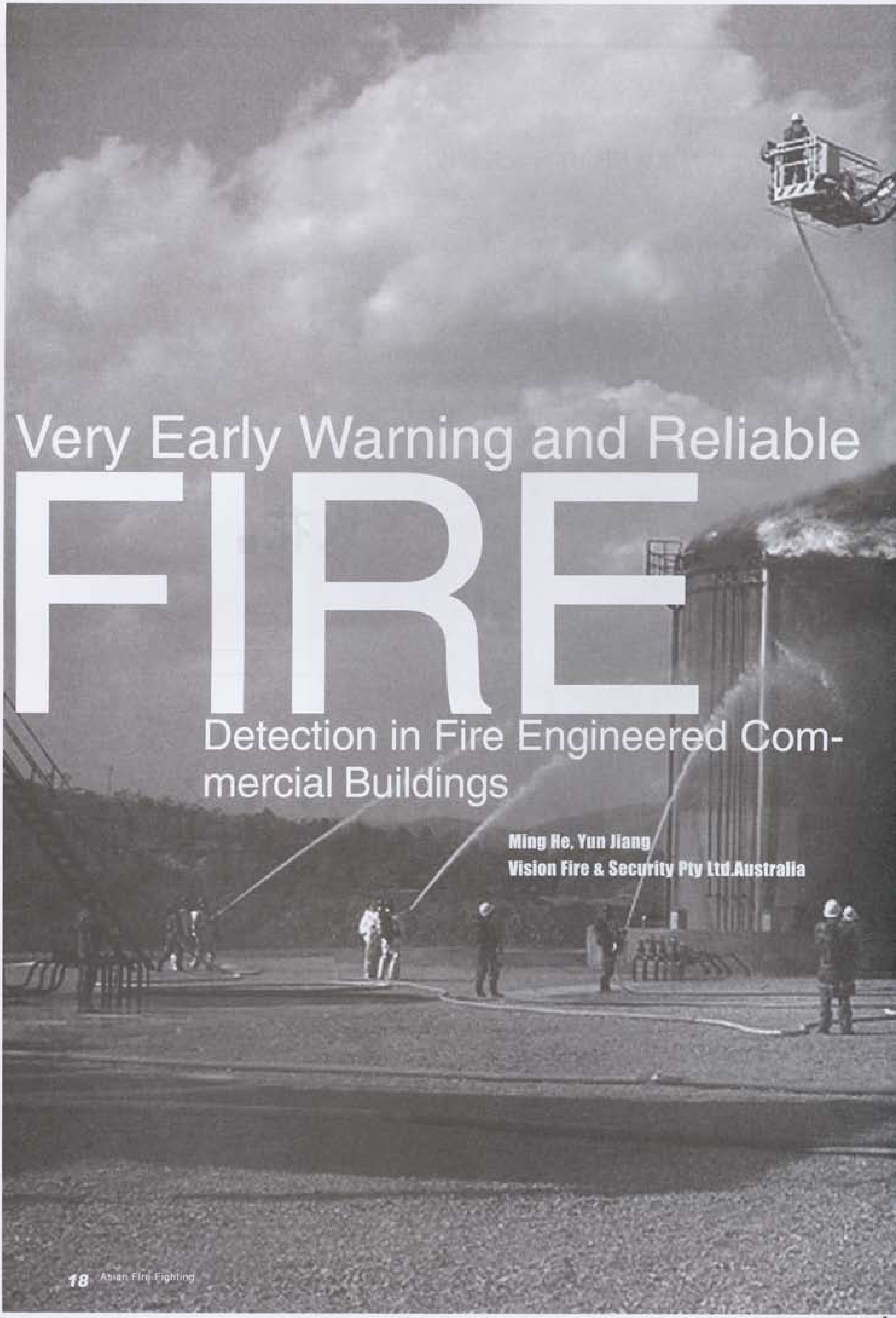

Very Early Warning and Reliable FIRE Detection in Fire Engineered Commercial Buildings

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ABSTRACTS

Many countries around the world have adopted the Performance-Based Design (PBD). The general approach of a performance-based design involves quantitative and qualitative statements a design must comply. Two of the key elements of Performance-Based Design regulatory are (1) permitting innovative design solutions that meet the established performance requirements and (2) encouraging cost-effectiveness and flexibility in design. The ultimate success of a PBD relies on the ability to apply well-defined methodologies to prove the equivalent (or better) performance in code compliance.

When a fire detection system is designed to actuate a suppression system, initiate evacuation procedure or operate other building management systems such as smoke extraction systems, a reliable and accurate fire alarm time prediction is paramount. In the context of a PBD, building safety margin and egress routes calculations are heavily depending upon fire detection system. When considering a fire detection system, certain norms or industrial practices are applied. They are seen as deemed-to-satisfy (DtS) solutions. However, when different fire detection technologies, especially more advanced technolo-

gies are considered for the same purpose, the ability to prove equivalent or better performance becomes critical. When an equivalent performance is established, different, normally a new and better technology can be adopted with a higher level of reliability.

When a better performance is evident, a system design can be optimised to satisfy not just building and life safety regulations but business continuity needs. The latter is very much relevant to the current and future development of fire engineering industry since more and more Performance-Based design is also a risk-informed fire safety solution.This paper focuses on applying advanced fire detection technology, Very Early Warning Air-sampling Smoke Detection (ASD) as part of a fire engineered solution for various building types, specifically in high-rise commercial buildings, large open and public spaces and high value warehouses. Three case studies covering these applications are used to describe the design and benefits of using advanced fire detection technology in such a challenge built environments.

Performance-Based Design promotes innovative solution and new technology. Finding the optimal solutions to satisfy building and life safety regulations and at the same time, meet risk management and business continuity requirements remains a challenge for fire engineering community.

1.INTRODUCTION

Nowadays, many new buildings and refurbished buildings require a proper fire engineering assessment and risk profile evaluation based on the building type and use. In order to meet building, life safety goals and risk management objectives, appropriate tools and methodologies are applied for codes and regulatory compliance and effective fire safety system design. Due to the rapid technology advancement, coupled with modern architecture design and changing risk profile, Performance-based risk-informed design is commonly adopted in conjunction with prescriptive Deemed-to-Satisfy (DtS) provisions.

An optimal fire safety system design can achieve many safety and economic goals, such as:

◆ Minimise building cost and maximise safety

◆ Address protection needs which are not covered in prescriptive codes, i.e. no other solution

◆ Fit-for-purpose solution for greater risk area protection

◆ Allow innovative technology and architecture design

◆ Provide greater flexibility in building use

In general, fire protection strategy is to prevent a fire start, if a fire does break out, must keep the fire small. Therefore a Very Early Warning fire detection solution:

◆ Underpins best practice in Detect, Analyse, Response, Measure "C Total Protection Solution

◆ Maintains or increases building safety margin: Fire Code orientated

◆ Ensures business continuity: Asset and Risk Management orientated

Today, performance-based building code has been in use in many countries. It provides great incentives for safer and more innovative building designs and also encourages the application of advanced technology. In contrast to the prescriptive ¡°deemed-to-satisfy¡± (DtS) approach, the cost of the solution is optimised when the building safety margin is maintained and sometime enhanced.

2.VERY EARLY WARNING FIRE DETECTION SYSTEMS

In their simplest form, ASD systems continually draw samples of air from the equipment or area requiring protection and assess these samples for the presence of smoke. The detector is a form of nephelometer "C an air pollution monitor having remarkably high sensitivity, typically hundreds of times higher than conventional smoke detectors. Such high sensitivity is required to detect the earliest traces of airborne particles or aerosols released due to the overheating of materials. One particular interest is how these systems handle fires in LOS or high airflow environments in which the smoke density and heat intensity can be dramatically reduced, preventing many conventional detection technologies from functioning effectively. Many ASDs can actively aggregate lower density smoke from sampling points to minimise the dilution effect.

As shown in Figure 1, an ASD system is typically implemented as a number of small-bore pipes distributed across a ceiling (above or below) with sampling holes drilled into each pipe at suitable intervals. Air is then continuously drawn into the pipe network via the holes to the centrally located detector using an air pump or aspirator. The density of smoke in the sampled air is compared to a set of pre-defined smoke thresholds. If the amount of smoke in the sampled air exceeds the set thresholds, alarms are issued accordingly.

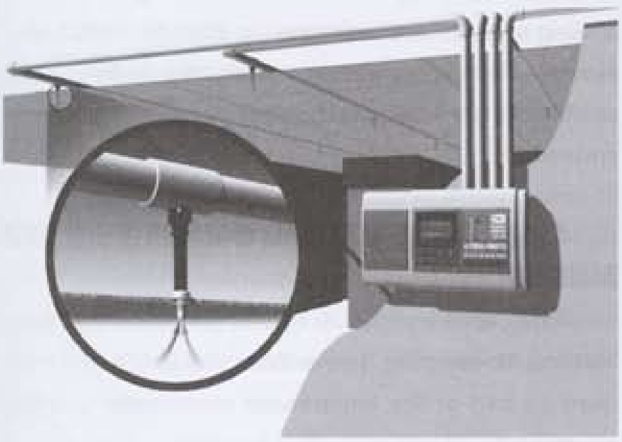

Figure 1: Air Sampled through a capillary and sample point

The location of the pipe network and the sampling holes is generally governed by local fire codes and standards such as Australian Standard AS 1670 [5], BS 5839 [2]or NFPA 72 [6]. Typically, the pipes and holes are laid out according to a grid pattern that places each hole where a conventional point detector would otherwise be located to meet the prescriptive codes. The true effectiveness of air sampling systems is thought to be its flexibility in application. Placing the sample holes at points where smoke is most likely to travel (i.e. affected by mechanical air conditioning) provides the most effective means of very early warning smoke detection, typically at return air grilles. It is also possible to use these systems to initiate fire suppression systems at a much later stage in the fire development cycle.

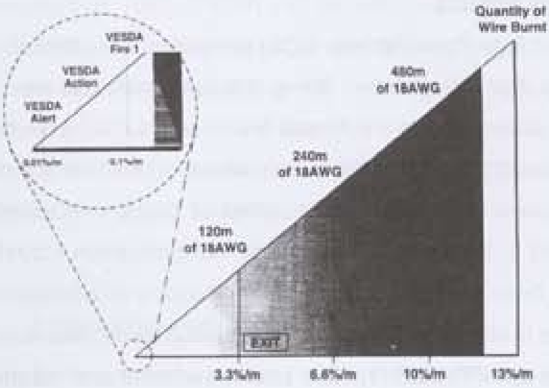

Figure 2: Smoke Obscuration measured based on a Burning wire within a 1000m2 room

How sensitive can ASD be? VESDA™®, a Very Early Smoke Detection ASD system, for example can set alarm levels from 0.005% Obscuration/m to 20% Obscuration/m. Obscuration is the effect that smoke has on reducing visibility. Higher concentrations of smoke result in higher obscuration levels, lowering visibility. Figure 2 shows the relative smoke density and its affect on a typical EXIT sign. At 3% Obs/m visibility of the EXIT sign is already hampered [7].

ASD can provide warning alarms at around 0.005% Obs/m, some hundred times more sensitive than conventional detection systems. Staged alarms and associated time delays ensure these systems are quite immune to nuisance alarms. The provision of staged alarms allows for activation of controlled and escalated responses. For example the Alert (i.e. the first alarm) condition may be used to call authorised staff to investigate an abnormal condition. Should the smoke condition continue to increase, the Action (i.e. the second alarm) condition could activate smoke control measures; begin warning sequences via the evacuation system and notify further staff members. Fire 1 (i.e. the third level) alarm indicates that a fire condition is very close or has started. At this stage the environment is evacuated. With the provision of a Fire 2 alarm level, ASD can initiate suppression systems.

3.CASE STUDY 1: VERY EARLY WARNING IN LARGE OPEN SPACES

Large Open Spaces (LOS) protection is traditionally a very challenging issue. Some of these challenges are: (1) the distance from a potential fire hazard to the detection points, (2) smoke being quickly diluted in a sheer volume of space and (3) a large number of occupants usually found in LOS applications. The fire protection industry has been searching for optimal solutions to adequately meet building and life safety design objectives. Standards such as NFPA92B [1] have been developed and adopted specifically for LOS applications. However, many LOS applications are usually part of a landmark building involving extensive innovative design ideas to accomplish visual, energy sustainability and useability goals. These unique features have not been exhaustively considered in the existing codes and standards.

A fair percentage of commercial/non-commercial buildings exhibit the characteristics of a LOS application. These include atria in office buildings/serviced apartments, hotels, convention and exhibition centres, museums and public libraries, main railway and airports terminals, sport stadiums, halls (municipals, universities, churches, etc.), entertainment and in-door recreation facilities, large warehouse type structures such as aircraft hangers, hardware/furniture stores, shopping malls, arcades, industrial sites and so on. When considering the best fire protection solution for such building types, the following aspects must be taken into consideration: (1) the key attributes of the building layout (i.e. ceiling height and interface to outside ambient environment), (2) ventilation (i.e. natural or mechanical), (3) airflow dynamics (i.e. building leakage, air supply and return vents and air handling unit (AHU) operation). Examples of the impact on fire growth and smoke propagation are the possibility of stratification, the extent of smoke dilution and uncertainty of a smoke plume forming.

Beam detectors have often been used in LOS environments such as warehouse applications mainly due to the fact that many other conventional point detectors such as ionisation or photoelectric type are not sensitive enough when mounted at a usually very high ceiling level. Not to mention the maintenance of conventional point detectors is quite difficult when mounted at such high ceiling levels. Over the years, recommendations for beam detectors design and installation have been changed to reflect the need for detailed design considerations in order to achieve the level of protection required. As stipulated in BS5839-1: 2002 revision [2], additional considerations include smoke plume forming, the need to provide ceiling level detection, etc. This highlights two important issues in regards to the effectiveness of LOS protection using beam detectors. The first issue is how to position the beam detectors when close spacing is required for supplementary detection of a rising smoke plume according to BS5839-1:2002 revision [2]. The second is how to assess the system design so different fire scenarios, hazards and locations can be covered.

4.CASE STUDY 2: VERY EARLY WARNING IN HIGH RISE BUILDING

Today, apart from its role in asset protection, Very Early Warning Air-sampling Smoke Detection (ASD) has been used as part of fire engineered commercial building solutions.

Historically, there are many high-rise building fires that caused substantial building damages, in some cases multiple fatalities. For instance, 2003 fire in Cook County Administration Building in Chicago killed 6 people and in 2004, fire in Venezuela's Parque Central, South America's tallest skyscraper caused severe building damage. Fire risks in commercial buildings are real. Coupled with such risks, modern commercial building architecture design with open and irregular spaces, new building materials and multi-use function all present challenge to fire safety system design.

Change of building tenants, layout and maximising building space usage, etc. demand a flexible fire system design. Limited egress options and measures in a commercial building require a very early and reliable fire detection system.

5.CASE STUDY 3: VERY EARLY WARNING IN HIGH VALUE WAREHOUSES

A typical large volume building structure like warehouses are, by virtue of their large volume and contents, a major fire risk. Almost 23,000 structure fires in storage properties are reported per year in the USA alone . They can contain a diverse range of products in open area storage spaces, from raw materials, wholesale goods and retail consumables to Flammable Paint. The warehouses can be automated or feature very low staffing levels measured as per area covered.

With high degree of warehousing automation, there are number of electrical and electronic systems running 24 hours a day and 7 days a week. Any overheating and overloading of electrical cables will be a potential fire hazard.

In the event of a fire, fire loading is not limited to product stored. Combustion material at the fire of origin may be vastly different to surrounding fuel mass when the fire is spread. Packing materials, pallets, battery or gas powered forklift trucks and other flammable materials add further to the risk.

Losses associated with a fire can be catastrophic and the consequences can range from stock loss to company closure. The consequences will have much greater impact on wider community when the warehouses are used as storage or depot to move goods for other customers and companies.

An additional consideration is the height of many storage areas, which can make conventional fire detection technologies unsuitable. Codes and standards specify the height of one particular detector or detection technology with little background information as to how the limits are calculated.

For many large or high value warehouses, Very Early Warning technology becomes extremely popular in loss prevention while prescriptive building code requirements are met. A suitable fire detection technology such as ASD can provide a total solution for building and life protection as well as ensuring business continuity. From a design perspective, ASD system can be designed to deal with possible smoke stratification, preventing high, difficult or dangerous access to ceilings for maintenance. In most cases, ASD multiple alarm thresholds can be readily applied to actuate pre-action sprinklers, smoke extraction systems, localised flashing lights and sounders.

6.CONCLUSIONS

There are many aspects of fire safety system design for various commercial buildings such as large open spaces, high-rise buildings and warehouses. The fire detection system is one of the most important elements. Reliable and early detection ensures life safety and minimises damage to building and assets, therefore maintaining business continuity.

Very Early Warning fire detection technology:

◆ Enable innovative and cost-effective engineering solutions

◆ Satisfy design safety margin

◆ Assess wider range of fire scenarios

◆ Provide flexibility for future changes of building layout

◆ Differentiate system performance from simple device specifications to improve the reliability of the assessment

◆ Combine product design tools and CFD fire modeling so "environmental effects" are considered

◆ Relate to Risk Management to achieve an optimal, not minimal outcome

It has been demonstrated in numerous successful installations worldwide that a Very Early Warning system is a perfect fit for many Performance-based and risk-informed fire safety system design. With continuing effort in fire modelling development and verification, the accuracy of alarm prediction for "active" fire detection technology such as ASD has been further improved. This provides the designers a high level of certainty while conducting both qualitative and quantitative assessment.