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Guidelines for Process Safety Management of Chemical Corporations

化工企业工艺安全管理实施导则

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Foreword

Appendix A of this Standard is informative.

This Standard was proposed by the State Administration of Work Safety.

This Standard shall be under the jurisdiction of the Subcommittee 3 on Chemicals of the National Technical Committee 288 on Safety Production of Standardization Administration of China (TC 288/SC 3).

Drafting organizations of this Standard: China Business Council for Sustainable Development, SINOPEC Research Institute of Safety Engineering (Qingdao), and Shanghai SECCO Petrochemical Company Limited.

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This Standard is issued for the first-time.

Introduction

Petrochemical industry is a high risk industry; all countries, corporations, international or geographical organizations are actively summarizing and searching the safety modes and methods for corporation management. In recent years, as the increasing of foreign sole-venture and joint-venture projects, the management modes and practices of international corporations with outstanding achievements in safety and environmental protection had been known, used for reference, and introduced gradually by domestic corporations, which build-up good management experiences and a set of effective management mode in the process of production and operation. On the basis of reference from safety management mode and management method of technological process in the production process of foreign petrochemical corporations, and in conjunction with the actual conditions in China, this guidelines for process safety management of chemical corporations was formed with a view to provide thoughts and frames for the essential safety management of chemical corporations.

This Standard was prepared on the basis of successful practices of corporations and with high workability. For the convenience of corporation's application, "Application Examples for Guidelines for Process Safety Management of Chemical Corporations" is served as informative appendix of this Standard, and favorable to use for reference of corporations in practice.

This Standard is the standard in conjunction with AQ/T 3012-2008 "Guideline of Safety Management System Implementation for Petrochemical Corporation". Corporations may use this Standard to strengthen the process safety management of management system and enhancement of overall safety performance.

Guidelines for Process Safety Management of Chemical Corporations

1 Scope

This Standard specifies the elements and requirements for process safety management of petrochemical corporations. It gives application examples of process safety management.

This Standard is applicable to the process safety management of petrochemical corporations.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Standard. For dated references, subsequent amendments or revisions of these publications do not apply. However, parties when enter in agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

GB/T 24001-2004	Environmental management systems — Requirements with guidance for use
GB/T 28001-2001	Occupational health and safety management system — Specification
AQ/T 3012-2008	Guideline of safety management system implementation for petrochemical corporation

3 Terms and Definitions

For the purpose of this document, terms and definitions given in GB/T 24001-2004, GB/T 28001-2001, AQ/T 3012-2008, and the followings apply.

3.1 Element

Critical factors of process safety management.

3.2 Process

b) Chemical principle information of the process;

c) Maximum design storage content of materials;

d) Safety operating range (temperature, pressure, flow rate, liquid level or liquid level component, etc.);

e) Any deviation from the evaluation result of normal operating conditions, include influence on the safety and health of personnel.

Note: Aforesaid process and technology information are usually contained in technical manuals, operation specifications, operating methods, training materials or other similar documents.

4.1.3 Process equipment information

Process equipment information shall at least include:

a) Material;

b) Process instrument diagram (PID);

c) Zoning plan of electric equipment hazard ratings;

d) Pressure relief system design and design basis;

e) Design drawing of ventilation system;

f) Design standard or specification;

g) Material and energy balance sheets;

h) Measurement control system;

i) Safety system (for example: interlock, monitoring or inhibition system).

4.1.4 Process safety information management

Process safety information are usually contained in technical manuals, operation specifications, training materials or other process documents. Process safety information document shall be incorporated in and managed by corporation's file control system; the latest edition shall be maintained.

Corporations may obtain the required process safety information through the following approaches:

a) Obtain Material Safety Data Sheet (MSDS) from the manufacturer or supplier;

b) Obtain basic process technology information from the supplier of project process and technology package or the general contractor of project;

a) Operation steps in each operational phase, such as initial starting, normal operation, temporary operation, emergency operation, normal stop, emergency stop, etc.;

b) Control range of normal operating conditions, consequences of deviation from normal operating conditions, and the steps to prevent deviation from normal operating conditions;

c) Relevant matters of safety, health and environment, for example, characteristics and hazards of dangerous chemicals, required measures to prevent exposure, treatment measures after personal contact or exposure, safety systems and their function (interlock, monitoring and inhibition system), etc.

4.3.2 Examination of operation specifications

The corporation shall carry out frequent examination of operation specifications as required, ensure that the operation specifications can reflect current operating conditions, including the change of chemicals, process equipment and facilities. Corporations shall confirm the adaptability and validity of operation specifications every year.

4.3.3 Application and control of operation specifications

The corporation shall ensure that operating personnel have a written operation specifications. Through training, help them to use operation specifications correctly, and make them to aware that such operation specifications are mandatory.

The corporation shall define the procedure and responsibility for preparation, examination, approval, distribution, modification and abolishment of operation specifications, ensure that the latest edition of operation specifications is in use.

4.4 Training

4.4.1 Establishment and implementation of training management procedures

The corporation shall establish and implement process safety training management procedures. According to the characteristics and skills that need to be mastered on various posts, specific training requirements for each post shall be specified and defined. Establish and implement corresponding training plan, and carry out regular examination and practice on the training plan. Ensure that employees know about the hazards of process system, as well as the relationship between these hazards and the working of employee; help employee to take correct working mode to prevent process accident.

4.4.2 Training procedures and frequency

Training management procedures shall cover training feedback evaluation method and

retraining specifications. Carry out evaluation on training plan, training methods, training personnel, trainer performance and training effect, and take the evaluation results as the reference of improvement and optimization of training scheme; retraining shall be conducted at least every 3 years; the frequency may be increased as required. If there are changes of process technology and process equipment, according to the requirement change management procedures, informing or training the operating personnel and other relevant personnel for changed contents and requirements is required.

4.4.3 Training record preservation

The corporation shall preserve training record of employee. The name, training time and training effect of employee shall be preserved in record mode.

In order to ensure that relevant employees come in contact with necessary process safety information and procedures, and to protect corporation's benefit, the confidentiality agreement may be signed between the corporation and employees who come in contact with business secret according to specific conditions.

4.5 Contractor Management

4.5.1 Definition of contractor

Contractors supply maintenance, repair, installation of equipment and facilities and a wide range of operation for the corporation; corporation's process safety management shall include the special requirements of contractors, ensure that each worker carries out delicate operation and not endanger the process and personnel safety.

4.5.2 Corporate responsibility

When the corporation selects contractors, relevant information about present and previous safety performance and present safety management of contractors shall be obtained and evaluated. The corporation must inform contractors the information of potential fire, blast or toxic, and harmful hazards related to their operation and process. The corporation shall carry out relevant training; control risk of overall process; regularly evaluate the performance of contractors; preserve the records of injuries and deaths, occupational disease in operational process of contractors. Relevant management requirements shall be made reference to 8.2 "Contractor Management" in "Guideline of Safety Management System Implementation for Petrochemical Corporation" (AQ/T 3012-2008).

4.5.3 Contractor responsibility

Contractors shall ensure that all their workers receive safety training on work-related process; ensure that workers aware the information of potential fire, blast or toxic and harmful hazards related to their operation and emergency plan; ensure that workers known about equipment safety manual, including safe operation specifications within

4.6.4 Establishment of safety inspection report before pilot production

On completion of field inspection, inspection group shall prepare the report of safety inspection before pilot production, and record the conditions of all check-items specified in check-list.

After the equipment are launched into production, project manager or responsible person is also required to complete "check-items required to be completed after pilot production". On completion of all check-items specified in the check-list, carry out final update of safety inspection report before pilot production, and retain the final copy.

4.7 Mechanical Integrity

4.7.1 Installation of new equipment

The corporation shall establish suitable procedures to ensure that field installation of equipment meets the requirements of equipment design specifications and installation guide provided by the manufacturers, such as prevent misuse of materials, inspection and test during installation process. Inspection and test shall be formed into report and preserved.

For the equipment (for example pressure vessels, pressure pipeline, special equipment, etc.) with the mandatory requirements on design, manufacture, installation and registration in China, it must meet the regulatory requirements; relevant supporting documents and records shall be reserved.

4.7.2 Preventative maintenance

The corporation shall establish and implement preventive maintenance procedures to carry out planned test and inspection on critical process equipment. Identify present defect of process equipment as soon as possible, and repair or replace in time, so as to prevent that small defect and fault came into disastrous material leakage and result in serious process accident. Preventive maintenance includes, but not limited to:

a) Check pressure vessel and storage tank; check safety valve; measure the thickness of heat exchanger tube; or carry out pressure test;

b) Clean flame arrester; replace rupture disc and sealing element of pump;

c) Test fire main system and carry out functional test of combustible/toxic gas warning system/emergency shut-off valve/alarm and interlock;

d) Monitor the vibration conditions of compressor; carry out thermometric analysis on electric equipment, etc.

4.7.3 Discard and dismantlement of equipment

There shall establish discard and dismantlement procedure of equipment, define

c) Whether it modifies operation specifications;

d) Select correct time for the change;

e) Change authorization for the plan.

4.9.3 Corresponding process safety information shall be updated.

4.9.4 Employee of the corporation and its contractors which may be influenced by the change must be informed about the change or receive relevant training prior to commencement.

4.9.5 Relevant management requirements of process change may reference to Chapter 11 in "Change Management" of "Guideline of Safety Management System Implementation for Petrochemical Corporation" (AQ/T 3012-2008).

4.10 Emergency Management

4.10.1 Establishment and implementation of emergency response system

The corporation shall establish emergency response system to implement emergency exercise; provide training for its employee to make them with the awareness of response to emergency; and be able to take correct response measures. Emergency exercise plan shall include the managing procedures of small scale leakage of dangerous chemicals.

4.10.2 Technological preparation of emergency response

The corporation needs to establish an integral emergency plan, which usually in written document, to specify how the factory to deal with abnormal or emergency conditions. For larger factory with complicated process, not only integral emergency plan, but also specific response measures relative to all kinds of specific hypothetical accident situations shall be required.

4.10.3 Establishment of emergency plan

Emergency plan is an important part of corporation's emergency response system. Establishment of emergency plan may reference to "AQ/T 3012-2008 Guideline of Safety Management System Implementation for Petrochemical Corporation, 13.3, Emergency plan".

4.10.4 Emergency response

The corporation shall establish emergency response group, which usually consists of corporation's personnel, or may also include external staff; the responsibility of each group member shall be clearly defined, so as to ensure that every member has no doubt about responsibility and authorization.

In the case of emergency conditions, according to the emergency response manuals, relevant responsible person can confirm safety zone and lead persons to escape to a safe place.

In accordance with the skills obtained from training, or in virtue of the guidance of emergency response manual, emergency response group members are required to start up emergency operation of process system, for example, emergency stop, operating emergency closing valve, power cutoff, start up fire equipment, lead irrelevant personnel enter into control zone, etc. In the case of emergency, the corporation shall authorize these personnel to have a right to shutdown process system as required and evacuate from working site if necessary. The corporation shall also ensure that emergency personnel can reach their respective duty-place within the specified time.

4.10.5 Emergency training and exercise

4.10.5.1 The corporation shall provide basic emergency response training for their employees and the employees of the contractors. Training plan shall be helpful to make the trainees learn about:

a) Emergency conditions that may occur in the factory;

b) How to report occurred emergency conditions;

c) Plane position, emergency evacuation route and emergency exit within the factory;

d) The requirements of safety alarm and their emergency response;

e) The position of emergency meeting point and the requirements of person-counting.

4.10.5.2 The corporation shall provide regular training for the members of emergency response group, so as to make them obtain and maintain the knowledge and ability to deal with emergency conditions, control accident, and participate in actual exercise.

4.10.5.3 According to the actual conditions, the corporation needs to decide whether it is necessary to communicate with the community nearby the factory, inform them the emergency conditions that may occur, or provide them with necessary training. Usually, make the community learnt about the following information, and make them known how to evacuate and protect themselves in the case of emergency conditions:

a) Basic conditions of the factory;

b) Major hazards present in the process of factory production;

c) Present major safety measures taken by the factory;

Evidences collected in the process of accident investigation shall include:

a) Physical evidence: residual materials, damaged equipment, instruments, pipeline, etc.;

b) Position evidence: when accident happens, the position of person, equipment, etc.; the position conditions of process system;

c) Electronic evidence: Process data saved in the control system, electronic edition of operation specifications, electronic document records, operating records of operators, etc.;

d) Written evidence: the working-shift records, the licenses issued for operation, written operation specifications, training records, inspection reports, relevant standards;

e) Relevant personnel: personal interview and condition presentation of eye-witness, victims, site operation personnel and relevant personnel, etc.

4.11.5 Establishment of accident report and implementation of corrective measures

4.11.5.1 Accident investigation report

On completion of accident investigation, establishment of accident investigation report is required; the report shall include the following items at least:

a) The date of accident happened;

b) Initial investigation data;

c) The process of accident and the description of damage;

d) The cause of accident;

e) Suggested corrective measures in the process of investigation.

4.11.5.2 Tracing the implementation of corrective measures

The corporation shall specify how to trace and implement the corrective measures suggested by the accident investigation. In the process of actual implementation of corrective measures, a certain initial suggested corrective measures may be difficult for actual implementation because of the limitation of objective conditions, or there are better schemes that may be available, all of which are required to have a written explanation and record.

4.11.5.3 Preservation duration of investigation report

For serious accident reports, it is permanent preservation; for ordinary accident reports,

procedure of the corporation. The following factors are required to be considered during the confirmation of conformity assessment frequency:

a) Regulatory requirements, standard regulations, corporation's policies;

b) Risk scale of the factory;

c) History conditions of the factory;

d) Safety conditions of the factory;

e) Safety accidents happened in similar factories or processes.

4.12.4 Implementation, tracing and improvement of assessment: Assessment procedures shall be documented. The differences between process management system and their implementing procedures found out in the assessment procedures shall be recorded; suggest and implement corrective measures.

On completion of on-site assessment, the assessment group is required to prepare process assessment report; provides the aspects that are required for improvement.

The most-recent two assessment reports shall be filed.

Appendix A

(Informative)
Application Examples of Guideline of Safety Management System Implementation for Petrochemical Corporation

A.1 Overview

Corporation's name: Petrochemical Corporation A has the ethylene equipment that is one of the largest single-line capacity in the world; it is also equipped with polyethylene equipment, styrene equipment, aromatic extraction equipment, polystyrene equipment, acrylonitrile equipment, polypropylene equipment and butadiene equipment. The petrochemical corporation has the characteristics of world level integration, and reflect the effect of scale economics. It introduces the most advanced process technologies in the world. The main products are as follows: ethylene, polyethylene, styrene, polystyrene, propylene, acrylonitrile, polypropylene, butadiene, benzene, toluene and byproducts, etc. It can supply urgently-needed, high-quality, multiple specifications and wide-range of petroleum products to domestic market of China.

Management mode: Establish safety management system; set up health, safety, security, environmental protection (HSSE) department to take charge of the implementation of specific health, safety, security, environmental protection affairs.

A.2 Guideline, objective and promises of HSSE

The guideline of HSSE for Petrochemical Corporation A shall be issued and implemented after it is approved and signed by the general manager and deputy general manager of the corporation. Simultaneously, employees and contractors of Petrochemical Corporation A shall sign on the promise-board.

A.3 Process Safety Information

A.3.1 Significance of process safety information

Before process hazards analysis, the corporation shall prepare written process safety information. Significance of process safety information includes:

a) Accurately describe process system; carry out production, operation and change according to the correct process information; effective prevent process accident from happening;

b) It is the foundation of process hazard analysis;

c) Ensure that production and maintenance are compliant with the purpose of initial design;

d) It is the important basis for alteration of process system;

caused by accidents;

f) Any other hazards related to the task.

A.4.3 Risk evaluation

Risk evaluation: calculate the risk on the basis of destructive probability and sequential severity of employees, properties, environment and reputation. Calculation formula is as follows:

$$R = PC$$

Where:

R - risk;

P - occurrence probability;

C - sequential severity.

Consequences analysis: potential damage quantification of hazardous events - it may be judged according to experience, or tested by establishing a realistic model with a relative-complex methods.

A.4.4 Selection of methods for controlling and reducing hazards

Selection of methods for controlling and reducing hazards shall comply with the following:

a) Carry out design with minimum risk; eliminate hazards from design;

b) Apply safety equipment; reduce risks to an acceptable level by using fixed, automatic or other safety protection design or equipment;

c) Supply alarm devices: detect hazard conditions by alarm devices; send out suitable alarm signal to persons concerned;

d) Establish special procedures and carry out training;

e) Residual risks: for the risks having on control measures at present time, record each residual risk and the reason of incomplete solution.

A.4.5 Implementation and tracing of control and preventive measures

A.4.5.1 Control and preventive measures shall include the following items:

a) All hazards, influence and threaten have been determined;

b) Occurrence possibility and consequence of hazardous events have been evaluated;

Table A.2 Integrity and Reliability of Operation

Frequency (cause)		Severity (consequence)		Possibility (safety equipment)		Anticipated effect score of integrated safeguard measures	Suggestion	Accumulated risk	Manageability
1. Key equipment failure, for example gas detector/safety valve/emergency stop valve, etc.	3	1. Equipment breakage 2. Equipment damage 3. Equipment emergency stop 4. Release to air	10	1. Alarm before tripping	3	3	Confirmation of suitable safety measures, for example, alarm, double metering equipment, standby equipment, regular inspection and calibration, buffer capacity, fireproof, explosion levels of equipment; proper combination of design standards for reduce serious hazards to an acceptable level	16	2
				2. Redundant equipment	2				
				3. Standby equipment	3				
				4. Regular inspection and calibration	2				
				5. Buffer stock to make other equipment continue running	3				

A.4.6.4 Hazard and operability analysis method (HAZOP method)

Hazard and operability analysis method is a major risk evaluation method of hazard and operability analysis, which shall be reviewed every 5 years. Hazard and operability analysis method is as follows:

a) Confirm the deviation causes that result in all problems;

b) Confirm deviation result with consider about any existing safety measures;

c) Confirm whether they are safety, environment or operation problems;

d) Evaluate the safety measures which result in significant consequences; determine whether they are sufficient for the severity of consequences; and put forward a proposal;

e) Offer the suggestion to eliminate or relieve measures for those that are judged as regular and significant consequences.

See Table 3, after investigation of all the guidance words is completed by the group, check each node one by one according to the process flow, until investigation of all Process instrument diagram (PID) is completed.

Table A.3 Hazard and Operability Analysis Records

Node:		Node boundary:		
Drawing No.:		Description of node purpose:		
Deviation	Reason	Consequence	Protective measures	Suggestion
1. No flow rate				
2. Increase flow rate				
Note: Guidance words list is as follows: no flow rate, reverse-flow, flow rate increase, flow rate reduction, pressure increase, pressure reduction, liquid level rise, liquid level drop, temperature rise, temperature reduction, instrument, decompression, contamination, chemical characteristics, ignition source, maintenance failure, abnormal operation, sampling, maintenance, abrasion/corrosion, equipment location, previous accidents, human factors, safety, environment.				

A.4.6.5 Layer of protection analysis method (LOPA method)

Layer of protection analysis provides layer-by-layer protection according to the logic theory of event tree, and prevents the occurrence of final serious consequences by one or multiple protective layers.

A.4.6.6 Failure mode and effect analysis method (FMEA method)

Failure mode and effect analysis method is a reliability mode and effect analysis method, it can identify the failure which may cause system performance and result in significant consequences. Failure mode and effect analysis method is applicable to

Table A.4 Analytical Records of FMEA method of Motor Control System

<table>
<tr><td colspan="3">System : motor control system</td><td colspan="5" rowspan="4">Failure model and effect analysis</td><td colspan="4">Date</td></tr>
<tr><td colspan="3">Subsystem</td><td colspan="4">Tabulation</td></tr>
<tr><td colspan="3"></td><td colspan="4">Project team head</td></tr>
<tr><td colspan="3"></td><td colspan="4">Team member</td></tr>
<tr><td>No.</td><td>Analysis item</td><td>Function</td><td>Failure mode</td><td>Inferred causes</td><td>Influence on the system</td><td>Failure testing method</td><td>Failure level (severity, S)</td><td>Occurrence frequency</td><td>R</td><td>Remark</td><td>Suggested measures</td></tr>
<tr><td rowspan="9">1</td><td rowspan="9">Main switch, Q_0</td><td rowspan="9">Overload protection, short-circuit protection, on/off</td><td rowspan="2">Cannot turn off</td><td>Bad contact of main contact (caused by abrasion, heating deformation)</td><td>Cannot starting</td><td rowspan="2">1. Measurement of contact resistance
2. Appearance inspection</td><td rowspan="2">4</td><td>2.1</td><td>8.4</td><td rowspan="9">Regular inspection and testing; replace any fault part in time; provide program control; preventative test</td><td></td></tr>
<tr><td>Mechanical failure</td><td></td><td>2.5</td><td>10</td><td></td></tr>
<tr><td rowspan="2">Not in place</td><td>Mechanical failure</td><td>Motor open phase burnt or tripping shutdown</td><td rowspan="2">1. Measurement of contact resistance
2. Appearance inspection</td><td rowspan="2">4</td><td>2.5</td><td>10</td><td></td></tr>
<tr><td>Bad contact</td><td></td><td>2.1</td><td>8.4</td><td></td></tr>
<tr><td rowspan="4">Cannot turn on</td><td>Unactuated protection</td><td>Cable/motor heating burnt</td><td rowspan="4">1. Measurement of contact resistance
2. Appearance inspection</td><td rowspan="4">4</td><td>1.6</td><td>6.4</td><td></td></tr>
<tr><td>Mechanical failure</td><td></td><td>2.5</td><td>10</td><td></td></tr>
<tr><td>Contact point conglutination</td><td></td><td>1.8</td><td>7.2</td><td></td></tr>
<tr><td>Insulation breakdown</td><td>Moisture/heating</td><td></td><td>1.8</td><td>7.2</td><td></td></tr>
<tr><td>……</td><td>……</td><td>……</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table A.5 Internal Examination Plan of Safety Operation Procedure

Examination purpose	Evaluate the compliance and validity of safety operation procedures			
Examination scope	Production division of relevant factories			
Examination criteria	Relevant requirements of factory integrated management system			
Examination date			Examination group report date	
List of examination group	Group head			
	Group members			
Grouping arrangement				
Examination factory	Examination content			
Factory 1 Factory 2 Factory 3 Factory 4 Factory 5	1. Update conditions of safety operation procedures 2. Placement conditions of safety operation procedures 3. Application and compliance conditions of safety operation procedures 4. Content integrity of safety operation procedures 5. Training conditions of safety operation procedures			

A.6 Training

A.6.1 Objective, mode and content of process safety training

A.6.1.1 The major objective of process safety management training: employees and maintenance personnel of production division.

A.6.1.2 Implementation type of training:

a) Classroom instructions, training course of operation control theories, etc.;

b) Simulated process safety model training;

c) Virtual training assistant (VTA) examination used to assess the effect of training personnel after process safety management training.

A.6.1.3 Process safety training at least includes the following contents:

a) Process overview;

b) Operation process;

c) Specific hazards and health hazards of process;

d) Emergency operations.

A.6.2 HSSE getting-started training of new employees

A.6.2.1 The last 3 days of training is targeted to production division employees; the training plan is mainly about process and occupational safety, which shall be proceed by classroom instructions. See Table A.6.

	5. Proceed keyboard review and practice with all trainees who have an opportunity of contact control board 6. Demonstration of button function - overall practice		
2 h	1. Continued control board operation 2. All participants operate and exercise each activity by turns, and record their opinions in daily records	1. Actual demonstration with module under stabilized conditions 2. Trainer issued daily records	
2 h	1. Continue exercise browse function on the simulation system 2. Comparison (1) Browse (2) System (3) System start up and shutdown (4) Upload and unload of module	Running module initial conditions under stability conditions	

A.6.2.3 Operator training simulator (OTS) process safety training course contents and interface are shown in Table A.8.

Table A.8 Training Plan

Related device/equipment			
Reactor	Fixed bed reactor unit	Fluidized bed reactor unit	Batch reactor unit simulation
Power equipment	Compressor unit	Centrifugal pump unit	CO_2 compressor unit
Complex control	Level control system unit		
Heat transfer equipment	Boiler unit	Heat exchanger unit	Tube heating furnace unit
Tower equipment	Distillation tower unit	Absorption and desorption unit	
New units	Catalyst extraction unit	Vacuum system	Tank field simulation

A.7 Contractor Management

A.7.1 Contractor management procedures

Contractor management procedures are shown in Figure A.6.

f) Safety facilities.

A.8.3 Environment protection facilities shall meet the process safety requirements.

A.8.4 Occupational sanitation and health facilities shall meet the process safety requirements.

A.9 Mechanical Integrity

A.9.1 Preventative maintenance

A.9.1.1 Status test

The corporation shall take online monitoring and offline testing for equipment status testing; carry out data analysis and management of offline data by utilizing status-test core database.

A.9.1.2 Establishment of maintenance plan

Establishment of maintenance plan is shown in Table A.11.

For example: According to the daily management and periodic analysis of equipment lubricating oil, plot the variation trend figure of lubricating oil indexes; understand about lubricating conditions and worn conditions of equipment. It is not only one of important indicators to identify equipment accident, but also one important reference and component of predictive maintenance plan.

Table A.11 Steam Turbine Maintenance Plan

No.	Maintenance details	Spacing interval	Personnel	Necessary time (h)	Remark
1005	Lubricant analysis		Analysis	2	
1015	Clean each viewing window and instrument		Operation	1	
1020	Check and clean lubricating oil cooler		Maintenance	16	
1025	Access pipeline and support		Pipeline	2	
1030	Lubricant replacement		Operation	16	On the basis of analytical result
1035	Clean bearing housing		Maintenance	4	
1040	Clean turbine oil tank		Operation	8	
1045	Wash bearing cooling water jacket		Maintenance	2	
1050	Clean lubricant filter		Maintenance	4	
1055	Check and clean high level oil tank		Operation	4	
1060	Check and set constant pressure of bark pocket of lubricant buffer tank		Maintenance	4	
1065	Check and replace bearings		Maintenance	4	
1070	Clean and check steam seal leakage of steam condenser and injector		Maintenance	16	
	……				

The corporation shall establish safe operation regulations or standards to control the hazards of fire, restricted space admission, energy isolation, and turn on process equipment or pipeline operations. It may adopt the operation control flow chart examples as shown in A.8.2 of AQ/T 3012-2008 "Guideline of Safety Management System Implementation for Petrochemical Corporation".

A.10.2 Examination elements of operation license

Examination elements of operation license are shown in Table A.12.

Table A.12 Operation License Examination

Writing procedures	Task and plan	License announcement and approval	Regular examination procedures
Personnel responsibility	Risk assessment	Supervision and administration	Accident sharing
Training and qualification	Operation license	Operation site maintained in safety conditions	Stop unsafe operation

Examination review shall be carried out every year, so as to find out the difference between elements and continuously improve operation control and management level.

A.10.3 Operating risk assessment

A.10.3.1 Operating risk assessment and measures

Risk assessment is one of important links in the process of operation control; it is the precondition to ensure security implementation of each operation.

Assessment may be carried out by compulsory measures and selective measures: compulsory measures are the measures that must be implemented for this operation; selective measures are the suitable measures according to the influence consideration of hazard factors of this operation. If other measures are required, it may be added in additional information/measures. See Figure A.8.

Table A.14 Risk Matrix

Severity	Possibility		
	High (H)	Medium (M)	Low (L)
High (H)	H	H	M
Medium (M)	H	M	M
Low (L)	M	M	L

d) Step 4: Control measures

Principle: Reduce risk to a reasonable and acceptable level; any risk exceed permissible upper limit shall be deemed as unacceptable.

Control measures under consideration shall be added according to the following sequence:

Elimination → replacement → control → mitigation

Control measures include:

1) Supply of protective equipment;

2) Safe operation system (such as operation license system);

3) Proceed training to enhance knowledge and awareness;

4) Supply of information (such as MSDS, emergency procedures);

5) Explanation and label;

6) Supervision;

7) Use personal protective equipment (PPE).

A.10.4 Fire operation and restricted space operation

Fire operation may result in accident if risk assessment and relevant measures are not in place. However, as long as there are proper methods and measures, restricted space operation and fire operation will become safe operation.

Example: crude distillation tower of ×× equipment is already out of service and under major overhaul, see Figure A.9.

- Relevant pipeline network have been washed, cleaned, steam-blown, water-washed according to normal procedures. However, residual hydrocarbon compounds within tower top pipeline have not been completely cleanout and not isolated, and not under gas detection. Residual hydrocarbon compounds are ignited by the ongoing fire operation of tower top pipeline. Two maintenance workers and one scaffolding worker are working in the tower, smoke from tower

Table A.15 Scope of Change Management

Change type	Description
Process chemicals and products change	New chemicals or additives used in any production process
	A additive disused in treatment flow
	Change lubricant grade of compressor or pump machine
	Change chemical specifications
	Add or cancel certain chemicals, storage change, or add or cancel containers
	Process control and operating parameters change of each product
	Change the position of addition/injection point
	Superseded with different types of chemicals
	Change the requirements of vapor concentration
	Dilute process additives
	Change the specifications and characteristics indexes of each product

Table A.15 (continued)

Change type	Description
Change of process/equipment technology	New or modified promoters or additives (change of process chemicals)
	Update treatment flow control hardware (change of control/instrument)
	Implementation of new innovative operation mode on the existing facilities (change of safe operation limits)
	Operating treatment flow in a different way to produce new products (change of operating procedures)
	Update monitoring system of toxic substances or hydrocarbon compounds (change of safety system)
	Change of on line analysis method (change of control/instrument)
	Change of equipment application
	Newly-added permanent or temporary equipment or pipeline
	Dismantlement of working equipment
	Replace or repair equipment with different equipment (Change the design and size of heat exchanger, the size of pump impellers and other equipment)
	Change safety operation or design limitations (but shall not operating beyond the range of safe operating limit)
Change of equipment/pipeline	Change of flow and equipment may need to change the requirements of pressure relief and discharge (increase flow output, increase working temperature or pressure, increase equipment size, change the heat insulation performance pipeline or equipment, etc.)
	Change of structure parts, reduce design load ability or fireproof ability
	Change of building ventilation system within the treatment area
	Change the materials of sealing ring, seal and cushion layer, etc.
	Installation of bypass connection or temporary connection for special operation around

	Newly-added or dismantle safety system or shutdown system
	Bypath or pressure relief system, safety system, or shutdown system out of service
	Replace/change system elements
	Pressure relief valve outlet was changed from closed system into direct exhaust to air, or changed from direct exhaust to air into exhaust to closed system
	Change of hydrocarbon compounds, toxic materials or fire hazard monitoring or inhibition system, etc.
Change of occupied buildings	Increase or reduce occupied range of buildings
	Change the structure occupied buildings
	Construction of new occupied buildings within a certain range of the existing production process
	Construction of new production process within a certain range of the existing occupied buildings
Change of management or laws and regulations	Change of published standards on gaseous, liquid or solid emissions
	Change plant layout
	Change of fire-fighting facilities or fire passage
	Change of government or corporation regulations

A.11.2 Management of change (MOC) investigation is shown in Table A.16

Table A.16 Investigation List and Items of HSE

MOC No.		Factory or group name	
Change name			
Participating inspection personnel			

No.	Inspection subject	Description	Existing safety measures	Action	Remark

HSE items need to be considered	Completed in the design and assessment period	Completed after designed and before pilot production	Completed as soon as possible after commissioning
Required or completed hazard and operability analysis/hazard identification			
Risk assessment			

Table A.16 (continued)

HSE items need to be considered	Completed in the design and assessment period	Completed after designed and before pilot production	Completed as soon as possible after commissioning
Fire hazard and emergency response plan			

A.12 Emergency management

A.12.1 Emergency plan

According to process hazard analysis report, the corporation shall establish overall emergency plan and a series of procedures to deal with emergency, including:

a) Evacuation procedures;

b) Toxic gas refuge procedures;

c) Medical treatment plan;

d) Detailed emergency plan of equipment;

e) Logistics emergency plan;

f) Detailed processing scheme of buildings;

g) Typhoon response options;

h) Emergency response schedule;

i) Security measures;

j) Investigation plan;

k) Others.

A.12.2 Classification of emergency response force

Response force and crisis management group usually are divided into Grade 1, 2 and 3:

a) Grades 1 and 2 response forces are tactic response work groups, which consist of the following staffs: operation manager, emergency service shift foreman, corporation fire brigade, security guard, medical treatment, chemical emergency fight group, and waste disposal group. Operation Manager shall be served as the conductor of accident scene;

b) Grade 3 emergency response is required to start risk management group, which consists of command team, operating team, project team, logistics team and finance procurement team;

c) Crisis management group shall be started in the case of accident that may result in influence on ambient communities or corporations.

A.12.3 Classification of process hazard accidents and emergency procedures

emergency response actions, see Table A.18.

Table A.18 Simulation Results of the Accident Consequence of a Certain Equipment

Equipment No.	Material	Leakage pore diameter (mm)	Distance (m)									
			Immediate threaten to health (500 ppm)		Flaming		Pool fire		Flash fire 12 000 ppm		Explosion	
			Wind speed ($m \cdot s^{-1}$)		Thermal radiation ($kW \cdot m^{-2}$)		Thermal radiation ($kW \cdot m^{-2}$)		Wind speed ($m \cdot s^{-1}$)		Shock wave (bar)	
			1.5	5	4	20	4	20	1.5		0.2	0.02
Omitted	Hydrogenated gasoline	5	54	21	7		28	11	10	2.5	54	70
		25	184	90	22		56	22	41	18	190	273
		150	895	309	44		239	121	261	43	921	1464
		200	1195	336	48		253	130	265	47	995	1505
Omitted	Toluene	5	44	12	5		20	11	6	2	42	53
		25	110	62	15		59	24	27	11	116	18l
		150	405	116	26		178	87	108	21	410	650
		200	417	135	28		181	89	100	24	274	454
Omitted	Solvent	5					17	10				
		25					46	23				
		150					100	55				
		200					152	89				
Note: 1 ppm = 10^{-6}.												

A.12.4 Effective alarm system

A.12.4.1 Factory shall set up effective alarm system, which shall be able to send out different alarm sound for different situation:

a) Fire hazard: stable tone;

b) Gas leakage: alternate tones at interval of 5 seconds;

c) Elimination alarm: alternate tones at interval of 1 second.

A.12.4.2 Fire hazard and gas detection alarm system shall display in different alarm indicator lights:

a) Red for fire alarm;

b) Yellow for inflammable gas leakage or toxic gas leakage.

A.12.5 Treatment of dangerous chemicals leakage

must be directly present in the damage);

b) Exceed the lowest report limits:

1) Loss time, hospitalization or death of employees or contractors;

2) Fire hazard or explosion result in the direct cost loss of corporation is greater than or equal to ×××× US dollars;

3) A large amount of combustible, inflammable or toxic chemicals is released from container or pipeline; and the release amount exceeds specified chemical release limit.

c) Accident site: production, application, storage, public engineering or pilot plant's facilities;

d) Serious release: that is, release amount within 1 hour or less than 1 hour reached or exceed the report limits.

A.13.2 Process safety index:

a) Total accident rate of process safety: (total process accidents × 200 000) / total working hours of employees and contractors

b) Total process accidents (PSIC): the total amount of all accidents according to the definition of process accident described in this Standard;

c) Advanced indexes: Show the health status of each important aspect in safety management system; measuring and supervising the collected advanced indexes may be able to indicate the damage conditions on the validity of crucial safety system as early as possible, and supervise and urge to take remedial measures;

d) Safety system of advanced indexes is as follows: the maintenance of mechanical integrity, follow of action items, management of change, process safety training and qualification.

A.13.3 Classification of process accidents and severity: classification of process accidents and severity is shown in Table A.20.

	contractor; various loss time injury or one or more serious off-site injuries	RMB ×××× 10^4	discharge lead to the entry of steam cloud into building or potential explosion zone restricted zone, in case of ignition, casualties may occur.	cost falls between RMB ××× 10^4~RMB××× 10^4. Government conducts investigation and supervision and management on process or local media reports or national media conducts brief report
1	Off-site fatal accident or various on-site fatal accident	Lead to the loss of direct cost above RMB ×××× 10^4	Chemicals discharge may lead to serious on-site or off-site casualties	National media conduct consecutive reports for numerous days or the necessary environment remedy cost exceeds USD ××× ×10^4.State government conducts process investigation as well as supervision and management or other important community influence

A.13.4 Accident investigation and analysis: accident investigation, all the accidents may be subject to source analysis according to Comprehensive List of Cause (CLC) to determine the property, direct cause and root cause of accidents; remedial action shall be taken to prevent the recurrence of accidents. See Figure A.11.

	Antecedent event - behavior - results analysis	
Initial preparation - Organize an investigation group; - Subject to proper training and guidance - Set job target scope; - Institute an inquiry and reserve evidence; - As for the recent supporting document, look up in the supporting websites **Collecting evidence** - Examine accident scene (accident position); - Utilize appropriate interview skill to interview privy; funnel-concentration of a large amount of evidence, and ask "5 WH"	**01. Behavior identification**	
	When an investigation group has no knowledge of the reason for a person's behavior, antecedent - behavior - consequence analysis mode (ABC) is quite useful, contributes to better knowledge of these behaviors; based on the comprehension, we can conduct comprehensive utilization of CLC for quality cause analysis. To be effective, ABC analysis must be conducted after evidence collection and before cause analysis.	Conduct ABC analysis: - Identify the behavior in the key factor: behavior is observable behavior, i.e. nothing is done, or nothing is said; - Take down behavior representation, including who does it; what task they are performing at that time; what they have done, what is undone; how is the consequence of the things; - Detailed is in "ABC Analysis Guide"
	02. Adopt correct tools	
	Two types of behavior	- If it is intentional, keep on with ABC analysis;

			cause for each key factor

Figure A.11 Reasons Integration

Reasons				Rectification measures
Possible direct reasons Behavior type **1. Fail to observe existing operation specifications** 1.1 Violation (individual) 1.2 Violation (collective) 1.3 Violation (executives) 1.4 No procedure available 1.5 Inapprehension of regulation 1.6 Others **2. Application of tool, device/equipment or vehicle** 2.1 Misuse of device/equipment 2.2 Misuse of tool 2.3 Use of obviously defected vehicle 2.4 Use of obviously defected tool 2.5 Wrong placement of tool, equipment or material 2.6 Improper operation speed of device/equipment or vehicle 2.7 Others **3. Protection equipment or method application** 3.1 Required protection	**6 Tool, device/equipment and vehicle** 6.1 Device/equipment fault 6.2 Device/equipment preparation 6.3 Tool fault 6.4 Tool preparation 6.5 Vehicle fault 6.6 Vehicle preparation 6.7 Others **7 Unexpected exposure** 7.1 Fire accidents and explosion 7.2 Noise 7.3 Charged electrical system 7.4 Energy source of non- electric device 7.5 Extreme temperature 7.6 Hazardous chemical 7.7 Mechanical maintainability 7.8 Rainstorm or force majeure 7.9 Others **8 Arrangement of operation field** 8.1 Crowded 8.2 Lighting problem 8.3 Ventilation problem 8.4 Unprotected climb 8.5 Operation site	**13 Behavior** 13.1 Prerequisite event does not exist 13.2 Prerequisite event is ineffective 13.3 Incorrect behavior is strengthened 13.4 Incorrect behavior is unsettled 13.5 Right behavior is not rewarded 13.6 Behavior analysis process is ineffective 13.7 Other **14 Level of skill/ability** 14.1 Required skill and ability are not assessed 14.2 Technical practice is ineffective 14.3 Technical guide does not exist 14.4 Skill is seldom used 14.5 Others Work factor **15 Training/knowledge transmission** 15.1 Training is not provided 15.2 Training is ineffective 15.3 Knowledge transmission is ineffective 15.4 Unable to answer training material	**19 Control of work (CoW)** 19.1 No operating scheme or risk assessment 19.2 Risk assessment does not work 19.3 Required license is not obtained 19.4 Specified control measures are not allowed to adopt 19.5 Operating scope change 19.6 Keep safety order at construction site 19.7 Others **20 Purchasing / material processing control** 20.1 Wrong order 20.2 Wrong delivery taking 20.3 Improper loading and unloading or transportation 20.4 Improper storage of materials 20.5 Improper labels of materials 20.6 Others **21 Tool and device/equipment** 21.1 Wrong tool or device/equipment provided	**Conclusion work** Assess existing precaution measures - to master whether every precaution measure is implemented or regarded as implemented before accident happens - as part of your analysis items, list every precaution measure and explain why it is ineffective - propose correction measures - determine or strengthen existing precaution measures before proposing new suggestions **Propose your opinion** - correction measures shall be specific and targeted at the reasons that are already been found - correction measures must involve and mention every reason listed **Check your thought** - investigation panel must discuss and determine whether the correction measures are

protection equipment 5.4 Personal protection equipment is defective 5.5 Ineffective warning system 5.6 Defective warning system 5.7 Ineffective safety devices 5.8 Defective safety devices 5.9 Others	**12 Mental stress** 12.1 Anxiety 12.2 Worries 12.3 Direction/requirement disorder 12.4 Direction/requirement conflict 12.5 Extreme decision-making requirement 12.6 Excessively concentration or perception requirement 12.7 Other overweight mental load 12.8 Other reasons	17.5 Operation's supervision and management process does not exist 17.6 Operation's supervision and management is ineffective 17.7 Others **18 Engineering technology/design** 18.1 Incorrect technical design 18.2 Incorrect design standard, specification or criteria 18.3 Incorrect ergonomics or human factor design 18.4 Ineffective construction supervision and management 18.5 Improper assessment on operation preparation 18.6 Improper monitoring on initial operation 18.7 Technical analysis on risk is ineffective 18.8 Other	organizations is insufficient 23.4 Communication between work groups is insufficient 23.5 Communication between teams is insufficient 23.6 No communication message is received 23.7 Incorrect information 23.8 Information implication is not understood 23.9 Others	

Analysis sheet (CLC) sample

A.13.5 Accident tracing and experience sharing

The corporation may develop action tracking system (ATS in short) to effectively trace every action. Each employee can report accidents and share near-accidents. See Table A.21.

Table A.21 Action Tracking System (ATS)

Construction	Query	Report
Field inspection action item	My action item	Report control platform
System approval action item	All action items	

2.1.1.1 Whether device/company has conducted the formal risk evaluation such as job hazard analysis(JHAs), job safety analysis(JSAs) on some main activities, the implemented operation category and so on? How many risk evaluations have been conducted and which main activities or operation category have been conducted for risk evaluation have been conducted? When have these evaluations been conducted? 2.1.1.2 Who is responsible for organizing these formal risk evaluations in the device and undertakes the responsibility for this? Who have participated in these evaluation activities? What background do they have or what kind of training have they taken in these specific fields? Have the production personnel participated in the evaluation activity?	
2.1.2.2 Has the established management hierarchy been granted a clear and appropriate operation approval authority on the basis of the relative risk of specific significant activities/operation category? 2.1.2.3 Which kind of specific main activities/operation category within the device must be approved by which level? Does irrationality exist in the above work arrangements for risk? Does approver have relevant background or training foundation?	

A.14.3.3 Review Tool for operation license is shown in Table A.23.

Table A.23 Review Tool for Operation License

Item	Score	Review standard	Scoring
Operation license (2 points)	-0.5 points/ item	No signature (including operation principal, supervisor, production department principal, HSSE engineer, gas detection personnel and operating personnel)	
	-0.5 points/ item	Signature on license signed by others	
	-0.5 points	License No. and name unfilled or incompletely filled	
	-0.5 points	Work permit not on the site	
	-0.5 points	No operation application form	
	-0.5 points	License unclosed or unreturned	
	-2 points	Operation beyond the scope of license	
	-10 points	Operation without license	
Staff qualification (1 point)	-1 point	Special work type without qualification	
	-0.5 points	Operation personnel without name tag	
	-0.5 points	Operation slip issuing personnel without authority of corresponding grade	
	-0.5 points	Guardian without qualification	
Protective equipment of personal security (1 point)	-0.5 points/ item	Operation personnel short of personal security protective equipment (for example: earplugs, gloves, safety glasses, masks, veils etc.)	
	-0.5 points/ item	Operation site short of personal safety equipment (fire extinguisher, fire blanket etc.)	

The tracing and verification of action item shall adopt action item tracking system (ATS), which will send e-mail automatically to remind people of action to complete their mission on time.

A.14.7 Tracking and verification of corrective measures

Tracing and verification of corrective measures is detailed in Table A.25.

Table A.25 Review Tracing Record

Inspection category:				Inspection place:					Inspection time:		
Participating inspection personnel:											
No.	Inspection item	Inspection content	Inspection criteria	Inspection result	Cause analysis	Rectification measure	Responsible person	Planned completion time	Actual completion time	verifier	Remark
1											
2											

_____ END _____

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