安全评价技术

在石化生产长周期运行中的发展应用

(The Development and Application of Safety Assessment Technology in Long-term Operation of Petrochemical Plants)

安全工程研究院　张海峰

Zhang Haifeng　President of Safety Engineering Research Institute

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一、石化生产长周期运行的重要意义

石化生产的长周期运行，是指在保持一定安全水平的条件下，延长生产装置连续运行时间，实现装置的“安、稳、长、满、优”运行和效益最大化。

Ⅰ. The importance of long-term operation of petrochemical plants

The long-term operation of petrochemical plants refers to extending the continuous operation time of production plant, and achieving the safe, stable, long-term, full-load and high quality operation and maximum profit of the production plant while maintaining certain safety level.

㈠长周期运行是工业化大生产发展的必然趋势

随着石化装置生产规模的大型化和上下游生产的衔接日益紧密，重要装置或上游装置的非计划停车带来的经济影响和损失就愈加显著。延长装置运行周期，消除非计划停车已成为工业化大生产发展的必然。

A． Long-term operation is the inevitable trend of development of industrialized mass production

Along with the macro-scaled operation capacity of the petrochemical plants and the closer connection between upstream and downstream production, the economic influences and losses caused by the unscheduled shutdown of major plants or upstream plants become more and more serious. Therefore it becomes an inexorable trend in the industrialized mass production to extend the plant operation cycle and eliminate the unscheduled shutdown.

(二)长周期运行是提高企业经济效益的重要措施

延长装置的运转周期，最大限度地发挥设备能力，增加装置有效生产时间，是石化企业提高经济效益的有效途径。

B. Long-term operation is an important measure to increase the economic benefit of enterprises

For petrochemical industry, extending the plant operation cycle, maximizing the equipment capacity； and it is also the effective way to increase the economic benefits of enterprise.

㈢长周期运行是企业管理水平的综合体现

石化生产的长周期运行，是企业综合管理水平的集中体现。优秀的企业管理是推行长周期运行的根本保障，推行长周期运行也能够促使企业全面提升管理水平。

C. Long-term operation is the overall representation of enterprise management level.

The long-term operation of petrochemical production plant is the collective representation of the comprehensive management level of enterprise. The high quality enterprise management is the fundamental assurance of the long-term operation of production plant, and the long-term operation of production plant can also impel the increasing of overall management level of the enterprise.

㈣长周期运行是增强企业国际竞争力的必由之路

一些国际化大公司对石化装置的安全管理早已由前期的定期计划检修转变为目标检修、完整性管理，从而提高了企业检维修工作的有效性，延长装置运行周期。

D． Long-term operation is the necessary route for enterprise increasing international competitiveness.

In nowadays, several international companies has been changed from the previous periodical scheduled maintenance to objective maintenance and integrity management. Such changes have increased the effectiveness of maintenance work in enterprise, so as to extend the plant operation cycle.

我国石化行业也在不断寻求能使企业安全长效运行的有效方法和技术手段。长周期运行是增强我国石化企业国际竞争力的必由之路。

The petrochemical enterprises in our country have also tried to find out the effective methods and technical measures that can facilitate the safe and long-term operation of enterprise. The long-term operation is the necessary route for enterprises in our country increasing international competitiveness.

二、安全评价对石化生产长周期运行的作用

石化生产的长周期运行是一项复杂的系统工程。安全评价贯穿于石化生产的整个生命周期过程中，是实现装置长周期运行的重要技术手段。

Ⅱ. Functions of safety assessment to long-term operation of petrochemical production plants

The long-term operation of petrochemical production plants is a complicated and systematical engineering. Safety assessment shall be conducted during the entire production cycle of petrochemical plant, and it is the major technical measures to assure the long-term operation of production plant.

㈠安全评价可以提高系统的本质安全化程度，这是实现装置长周期运行的基础

通过安全评价，系统分析事故隐患发生的可能原因和条件。特别是在项目初期，从设计上采取相应措施，实现生产过程的本质安全化，这是实现装置长周期运行的条件和基础。

A. Safety assessment can increase the intrinsic safety level of the system, and it is the basis for plant long-term operation.

The possible reasons and conditions of accidents potential can be systematically analyzed via safety assessment. Especially in the beginning stage of project, relevant measures shall be adopted during design stage and multilayer safety preventive measures shall be provided so as to assure the intrinsic safety level during production. The intrinsic safety level of the plant is the preconditions and basis for plant long-term operation.

㈡安全评价可以实现装置寿命周期内的全过程安全控制，这是实现装置长周期运行的技术保障

1.安全预评价：在项目初步设计前进行。可避免安全设施不符合要求或存在缺陷，提高项目的本质安全程度。

B. Safety assessment can realize the safety control for the entire production cycle of plant, which is the technical guarantee for plant long-term operation.

● a. Safety pre-assessment: The safety pre-assessment shall be performed before the plant preliminary design. The safety pre-assessment can also prevent that the safety facilities are not in compliance with the requirements or defective, so as to increase the intrinsic safety level of the project.

2.安全验收评价：在建设项目竣工、试生产运行正常后进行。是对项目安全设施“三同时”落实情况进行的符合性评价。

3.安全现状评价：在项目有效寿命期内，定期针对生产装置的安全现状进行。

安全评价贯穿于装置生命期的各个阶段，是装置长周期运行的重要保障。

● **b.**Safety acceptance assessment: the safety acceptance assessment shall be performed after the project construction completion, successful commissioning and test run. The safety acceptance assessment is the comprehensive assessment of safety compliance for the execution of "three same time" regulations .

● c.Current safety status assessment: The current safety status assessment shall be performed within the project effective lifecycle.

From the above we can see that safety assessment exists in each stage of the plant lifecycle, and is the important guarantee for the plant long-term operation.

㈢安全评价可以实现对设备风险的有效管理，这是实现装置长周期运行的关键

随着对装置长周期运行的迫切需求，基于风险的设备管理技术，已逐渐引入到我国石化安全生产中。通过综合实施各种风险管理评价技术，可以显著延长设备长效安全运行的周期，提高经济效益。

C. Safety assessment can realize the effective management on equipment risk, which is the key point to assure the plant long-term operation.

Along with the urgent requirements of long-term operation ,The Risk Based Equipment Management Technology is introducing to petrochemical production plant in our country step by step. The comprehensive execution of various risk assessment technologies may greatly extend the long-term and safety operation cycle of the enterprise, and increase the economic benefits.

基于风险的设备管理技术，主要包括RBI和RCM等，是实现石化生产长周期运行的重要手段。这些技术是从设备失效模式入手，分析设备的失效频率和后果，对设备风险进行评价，并采取有针对性的管理措施。

The Risk Based Equipment Management Technology, which mainly includes RBI, RCM and etc, is the important measures to assure the long-term operation of petrochemical production plant. These technologies are based on the equipment failure mode to analyze the frequency and aftereffects of the equipment failure, and perform the equipment risk assessment. Pertinent management measures shall be taken according to the level of risks.

1.RBI技术

基于风险的设备检验技术(Risk Based Inspection，即RBI)是对静设备和管线进行的定量风险分析。

其主要内容包括：

(1) 设备风险评价

分析评价设备失效的可能性和失效后果，对风险等级进行排序并提出管理措施。

a.RBI technology ：

Risk based inspection (or RBI) is the quantitative risk analysis for the stationary equipment and pipeline.

The risk assessment contents of RBI technology include:

Equipment risk assessment :

Systematically analyze the probability and consequence of equipment failure, arrange risk level and propose the measures to minimize the risk.

⑵确定检验方案

检验方案根据每台设备的风险大小来确定。基于风险评价建立检验计划，用检验工作管理风险，降低检维修费用，将检验资源应用到高风险的区域，以运行周期最小的成本，获得最大的利润。

其关键点是评价每一个相关设备项的风险，然后判断最合适的那种装备的检测技术。

Determination of Inspection Programs

The Inspection Programs are worked out according to equipment risk level. RBI analyzed all inspection methods and evaluated the relative efficiency on reduction of loss of efficiency possibility for each inspection method. An optimal program will be provided after these inputs and cost of each process are provided. The critical point of this program is to evaluate the risk of each relative equipment unit and then the most applicable equipment inspection technology will be determined.

(3) 执行RBI过程产生的结果

- 对所有评价设备的风险排序；
- 对每台设备给出详细的检验方案；
- 每台设备提出详细的风险管理措施；
- 采取措施后期望得到的风险水平。

Results Generated From Execution of RBI Program

- ◇Risk level sequence of all evaluated equipment units;
- ◇Detailed inspection program of each equipment unit;
- ◇Detailed risk control measures for each equipment unit;
- ◇The expected risk level after the measures are taken.

2.RCM 技术

以可靠性为中心的维修（Reliability centered Maintenance，即RCM），是在对动设备可能故障对系统影响评估的基础上，决定维修计划的一种设备管理计划。其依据的基础同样是设备的风险和可靠性。

b. RCM Technology

Reliability Centered Maintenance (RCM) refers to a maintenance strategy to identify the maintenance plan based on the integrated system reliability impact assessment due to any possible failure of rotating equipment elements. assessment method for RCM is to set up the required management actions for equipment or unit based on the reliability and risk level; thus the disadvantage of higher integrated failure rate as a result of equipment disassembling in the conventional rotating equipment maintenance is eliminated.

无论RBI还是RCM ,都是基于风险的设备管理技术，是针对设备的风险制定风险管理措施。其目的是为了提高装置可靠性、有效延长装置的运行周期。这类技术已成为实现装置长周期运行的关键技术。

Either RBI or RCM is a risk-based safety assessment technology and either of which is to analyze the degradation frequency and degradation consequence of the equipment unit and to evaluate the equipment risk level. Either technology is to set up the applicable risk control actions against on the equipment risk level according to the assessment results. Therefore, a series of risk-based safety assessment technologies, e.g., mainly RCI and RCM, have become the critical technologies to achieve the unit long-term operation life.

三、安全评价技术在我国石化生产长周期运行中的发展应用

综合运用各种评价方法和技术，不遗漏任何部位和环节；掌握系统的风险和安全水平；对重要危险进行重点评价和管理，确保装置长周期运行。

Ⅲ. Application and Development of Safety Assessment Technology in China Petrochemical Production Long-Term Operation Service

Using various assessment methods and technologies or combination of them without omitting of any part or point, understanding the system risk level and safety level, and critical assessment and management is provided on the critical risks , so that long-term operation life of the installation with safety level conditions maintained can be achieved.

采用全面评价、重点评价和跟踪评价相结合的评价模式，应用多种危险辨识和评价方法，同时重点推行了对确保装置长周期运行具有重要作用的基于风险的检测技术。

以南方某石化企业乙烯装置为例：

乙烯装置是石化企业的“龙头”，其运行周期对整个企业的生产经营安排和盈利能力起着举足轻重的作用。

The safety assessment technology for long-term operation of petrochemical unit shall use the combination of comprehensive assessment, critical point assessment and tracking assessment method and use various risk identification and assessment method. Meanwhile, the risk-based inspection technology, which is important to assure a long-term operation life of the unit, is proposed.

we did the long-term operation assessment of the ethylene plant of a large capacity petrochemical enterprise in southern China.

Ethylene Plant is the leading plant of a petrochemical enterprise. Therefore, the operation period of ethylene plant plays a very important role on the production run planning and profitability of the integrated enterprise.

所评装置在运行两年后，没有停车检修。我们运用综合性安全评价技术，对装置实施全面评价、重点评价、设备风险分析和跟踪评价等多层次、全方位的评价。对重要设备和部位采取相应措施，确保其长周期安全运行。

We used the comprehensive safety assessment technology to conduct multiple-layer and complete assessments, e.g., comprehensive assessment, critical assessment of the unit, equipment risk analysis, tracking assessment, and so on, so that we are capable of “know fairly well” on the equipment operation status and we also proposed the technical measures to assure safety operation of the unit. The applicable measures and preventives shall be provided for the critical equipment and parts to assure a long-term safety operation of this plant.

在此过程中，我们实施的综合评价技术包括：

㈠全面评价：采用以安全检查表法为主的定性评价方法，从工艺、设备、安全控制、电气、公用工程、消防设施、安全管理等各个方面，评价装置的整体安全水平。找出可能制约长周期运行的主要环节和重点部位。

In the assessment process, the utilized comprehensive assessment technologies include the followings:

A. Complete Assessment Technology: The qualitative assessment method mainly using the safety inspection table practice is used; this method mainly focus on the features of the evaluated unit; it evaluates the safety status of the unit in respect of process, equipment, safety control, electrical, utilities, fire facilities, safety management, etc and it checks the existing non-safety factors and implications and identify the integrated safety level of this unit. It is to analyze and identify the main points and critical parts to have the possible restriction on long-term operation of the system.

㈡重点评价：采用有针对性的评价方法和技术如：故障树法、危险和可操作性研究等方法，评价危险设备和重点部位发生重大事故的原因和条件，提出防范措施。

㈢基于风险的设备管理技术的实施：为了实现乙烯装置运行时间的延长，在对设备进行全面分析检验的基础上，进行风险评价，并对风险排序；给出详细的检验方案，同时分析采取措施后的期望风险水平。

B. Critical Point Assessment Technology: Deep assessment on the hazardous equipment and critical parts shall be conducted. It is conducted to use the applicable assessment method and technology, i.e., Fault Tree Method, HAZOP Method and so on, to analyze and identify the basic reasons, the involving conditions for significant event occurring of hazardous equipment and to propose the preventive measures to prevent from the significant event.

C. Execution of Risk-based Safety Assessment Technology: To achieve the objective to extend the operation life of the ethylene plant, it has equipment risk assessment and risk level sequence on the basis of a complete analysis and inspection of all the evaluated equipment. It gives the detailed inspection program for each equipment while it analyzes the expected risk level of the equipment after applicable measures are taken.

在进行综合评价后，制定实施动态跟踪评价方案。对风险等级高的设备定期进行跟踪检测和评价，确保装置一直处于受控状态下。

在实施综合安全评价，采取多项安全措施的共同作用下，该乙烯装置长周期运行取得了良好效果，装置连续运行时间达到76个多月，且运行状态良好。

The operation of a plant is a dynamic process and the risks of the plant and its equipment vary along with the time elapsing and variation of various impact factors. Therefore, we prepare and implement a set of applicable dynamic tracking assessment program after the previous comprehensive safety assessment activities are conducted. For the equipment with high risk level, regular tracking inspection and assessment shall be conducted to assure that the plant is always under control and to assure the safety of extended operation.

With the combined act from execution of comprehensive safety assessment and a number of safety measures, this ethylene plant has a good effect on the long-term operation service, i.e., the plant achieves a continuous operation duration of more than 76 months and this plant has a good operation status during its operation.

四、结束语

随着我国石油化工行业的迅速发展和科学技术的不断进步，安全长效生产已成为我国石油化工行业发展的必然，安全评价是确保石油化工生产长周期安全运行的有力手段，在保障石化生产安全运行中发挥了重要作用。

Ⅳ. Conclusion

With rapid progress of China petrochemical industry and continuous improvement of the scientific technology, the safety and long-term production has becomes an inevitable tendency on the development of China petrochemical industry. The purpose of a safety assessment is a forceful mean to assure the long-term safety operation of the petrochemical plants and it plays a very import role on assurance of safety operation of the petrochemical plants.

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