Research and Application of Standardization of Field Maintenance of Centrifuge Compressor in Long-Distance Pipeline

Liwei Wang*
PipeChina West Pipeline Company, Urumuqi City, Xinjiang 830011, China

*Corresponding author e-mail: wanglw04@pipechina.com.cn

Abstract. This paper expounds the necessity of carrying out the standardization of on-site maintenance and puts forward the problems in the current maintenance. Besides, solutions were proposed based on the problems and the implementation effect was eventually summarized.

Keywords: Standardization, Maintenance and Repair, Process, Safety

1. Preface
There are 151 gas pipeline compressors that are under the jurisdiction of West pipeline company, with the increase of gas pipeline operation time, the frequency of on-site 25K and 50K maintenance for compressors is increasing accordingly on yearly basis. In order to ensure safe operation for maintenance of the pipeline compressor, the high quality maintenance and inspection should be made in the whole process. As a result, the company carried out the compressor overhaul standardization management, which is a mode transformation from extensive management pattern with operation as the management task to intensive management with various procedures as quality control so as to continuously improve the level of maintenance of standardized operation.

2. Necessity of Standardized Maintenance

2.1. Security
A. In the actual related chemical production equipment maintenance, all kinds of personal injury accidents caused during maintenance often occur due to various reasons. Through the summary of experience, it can be seen that the main problems can be classified in the following aspects: One is the concept of maintenance safety standardization procedures failed to be kept firmly in mind by maintenance units and personnel, maintenance work is still conducted in accordance with the previous methods without any change. The second is that maintenance personnel are not aware of the safety maintenance standardized procedures. This kind of habitual operation behavior often leads to maintenance accidents [1].

B. For many years, although the equipment managers of enterprises have been looking for more convenient and feasible equipment maintenance management mode and method to prevent and avoid the occurrence of equipment maintenance related quality accidents and personal safety accidents, the
production practice has proved that it is a good method to effectively prevent the accident of equipment maintenance by formulating the scientific and reasonable safety work standard of chemical equipment maintenance and the safety standard of equipment maintenance work procedure [2].

2.2. Economic Effectiveness
In today's society, modern enterprises should not only pay attention to social benefits in the production process, but also maintain their own economic benefits [3]. According to the statistical analysis of the Trans Canada pipeline, the cost for operation and maintenance for the compressor unit accounts for about 70% of the operation and maintenance cost of the whole natural gas pipeline. Therefore, the implementation of standardized management can reasonably avoid unnecessary waste of funds and energy consumption, so that spare parts should be replaced to the full, reasonable replacement of spare parts, no waste of manpower and material resources, and lay a solid foundation for the stable operation of the compressor unit.

2.3. Maintenance Quality
Compressor plays a very important role in pipeline transportation, and as most of the compressor units in the company are imported ones, which are complexly designed with precise assemble, as a result, it has always been regarded as the focus and difficulty of the company's work, putting more demanding requirements for staffs. In the overhaul process, there are various tasks and scale of overhaul is extensive with more status of equipment, so more staffs are needed for cross work [4]. Its operation order and process also play a crucial role in the efficiency and quality of the whole operation, so it is urgent to design a complete set of maintenance standardization process to comprehensively improve the maintenance quality of the unit.

3. Problems
All-dimensional and whole-process safety management for all staffs must be emphasized and the onsite venues should be clean with order and various safety signs should be well prepared and placed in a eye-catching venues. The safe passage is unblocked, the maintenance area is isolated by fence, the interval management is strengthened, the deployment site is effectively standardized, and the modular management is very conducive to the work, which virtually eliminates part of the security hidden danger and creates a good working environment [5].

3.1. Safety
A. There are many rules and regulations with requirements fall out of the onsite management, which adds difficulty in onsite maintenance, causing omissions.
B. The technical disclosure remains on the surface. The security technical disclosure structure is not sound enough, the content is not comprehensive and systematic enough, and the general focus is on the technical disclosure.
C. Risk identification is not in place. We found that in the process of on-site inspection, maintenance and repair, personnel failed to adequately to conduct risk identification work in the whole operation, and they did not realize the importance of risk identification, simply considering that risk identification is just about compliance or whether the work is conducted or not. whether compliance. Consequently, The risk identification was put on the shelf and did not continue to be identified, executed, re-identified and re-executed during the whole maintenance process, resulting in a serious disconnection between risk identification and on-site maintenance.
D. Safety confirmation is not in place. The premise of unit maintenance is to isolate all energy sources, including process isolation and electrical isolation, both indispensable. But in the on-site maintenance process, always found that the safety confirmation is not in place.
3.2. Tools
A. Most of the general tools and tools are antique, and a large number of tools in some sets are missing, which affects the development of field operations. At the same time, most of the tools are traditional manual tools during on-site maintenance. The tools can be used with low efficiency, and the people can not be liberated from the repetitive and monotonous work.
B. High professional skills can be used for maintenance of compressors and specialized tools with a large amount and different kinds are required. However, there are tools, at times, be lost and deformed. The onsite maintenance efficiency and overhaul quality can be greatly influenced if tools fail to be normally used.

3.3. Personnel
A. Insufficient safety education of maintenance personnel, poor safety awareness and low safety prevention level. At the present stage, most maintenance units only carry out a short time of safety education for maintenance workers before maintenance, without comprehensive and systematic safety education and training, and individual personnel still developed “three violations”[6].
B. Some maintenance operators are not clear about the maintenance contents and maintenance standards, and they are only satisfied with participating in on-site physical labor rather as masters

3.4. Quality
A. Some manufacturers keep the key data confidential and only provide general instructions without specific installation data without maintenance methods and quality requirements. Especially, the disassembly methods of special parts and the use of special tools were not provided for reference [7].
B. For the spare parts that can be replaced or not, there is a lack of judgment basis, which leads to the strong randomness of replacement of spare parts, and the existence of overrepair or underrepair.

Figure 1. Actual consumption and Out-of Stock statistics of unit maintenance of spare parts in recent years

As shown in Figure 1, we have made statistics on the spare parts that have been consumed in large quantity for maintenance of compressor units in recent years, and the actual quantity of spare parts out of storage is more than the actual quantity consumed. There are also some units that have not been replaced with some spare parts, which leads to rework and maintenance in the later period, as shown in Table 1.
Table 1 Maintenance and rework statistics in recent years caused by no replacement of spare parts

| Name of spare parts          | Location                      | Fault by non-replacement                      | Frequency of occurrence |
|------------------------------|-------------------------------|----------------------------------------------|-------------------------|
| 0 shaped ring of shield      | coupling guard                | Oil spilling of the coupling guard            | 1                       |
| O shaped support ring        | Compressor end cover          | Air leakage of compressor end cover           | 1                       |
| Dry gas based sealed adjusting pad | Interior part for dry gas seal | Leakage from the dry gas seal               | 4                       |
| Temperature probe            | Radial bearing, thrust bearing | Damage of temperature probe                  | 2                       |
| Combustion adjustment valve  | Fuel gas system               | The combustion valve is stuck                 | 6                       |

3.5. Maintenance Process

Unit overhaul is a systematic project, which can be done by multiple organs and units, such as departments in safety, material, operation and maintenance, and compliance should be followed in the maintenance programs. It is not only necessary to meet the requirements of the company system and regulations, but also to communicate with these organs and departments. At present, the company lacks a standard maintenance process to guide the on-site maintenance.

3.6. Insufficient Application of New Technologies

Like most of the domestic equipment maintenance enterprises, some of our maintenance concepts are relatively backward, the understanding of new maintenance technology channels are not smooth with more emphasis on pursuit of short-term benefits, the traditional maintenance technology is still adopted, resulting in excessive waste of resources, environmental pollution and increased social costs and other problems [8] In the entire standardized management of maintenance and overhaul, the management mode and means should be constantly innovated to gradually become scientific and standardized [9]

4. Implementation of Standardized Maintenance

Starting from the control of the process, site, safety, tooling, working hours, working procedure, quality and other aspects of the on-site maintenance of the compressor unit, the main contradictions and problems arising in the maintenance process are solved, and the innovation, efficiency, practicality, guidance, demonstration and standardization of the results are highlighted.

4.1. Standardization of Maintenance Process

A. Before maintenance, monthly and weekly operation plans should be reported in advance, and carry out work order preparation, scheme preparation and approval, etc.

B. Before the start of the operation, safety education and training, program learning, technical disclosure, JSA analysis before the operation, bill handling, compressors isolation (jointly confirmed by the operation personnel and maintenance personnel), emergency drill and other work shall be carried out

C. In the process of operation, the relevant provisions of norms, procedures and operation instructions shall be strictly followed. After the completion of the operation, the bill shall be closed, the unit shall be isolated and restored, and the machine shall be taken up for testing (72 hours).

D. The handover and acceptance of the unit after maintenance and the preparation of maintenance report. If there are any remaining problems, they shall be indicated in the maintenance report for subsequent rectification.
4.2. Standardization of Onsite Maintenance
A. Standardizing the visual image. To wear the work permit, and be dressed in the maintenance work suit, anti-static shoes, safety helmet, anti-noise earmuffs or earplugs and other labor protection products distributed by the company.

B. Standardizing operation board. To prepare on-site maintenance board, including operation brief, organizational structure, requirements on operation safety, requirements on operation quality, today's operation content, etc., and reserve a place to place operation plan, operation bill, risk identification and emergency disposal.

C. Zoning standardization, and repair the scene is divided into the following areas: visual management information display area, maintenance areas, instruments put area, parts put area, homework board area, security appliances put area, waste storage area, repair units and operation units in the middle place with alert pile is isolated from, and set aside fire, emergency evacuation.

4.3. Maintenance Safety Standardization
A. Pre-operation safety analysis. JSA safety analysis should be carried out according to the main operation steps before the start of the operation, and the main steps are standardized decomposed. Taking specific maintenance tasks as the starting point, the tasks are decomposed layer by layer to form a detailed disclosure of safety technology, so as to ensure the integrity and thoroughness of the disclosure of safety technology in maintenance work [10].

B. Energy isolation. To prepare process and electrical energy isolation form. Based on contents of isolated form, process valves and the power supply equipment of MCC can be switched on or off with signs on it or locked. Preparing locking ledger, which should include locking time, person, reason, equipment number and other information. Full-size pressure blind plate should be installed for inlet and outlet flanges of the compressor unit.

4.4. Standardization of Maintenance Tooling and Spare Parts
Containerization and standardized management should be conducted for the compressors overhaul, repair and replacement of dry gas seal general tools and maintenance spare parts, which not only saves the time to prepare tools and spare parts, but also helps us find the missing tools in time, at the same time, the pare parts can be replaced.

4.5. Standardization of Maintenance Procedures
In order to ensure that the maintenance process is controllable, standardized management is carried out for the major and medium repair procedures of various types of compressor units. The field operation instructions for each type of operation are strictly prepared and the quality control of each procedure in the operation process is carried out.

4.6. Standardization of New Technology Application
To actively carry out technical exchanges with the industry and original equipment manufacturers, and complete the application and approval of renovation projects or new technology application programs in advance when carrying out the overhaul of units, so that the overhaul, renovation projects and new applications can be implemented simultaneously, and a number of problems can be solved by taking advantage of one overhaul.

5. Application Effect and Conclusions
A. It has changed the situation that the maintenance site is disorganized and the visual management is not in place.

The standardized management of the maintenance site, each area of the operation site is correspondingly planned, and the operation display board make the maintenance personnel, the content of the maintenance tooling and the maintenance process be clearly viewed. At present, the planned and unplanned compressor maintenance site is in good order.
B. Enhancing maintenance and safety control

Through the maintenance and safety standardization management, the pre-operation safety analysis project is standardized, and the unit energy isolation control is strengthened. The personal safety protection regulations are in place. The disassembled pipe plugging is beautiful and effective, and convenient for reassembly. The safety management of compressor maintenance at all levels has been normalized according to the standardized requirements.

C. Containerized maintenance tooling is beautiful and convenient

Through the standardized management of overhaul tooling, the common tools are placed reasonably and standardized on site, and the loss of common tools is eliminated. After the special tools are containerized, it is convenient to carry, without any omission.

D. Maintenance efficiency is controlled and maintenance quality is greatly enhanced

Through the standardization of maintenance hours and procedures, the planning of maintenance time and procedures has been strengthened, and the maintenance projects have been carried out on time according to plan, and the maintenance quality has been guaranteed.

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