors is very complex. It is a challenge for many enterprises to select contractors, enter the site, operate on site and leave the site. The factory needs to restrict the Contractor's access to irrelevant process areas, and can also control the Contractor's role activities and hazards through the work permit[7]. There are many aspects involved in daily operation. The above list is that the elimination and control of hazards should be given priority.

### 1.5 Modification and repairment

In case of any defect in the operation of the process equipment or any potential accident found in the safety inspection and inspection of the equipment, the hidden danger must be eliminated immediately. In the process of equipment transformation and repair, a scientific transformation and repair scheme shall be formulated, and the construction unit with corresponding qualification shall be selected for construction. The special equipment shall be informed before handling, and shall pass the supervision and inspection of the corresponding inspection agency[8].

### 1.6 Dismantle

In this stage, there are relatively large operational safety hazards, such as cleaning and replacement before demolition, elimination of hidden dangers, and prevention of collapse of some equipment and structures due to long-term corrosion[9].

## 2 Conclusion

Through the safety management of different stages of the whole life cycle of the chemical process unit, the unsafe factors of the substances can be effectively controlled to ensure the safe operation of the chemical process unit and reduce the occurrence of accidents.

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