

Analysis about Risk Changes before and After Inspection of 23 Storage Tanks and Research on the Inspection Strategy

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Abstract. Inspection of storage tanks has been taken less seriously over past years, as not required by laws. Therefore, projects adopting risk evaluation technology of atmospheric-pressure storage tanks are rarely seen. Characterized by large volume and high risks, hazardous chemicals often lead to serious accidents. This paper evaluates risks of 23 atmospheric-pressure storage tanks of 100 thousand m³ of a storage house. Supposing the storage house implemented inspection within 5 years or 10 years, this paper studies risk changes before and after the inspection. It puts forward an inspection strategy to guarantee long term safety of storage tanks according to the risk analysis outcome.

Introduction

In recent years, with China's rapidly growing demand of energy and crude oil demand constantly refreshes record, the large-size crude oil storage tank has been an inevitable trend [1, 2]. Most large storage tanks in China are located along riverside and coastal cities or located at deep-water wharfs. There are more than 20 tank areas or tank groups which are being constructed or being planned in Yangtze drainage area [3, 4]. Chemical safety of this area determines water supply or survival of tens of millions of local residents. Hazardous chemicals of large volume and high risks may lead to explosion, erosion and pollution in case of accidents. Hidden risks, long-lasting hazards, expansive influence, catastrophic consequences of chemicals often cause more serious social panic than other industries. Figure 1 shows an accident of storage tank. The risk assessment of the storage tanks turns periodic inspection into risk-based inspection, which both ensures safe operation and has a great cost savings [5-7]. 23 storage tanks are all floating-roof tanks, whose host materials include SPV490Q, 16MnR, Q235-B, and Q235-A; the containing medium for storage tank are crude oil, and time-to-use starts from August 2006 to April 2007.



Fig. 1 shows an accident of storage tank

Analysis about Risk Distribution

This paper calculates risks of wallboards and baseboards of 23 storage tanks [8-10], so as to predict risk distribution of the current year and in future 5 years or 10 years. Table 1 shows the risks of wallboards and baseboards of 3 tanks as examples.

Table 1 The risks of wallboards and baseboards of 3 tanks as examples

Tank No.	Unit Name	2016.9 Damage Level	Present Consequence Level	Present Risk Level	2021.9 Damage Level	Consequence Level 5 Years Later	Risk Level 5 Years Later	2026.9 Damage Level	Consequence Level 10 Years Later	Risk Level 10 Years Later
T-6	Wall boards	3	C	2	3	C	2	3	C	2
	Base boards	3	D	3	3	D	3	4	D	3
T-18	Wall boards	2	C	2	3	C	2	3	C	2
	Base boards	3	D	3	4	D	3	4	D	3
T-48	Wall boards	2	C	2	2	C	2	2	C	2
	Base boards	3	D	3	4	D	3	4	D	3

Devices with higher risks mainly concentrate on baseboards and devices with lower risks mainly concentrate on wallboards. Risks of baseboards increase faster than those of wallboards.

Risk Trend after Inspection

Risk evaluation aims to provide basis for working out an inspection strategy. Risks of storage tanks will experience more changes after inspection. Supposing a storage house implements inspection within 5 years and 10 years, this paper studies risk changes before and after inspection and obtains the outcomes shown in Fig.2 and Fig. 3.

Yellow wedges in the figure indicate risk changes over time without inspection. Blue wedges indicate risk changes over time after inspection. Inspection within 5 years and inspection within 10 years could respectively reduce risks of 23 storage tanks by 27.23% and 64.09%.

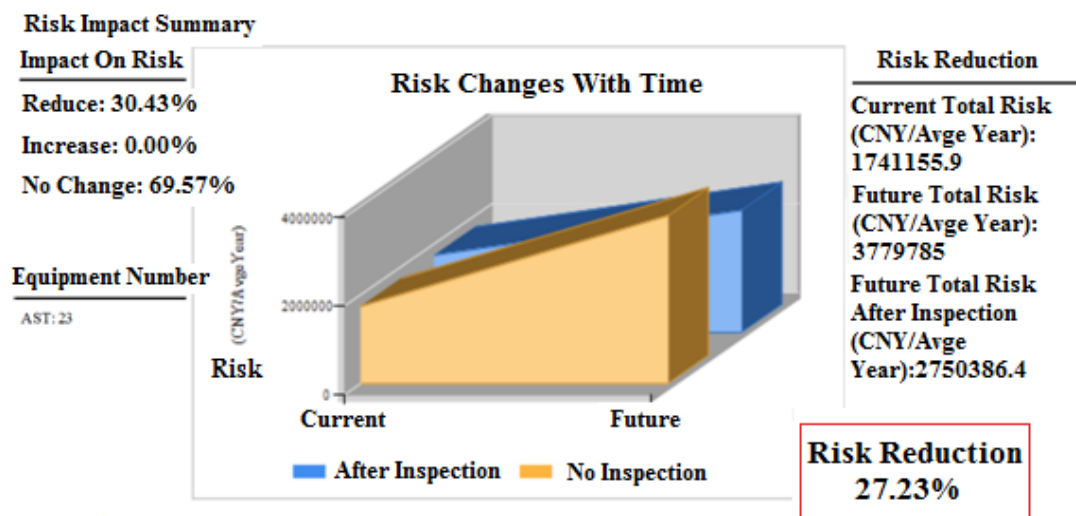


Fig.2 Risk changes before and after inspection within 5 years

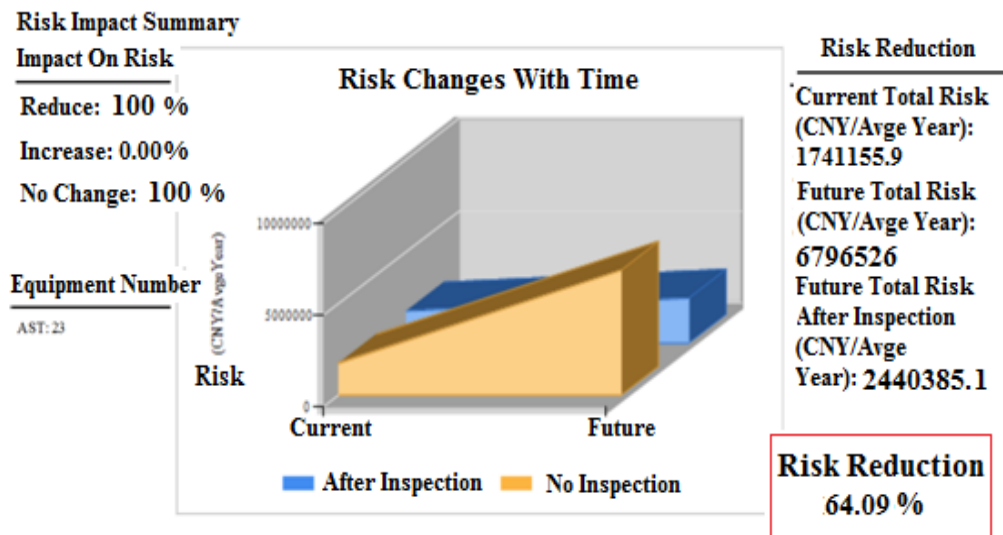


Fig.3 Risk changes before and after inspection within 10 years

Suggestions for Inspection Strategy

According to risk analysis outcome, baseboards of 23 storage tanks present medium or higher risks and wallboards only present medium risks. Therefore, the time for baseboard damage factor to reach target value shall be taken as reference to determine inspection moments of storage tanks. Inspection moments are suggested in Fig. 4.

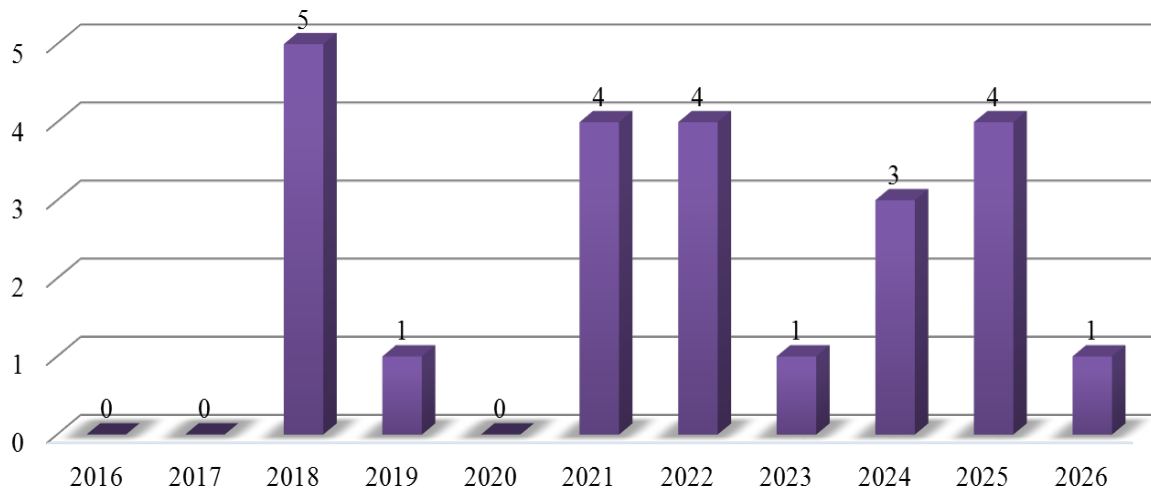


Fig. 4 Inspection moments suggested by baseboard risk

According to hidden invalidation mechanism and risk evaluation outcome of 23 storage tanks, this paper comes up with the inspection strategy in normal condition of the 23 storage tanks. Inspection strategy of 3 storage tanks is shown in Table 2 as examples.

Summary

This paper evaluates risks of 23 atmospheric-pressure storage tanks of 100 thousand m^3 of a storage house. Supposing the storage house implemented inspection within 5 years or 10 years, this paper studies risk changes before and after the inspection. It puts forward an inspection strategy to guarantee long term safety of storage tanks according to the risk analysis outcome.

Table 2 Inspection strategy of 3 storage tanks as examples

Tank No.	Latest Inspection Moment	Suggested Lowest Effectiveness of Inspection	Inspection Strategy of Open Tank	Online Inspection Strategy
T-06	2021-12	Low Effectiveness	Baseboard: a) ultrasonic thickness measurement on basis of spot check Wallboard: a) macroscopic examination of no more than 50% b) fixed ultrasonic thickness measurement of external part	Baseboard: a) acoustic emission inspection Wallboard: a) macroscopic inspection of less than 5% b) fixed ultrasonic thickness measurement of external part
T-18	2019-10	Medium Effectiveness	Baseboard: a) 100% macroscopic inspection and etch pit measurement b) ultrasonic thickness measurement of suspicious part by 10% of baseboard flux leakage, high frequency guided waves, or ultrasonic C scanning system c) ultrasonic reexamination of baseboards with abnormal flux leakage signals d) implement vacuum leakage test in case of the etch depth $\geq 1/2$ of the plate depth Wallboard: a) macroscopic examination of no less than 20% b) Implement ultrasonic thickness measurement or ultrasonic C scan at the part inspected by fixed thickness measurement	Baseboard: a) acoustic emission inspection b) implement high frequency guided wave inspection at the margin plate with abnormal signals of acoustic emission inspection (implement the inspection at outer part of the margin plate) Wallboard: a) macroscopic examination of no less than 20% b) Implement ultrasonic thickness measurement or ultrasonic C scan at the part inspected by fixed thickness measurement
T-48	2018-11	Medium Effectiveness	Baseboard: a) 100% macroscopic inspection and etch pit measurement b) ultrasonic thickness measurement of suspicious part by 10% of baseboard flux leakage, high frequency guided waves, or ultrasonic C scanning system c) ultrasonic reexamination of baseboards with abnormal flux leakage signals d) implement vacuum leakage test in case of the etch depth $\geq 1/2$ of the plate depth Wallboard: a) macroscopic examination of no less than 20% b) Implement ultrasonic thickness measurement or ultrasonic C scan at the part inspected by fixed thickness measurement	Baseboard: a) acoustic emission inspection b) implement high frequency guided wave inspection at the margin plate with abnormal signals of acoustic emission inspection (implement the inspection at outer part of the margin plate) Wallboard: a) macroscopic examination of no less than 20% b) Implement ultrasonic thickness measurement or ultrasonic C scan at the part inspected by fixed thickness measurement

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