COMPARATIVE STUDY OF FIBERGLASS REINFORCED PIPE FOR OIL AND GAS PROCESSING INDUSTRIES BASED ON FIRE AND EXPLOSION RISK ANALYSIS

By

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DECLARATION

No portion of the work referred to in this project report has been submitted in support of an application for another degree or qualification of this or other institution of learning.

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Abstract of project to the Senate of Universiti Putra Malaysia
In fulfillment of the requirements for the Master of Science

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In this paper the suitability of fiberglass-reinforced pipe (FRP) for use in oil and gas processing industries fire fighting system was studied. The study covered the issues on the reliability as well as the cost benefit that could be obtained from the FRP material as compared to conventional metallic materials commonly used in the said system. In addition, a discussion on the recent test results on FRP material concerning its mechanical and thermal properties, fire resistance, corrosion resistance, cost benefits and consequently approval status by the International Regulatory and Classification Societies are also presented in this paper for evaluation of its suitability.

The results of the study show that the FRP pipes are suitable for oil and gas processing industries fire fighting system provided that the "blowdown" system and the firewater deluge system are appropriately and properly engineered to the relevant codes and standards.

From the economics standpoints, the use of FRP materials in the piping system involving pipes and fittings diameter larger than 4 inch will provide substantial cost saving as opposed to other metallic materials. The cost saving will become more obvious with the increase in degree of piping system complexity.

Abstrak projek yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Sarjana Sains

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Oleh

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July 2001

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Kajian ini bertujuan mengkaji kesesuaian paip yang diperkuatkan dengan gentian kaca (fibreglass-reinforced pipe (FRP)) untuk kegunaan sistem pencegahan kebakaran di dalam industri yang melibatkan pemprosesan minyak dan gas. Kajian ini meliputi isu-isu seperti kebersanan dan juga penjimatan kos yang boleh diperolehi dari FRP berbanding dengan bahan-bahan besi yang biasa digunakan di dalam sistem pencegahan kebakaran sebelum ini. Di samping itu kesesuaian FRP paip dari segi sifat-sifat mekanikal dan haba, daya tahannya terhadap kebakaran dan pengaratan, penjimatan kos dan status kelulusan kegunaannya oleh "International Regulatory and Classification Societies" juga diperbincangkan.

Hasil kajian menunjukkan bahawa FRP paip adalah sesuai digunakan untuk sistem pencegahan kebakaran di dalam industri minyak dan gas sekiranya sistem "blowdown" dan sistem pancuran air direkabentuk mengikut kehendak-kehendak kod dan piawaian yang berkenaan.

Dari sudut ekonomi pula, kegunaan FRP di dalam sistem pempaipan akan memberi penjimatan kos yang banyak berbanding dengan bahan besi yang lain bagi sistem yang memerlukan paip bersaiz 4 inci ke atas. Penjimatan kos akan terus bertambah apabila sistem pempaipan menjadi lebih komplek.

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INTRODUCTION

1.0 Introduction

Since the development of lightweight, high strength, high stiffness fibre-reinforced plastics in the 1940's, applications for this newly discovered material has triggered interest among researchers and technologists. Initially, FRPs were designed for use in aerospace and transport industries where weight was of primary concern (Bakis, 1993). Its application has been extended to other industries with possible prospect for practical and economical alternatives to conventional steel applications. "The replacement, where practicable and safe, of steel by non-metallic materials is inevitable" (Cowley,1987). The relative usage of FRP in various industries as at 1987 is shown in Table 1.1 (Dyson, 1990).

Table 1.1 Uses of FRP (Dyson, 1990)

Industries	%
Building/construction	28
Automatic/Transport	25
Electronic/Electrical	21
Marine	12
Sport/Leisure	7
Consumer Goods	6
Aerospace	1

In view of its excellent corrosion resistance properties, ease of installation and low maintenance cost, FRP has been approved by many National Authorities and Classification Societies for use in shipboard piping system applications. However, its application so far has been restricted to non-critical services e.g fresh and seawater lines which include potable water, chilled water, waste and sewage water, chlorinated seawater lines, ballast piping system, crude oil washing system and inert gas scrubber effluent piping system. Further improvements in the composition and manufacturing techniques and technology of FRP, however, has prompted its application in services such as fire water lines. The use of this material in critical services, however, will require careful considerations such as not to cause any potential hazard to the installation or personnel (Crawford – 1987).

1.1 Problem Statement

Hostile weather environment faced by many off-shore oil and gas installations has always presented problem to the piping system and its related support steel structures. In addition to the usual risk of internal corrosion, they are also exposed externally to extremes of temperature, direct sun light, severe wind and rain conditions and salt laden atmosphere - factors which contribute to the corrosion problem in the piping system as well as steel structures. Corrosion of pipes and steel structure will cause progressive weakening of the structures, leakage and unsightly rust-staining and this is further aggravated by rising costs for maintenance. The use of a corrosion-resistant material in place of steel in off-shore environment is highly desirable provided adequate strength, cost-effectiveness and long term performance can be achieved.

Some steel alloys such as cooper nickel, stainless steel, duplex and titanium have all been utilized extensively in some of the critical services such as hydro carbon lines, fire water lines, produced water lines and drain lines where the fluid handled are corrosive for normal carbon steel to handle. In view of the bi-metallic 'corrosion' problem and high material and installation cost, the use of steel alloys has become less preferred as compared to FRP material.

Fibreglass reinforced plastic (FRP) pipe has become a new alternative to steel pipes where corrosion is seen to be a significant problem. Since 1960s the use of non-metallic piping has been applied in shipboard installation but its application has been restricted to non-critical services only (Murtagh et. al – 1987). Its application in critical services, however, is still not well accepted in both shipboard and off-shore installations. A number of reasons could be attributed to the existence of major obstacle to the wide spread use FRP pipe for critical services in shipboard and off-shore installation. Among those identified are :-

1. In most cases many tend to perceive the FRP pipe to be the same as normal thermoplastic such as PVC and CPVC which are susceptible to fire and mechanical impact (Cassa et. al – 1984).
2. It is a common perception that much thermosetting resin system begins to degrade at temperature of approximately 200°C and will have structural integrity failure above 350°C (P.R. Mark – 1987). Because the FRP resin is manufactured of hydro carbon derivatives, it is often thought that the material itself is combustible. Furthermore, the presence of various additives in final FRP products to modify or control properties has also created concern on potential emissions of toxic fumes and smoke during fire.
3. The absence of international design and performance Standard or Specifications as standard guidelines to be followed by various FRP pipe manufactures, to produce standardized FRP pipes and fittings with respect to their outside or inside diameter and standard schedules relating nominal pipe sizes to wall

thickness, is one of the many factors that lead to poor acceptance of FRP pipes in off-shore installations.

4. Concern also exist that the movement of certain fluid through non-conductive materials such as fibreglass pipe may result in the accumulation of static electrical changes for which it should be avoided in any off-shore installations to prevent the existence of source of fire ignition (Cassa et. al, 1984).

1.2 Objective of Study

The objective of this report is:-

1. To evaluate the suitability of FRP pipe as an alternative to metallic material for use in off-shore fire fighting system from both the safety and cost saving perspectives using OHRAT, LEAK, PHAST and CHAOS programs.

1.3 Scope of Study

The scope of this report is limited to potential application of FRP pipes in off-shore oil and gas production facilities fire fighting system with respect to the following issues:

1. Their performance under fire conditions.
2. Their resistance performance to explosion.
3. Their performance in corrosive environment
4. Their acceptance and regulatory approval status
5. Their cost in relation to other materials

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