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## Evaluation of Risk Management Maturity: Measurable Proactive Indicators Suitable for Chinese Small and Medium-Sized Chemical Enterprises

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# Evaluation of Risk Management Maturity: Measurable Proactive Indicators Suitable for Chinese Small and Medium-Sized Chemical Enterprises

Jian Sun\*, Cong Liu, Hongyong Yuan

<sup>1</sup>Department of Engineering Physics/Institute of Public Safety Research, Tsinghua University, Beijing China

\*Corresponding author's e-mail: sunjiansafety@qq.com

**Abstract.** Implementing risk management in chemical industry may bring a number of benefits. Risk management maturity reflects risk management capability of an enterprise from various aspects. The aim of this article is to determine a group of measurable proactive indicators suitable for Chinese small and medium-sized chemical enterprises to evaluate risk management maturity. The article describes the development process of the measurable proactive indicators. Appropriate proactive indicators are extracted from literature and divided into four families based on their characteristics, named operation based indicators, management based indicators, individual based indicator, resources and technology based indicators. Typical measurement examples of proactive indicators are proposed according to risk characters of chemical enterprises. Sixteen small and middle-sized chemical enterprises from China provide risk management records on fourteen indicators. The analysis result show the proposed measurable proactive indicators are available for Chinese small and middle-sized chemical enterprises and could reflect the risk management maturity of an enterprise.

## 1. Introduction

Risk management for chemical enterprises with numerous hazardous materials are of particular importance [1]. There are nearly 300,000 chemical enterprises in China, of which over 80% are small and medium-sized enterprises (SMEs) with poor risk management capability. Governments at all levels require to strengthen risk identification and management.

Enterprises can use proper measurable indicators to evaluate their current level of risk management maturity, to understand their strengths and weaknesses and to take suitable measures to improve their risk management performance [2]. During the past decade, several technological tools have been developed for construction and aviation industries to measure risk management maturity [3]. Almost all of the maturity measurement technological tools are based on the use of measurable indicators [4-6]. It has been proved that measurable indicators play an important role in the process of improving risk management performance [7].

In China, it is urgent demand to implement overall risk management among chemical enterprises. Main goal of this article is to determine measurable indicators suitable for Chinese small and middle-sized chemical enterprises to evaluate risk management maturity. The article is organized as follows: to begin with, proactive indicators are selected from literature. Definition or description of selected indicators are stated. Second, selected proactive indicators are divided into four families according to their characterizes and measurement examples are proposed. Third, sixteen Chinese small and middle-



sized chemical enterprises are invited to provide their risk management records on measurable proactive indicators. Finally, applying results of measurable proactive indicators for evaluation of risk management maturity are discussed.

## 2. Material and Method

### 2.1. Types of Measurable Indicators

Reactive indicators and proactive indicators display risk management maturity from different perspective. The focus of most reactive indicators is accident frequency, severity and cost, whereas proactive indicators can be a useful tool to help organizations to track, measure and adjust their risk management activities so they can effectively avoid harm. Proactive indicators could provide advanced warning of potential problems and therefore implementing preventive measures before accidents occur. The link between the proactive indicator and the corresponding target can be confirmed if the reactive indicator trends downward [8, 9]. Therefore, proactive indicators are adopted for evaluation of risk management maturity in present article.

### 2.2. Selection of Measurable Proactive Indicators

The literature regarding indicators of risk management maturity are surveyed. In Table 1, the principal proactive indicators mentioned in the literature are listed. The meanings of indicators are defined or described.

Table 1. The principal measurable proactive indicators regarding risk management maturity mentioned in the literature

No.	Aspects	Proactive Indicator	Definition or Description	literature
1	Risk management operation	Identification of hazards	Identify hazards or predict accident consequence with certain tools or means	[2, 10, 11]
2		Risk estimation and evaluation	Risks are quantified or described qualitatively	[2, 11, 12]
3		Preventive and corrective actions	Take measures to mitigate or avoid risk	[12]
4		Risk characterization	Reflect threats, consequences and probability of risks by use methods	[2]
5		Monitoring and review	Constant process aimed at verifying or recording the improvement of a risk management operation	[13]
6	Managerial function	Communication of OHS risks	Exchange or share of OHS information among stakeholders	[9, 14-19]
7		Disciplinary policy	Formulate and execute disciplinary policy of risk control	[17, 20, 21]
8		OHS training	Ensure employees acquire OHS awareness, knowledge and skills	[2, 15, 18, 22]
9		OHS-related behavior	Worker behaviors accord with OHS guidelines or regulations	[2, 15, 22]
10		Compliance with OHS guidelines or regulations		[15, 23-25]

11		OHS inspection	Help protect workers' rights under OHS laws and enhance employers' awareness of their responsibilities	[22, 24, 26]
12	Individual quality	Worker commitment and participation	Dedication or response of workers in risk management activity	[12, 15, 18]
13	Resources and technology	Technology	Integration of technology into risk management processes	[2]
14		Budget	Investigation on all risk management related activities, including individual, machine, environment, regulation culture, etc.	[2, 18, 24]
15		Workload	Staff workload or working hours	[27]

Above fifteen proactive indicators basically show four aspects of risk management maturity in industry, named as risk management operation, managerial function, individual quality, resources and technology respectively [4]. The next major task is to extend number of indicators and raise measurement examples according to risk characteristics of chemical enterprises.

### 2.3. Proposition of Measurement Examples

First, measurement examples of operation based indicators are proposed in Table 2. "Operation based indicators" refers to quantification of risk management activities, including identification and evaluation of risks, preventive and corrective actions, risk characterization by category or level, and monitoring and review. These indicators provide an overseeing of risk management activities and application of risk-reducing approaches.

Table 2. Measurement examples of operation-based indicators

Code	Indicator	Examples of Measurement
O1	Identification of risk	Number of hazards identified
		Number of special inspection on the safety of chemicals.
		Number of special inspection on the work related risks
		Number of persons trained in hazard identification
O2	Risk estimation and evaluation	Number of estimations o revaluations carried out
		Risks identified per level or per category
O3	Preventive and corrective actions	Number of preventive and corrective measures recommended
		Number of preventive and corrective measures found effective
		Number of preventive measures per type of hazard (e.g., closed spaces, etc.)
		New number of hazards reported after implementation of preventive and corrective measures
O4	Risk characterization	Correlation between proactive and reactive indicators
		Number of potential hazards classified by severity
		Number of hazards per specific category (e.g., closed spaces, heights, etc.)
O5	Monitoring and review	Number of new evaluations of risks
		Effectiveness and efficiencies of corrective actions implemented

“Management based indicators” refers to quantification of the role of management at risk control. They particularly focus on deployment of risk management at all levels of the business, including the communication of risks, OHS training for workers, disciplinary policy, organizational and process changes, evaluation of proactive indicators, OHS inspection, compliance with OHS regulations, etc. Measurement examples of management based indicators are proposed in Table 3.

Table 3. Measurement examples of management-based indicators

Code	Indicator	Examples of Measurement
M1	Contribution of management	Number of suggestions implemented by managers
		Number of positive risk evaluations carried out by managers
		Number of managers participating in OHS meetings
M2	Communication of risks	Number and frequency of risk management meetings
		Number of OHS information posters
M3	Leadership and disciplinary policy	Number of OHS-related disciplinary actions
		Number of recognitions of safe behaviours
M4	Organizational or process changes	Number of new OHS organizational practices implemented
		Frequency of OHS audits
M5	OHS training	Hours of training/hours of work ratio
		Number of training sessions
		Number of emergency exercise
M6	Evaluation of proactive indicators	Number of evaluations correlating predictive measures with OHS results.
		Number of preventive actions for reaching OHS objectives
M7	OHS inspection	Number of workplace inspections
		Number of in-house regulatory inspections
M8	OHS compliance	Percent compliance (and/or non-compliance) with applicable regulations and standards
		Number of compliance inspections carried out by external evaluators

“Individuals based indicators” (Table 4) refers to quantification of individual efforts and abilities at risk management. Including information on work related risks, perception of work related risks, worker involvement and participation with regard to risk management, safe behavior and education years, etc. Measurement examples of individual based indicators are proposed in Table 4.

Table 4. Measurement examples of individuals based indicators

Code	Indicator	Examples of Measurement
I1	Information on work related risks or hazards	Number of lessons focused on property or protection of chemicals
		Number of consultations of individual regarding to work related risks or hazards
I2	Perception of work related risks	Number, frequency and results of surveys or questionnaires on the perception of OHS in the organization
I3	Worker commitment and participation	Number of workers involved in risk management activities or emergency exercises

		Number of staff who work full-time on safety management
I4	Safe behavior	Number of observations of behavior indicating mindfulness of OHS
		Observed ratio of high-risk to low-risk behaviors
I5	Education years	Percentage of workers who have bachelor degree (or above)

“Resource and technology based indicators” refers to the input of resource and technology at risk management. Including work environment, workload, technology application, preventive maintenance, fund, etc. Measurement examples of resources and technology based indicators are proposed in Table 5.

Table 5. Measurement examples of resources and technology based indicators.

Code	Indicator	Examples of Measurement
T1	Work environment	Number of evaluations of written procedures relating to OHS risks
		Number of managers trained regarding specific tasks
T2	Workload	Frequency of measurement of workload
		Number of workers who work less than 10 hours
T3	Technology	Level of integration of risk management technology
		Level of automation that is being applied in manufacturing
T4	Preventive maintenance	Percentage of worker designated as maintenance time
T5	Fund	Investment on labor protection products
		Ratio of OHS allotment to overall budget

### 3. Discussion

#### 3.1. Evaluation of Measurable Proactive Indicators

In order to evaluate availability of proposed four families of measurable proactive indicators. Sixteen oil process-related chemical enterprises with employee number varying from 120 to 180 are invited into investigation. They are located in Heze city (Shandong province, China) where gathers a large number of oil refiners and processors though it is an underdeveloped area in China. These chemical enterprises are relatively uniform in production mode and major process units. These chemical enterprises are ranked according to records of OHS related accidents in the previous 24 months. Top eight enterprises are composed group A, while the rest composed group B. The applying results of measurable proactive indicators for evaluation of risk management maturity between group A and group B are displayed in Table 6.

Table 6 Applying results of measurable proactive indicators for evaluation of risk management maturity between group A and group B

Code	Indicator	Examples of Measurement	Group A	Group B	Gap
O1	Identification of risks	Number of special inspection on the work related risks per month	3.8	3.6	0.2

O2	Risk estimation and evaluation	Number of risk evaluations carried out and validated per month	3.5	3.4	0.1
O3	Preventive and corrective actions	New number of hazards reported after implementation of preventive and corrective measures per month	1.1	1.1	0
O5	Monitoring and review	Number of new evaluations of risks per month	1.2	1.1	0.1
M1	Contribution of management	Percentage of positive risk evaluations carried out by managers	65%	45%	25%
M2	Communication of risks	Number of risk management meetings per month	2.4	1.0	1.4
M3	Leadership and disciplinary policy	Number of OHS-related disciplinary actions per month	6	3.2	2.8
M5	OHS training	Hours of training/hours of work ratio	0.08	0.04	0.04
M8	OHS compliance	Number of compliance inspections carried out by external evaluators per year	3.5	2.2	1.3
I1	Information on work related risks or hazards	Number of lessons focused on property or protection of chemicals in last year	4.5	2.0	2.5
I3	Worker commitment and participation	Percentage of workers involved in various risk management activities in last year	85%	37%	48%
I5	Education years	Percentage of workers who have bachelor degree (or above)	18.2%	13.3%	4.9%
T2	Workload	Percentage of workers who work less than 10 hours per day.	95%	70%	25%
T5	Fund	Investment on labor protection products per person in the last year (Yuan)	220	115	105

Managerial staffs of sixteen chemical enterprises provide risk management records on 14 indicators. Average value of measurable indicators were computed and compared between two groups. From Table 8, it can be found there is a gap of average value between group A and group B. Generally, group A acquired higher average value than Group B on each code, which are consistent with local government statistics regarding OHS-related injuries. This phenomenon confirmed conclusion that enterprises better that carried out proactive risk management activities resulted in less accident records [2]. This result shows selection of proactive indicators and examples of measurement are appropriate. These measurable proactive indicators could reflect risk management maturity of Chinese small and medium-sized chemical enterprise.

After carefully observation, in addition, it can be found invited chemical enterprises obtain similar average value at operation based indicators (O1, O2, O3, O5). Carrying out risk management operations are compulsive requirement by local government, so all respondents have good recodes. Gag appears on other indicators because Group B made less efforts at management, individual, technology and resources. For example, there are obvious gap appear on indicators (M2、I1、I3、T2) between Group A and Group B.

#### 4. Application of measurable proactive Indicators

Enterprise management department may use these indicators to get a basic understanding of their risk management maturity. Through using these measurable proactive indicators, managers can know what their peer have done and how they are performing relative to others in their industry. For example,

Figure 1 described comparison results of measurements of proactive indicators between two enterprises from different groups.

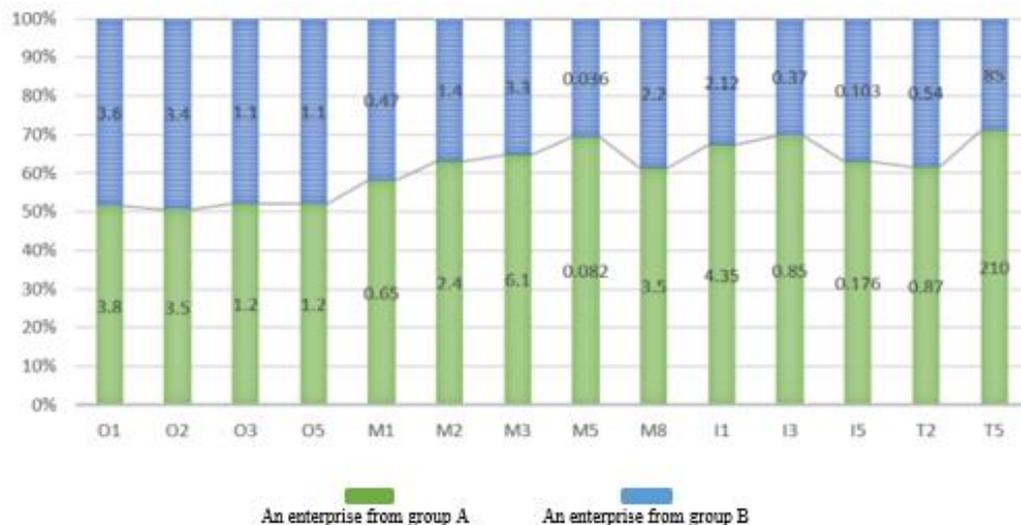


Figure 1 Comparison results of measurements of proactive indicators between two enterprises

For Chinese SEMs in chemical industry, measurable proactive indicators are a new addition to risk management, two or three proactive indicators are a good place to start. It would be better to focus on a few key indicators that reflect the performance of risk management. Proper measurable proactive indicators could help Chinese SEMs to get quantificational instruction for risk reduce.

First, measurement examples of operation based indicators are proposed in Table 2. “Operation based indicators” refers to quantification of risk management activities, including identification and evaluation of risks, preventive and corrective actions, risk characterization by category or level, and monitoring and review. These indicators provide an overseeing of risk management activities and application of risk-reducing approaches.

## 5. Conclusion

Four families of measurable proactive indicators which could reflect various aspects of risk management maturity are selected from literature. They are named as “operation based indicators”, management based indicators, “individuals based indicators”, “resource and technology based indicators” Typical measurement examples are proposed for these indicators. Sixteen oil process-related chemical enterprises are invited to access availability of proposed indicators for evaluation of risk management maturity. Results show that selection of indicators and proposition of measurement examples are appropriate. Enterprises with lower work related accident records obtain higher value on each proactive indicator. Chinese SEMs would adopt such measurable proactive indicators to understand their basic risk management maturity.

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