DEVELOPMENT OF AN EFFECTIVE INSPECTION PLAN FOR PRESSURE VESSELS ACCORDING RISK-BASED INSPECTION TECHNOLOGY FOR POLYETHYLENE PLANT

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To my mother and father

To my Lotte Chemical Titan Colleagues

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ABSTRACT

In order to ensure the asset integrity, all unfired pressure vessels (UPVs) should be examined at the intervals recommended in inspection codes or risk-based inspection (RBI) assessment. RBI assessment may allow previous inspection intervals to be extended and the inspection method may be reselected. In this paper, RBI study performed on 114 unfired pressure vessels components for Unipol Polyethylene Plant. Risk assessment performed and determines the risk ranking. Inspection plan developed base on the risk assessment result. The risk-based inspection plan compared with conventional inspection plan i.e. API 510's inspection intervals. This thesis will summarize the fundamental steps for API 580 Risk-Based Inspection methodology, i.e. the risk calculation and assessment, evaluated the damage mechanism via the corrosion loops, and the inspection technologies.

ABSTRAK

Demi menjaminkan keintegritian aset, semua pengandung tekanan tidak berapi (PTTB) perlu diperiksa dalam tempoh masa yang disyorkan dalam kod pemeriksaan atau penilaian pemeriksaan berdasar risiko (RBI). Penilaian RBI boleh membenarkan tempoh pemeriksaan yang disyorkan dalam kod pemeriksaan lama dilanjutkan dan cara pemeriksaan akan dicadang semula. Dalam kajian ini, penilaian RBI akan dilaksanakan atas 114 PTTB dan komponentnya untuk kilang proses polyethylene. Penilaian risiko akan dijalankan dan menentukan tahap risiko untuk semua PTTB. Pelan pemeriksaan akan dibentukan berdasarkan keputusan risiko. Pelan pemeriksaan RBI akan dibandingkan dengan pelan pemeriksaan yang berdasarkan cara konvensional terutamanya tempoh pemeriksaan. Dalam kajian ini akan merumuskan langkah asas untuk API 580 RBI, iaitu cara penilaian risiko dan penilaian, penentuan cara kemerosotan berdasarkan corrosion loops dan teknologi pemeriksaan.

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$P_f(t)$	-	Probability of Failure
gff	-	Generic failure frequency
$D_f(t)$	-	Damage factor
F_{MS}	-	Management systems factor

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CHAPTER 1

INTRODUCTION

Petrochemical plants and refineries consist of hundred pieces of pressure vessels, heat exchangers, towers and other unit operation which operate under various operating condition. They tend to deteriorate due to corrosion, aging, wear, and etc. In addition, process safety for a petrochemical process relies among other things, on the adopted management criteria. It will affect the plant life-cycle, production activity, until the possibility to dismantle. If the consequence of failure is low, the number of maintenance activity will be low at the time of failure. However, if the failure consequence is high, the deterioration of equipment will lead to unplanned shutdowns, production losses, high maintenance cost and severe safety, health and environment issues. If the plant equipment or pressure vessel deterioration condition can be modelled, it is possible to predict the time for failure, and suitable inspection activities can be planned on the basis of the service age and the anticipated failure time. A risk-based inspection not only extends the interval between shutdowns but also produces millions of dollars in savings. (Hameed & Khan, 2014)

1.1 Background

1.1.1 Global RBI Activities

The objective for the study is to show how to implement risk based inspection method for piping system in naphtha cracking unit. Their scope of focus was to provide inspection personnel with optimal planning tools for piping inspection and predict the potential piping risk effectively. API 581 was used as the analyst tools to understand the potential risk. In addition, applied risk based inspection for process piping in refinery plant (Chang, Chang, Shu, & Lin, 2005).The outcome of the study is the risk ranking distribution but no inspection plan.

Besides piping inspection, risk analysis for low density polyethylene equipment was conducted at Sinopec Shengli Oilfield. (Wang, Yan, Zhang, Zhao, & Chen, 2011)Their focus in the study is to identify the risk for high pressure polyethylene ethylene devices. Qualitative analysis was conducted to determine the risk and danger zone. Study on maintenance strategy optimization for ethylene oxide production facilities was conducted (Khan & Haddara, 2004). Their objective is to determine the maintenance interval by risk level and fault tree analysis.

A comparison of API 510 and API 581 was conducted for Abadan Oil Refining Company (AORC) and Esfahan Oil Refining Company (EORC) (Shishesaz, Bajestani, Hashemi, & Shekari, 2013). The calculated inspection intervals reveal that in both units there exists some equipment with inspection intervals less than current overhaul (turnaround) intervals, and also lots of items with inspection interval much longer than current overhaul interval. Based on RBI analysis results, RBI permits the shift of inspection and maintenance resources to provide a higher level of coverage (inspection plans with higher effectiveness) on the high-risk items and an appropriate effort (inspection plans with less effectiveness) on lower risk equipment during plant turnarounds.

In addition, the components with inspection intervals longer than twice the adjusted overhaul interval can be eliminated from future overhaul plan, leading to shorter outage time while keeping plant risk within acceptable range.

Having compared the RBI recommended inspection intervals with intervals calculated based on API 510, it can be concluded that, for components in which thinning is the only active damage mechanism, API 510 calculation procedure is much more conservative API 581. Generally, the RBI recommended inspection intervals are usually as long as twice the API 510 inspection intervals. It is also concluded that API 581 calculations can be used for determination of a more exact value for RSF_a in FFS calculations. (American Petroleum Institute, API 510 Pressure Vessel Inspection Code: In-Service Inspection, Rating, Repair and Alteration, 2008)

1.1.2 RBI Implementation in Malaysia

In Malaysia, based on jurisdictional requirement, i.e. Factories and Machinery Act 1967 P.U. (A) 43/70, Factories and Machinery (Notification, Certification of Fitness and Inspection) Regulation, 1970, all unfired pressure vessel (UPV), steam boiler or hoisting machine other than a hoisting machine driven by manual power shall hold a valid certificate of fitness (CF) in respect thereof so long as such machinery remains in service. The period of validity of every certificate of fitness shall ordinary be fifteen calendar month from the date of inspection or such longer period not exceeding three years as the chief inspection in his discretion may consider appropriate: (Malaysia, Factories And Machinery (Notification, Certificate Of Fitness And Inspection) Regulations, 1970, 1970)

Provided where any steam boiler, unfired pressure vessel or hoisting machine is out of service for a long period immediately subsequent to an inspection by reason of dismantling or repair of any defect the Inspector may issue a certificate effective from the date when such machinery is replaced in service.

In order to renew the certificate of fitness, the respective machines must stop and open for internal inspection after 15 months period of operation. Industries can apply for extension of CF due to various reasons, but normally based on:

- Economic reasons, such as loss of competitiveness, orders from clients and etc.
- Technical reasons, such as machine integrity maintenance and etc.
- Safety reason.

Hence, certificate of fitness can be apply for extension up to 72 months and with approval from chief inspectors and minister approval. Each extension process, the UPV's owner must submit the application to authorities 6 months before the current certificate expires. 4 different application processes is require to extent the CF to 72 months. Figure 1.1 shows the flow sequence for extension application:

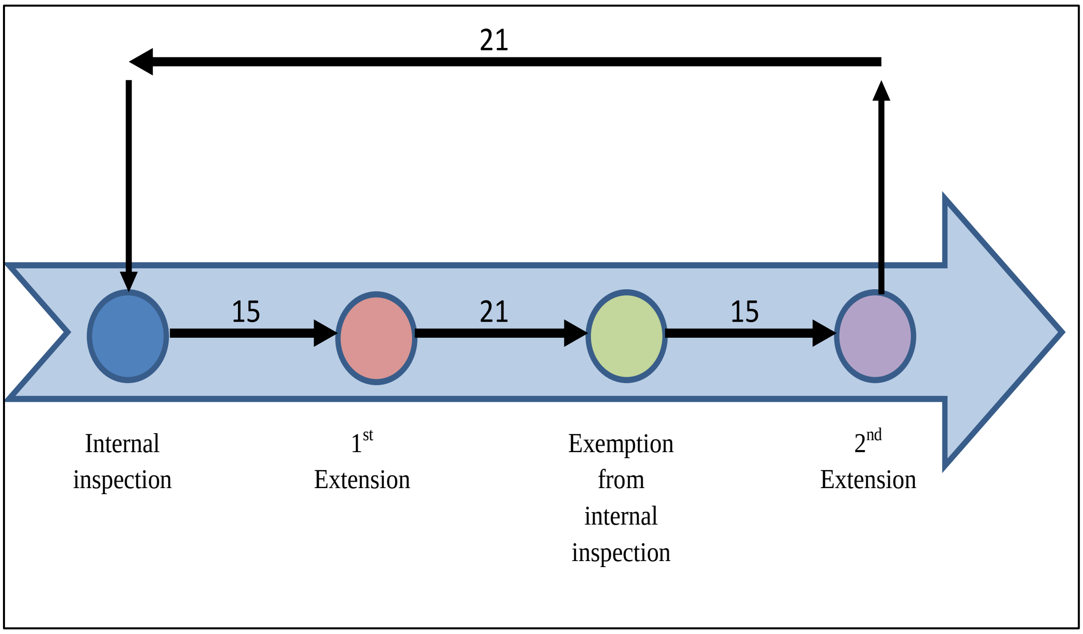

Figure 1.1 Flow sequence for CF extension application

The principle for this CF is time-based inspection. The equipment's risk and safety in rely on inspector findings during internal inspection, hence the responsibilities on machines safety is not on owners. This method will affect owners' plant productivities and equipment safety is merely relying on inspectors' findings. The authorities aware the gap for this and regulation amendment had been make during April 2014 and come into operation on 1st June 2014 (Department of Occupational Safety and Health, Malaysia, 2014).

The new regulation had been introduce as Factories and Machinery (Special Scheme of Inspection) (Risk-Based Inspection) Regulation 2014. The principle of this scheme is to shift the responsibilities to machines' owners to ensure the equipment safety. In addition, the inspection period and type will be based on the risk taken by each machines. The validity for this scheme is 150 months and along this scheme only 2 internal inspections is required after the internal inspection during new scheme application. Compared with previous regulation, the validity for this CF had increase from 72 months to 75 months and only required 1 application process instead of 4 applications. This implementation will help to reduce the numbers of shutdown for internal inspection without compromise the safety and risk in the plant. (Malaysia, Factories and Machinery (Special Scheme of Inspection) (Risk-Based Inspection) Regulations 2014, 2014)

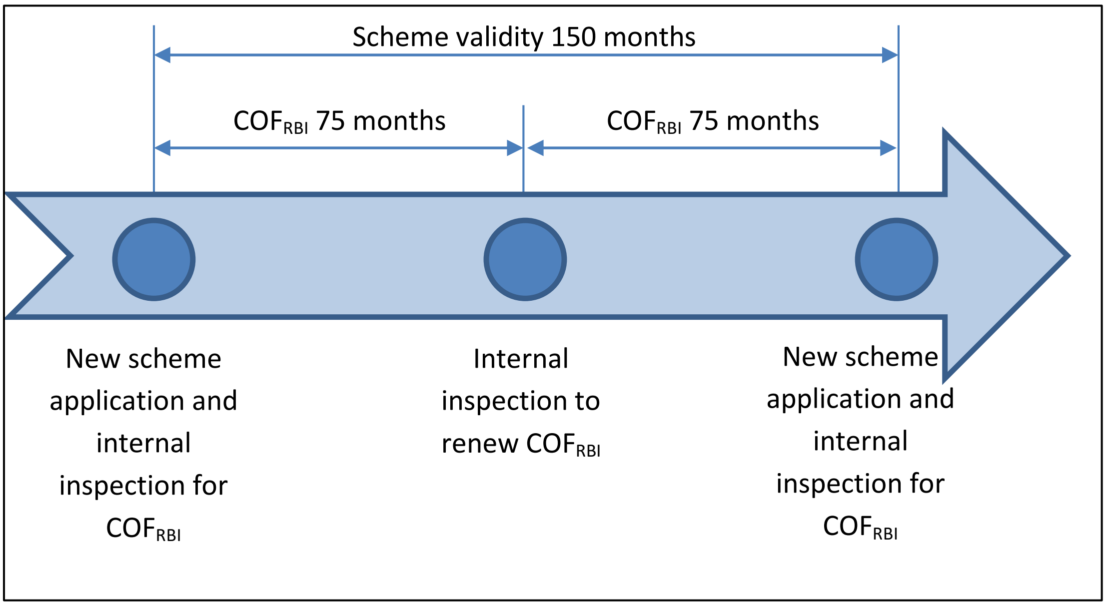

Figure 1.2 COF_{RBI} Validity

1.2 Research Problem

In Malaysia, due to the regulation is newly implemented and most of the petrochemical and chemical processes industries not aware the benefits and advantages for risk-based inspection and risk-based inspection planning. In addition, no specific guidelines for plants' owners to follow when implement RBI to replace the traditional maintenance method.

1.3 Research Scope and Objectives

In this study, the scope will focus will on a Unipol Polyethylene Plant which located in Pasir Gudang, Johor in service since 1992.

- The objectives for this research can be introduced into 3 objectives:
- To develop corrosion loop for unfired pressure vessels in polyethylene plant and determine the potential damage mechanism.
- To identify unfired pressure vessels risk criticality based on Risk Based Inspection (API 580).
- To propose an effective inspection plan for unfired pressure vessels based on Risk Based Inspection for aging plant.

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