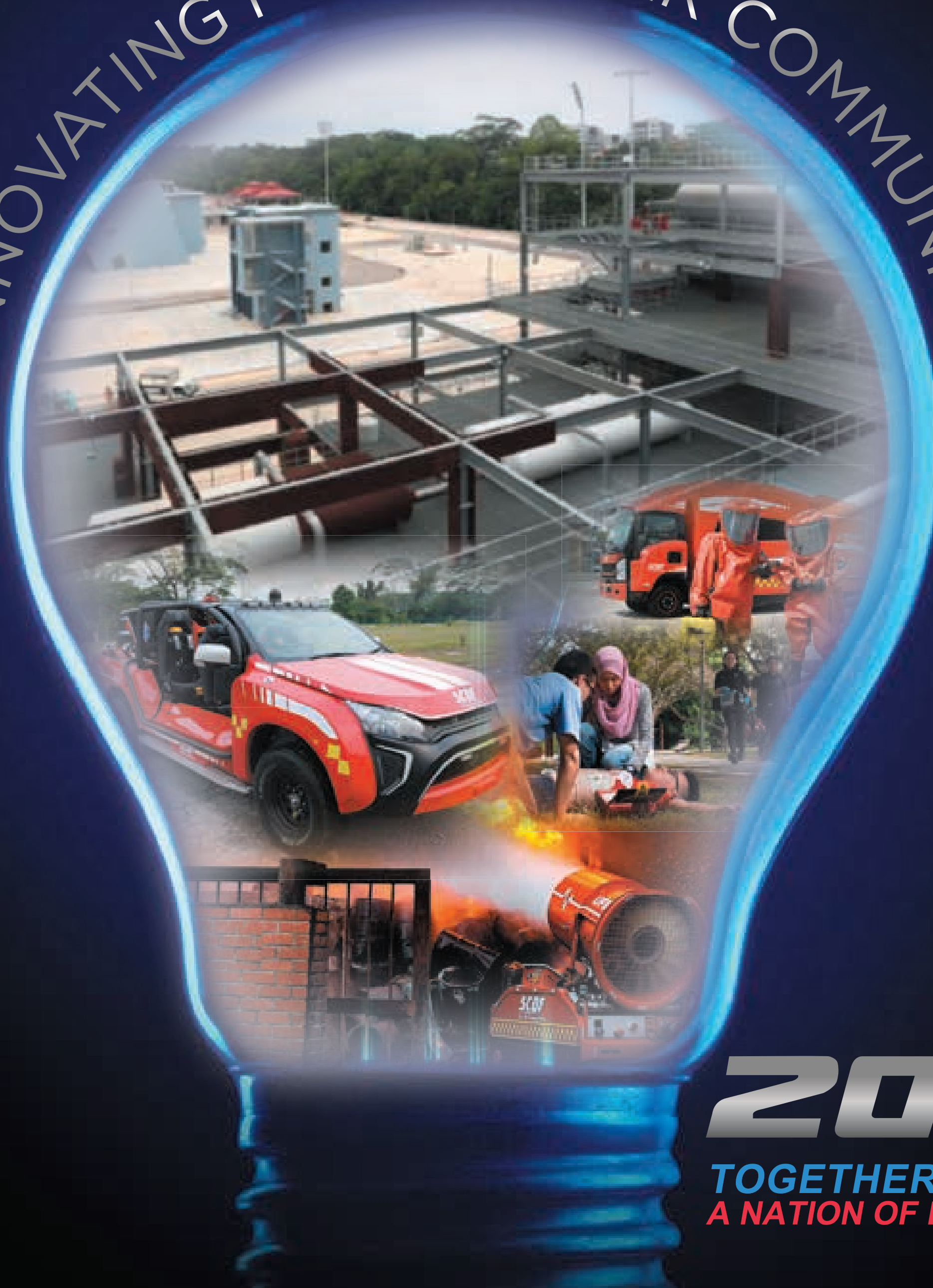
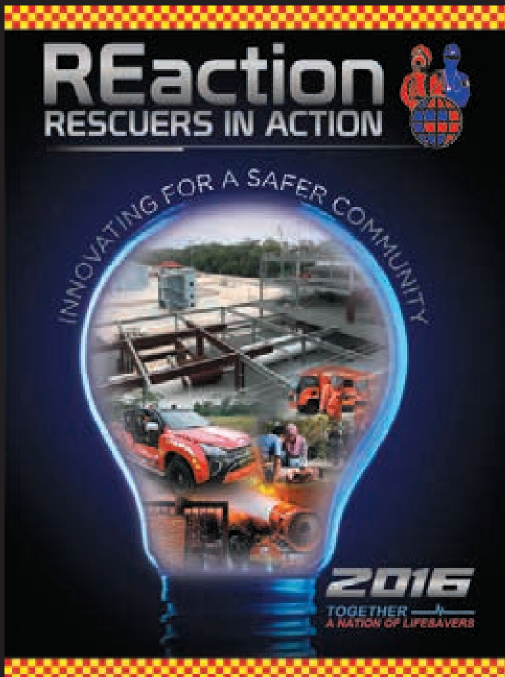
REaction
RESCUERS IN ACTION

INNOVATING FOR A SAFER COMMUNITY



2016

TOGETHER
A NATION OF LIFESAVERS



REaction

Rescuers in action is the SCDF's annual technical publication which aims to be a platform to both invoke thought provoking discussions and to share knowledge and case studies.

REaction will be issued yearly in conjunction with the Singapore-Global Firefighters and Paramedics Challenge (SGFPC).

By providing articles covering a myriad of subjects, we hope for REaction to continue being a repository of knowledge for both academic and practicing readers.

We hope that you have gained new insights and found REaction beneficial to you.

EDITORIAL BOARD

Please address all contributions and correspondence to:

Editorial Board (Attn: MAJ Lee Kok Chuen)
Civil Defence Academy,
101 Jalan Bahar, Singapore 649734

For comments and feedback, please email to:
SCDF_CDA@SCDF.gov.sg

TOGETHER
A NATION OF LIFESAVERS

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FOREWORD

On behalf of the Singapore Civil Defence Force (SCDF), let me welcome our guests and participants to the Singapore-Global Firefighters and Paramedics Challenge (SGFPC) 2016. Over the years, the SGFPC has grown to become a global nodal point for the sharing of firefighting, rescue and Emergency Medical Services (EMS) knowledge. Strong friendships have also been forged among members of the global life-saving fraternity. Many of you have returned year after year, and I am especially happy to see all of you once again.

The gathering of life-savers from all over the world provides us with a good opportunity to exchange new ideas, and spark off ground-breaking innovations that will help in our work. The SCDF has thus chosen “Innovating for a Safer Community” as the theme for SGFPC 2016. The SCDF sees innovation as a powerful enabler to help us achieve outcomes that are beyond conventional means. Innovation is very much embedded in the DNA of the SCDF, and the spirit of innovation runs deep and permeates all levels of the Force. I am delighted to share that for its ongoing commitment towards innovation, the Force has been accorded the prestigious Innovation Excellence Award by SPRING Singapore in October 2016. I hope that the exchange of ideas during SGFPC 2016 would further SCDF’s mantra that “Everyone has the Potential to Innovate” in hopes of contributing towards the creation of a safe and secure community.

The Innovation Excellence Award should not be regarded as a pinnacle of achievement, but a base from which the SCDF can scale new heights. The SCDF remains committed to improving our practices and pursuing higher standards. One way to achieve this is to let effective and useful innovations transcend boundaries and be shared among the global life-saving fraternity. In this issue of ‘REaction’, we have put together a collection of articles which endeavour to innovate existing solutions and learn from past experiences in operations. On this note, I would like to express our sincere appreciation to our article contributors from the French Embassy in Singapore, ASEAN Coordinating Centre for Humanitarian Assistance on disaster management (AHA Centre), Hong Kong Fire Services Department (HKFSD), Changi Airport Group Airport Emergency Services and Dupont Pte Ltd for their contribution to ‘REaction’. We hope that the articles in ‘REaction’ will continue to generate interest, drive discussion, and catalyse new solutions or insights on issues which are relevant and current to the emergency services.

I wish everyone an engaging read and a fulfilling SGFPC 2016!

Eric Yap
Commissioner
Singapore Civil Defence Force

SGFPC ORGANIZING CHAIRMAN'S PREFACE

This is the third edition of the REaction publication since its conception in 2014. REaction started from a bold dream to share the knowledge and experiences of emergency responders, and has grown to become the publication it is today. We are thankful for the growing support for this publication, and are proud to have an increasing pool of overseas and local contributors year on year.

For this year, the chosen articles have the innovation theme woven into their underlying fabric. The publication starts off with an article about how SCDF uses technology and innovation as a powerful enabler. In an ever-changing global environment, innovation is essential in developing new methods and technology to tackle the complex challenges we are constantly faced with. This spirit of innovation is exemplified in various case-studies throughout the publication, namely the Jurong Aromatics Corporation (JAC) Oil Tank Fire, and the development of an alternative HazMat decontamination process.

As a valued member state of ASEAN, we felt that more publicity needs to be given to the vision of "One ASEAN, One Response". Hence, the SCDF has engaged the ASEAN Humanitarian Assistance (AHA) Centre for an article which documents the vision from its roots to its ratification by the leaders of ASEAN member states in 2016.

We are also honored to include articles from our international partners. In 2015, Paris suffered a series of terrorists attacks. The lessons learnt from the attacks have been graciously shared by the French Embassy in Singapore for the benefit of responders all over the world.

SCDF works with many strategic partners in the course of its work to build a safer community. As such, the editorial team felt that it would be good to showcase some of the work contributed by these partners; Dupont, Hong Kong Fire Services, Airport Emergency Services of Changi Airport Group to name a few.

We hope that everyone will have an insightful reading experience. We welcome feedback on what you would like to see being covered in future, or how we could improve.

Finally, I would like to thank the REaction editorial team. Without their dedication and hard work, this publication would not be a success.

AC Teong How Hwa
Organising Chairman
SGFPC 2016

MEANING BEHIND THE SGFPC LOGO

The Singapore-Global Firefighters and Paramedics Challenge (SGFPC) logo is composed of the images of a firefighter and a paramedic protectively overlooking the globe. The two figures signify the twin pillars of emergency response and their common life-saving mission anywhere in the world, while the colours reflect the passion (red) and dedication (blue) of these everyday heroes who lead extraordinary lives in a noble and sacrificial calling. The interlocking red and blue tiles in the globe represent the strong bonds of professional and personal friendship that the SCDF shares with the international fraternity of emergency responders.

27 YEARS OF CHANGE AND INNOVATION

2025 A NATION OF LIFESAVERS

“A Nation of Lifesavers” is a bold vision statement that will propel SCDF to higher levels of service delivery, operational effectiveness, and service excellence. This visual serves to illustrate the types of operational response that SCDF will be able to field at the conclusion of the Force’s transformation efforts in 2025.

The new vision will see the different communities (residential, commercial and industrial) taking greater and more sustainable ownership over their spheres of influence and surroundings to ensure the safety of their neighbourhood. The underlying premise of our vision is that while SCDF continues to provide the highest standards in our response, the community is still in the best position to respond to an incident. This bridges the critical interval between incident occurrence and SCDF’s arrival on-scene.

A Joint Community - SCDF Response Model For Increased Survival Outcomes

The following scene shows different response elements with respect to a casualty in the community, and illustrates how different response avenues synergise to contribute towards a more effective and enhanced joint-response model.

MyResponder App

The "MyResponder" Mobile Smartphone Application has the ability to swiftly link SCDF Ops Centre, community responders and cardiac arrest victims, through the App's linkage to the national AED Registry.

Active Responder

Someone who has volunteered time to serve in the NEAR Programme and be notified by SCDF OPS Centre when emergencies happen.

Bystander Responder

Someone who witnesses and then assists the casualty.

Concerned Citizen

Someone who may not have received training but has basic EP knowledge to know what to do when an emergency occurs.

Greenwave

This initiative will see all oncoming traffic lights turn green, in order to let an ambulance convey an on-board casualty to the hospital in the shortest possible time. This will be a nation-wide effort that will see all traffic lights across the Island coordinated under Project Greenwave.

AED at HDB blocks

The project is spearheaded by SCDF and MOH and supported by PA and the Singapore Heart Foundation to make available AEDs at HDB blocks. It is envisioned that community bystanders can quickly assess the AEDs and utilize them to render assistance to victims of cardiac arrest.

Fire Medical Vehicle

The Fire Medical Vehicle (FMV) affords SCDF the ability to deploy a single asset which can handle fire, rescue and medical incidents. The FMV is thus a single vehicle that has the capability of dealing with a wider range of operational scenarios.

AED in Taxis

A pilot project fronted by a local transport operator, where taxis will be equipped with AEDs, with the taxi drivers trained in CPR-AED. They will quickly respond if they happen to be near an incident. SCDF hopes to widen this initiative to include all local taxi companies.

Technology As A Force-Multiplier For Higher Operational Effectiveness

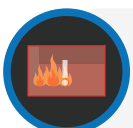
This infographics depicts a Warehouse Fire and how the Force will deploy its myriad of capabilities to swiftly and decisively mitigate the incident. From next-generation appliances (HCV, LFAV) to robotics (UAVs, UFM), these new technologies illustrate SCDF's continued drive to leverage on new technologies to enhance its operational excellence, when dealing with incidents.

Company Emergency Response Team (CERT)

CERT, a group of in-house first responders trained to prevent incident escalation, working hard to contain the incident, prior to SCDF's arrival.

Unmanned Aerial Vehicle

Small drones, fitted with cameras, allow SCDF personnel to monitor the situation of the fire from the air. They will be deployed during large scale incidents.



Fire And Smoke Telecamera (FAST) System at Warehouse Fire

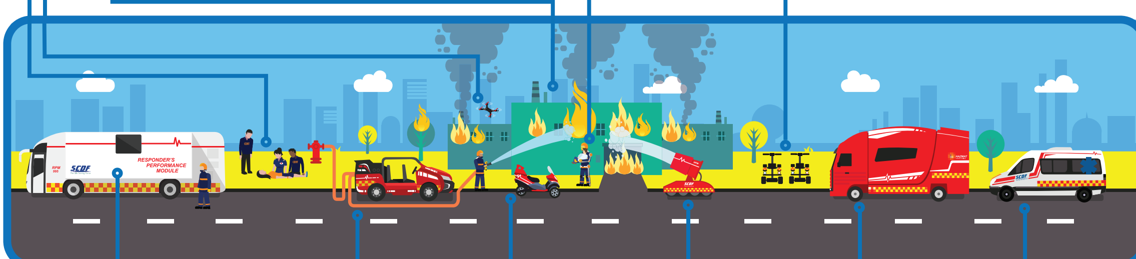
Using video analytics and advanced image processing, it detects the presence of fire and smoke at its source within seconds. It then sends an immediate alert to the fire command centre for a quick response.

FRS - EMT in Exoskeleton

Fire Response Specialists will be cross-trained to operate as Emergency Medical Technicians (EMTs) so that they are able to attend to victims of both fire and trauma incidents. In this instance, a FRS-EMT is wearing an exoskeleton, which aims to enhance operators' capacity to carry heavy loads by improving their physical endurance during fire-fighting operations.

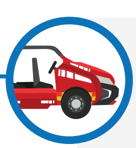
Mobile Transporter

A mobile electric vehicle to carry SCDF personnel and allows them to cover large areas quickly while also detecting toxicity levels in the air and sending back information to the control vehicle (HCV) wirelessly.



Responders Performance Module (RPM)

Employing sports science to more efficiently combat fatigue and enhance heat recovery, the RPM will allow responders to recuperate quickly, so that they can be quickly re-deployed to combat a fire. This enhances SCDF's operational effectiveness.



5th Gen LFAV

First introduced in 2000, the Light Fire Attack Vehicle (LFAV), or affectionately known as the Red Rhino, has grown from strength to strength. The latest version is packed with more capabilities that allow it to respond to a variety of fire and rescue incidents more effectively.

Firebike

Fire bikes are now equipped with the CAF Backpack which utilizes special technologies that extinguishes fire four times faster than water, while using 70% less water, thereby effectively minimizing water damage to properties during fire-fighting operation.

UFM

The Unmanned Firefighting Machine (UFM) is a remote-controlled, versatile fire-fighting unit built to operate under extreme conditions as well as complex and hazardous environments. This reflects SCDF's use of technology and keeps SCDF responders away from highly-hazardous areas.

Next-Gen HazMat Control Vehicle (HCV)

The HCV is deployed for the identification of hazardous substances, assessment of contamination and to determine the mitigation approach for the incident. With new detection technologies, communications equipment and vehicle-in-vehicle concept, it is highly capable.

Ambulance

SCDF will develop a more robust response system to meet the growing demand for emergency medical services in order to improve overall patient outcomes and survival rates .

Building A Strong SCDF Through Training Transformation

SCDF will establish a new training regime to ensure that staff are equipped with the competencies and capabilities that are needed to succeed in the evolving operating landscape. This will be done through various measures that include new training programmes, harnessing the latest training technologies, and partnering with institutions of higher learning.

Chemical Hub Training Facility

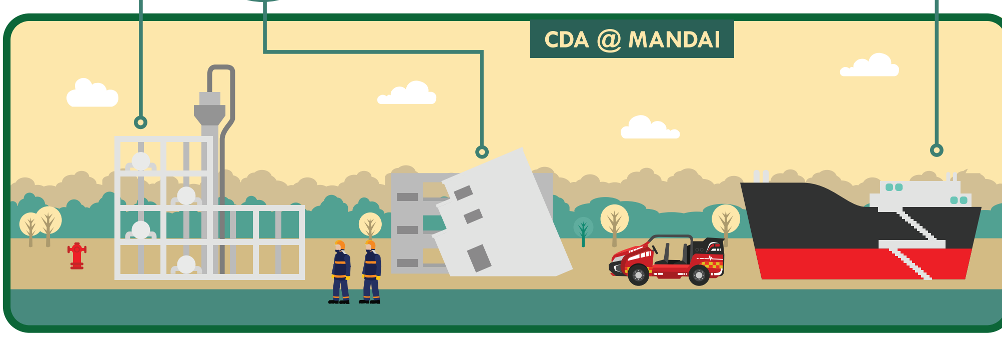
A realistic replication of a petrochemical plant that is able to simulate jet fires, pool fires, pipe rack fires, gas cylinder fires, loading arm fires and various sealing and plugging operations for chemical leaks.

Ship Fire Fighting And Rescue Training Facility

A realistic replication of ship internal structures that is able to simulate fuel spill fires, engine room fires, cargo hold fires and galley fires.

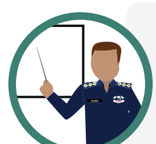
Urban Search And Rescue Training Facility

A realistic replication of an urban settling collapsed structure that is able to simulate basement flooding and post-blast environment.



Realistic Environment For Training

The creation of realistic environments and scenarios to allow for better training and learning outcomes for SCDF Trainees.

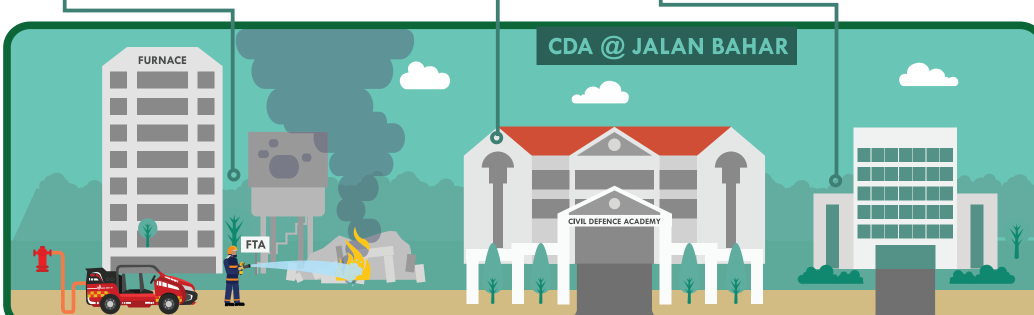


Leadership Centre for Disaster Management Training in Asia Pacific

Through collaboration with a reputable tertiary institution, SCDF will be developing CDA into a centre of excellence for executive leadership level disaster management training.in the Asia Pacific Region. This will place SCDF in the fore-front of the academic field of Emergency Management and Urban and Search Rescue knowledge. This is expected to enhance the development of SCDF Officers in disaster management.

Enhanced Training

Enhanced computers and simulation technology provides a more realistic and safe training environment that allows mistakes to be viewed as part of effective learning.



Editorial Preview

The SCDF has just been accorded the prestigious Innovation Excellence Award, administered by Spring Singapore. SPRING Singapore is an agency under the Ministry of Trade and Industry, responsible for helping enterprises grow and building trust in Singapore products and services. This is testament to the innovation culture within SCDF, which has spawned the birth of the Light Fire Attack Vehicles and the myResponder app amongst many.

The leveraging of technology and innovation has also allowed SCDF to take on challenges of resource constraints and manage the complexities of a constantly evolving operating environment. How then does the SCDF constantly challenge itself to sustain and harvest creative ideas to push itself from a small force in the early 1990s to its current standing?

This article describes the innovation framework adopted by SCDF in its mission to protect and save lives. Interested persons who want to learn more about SCDF's innovation framework can contact the Editorial Board to find out more.

LEVERAGING TECHNOLOGY & INNOVATION TO PROTECT & SAVE LIVES

LTC Goh Boon Han, Senior Assistant Director, Operations Department
MAJ Loh Jia-Tien, Senior Staff Officer, Operations Department
Singapore Civil Defence Force

Introduction

Innovation is in the organisational DNA of the Singapore Civil Defence Force (SCDF) and has enabled the Force to take on the challenge of resource constraints and manage the complexities of an ever-evolving operating environment. SCDF has a clearly defined innovation framework to generate, evaluate and realise ideas.

SCDF recognises the value of engaging all staff in the innovation process and this is underpinned by the central tenet that "Everyone has the potential to innovate", which necessitates the involvement of all staff in the SCDF. SCDF has pursued innovation at two levels:

(a) "incremental innovation" which is usually a "ground-up" process involving mass participation. Structured activities are carried out to sustain and harvest a pipeline of creative ideas that can bring about increased efficiency in daily routines and operations;

(b) "radical innovation" which can be a "ground-up" or "top-down" process to find strategic solutions or new knowledge and technologies that are potentially game-changing.

SCDF's innovation efforts can be categorised under 3 main themes:

(a) Enhancing processes and systems;
(b) Building Capabilities; and
(c) Crafting the future.

Collectively, they encompass various different aspects of innovation, such as hardware innovations, evolution of concept of operations, and innovations in processes and systems.

Enhancing Processes And Systems

The SCDF is constantly scanning the horizon for potential challenges and exploring new and better ways of doing things. With the rapid development of Singapore in the 1980s, the construction boom presented a challenge to SCDF's Fire Safety Regulatory Framework. The SCDF saw a need for this framework to keep pace with developments, while balancing the need for safety and being pro-enterprise.

Fire Safety Regulatory Framework

Over the last 10 years, the number of fire safety building plans submitted to SCDF for approval has almost tripled, from about 8300 plans in 2004 to over 24,000 plans in 2015. In the past, every building plan submitted to SCDF had to be checked for compliance before approval was granted. This was not only a time-consuming and labour intensive process, but it also resulted in the Qualified Persons[1] (QPs) relying on SCDF to detect and inform them of non-compliances. This shifted the responsibility of ensuring safety solely onto the shoulders of the SCDF. The approval process took weeks, months or even a year for complex projects. This was an unsustainable model and the SCDF recognized the need for change very early on.

1 *Under the Fire Safety Act, all fire safety works must be designed by Qualified Persons (QPs) and approved by SCDF. QPs are either architects or engineers registered with the Board of Architects or Professional Engineers Board in Singapore.*

To adapt to this challenge, SCDF embarked on the Self-Declaration System in Jul 1996 as a transition prior to the full implementation of the Self-Regulation System in 1998. In this system, SCDF would only conduct checks for critical fire safety requirements (e.g. exit staircases) that would be difficult to rectify on site if not provided for in the submissions. Under the Self-Regulation System, plans for fire safety works could now be approved within two working days[2] based on the statutory declaration by QPs that the plans are in compliance with the prevailing Code of Practice for Fire Precautions in Buildings, or better known as the Fire Code.

Had the SCDF not moved decisively to address this challenge in the 1990s, significantly more manpower (40 personnel) would have been required to check and approve the plans as compared to the current manpower (7 personnel).

Checks & Balances

To ensure that the Self-Regulatory System works, necessary safeguards[3] had to be put in place to ensure that the system is effective and not abused. SCDF randomly audits about 10%[4] of the plans submitted and deterrent actions would be taken against errant QPs whose plans are not in compliance with the provisions in the Fire Code.

Performance-Based Fire Code

Apart from the innovative changes made to the approval process, there was also a need for the regulatory framework to support innovative and creative designs in our buildings. Before a performance-based fire code was introduced in SCDF, all buildings had to comply totally with the requirements prescribed in the Fire Code. Many iconic buildings and structures in Singapore today, such as Marina Bay Sands, Sports Hub and Gardens by the Bay (See Figure 1), would not have been possible if SCDF had not provided an alternative approach.

In a Performance-Based design, only the performance requirements are stated while leaving the means of achieving them to the fire safety engineers. This allows building practitioners to exercise their creativity as there is now more flexibility in designing fire safety measures. Instead of just strictly adhering to fire code requirements. Practitioners can based their design on fire engineering principles. This also contributes to a more vibrant and diverse urban landscape in Singapore.

2 *Construction works can commence immediately after approval is granted. This system helps to facilitate a more pro-business environment and also enhances the competency and continual professional development of the QPs.*

3 *All completed fire safety works would have to be inspected by Registered Inspectors (RIs) who are also QPs who have worked in the industry for a minimum of 10 years. They are registered with the SCDF and are expected to inspect the buildings to ensure compliance to the fire code before SCDF issues the Temporary Fire Permit (TFP) or Fire Safety Certificate (FSC) to the building. This is a pre-requisite for the issuance of the Temporary Occupation Permit (TOP) or Certificate of Statutory Completion (CSC) from BCA. SCDF also carries out enforcement checks on building premises to ensure that building owners or occupiers comply with fire safety in their buildings.*

4 *Out of the 10% of the plans selected for audit checks, only about 0.5% of the plans have major non-compliant issues. The errant QPs for these projects were surfaced for disciplinary action.*

Figure 1: Photo of Gardens by the Bay(Photo credit: www.gardensbythebay.com.sg)

Evolving Operating Environment

As Singapore became more urbanized and densely populated, the scarcity of land meant that it would not be possible to build many fire stations. SCDF also found that it was challenging for the standard fire engines to negotiate narrow roads and multi-storey carparks during operations.

To adapt to the challenges of the operating environment, the SCDF developed the Red Rhino or Light Fire Attack Vehicle (LFAV) over the past decade or so. A fire engine without a water tank was unheard of in the world 15 years ago, and many did not believe that it could be accomplished. However, by taking full advantage of Singapore's well-established fire-hydrant network, the size of the fire engine was drastically reduced and the Red Rhino was developed.

The compact size Red Rhino also proved instrumental in the establishment of a new forward deployment arrangement- Satellite Fire Posts (SFPs). These SFPs which are located at the void decks of Singapore's public housing estates costs 90% less than a conventional fire station. The LFAV can also be parked at any normal parking lot within the estate, thus facilitating its ease of deployment. The ability to be deployed at such locations is crucial in achieving faster response times, which would have not been possible if SCDF relied on just conventional fire stations.

Various versions and enhancements of the Red Rhino have been rolled out over the years as part of the continual innovation process. The latest 5G Red Rhinos (See Figure 2) are now equipped with an integrated Compressed Air Foam System (CAFS), which extinguishes fires four times faster than water while using 70% less water, hence minimising water damage caused during fire-fighting operations, and improving operational outcomes.

Self-Help Concept

The SCDF cannot be everywhere immediately when an incident occurs. Hence, a self-help framework was developed for the industry.

The Fire Safety Manager (FSM) scheme was introduced in 1994, and it became mandatory for designated building owners to appoint trained and certified FSMs[5] to assist them to prepare the premises in response to any emergencies. The FSM has to perform duties such as prepare and execute Emergency Response Plans (ERP), co-ordinate and supervise the Company Emergency Response Team (CERT) and also to ensure fire safety requirements are complied with at all times. The CERT provides for incipient firefighting and basic first aid before the arrival of SCDF.

Figure 2: LF 5G aka Red Rhino

5 *Designated buildings that require owners to appoint a FSM and establish Company Emergency Response Team (CERT) refers to (a) any public building that is of: (i) 9 storeys or more (including basement) in height; (ii) is used as a hospital; (iii) has a floor area of 5000 sqm; or (iv) has an occupant load of 1000 persons or more and (b) any premises used of industrial purposes and that (i) has a floor area of site area of 5000 sqm or more; and (ii) has an occupant load of 1000 persons or more.*

SCDF established the CERT framework in 2005. Companies storing more than five metric tonnes of petroleum and flammable materials are required to form CERTs to mitigate and prevent escalation of incidents prior to SCDF's arrival. Since Sep 2013, this was further extended to Public and Industrial Buildings with high occupant loads and large sizes. Thereafter, a National CERT standard was introduced to guide the building owners in the establishment of the required CERTs. This standard stipulates the training and equipping requirements of the CERTs based on a broad fire risk classification (i.e. Tier 1, 2, and 3) of the buildings. To ensure the readiness and competency of these CERTs, these teams are subjected to regular audits by the SCDF. The concept of CERT has made fire safety a shared responsibility between building owners and SCDF. The early CERT interventions have, on numerous occasions, limited the spread of fires and minimised the possible damages.

Building Capabilities

In 1989, the SCDF was still in the early stages of development, having been established in 1986 and subsequently merging with the Singapore Fire Service.

In the early 1990s, the petrochemical and pharmaceutical sectors in Singapore rapidly expanded and Singapore moved towards high-tech industries that made use of hazardous chemicals in their operations. Also, with the Tokyo subway Sarin gas attack in 1995 and other terrorist incidents emerging as a threat around the world, there was an urgent need for the SCDF to quickly develop Hazardous Materials (HazMat) response capabilities to deal with the very real threat of an industrial accident or a chemical agent attack.

HazMat Response

The SCDF was the agency tasked with providing for response and mitigating of HazMat incidents in Singapore. From 2002 onwards, the fire stations underwent a major capability upgrade with the introduction of a tiered response to a hazardous materials emergency. All responders from the regular fire stations were trained to provide response to HazMat incidents. The next tier of response involves specialist response: the HazMat Incident Team (HIT) from the specialist HazMat fire stations conducts mitigation and decontamination operations.

The HazMat Emergency Assessment and Response Team (HEART), based in HQ SCDF, was established to provide round-the-clock specialist advice to ground commanders during HazMat incidents. HEART responds using the HazMat Control Vehicle (HCV). The HCV is deployed during hazmat incidents to identify the type of HazMat involved, to assess the extent of the contamination and to provide better situational awareness of the situation. The latest next-Gen HCV (See Figure 3) which was launched in Apr 2015 is the first-of-its-kind in the world to integrate both a command and control element and a functional laboratory for the analysis of hazardous materials. It also features a vehicle-in-vehicle innovation by using Mobile Transporters to conduct swift monitoring operations.

Figure 3: HazMat Control Vehicle

To address the risk of terrorists making use of vehicles transporting HazMat as a weapon against potential targets, the SCDF introduced the HazMat Transport Drivers' Permit (HTDP) in April 2003. This programme requires HazMat transport drivers to be subjected to security screening, as well as undergo emergency procedures training.

As another layer of protection, the HazMat Transport Vehicle Tracking System (HTVTS) was introduced in Jul 2005 to monitor and control the movement of vehicles carrying HazMat along major transportation routes in the country. Using this system, the location of the vehicle can be monitored in real-time, remotely immobilized and brought to a safe and gradual stop at the press of a button from the Operations Centre once a breach in security is detected.

Incident Management

To improve incident management and command and control, the Advanced C3 Emergency System (ACES) was developed and commissioned in late Nov 2013. ACES enhances sense-making capabilities and supports the decision-making process of Senior Commanders when they have to make crucial time-critical decisions during a crisis. A notable part of the ACES infrastructure is that all main turnout appliances such as fire engines and the Light Fire Attack Vehicles are mounted with in-vehicle cameras that can transmit real-time video imagery of incidents back to the Operations Centre. The Operations Centre Specialist is able to remotely pan, tilt and zoom in the cameras for better views of the situation.

The SCDF also established a social media monitoring function in the Operations Centre to complement ACES. Twitter and other social medial platforms are monitored for breaking information about an incident that members of the public may have posted. This allows SCDF to get hold of pre-arrival pictures of incidents, and sometimes, even near real-time images of the incident as it evolves. This provides ground commanders with an additional data source to help them with decision making on the ground, during an emergency.

SCDF also deploys the HazMat Incident Management System (HIMS) for HazMat incidents. HIMS provides an intelligent knowledge fusion and visualisation interface for on-scene commanders and responders to access real-time situational information. Specially designed sensor interface boxes (SIBs) are attached to detectors for wireless transmission of real-time readings from the incident site. The readings would be used in predictive simulation models to provide a comprehensive situational picture to commanders to take the most appropriate actions to protect the public.

Crafting Our Future

Against the backdrop of an uncertain security landscape, ageing population, and resource constraints, the SCDF has to continually improve and adapt to stay ahead of the challenges. The SCDF is continually working with partners to explore various technologies aimed at improving service delivery and efficiency. A bold vision of building a Nation of Lifesavers by 2025, has been set which allows for tapping on the community to enhance emergency response at the onset of any incident.

Figure 4: VR technology utilised in Training of trainees

Innovation in Training

The SCDF has embarked on innovation in training and reaped significant benefits from it. The training pedagogy has been adjusted from the traditional classroom setting to a self-directed learning approach. Trainees can now calibrate the pace of their learning at their own time while clarifying doubts with instructors during tutorial sessions. This optimises the learning engagement experience. The SCDF also leverages on virtual reality[6] (VR) (See Figure 4), high-fidelity and realistic training simulators, to provide immersive training training. These initiatives have led to the streamlining of training activities and programmes. A good example is the Rota Commander Course (RCC), which was streamlined from a 32-week programme to a 28-week programme despite more content (e.g. the Hazmat Specialist Module) being added into the course.

Innovation in Operations

Sense-making and Data Analytic Capabilities

The SCDF is developing a strategy for Data Analytics and sense making in 4 areas: Descriptive, Diagnostic, Predictive and Prescriptive. Current and future projects are categorised under each of the four domains. SCDF is also looking to further leverage on new technologies to harness data for analysis and optimise performance, predict demand and project new capabilities in time for the future.

6 *An example is the use of VR in creating large-scale scenarios such as an oil-tank fire fighting operations. The VR environment allows the scenario to be set up very quickly and trainees can have multiple attempts to practice their decision making and tactical deployment skills, without any real use of logistics and at no inconvenience to the premises owners. This also enables the learning to be accelerated as trainees get to hone their decision making and tactical deployment skills in a safe environment before proceeding to practical exercises, which are more time-consuming to set up.*

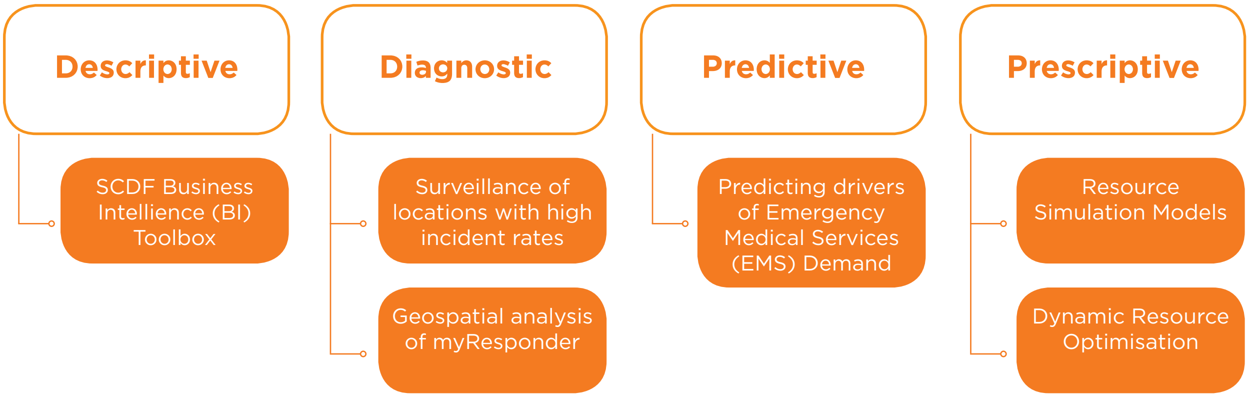


Figure 5: Strategy for Data analytics and sense making

The Dynamic Resource Optimization project is an example of one of the key projects aimed at revolutionising the concept of operations. It transits from a system where resources are deployed at fixed locations, to one that utilises a dynamic deployment model. The dynamic deployment of emergency appliances is a technology-driven shift in the SCDF's concept of operations. It entails an analytics engine that constantly evaluates the current state of readiness for potential coverage gaps and identifies non-conventional launch sites, beyond fixed fire stations and fire posts.

To further enhance SCDF's sense-making capabilities in the future, the "eye in the sky" concept is being explored to make use of Unmanned Aerial Vehicles (UAVs) for surveillance, sense-making and HazMat monitoring.

The SCDF is also looking at developing the Integrated Incident Management Command Control and Communications System (IM3C) to centralise all Command and Control, Communications, Computer and Intelligence (C4I) activities on a single information exchange platform. This amalgamates present and future ICT systems and improves connectivity amongst various stakeholders who are involved in SCDF's life saving mission. Built for future readiness, the IM3C will also be able to assimilate emergent technologies by incorporating new sub-systems in the future.

Unmanned Fire Fighting Machine (UFM)

The UFM[7] (See Figure 6) was added to SCDF's arsenal in 2014 to allow for the conduct of fire-fighting operations deep within risk areas, without exposing fire fighters to extreme heat and endangering their lives. These robots provides versatile fire-fighting power under different conditions, such as structural or tunnel fire incidents, and allow fire-fighters to focus more on search and rescue operations.

Figure 6: Unmanned Fire Fighting Machine in action

7 *The UFM features a high capacity (35kW) positive pressure ventilator, a water mist fog (400-l/min) and a water beam (3000-l/min), which has the equivalent discharge rate of about three 64mm fire-fighting jets. From a manpower perspective, 3 x 64mm jets would require 3 teams of 2-man to operate.*

Vision 2025: A Nation of Lifesavers

The central pillar of SCDF's vision 2025 is to expand upon the self-help concept that has been successfully implemented for the industries (CERT) and adapt it to the communities.

SCDF believes that the community has matured and is ready to begin applying the emergency preparedness knowledge they have accrued from SCDF's many emergency preparedness programmes. However, it is anticipated that this would continue to be a challenge because volunteerism cannot be mandated and the communities are more loosely organized (as compared to the industrial and commercial sectors that are required to support SCDF in its life-saving efforts). SCDF's plan is to galvanize the community and spur them to volunteer as Community First Responders through a three-pronged approach: the "Hardware", "Heartware" and the "Software".

Hardware

In terms of hardware, the SCDF has embarked on a long term plan to install Automated External Defibrillators (AED) at the lift lobbies of public housing estates island-wide (1 AED per 2 to 3 blocks) by 2018. These AEDs are geo-tagged and the locations fed into a national database of AEDs so that there is an overview of where all the AEDs are located. In addition, SCDF has worked with private transport corporations in a pilot project for 100 taxis to carry AEDs as well.

Heart-ware

The SCDF is also constantly providing training to the community in the three fundamental aspects of Community Emergency Preparedness known as "The Triangle of Life" (First Aid, CPR/AED and Basic Fire-Fighting). The Dispatcher-Assisted First Responder (DARE) Programme was also developed in collaboration with Ministry of Health (MOH) for SCDF 995 Operations Centre Specialists to guide community first responders to perform CPR and on the use of AEDs. From April 2016, the existing Community Emergency Preparedness Programme (CEPP) and Emergency Preparedness (EP) Day has also be restructured and re-aligned to better support SCDF's Vision 2025.

Software

Riding on the proliferation of smart phones in recent years, the SCDF and IDA jointly developed the myResponder (See Figure 7) mobile app. It utilizes geo-location technology to alert trained Community First Responders to suspected cardiac arrest cases within a radius of about 400m and also points them to the nearest available AEDs. In the near future, myResponder aims to be able to assign different roles for multiple responders. The app user experience will be enhanced with 3-D mapping of AED locations, thereby reducing the time needed to retrieve the nearest AED. In the longer term, the role of myResponders will be expanded to respond to fire and rescue incidents.

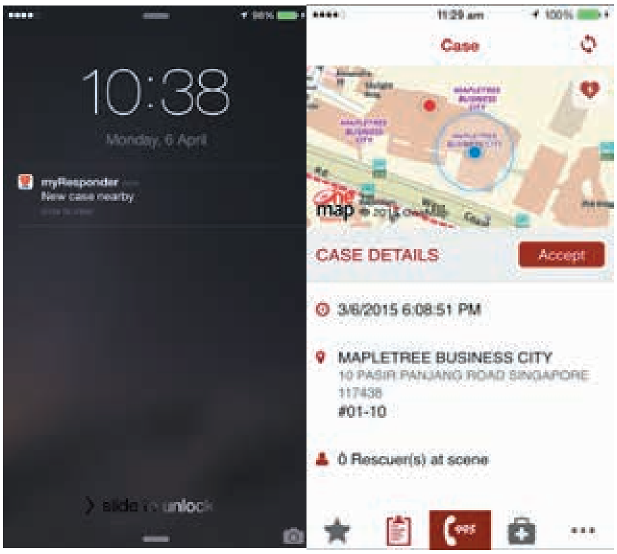


Figure 7: myResponder App notification

Tiered Emergency Medical Services (EMS)

To further the vision of "A Nation of Lifesavers" and optimize resources to better serve the public, the SCDF is working on integrating the fire and medical response in the EMS Tiered Response Plan.

Due to of the ageing population in Singapore, medical calls have been consistently increasing at a rate of about 5% every year for the last 10 years. This current model of response is unsustainable. Hence, the SCDF is revamping the medical services operating concept altogether, to prioritise expedient response to the most urgent medical cases.

Another key strategy to the Tiered EMS plan is to cross-train firefighters to function as Emergency Medical Technicians (EMTs). These dual-skilled EMTs respond to medical incidents in the new hybrid Fire & Medical Vehicle, as well as in the more common Fire-Bikes, LFAVs and Pump Ladders deployed at the Fire Stations.

This EMS Tiered Response Plan will be launched from 1st April 2017 onwards and gradually scaled up to its optimal state in 2025.

Conclusion

Innovation and Technology has always been a force-multiplier, and in some instances, a game changer to SCDF's organizational transformation. This is why the SCDF will always be keeping a keen eye out for new and trending developments that have the potential to be integrated into our operational capabilities.

While fire-fighting and rescue missions remains a manpower-intensive function due to the nature of operations and time constraint, the decisive introduction of innovations and technological initiatives has enabled the SCDF to progress to become the leanest emergency response force [1] amongst major cities in the world, and with one of the lowest fire incidents [2] and fire fatalities [3] per 100,000 population.

The process of innovation is a never ending cycle, and the SCDF will continue to leverage on technology and innovation in pursuit of its mission to protect and save lives and property.

References

1 *Number of Fire Personnel per 100,000 population (International Fire Chiefs' Association of Asia (IFCAA) 2014) Singapore-51; Hong Kong-128; Tokyo 134; New York-128; London-60.*
2 *Number of Fires per 100,000 population (IFCAA Fire Statistics 2014) Singapore-86; Hong Kong-88; Tokyo 36; New York-500; London-247*
3 *Number of Fire Deaths per 100,000 population (IFCAA Fire Statistics 2014) Singapore-0.15; Hong Kong-0.33; Tokyo 0.71; New York-0.80; London-0.50*

Editorial Preview

The ASEAN region is one of the most disaster-prone regions in the world. Three notable large-scale disasters: Indian Ocean Tsunami, Cyclone Nargis and Typhoon Haiyan have happened in the region. With increasing occurrences of disasters and the enlarged scale of immediate response required, ASEAN must remain ready to mitigate any future disaster.

Singapore is one of the 10 member states in ASEAN. The SCDF supports the ASEAN Coordinating Centre for Humanitarian Assistance on disaster management (AHA Centre) , with deployment of its officers for ASEAN-Emergency Response and Assessement Team (ERAT). This pool of trained and rapidly- deployable experts can be deployed within 24 hours to the ASEAN region.

This article charts the vision of "One ASEAN, One Response" from the beginning when the ASEAN Agreement on Disaster Management and Emergency Response was developed to the establishment of AHA Centre etc . Read on to learn more about the One ASEAN, One Response story! Interested persons who want to find out more can contact the Editorial Board for further information.

ONE ASEAN, ONE RESPONSE

Andri Suryo, Communications Officer
The ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management (AHA Centre)

Introduction – The ASEAN Agreement on Disaster Management and Emergency Response

The vision of "One ASEAN, One Response" took root when the ASEAN Committee on Disaster Management (ACDM) developed the ASEAN Agreement on Disaster Management and Emergency Response (AADMER) in 2005, through a series of ACDM meetings. The AADMER was entered into force on 24 December 2009. It serves as a framework that facilitates ASEAN's cooperation and coordination in responding to disasters, to foster a resilient community.

AADMER includes comprehensive lessons and inputs for improving regional disaster management mechanisms, comprising Disaster Risk Identification, Assessment & Monitoring, Disaster Prevention & Mitigation, Disaster Preparedness, Emergency Response, Rehabilitation, Technical Cooperation & Scientific Research, and Establishment of the AHA Centre. Through AADMER, regional policies, as well as operational and logistical mechanisms for ASEAN Member States (AMS) were established for ASEAN to extend assistance in disaster response.

The AADMER identifies six General Aims, including:

1. Improve capacities of ASEAN for effective and efficient regional early warning and monitoring, preparedness, emergency response, and disaster reduction in the region through supportive policies, systems, plans, procedures, mechanisms, and institutional and legal frameworks at regional and national levels.

2. Enhance humanitarian assistance and emergency response coordination to provide efficient, timely, and reliable response.

3. Strengthen technical and institutional capacities of AMS through the provision of capacity development and training programs for disaster management, disaster risk reduction, and emergency response.

4. Assist AMS and promote regional collaboration in disaster risk reduction.

5. Foster closer partnership and more collaborative initiatives on disaster preparedness and response, disaster risk reduction, recovery, and rehabilitation with partner organisations.

6. Support community-based approaches in disaster management, and enhance disaster awareness of the people in ASEAN to instil a habit of safety and resilience.

AADMER has been facilitating regional cooperation between and amongst AMS, and contributed to the enhancement of the ASEAN Community and disaster risk reduction.

The ASEAN Coordinating Centre for Humanitarian Assistance on disaster management

In 2011, at the 19th ASEAN Summit, the agreement of the establishment of the AHA Centre was signed by the ASEAN Foreign Ministers, witnessed by the ASEAN Heads of States. The AHA Centre plays a key role in facilitating co-operation and coordination among relevant parties, as well as with the United Nations and international organisations in promoting regional collaboration. This facilitates parties dealing with disaster situations.

The AHA Centre is recognised in the ASEAN Charter as one of the ASEAN centres in the region. Strengthened cooperation between AHA Centre and relevant regional and international organisations and agencies ensures prompt and smooth communication in times of disaster. The importance of such cooperation, as well as the enhanced coordination mechanisms to facilitate the flow of timely support, was stated in the ASEAN's Leaders Bali Declaration on ASEAN Community in a Global community of National-Bali CONCORD III during the 19th ASEAN Summit 2011 in Bali, Indonesia.

Standard Operating Procedure for Regional Standby Arrangements and Coordination of Joint Disaster Relief and Emergency Response Operations

At the 11th ACDM meeting, committees adopted the Standard Operating Procedure for Regional Standby Arrangements and Coordination of Joint Disaster Relief and Emergency Response Operations (SASOP). The SASOP included guidance regarding the formation and activation of the AHA Centre.

There are four elements in the SASOP, including:

1. Guides and templates initiating and establishing the ASEAN standby arrangements for Disaster Relief and Emergency Response.
2. Procedures for joint disaster relief and emergency response operations.
3. Procedures for facilitating and using military and civilian capabilities and capacities.
4. Methodologies for conducting ASEAN regional disaster emergency response simulation exercise to test the effectiveness of SASOPs.

A number of meetings and exercises have been conducted throughout the past years to validate the applicability of SASOP to be reported and submitted to the ACDM for adoption in future renditions of the SASOP.

The AHA Centre is also tasked to perform most of the aspects under SASOP, including:

- Notification of Disaster;
- Request for Assistance;
- Offer of Assistance;
- Disaster Situation Update;
- Joint Assessment of Required Assistance;
- Mobilisation of Assets and Capacities; and
- Demobilisation of Assistance and Reporting.

Figure 1: The establishment of JOCCA

Joint Operations and Coordination Center of ASEAN

The Joint Operations and Coordination Center of ASEAN (see Figure 1) (JOCCA) is essential for all AMS response entities to converge and coordinate during deployment to an affected disaster area.

The AHA Centre organises the ASEAN-Emergency Response and Assessment Team (ERAT) to support the national Focal Point during the initial phases of disaster to carry out tasks, such as:

- Conducting rapid assessment;
- Coordinating with the AHA Centre for the mobilisation, response and deployment of regional disaster management assets; and
- Facilitating incoming relief assistance from AMS.

The team is made up of officers across AMS, who are ready to be deployed to affected areas during the disaster period. The ASEAN-ERAT team has steadily built up its expertise in handling disasters through regular training and deployment exercises. The ASEAN-ERAT team is one key establishment within the AHA Centre's area of focus, which is preparedness and response. The other area of focus of the AHA Centre is disaster monitoring, conducted through the Disaster Monitoring and Response System (DMRS), International Communication Tools (ICT), as well as WebEOC – which is use to communicate and share information to all AMS, so that essential information can be disseminated in a timely manner.

Figure 2: Coordination meeting between ASEAN-ERAT with other agencies inside JOCCA

During the deployment of the ASEAN-ERAT team to the disaster area, the team will establish JOCCA to coordinate with and report directly to the National Disaster Management Offices (NDMOs) in the AMS that it responds to.

ASEAN Joint Disaster Response Plan

As the operational engine of AADMER, the AHA Centre has also developed the ASEAN Joint Disaster Response Plan (AJDRP). The AJDRP is a framework for planning disaster response strategies for large-scale disasters. The utilisation of AJDRP allows the AHA Centre and relevant disaster response agencies to respond more effectively when handling disasters within the ASEAN Region.

Figure 3: Opening ceremony of the AJDRP, officiated by Secretary-General of ASEAN

Figure 4: Group photo taken during One ASEAN One Response Roadshow in Manila Philippines

The AJDRP Workshop aims to:

1. Increase understanding of ASEAN's mechanisms relating to humanitarian assistance and disaster response;
2. Raise awareness of the concept of "One ASEAN, One Response", and its impact on how ASEAN will collectively respond to disasters within and outside the region;
3. Strengthen cooperation among AMS, AHA Centre, and other humanitarian actors in the development of AJDRP;
4. Identify the minimum level of assets and capacities needed for ASEAN response and its availability in the region; and
5. Better coordinate and facilitate assistance, including distribution of relief assets and capacities among AMS and other humanitarian partners.

To meet the objectives of the workshop, one of the key speakers, Mr. Wisnu Widjaja, Deputy Minister for Prevention and Preparedness of the Indonesian National Board for Disaster Management stressed three important takeaways: the importance of anticipating the occurrence of disasters in the region; the recognition of each stakeholder as valuable partners who share the goal of minimising loss of lives and suffering, as well as to reduce disaster losses; and the understanding of the importance of a comprehensive preparedness regime.

The vision of One ASEAN, One Response

The AHA Centre formulated "One ASEAN, One Response" based on 3S: Speed, Scale, and Solidarity. Speed refers to how quickly emergency response can be delivered, Scale refers to how big the response is, and Solidarity is about the inclusivity of the response. Through the "One ASEAN, One Response" vision, ASEAN aims to:

1. Enhance ASEAN Member States' collective response to disasters

   The magnitude and complexity of disasters require the mobilisation of resources from all relevant sectors and in ASEAN, including stronger civil-military coordination, and coordination with other parties;

2. Enhance ASEAN Member States' coordination role

   The capacity and mandate of Secretary-General as the Humanitarian Assistance Coordinator (SG-AHAC) and the AHA Centre's shall be further enhanced;

3. Increase ASEAN Member States' visibility

   Increase the visibility and better communication of its response to the public and key stakeholders.

Road to One ASEAN, One Response

A series of events, workshops, summits, and conferences have been conducted to promote the "One ASEAN, One Response" vision to all AMS and key stakeholders.

The AHA Centre, together with NDMOs in several AMS, conducted a series of roadshows to promote the ASEAN Regional Mechanism on Disaster Management, as well as to inculcate the "One ASEAN, One Response" vision.

The inaugural roadshow was held in Jakarta, Indonesia in April 2015. Jointly held by the AHA Centre and the Indonesia National Disaster Management Agency (BNPB), it was attended by 140 guests comprising government officials, the private sector, CSOs, academics, and the national media. The roadshow then headed to Manila, Philippines; Bangkok, Thailand; Phnom Penh, Cambodia; and Vientiane, Lao PDR, engaging more than 1,000 attendees in total. The roadshows will continue in 2016 in other AMS.

Signing Ceremony of the ASEAN Declaration on One ASEAN, One Response: ASEAN Responding to Disasters as One in the Region and Outside the Region

The 28th and 29th ASEAN Summits and Related Summits that were conducted in Vientiane, Lao PDR on 6-8 September 2016 were attended by the Leaders of ASEAN and the Heads of State/Government of ASEAN Dialogue Partners, including Australia, China, India, Japan, Republic of Korea and the United States. It was held back-to-back under the Chairmanship of Lao PDR.

At the summit, leaders reviewed the progress of implementation of the ASEAN Community Blueprint 2025 and provided guidance and directives in addressing the challenges of implementing the plans. Leaders of the ASEAN Member States signed an agreement on a collective response to disasters. It is part of the realisation of the "One ASEAN, One Response" vision, where the agreement affirms the ten-nation alliance's will to respond to disasters inside and outside the region in a collective matter.

Conclusion

The declaration of One ASEAN, One Response is a key milestone in the strengthening of co-operation in disaster management, that has been agreed upon under the Agreement on Management of Disaster and Response to Emergency (AADMER) concluded in December 2007.

The declaration was inspired by and united under the motto of ASEAN, "One Vision, One Identity, One caring and Sharing Community" and further emphasises the role of the AHA Centre in realising the unity of effort with the spirit of "One ASEAN, One Response".

This has affirmed the AHA Centre as the primary ASEAN regional coordinating agency on disaster management and emergency response, and endorsed the ASEAN-Emergency Response and Assessment Team (ASEAN-ERAT) as the official response team of ASEAN. It also confirmed the ASEAN Agreement on Disaster Management and Emergency Response (AADMER) as the main regional policy backbone and common platform for the implementation of "One ASEAN, One Response" [1].

It is with great hope that the endorsement from ASEAN Head of States will expedite the process of turning the vision of "One ASEAN One Response" into a reality.

References:

1 *Asean Declaration On One Asean, One Response: Asean Responding To Disasters As Ne In The Region And Outside The Region, Asean Secretariat 2016. Available From Http://Asean.org/Storage/2016/09/Declaration-On-One-Asean-One-Response.pdf*

Editorial Preview

The Jurong Aromatics Corporation (JAC) oil tank fire occurred on 20th April, 2016. With the proliferation of smart phones and social media, pictures and videos of the fire proved shocking to younger Singaporeans who had not witnessed the last major storage tank fire at Pulau Merlimau in 1988. For many young emergency responders, this was likely their first encounter with such a fire situation.

At the height of the JAC fire, 150 responders and 38 fire-fighting appliances were deployed on-site to mitigate the situation. How did the SCDF bring the fire and subsequently extinguish it in under 5 hours?

This article provides an overview of the response framework and firefighting strategies adopted by the SCDF. Interested persons who want to learn about the incident can contact the Editorial Board to find out more.

FIGHTING THE JAC OIL TANK FIRE: SCDF's RESPONSE FRAMEWORK AND STRATEGIES

COL Alan Chow, Commander 1st SCDF Division HQ
CPT Clara Toh, Commander Banyan Fire Station
Singapore Civil Defence Force

Figure 1: Picture of the JAC Oil Tank Fire

Introduction – Storage Tank Fires in Singapore; A Historical Perspective

The last major storage tank fire in Singapore occurred on 25 October, 1988 – when a naphtha storage tank at the Singapore Refining Company (SRC) refinery on Pulau Merlimau[1] caught fire. The fire, which initially affected only one tank subsequently spread to three other nearby storage tanks, resulting in the biggest offshore fire in Singapore's history. The SRC refinery fire eventually took 6 days to extinguish and resulted in 25 casualties, and damages estimated at $15 million.

Since the 1988 SRC refinery fire, more stringent fire safety standards had been implemented for storage tank facilities. These measures had been effective in minimising the occurrence of any large storage tank fire incident in Singapore over the last 28 years, until the recent Jurong Aromatics Corporation (JAC) storage tank fire that occurred on 20th April, 2016.

The SCDF has also significantly enhanced its large storage tank fire-fighting capabilities and incident management framework since the 1988 SRC refinery fire. This includes the enhancement of fire-fighting equipment, such as enhanced large monitors and foaming systems. SCDF has also worked closely with the petrol-chemical industry in the formalisation of mutual aid arrangements, and regularly engages key industry players in conducting both table-top scenario planning as well as actual joint deployment exercises. This allows for the practicing of coordination and responses for different types of contingency scenarios that may occur on large storage tank facilities.

The recent experience with the management of the JAC Storage Tank Fire had reiterated the importance of such engagements and exercises. The coordination, practice and learnings from past preparatory activities has served most useful in facilitating the quick response as well as operational deployment of the SCDF during the management of Singapore's most recent storage tank fire.

1 *Pulau Merlimau was one of the southern islands off the coast of Jurong prior the reclamation works which subsequently connected several other islands in the vicinity to form today's Jurong Island.*

SCDF's Incident Response System

To facilitate the understanding of SCDF's response and management of the JAC incident, it would be appropriate to provide an overview of SCDF's incident response and management framework to set the context and elucidate the rationale of the measures and activities undertaken by the SCDF in the management of the incident.

The SCDF incident response system is premised upon a graduated tiered-response framework which involves the activation of appropriate resources for different types of incidents according to a pre-determined task force concept.

This graduated framework (See Figure 2) essentially comprises 3 levels of escalation:
i) Basic Task Force (BTF)
ii) Enhanced Task Force (ETF)
iii) Operations Civil Emergency (Ops CE)

The types and quantity of resources to be deployed for a particular incident depends on the nature and size of the incident, the impact of the incident and the resources deemed adequate for the rapid mitigation of the incident-type. Additional resources would be requested by the SCDF Incident Manager to supplement the ETF if required.

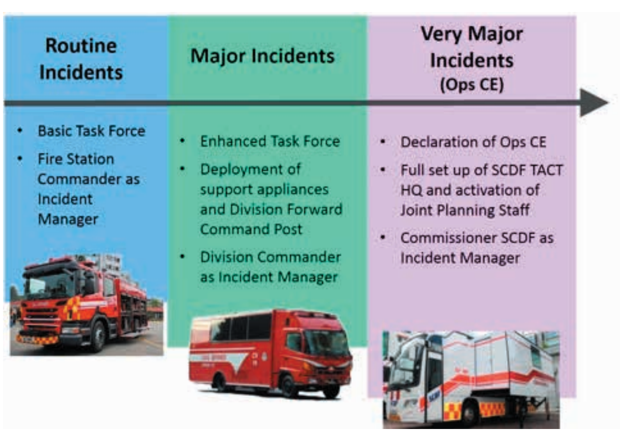


Figure 2 Graduated Tiered-response framework

The framework ensures that adequate resources (i.e. pre-determined for different types of incidents) are promptly deployed to an incident site based on the level of incident escalation. Correspondingly, the level of command presence at the incident site would also be calibrated to the nature and size of the incident.

At the initial phase, the BTF will be activated comprising resources from the nearest SCDF units. During this phase, the incident command will be pegged at the ***Fire Station Commander level.***

When an incident is verified by the initial incident commander to be beyond the scale of the BTF to manage, the ETF will be activated. The ETF will comprise additional resources and specialized appliances required for the management of the incident-type. Incident command at the ETF level is then escalated to the ***Divisional Commander level.***

If the consequences are sufficiently severe, requiring a whole-of-government (WOG) approach to manage, the incident can be declared as an Operation Civil Emergency (Ops CE). When Operations Civil Emergency (Ops CE) is declared, ***Commissioner SCDF*** will be the overall Incident Manager (IM). During Ops CE, the SCDF Tactical HQ and other related agencies would also be activated to provide on-site support to the IM.

The JAC Large Storage Tank Fire

On 20th April 2016 at approximately 1500hrs, the SCDF Operations Centre received multiple calls informing of a major fire at the JAC's facility at 23 Tembusu Road on the Jurong Island. Located on a 58-hectare site within the Banyan sector of the Jurong Island, the JAC facility is one of Singapore's largest aromatic greenfield facility with 46 large storage tanks on its premises.

Due to the variety and large quantities of petroleum and flammable materials (P&FM) stored onsite, the JAC facility is classified as a high-risk installation[2] (HRI) by the SCDF. Hence, upon notification of the incident, the SCDF Operations Centre promptly activated the pre-determined Basic Task Force (BTF) for an oil tank fire incident to respond to and verify the occurrence of a large storage tank fire on the premise.

Figure 3: View of the fire incident from the first responding forces

Resources from the nearby Banyan and Jurong Island Fire Stations were the first SCDF resources on-site. There was no doubt about the magnitude and intensity of the fire as a towering column of smoke and flames (See Figure 3) was already clearly visible even from afar.

On arrival, the BTF quickly verified with the JAC's Company Emergency Response Team[3] (CERT) that the tank fire which had started at a condensate storage tank (800-TK1B) had developed very rapidly, and quickly ensued into a full surface tank fire within minutes of the initial roof collapse. On the BTF Commander's confirmation of the incident, the Enhanced Task Force (ETF) was then activated. The resultant full surface tank fire involving a 46.6 metre diameter large storage tank eventually took about 5 hours to extinguish. Over 150 firefighters and 38 fire-fighting appliances from the Singapore Civil Defence Force (SCDF) were deployed to mitigate the 5-hour blaze.

At the height of the operations, the SCDF's Tactical Headquarters (TACT HQ) was also deployed to facilitate the management and oversight of the operations. Besides the SCDF, officers from other relevant related agencies (including the Singapore Police Force, National Environment Agency and the Jurong Town Corporation) were also activated to support the SCDF in the management of the incident.

Though the storage tank fire was rapidly brought under control and eventually extinguished by the SCDF within 5 hours, the entire operation which also entailed the cooling and transference of the remaining effluents left within the affected tank spanned over a period of 6 days. The entire operation was successfully completed on 25th April 2016.

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2 *SCDF has a High-Risk Installations (HRIs) Categorization Framework where companies/facilities/installations are grouped into different risk types based on the main hazards posed on the premise. SCDF would formulate a dedicated contingency plan for various contingency scenarios for all premises classified as HRIs.*

3 *CERT – Company Emergency Response Teams. In accordance to Singapore's Fire Safety Act (Chapter 109A), all premises with Fire Safety Managers (FSMs) are required to establish and maintain its own CERT for first response to incident(s) within their premises. Singapore's CERT framework is segregated into 3 tiers of proficiency and equipping; with Tier 1 CERT having the highest level of proficiency and equipping; and Tiers 2 and 3 CERT having gradually stepped-down levels of proficiency and equipping. All premises with storage of Petroleum and Flammable Materials (P&FM) in excess of 5 metric tons are required to have a Tier 1 CERT. For more details on Singapore's CERT framework, please refer to https://www.scdf.gov.sg/content/scdf_internet/en/building-professionals/CERT.html*

SCDF's Response in Managing the Incident

Though the operational response mounted for the JAC Storage Tank Fire was pegged at the ETF level, Commissioner SCDF and SCDF's Advanced Planning Group[4] (APG) were also on-site shortly after the ETF activation to provide operational guidance and supervision of the incident response. As a tactical consideration, the SCDF Tactical HQ[5]was also forward deployed to Jurong Island to closely monitor the incident developments, due to the propensity of large storage tank fires to rapidly escalate.

SCDF's overall management of the incident can be broadly categorised into ***four main operational phases,*** namely:

Phase I – Initial BTF Response
Phase II – Full ETF Response
Phase III – Cooling and Monitoring Operations
Phase IV – Recovery and Stand-Down

During each operational phase, clear operational objectives were vital in guiding and determining actions that were undertaken at each phase of the operation.

Phase I – Initial Response

During the initial response phase, 5 key operational objectives guided the tasks of the first-arriving SCDF responders. These were:

- Confirmation on the scale of the incident;
- Establishing the substance/content of the affected storage tank on fire;
- Identifying risk(s) associated with the substance and in proximity to the affected tank;
- Conducting search and rescue of casualties (if any); and
- Containing and preventing fire spread to adjacent and nearby storage tanks

The first arriving responders promptly conducted an Appreciation of Situation (AOS) and established that there were no reported casualties at that juncture. The crew quickly gathered key information (including the content of affected tank, its size, as well as details on surrounding risks/hazards – proximity to surrounding tanks and their contents) and apprised SCDF Operations Centre to provide updates on the incident.

The territorial Banyan Fire Station Commander was the initial on-site Incident Manager during this phase. The prompt confirmation on the magnitude of the incident (i.e. full-surface tank fire) by the Station Commander facilitated for the rapid escalation of resources to the ETF-level to support of the operation.

While awaiting the arrival of the ETF resources, the strategy adopted by the SCDF first responders in this initial phase where resources were limited (to the BTF appliances) was primarily defensive. The priority was on providing cooling and exposure protection to two other tanks (i.e. 800-TK1A and 800-TK1C) and a pipeline service corridor which were in close proximity to the affected tank (800-TK1B). Working closely with the JAC's Company Emergency Response Team (CERT) , the SCDF responders ensured the actuation of all applicable fixed firefighting protection systems in the area; as well as the deployment of additional ground monitors to provide cooling and exposure protection to these surrounding hazards, so as to minimise the risks of any further escalation of the incident.

4 *The APG comprised selected members of SCDF's Senior Management who would provide operational support and inputs to the Commissioner during the management of a Civil Emergency. Members of the APG will include SCDF's Director of Operations, Hazmat, Medical, Technology and Logistics, etc.*
5 *The SCDF Tactical HQ (Tact HQ) comprises 5 Command Vehicles (CVs) which can be forward-deployed to serve as the on-site command post to facilitate SCDF's management of any major Civil Emergency (Ops CE) level incident direct at the incident site.*

Phase II – Full ETF Response

The full ETF comprising large monitors, large pumps, foam PODs (Platform On Demand), hose-laying trucks and other support appliances were all mustered on site within 1.5 hours from the onset of the incident. With cooling measures and exposure protection of surrounding risks properly in place; and the full ETF resources at hand for deployment, the strategy could then be shifted to take on an offensive stance. With the escalation of resources, 1st SCDF Division Commander assumed the role of Incident Manager upon his arrival on-site.

The key operational objective in the second phase of the incident was to effectively mitigate and extinguish the full surface tank fire. To achieve the objective, 3 key tasks had to be prioritised and executed:

- Site Management and Sectorization;
- Establishment of Key Control Points; and
- Deployment of Large Monitor and Foam System for Fire Mitigation

Site Management and Sectorisation

Due to the wide area of operation and large number of appliances involved, proper site management was essential to ensure effectual coordination and management of the resources on-site. To facilitate the management and coordination, the entire area of operations was divided into 3 geographical sectors (See Figure 4). Each geographical sector was assigned a Sector Commander (pegged at the Fire Station Commander level) for effective command and control within the respective sectors.

In addition to the geographical sectors, critical tasks and functions were also each assigned Functional Task Commanders (similarly pegged at the Station Commander level). In brief, 3 Functional Task Commanders were appointed to oversee critical tasks:

- Fire Suppression
- Foam Supply
- Water Supply

For the purpose of differentiation and ease of reference, Functional Task Commanders would be referred to as Officer-in-Charge (OIC) – e.g. OIC Fire Suppression, OIC Foam Supply, etc.

The blend of geographical and functional task sectorisation was practical and effective in dividing the required tasks of managing specific areas and critical tasks to different appointed officers, ensuring that each aspect could be properly focused upon to facilitate the effective management of the entire incident.

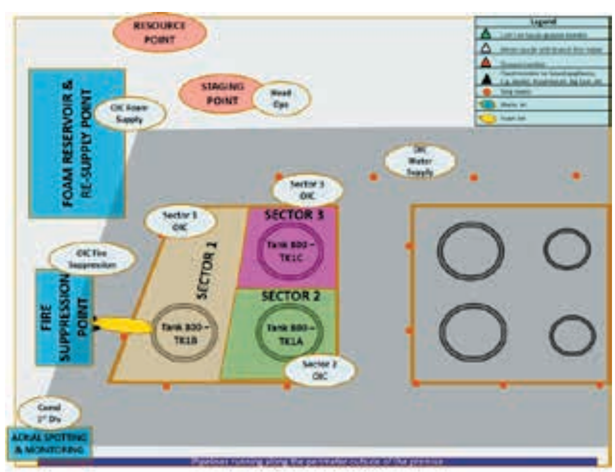

Figure 4: Sectorisation plan for the Operation

Establishment of Key Control Points

In addition to sectorisation, the establishment and appropriate positioning of key control points were also essential to ensure the effective management of the incident site. A key consideration was ensuring that the various control points were properly set up in a coherent manner to facilitate the efficient flow of resources in (and out) of the incident area without causing major obstruction to the operation.

The Staging Point (SP), Resource Point (RP), First Aid Point (FAP) and Ambulance Point (AP), Vehicle Marshalling Area (VMA) and Forward Command Post (FCP) were established for the management of the incident. There were also several additional distinct control points that were established specifically for the management of oil tank mitigation operations. The additional control points were:

- Foam Reservoir and Re-supply Point
- Fire Suppression Point
- Aerial Spotting and Monitoring Team

Figure 5: Source of pictorial illustration: The New Paper, 23 April 2016

A succinct elaboration on the considerations taken for the establishment of each key control point will be discussed in the ensuing segments.

- ***Staging Point*** – The Staging point was established at the perimeter meter of the risk area to facilitate the coordination of all resources and manpower entering into the immediate area of operations. The Staging Point was manned by a Staging OIC (Division Operations Officer) whose tasks is to assist the Incident Manager in coordinating all on-site requests and resource requirements; as well as updating any critical developments related to the firefighting operation. The Staging Point also provides the Incident Manager with real-time updates on the progress of the operations.

- ***Resource Point*** – The Resource point is the mustering area of all resources deployed to site but yet to be committed into the immediate area of operations. The Resource Point consolidates the status of all available on-site resources (both manpower and equipment); and coordinates closely with the Staging Point for the pushing of the required resources to the Staging Point before onward deployment into the immediate Area of Operations. The Resource Point OIC needs to constantly monitor the quantity and types of resources and equipment available onsite, so that additional support can be requested promptly, if required. The Resource Point for the JAC incident was located not far from the Staging Point, and served as the link between VMA, Staging and the Foam Re-supply Point.

- ***First Aid Point (FAP)*** – As with all major incidents, the FAP was promptly set up by the first arriving SCDF ambulance crew in the early phases of the operation for the management of any possible casualties. Though no casualties were reported during the midst of SCDF's fire-fighting operations, the FAP was manned throughout the 5-hour initial two phases of the incident. SCDF Paramedics manning the FAP worked closely with JAC's Medical Centre personnel to ensure that medical support was rendered where necessary.

- ***Ambulance Point (AP)*** – An AP was also set up in the early stage of the operation to standby for conveyance of any possible casualties. It eventually stood down together with the FAP when it was no longer required.

- ***Forward Command Post (FCP)*** – As part of the ETF, 1st SCDF Division's Forward Command Vehicle (FCV) was also activated to the incident site to provide operational support to the Division Commander in the management of the incident. The FCP led by the Division Head Operations performed the function of updating SCDF Operations Centre, preparation of essential staff aids, and as well as coordination of requests for additional reinforcements between the Incident Manager and SCDF Operations Centre.

- ***Vehicle Marshalling Area (VMA)*** – The VMA was set up to coordinate the directing of all subsequent arriving appliances into the incident. This was particularly crucial in the case of the JAC operation, as the movement of the many foam PODs arriving onsite had to be well coordinated for the timely placement and replenishment of the reservoir supplying foam to the large monitor set up. Hence, the VMA was still sited within the JAC premises (albeit some distance away; beyond the resource point) in order to be close enough to facilitate the re-supply and yet not to crowd the immediate vicinity of the incident site.

Specific to fighting this oil tank fire, 3 Tank-Fire Control Points were established:

- Fire Suppression Point – The fire suppression point is essentially the control point where the large monitor(s) for the foam application operation is sited. This control point is manned by the Fire Suppression OIC. The following are the key considerations for the positioning of the large monitor (or fire suppression point), namely the:

    - Effective range of the large monitor(s);
    - Adequacy of safety distance from the radiant heat of affected tank (if required, water curtains can be established to reduce the radiant heat effects); and
    - Wind direction - if possible, monitors should be positioned for application with the direction wind for optimal effectiveness.

Besides positioning and deploying the large monitor(s) in consultation with the Incident Commander, the Fire Suppression OIC also coordinates closely with the OIC water supply and OIC foam supply to ensure that water and foam supply to the large monitor(s) remains seamless and continuous during the foam application operation.

- ***Foam Reservoir and Re-supply Point*** – The foam reservoir and re-supply point comes under the jurisdiction of the OIC Foam Supply; and essentially refers to the 2 units of Foam PODs which were established to serve as the stationary 'base- PODs' or foam reservoir in support of the foam application operation. The foam reservoir for the JAC operation was established along an access road running perpendicular to the left of the affected tank. This control point not only establishes the connection of both foam and water supply lines from the foam PODs to the large monitor; it also performs the critical task of supervising and coordinating the replenishment of the foam supply (from the mobile PODs to the base PODs /reservoir). Key to the positioning of this control point is ensuring sufficient space to facilitate the quick movement and change of the mobile foam PODs re-supplying the 2 base PODs (or foam reservoir).

- ***Aerial Spotting and Monitoring Team*** – Due to the elevated nature of storage tank surfaces, effective mitigation will depend significantly on the accuracy of ensuring proper foam application on the affected liquid surface. Hence, a team from the Combined Platform Ladder (CPL) deployed along Banyan Avenue (i.e. public road located just outside the area of the affected tank) was tasked to conduct spotting and monitoring from an aerial vantage to gauge the effectiveness of the foam stream on the liquid surface.

The principles of foaming operations were closely adhered to for the management of the JAC incident. In accordance to SCDF's large storage tank fire-fighting doctrine, the calculation of foam requirements and water supply adequacy had earlier been computed upon the confirmation of the affected tank's content and dimensions.

Based on the computed foam requirements, foam PODs (for 2 times the required contact rates to mitigate the tank fire) had also been promptly activated to site from the various SCDF units. As an operating principle, 2 x Contact Rate (CR) of the foam requirement[6] needed for mitigating the tank fire must be mustered onsite before the foaming operation can commence. In addition to mustering the foam requirements, it was also essential to ensure that continuous, uninterrupted foam supply was maintained throughout the entire foaming operation. This was achieved through the setup of a foam supply relay system (comprising 2 base PODs serving as the foam reservoir; and a mobile fleet of foam PODs re-supplying to the 2 base PODs) to establish the constant supply of foam to the large monitor[7].

With all key resources mustered and control points in position, foam application operation was initiated at 17:15 hours (approximately 2 hours after SCDF's first arrival on-site).

Sustained foam application and aerial monitoring was conducted to ensure the effectiveness of the "Footprint Method"of foam application for fire extinguishment.[8]

Figure 6: Coordinated and sustained foam application efforts using the 'footprint method' enabled the SCDF to first bring the full surface tank fire under control before subsequently extinguishing the fire after 2.5 hours of persistent foaming operation.

6 *The first contact rate is to cater for the 1st hour of uninterrupted fire-fighting; the 2nd contact rate serves as a 100% reserve for a second hour of foam application, if required. Nevertheless, close monitoring on the effectiveness of the foam application must be sustained throughout the operation; and additional foam supply must be promptly made available for sustained foam application otherwise initial efforts will be in vain if a successful burn-back occurs.*

7 *Close monitoring of the foam level was required to ensure that the foam reservoir's level remained adequate throughout the foaming operation. Monitoring of the foam level was tracked via 2 means (i.e. time and visual) – namely, via theoretical calculation of foaming time based on flow rate and pod capacity, as well as actual visual confirmation of the remaining foam level in the foam PODs.*

8 *The footprint method uses traditional 'surround and drown' techniques and concentrates foam application predominantly towards the centre of the tank.*

The foaming operation was not without its challenges – there were persistent pockets of fires where the foam layer had difficulty blanketing due to 'inward folds' (See Figure 6) that were formed where the tank buckled inwards due to heat damage. During the foaming operation, there were also two particularly intense occurrences of 'burn-back' which threatened to thwart the entire foaming operation. Nevertheless, with coordinated and sustained foam application, the full surface storage tank fire was eventually brought under control and subsequently extinguished by the SCDF after 2.5 hours of persistent foaming.

Figure 7: 'Inward folds' formed along the rim of the affected tank where it buckled inwards due to the intense heat created persistent pockets of fires where the foam layer had difficulty blanketing.

Phase III – Cooling & Monitoring Operations

After the successful mitigation of the tank fire, the key operational objective transited to ensuring that any risk of the tank fire rekindling is minimised. The key considerations in this phase were mainly to ensure no rekindling of the tank fire; as well as to scale down the operation and resources accordingly for a gradual phased return to normalcy.

Key activities in this phase primarily involved the continued cooling of the affected tank to reduce the core temperature of the tank's contents.

A 'surround and cool' approach using water-jets from a combination of ground and appliance-mounted monitors was adopted to ensure comprehensive cooling of the affected tank. Cooling efforts were complemented with constant monitoring (from both the aerial and around peripheral perspectives) of the affected tank's temperature via the use of thermal imagers to gauge the effectiveness of the cooling efforts and identify 'hotspots'. Foam blanketing, conducted at intervals, was also maintained for vapour suppression to minimise the risk of any possible re-ignition.

Lastly, the full large monitor and foam supply setup (with 1 x CR of foam requirement) was also maintained onsite throughout the entire cooling operation as a contingency measure for rapid intervention in case of any rekindling of the tank fire.

Notwithstanding the minimal crew required to maintain the above measures, most other supporting resources were promptly returned from the incident site when their assistance was no longer required. Cooling operations were maintained overnight and eventually stood down when the tank's temperature was brought to ambient levels.

During this phase, discussions with the JAC management on the management of the effluents and residual content within the affected tank also ensued. The JAC CERT was also engaged to assume a more active role in maintaining the monitoring operations.

Phase IV – Recovery and Stand-Down

In the final phase of the operation, the key objective was to eliminate all potential risk(s) from the incident site before the operation formally stood down. The desired outcome was the complete transference of the affected tank's exposed residual contents into another containment apparatus.

Though the re-ignition risk posed by the affected tank's residual contents was not deemed to be high, it nevertheless posed some safety concerns. Hence, the principal consideration at this stage was to ensure that that rapid intervention measures were in place should any accident(s) occur during the transference process.

Transfer operations were undertaken by JAC to displace the affected tank's residual contents into an unaffected adjacent empty tank (800-TK1A). JAC's CERT was deployed on-site to provide rapid intervention coverage during the lengthy transference process. Prior to the commencement of the transference operation, SCDF ensured that the CERT established adequate on-site fire-fighting and foam stock to provide rapid intervention action(s) should the need arises.

Throughout the duration of the 3-day transference operation, SCDF continued to conduct frequent site visits and temperature monitoring at 3-hourly intervals throughout the period. SCDF also provided on-site assistance (to assist with foam blanketing during periods of inclement weather and elevated lightning risk) upon JAC's request during the period. SCDF's senior management was also constantly kept updated on the progress of the transference operation. The entire operation was only terminated upon complete displacement of all residual contents as verified by SCDF.

Conclusion

Drawing reference to the article's opening narrative – i.e. Singapore's last major storage tank fire in Pulau Merlimau (1988), it can be inferred that the SCDF has made significant headway in terms of its storage tank firefighting strategies and capabilities. Coupled with the continual focus on workplace safety, higher industry safety standards and advancement in fire protection systems, incidents such as the April 2016 JAC large storage tank fire should continue to be a statistically uncommon phenomenon.

Nonetheless, though storage tank fires may be rare occurrences, ineffective management of such incidents can have very dire consequences. Hence, it remains imperative that emergency response authorities such as the SCDF continue to improve and adapt to formulate efficient and effective strategies for the mitigation and management of large storage tank fires.

The SCDF has garnered many lessons and useful experiences from managing the JAC incident. The incident has reiterated that aside from an efficient response framework, sound operating doctrine and effective equipping; pre-planning and formulation of joint response arrangements based on a multi-agency approach are also key elements in mounting an effective response. In this light, the significance of deployment exercises for validation of doctrines and joint-agency arrangements also cannot be understated.

Going forward, SCDF will continue to work closely together with relevant related agencies and authorities as well as the petrol-chemical industry to jointly improve and refine our response framework and capabilities to ensure the robustness of joint response to any emergency situation(s) that may arise.

Editorial Preview

"Ladies and Gentlemen, a vehicle has exploded near the carpark area D, near entrance A of the Sports Hub. Please evacuate in an orderly fashion to the nearest exit and move to a safe area". This seems to be a scene right from a terrorist attack, except that this was actually a prelude to the Exercise Northstar IX, at the Sports Hub.

The SCDF, being the lead agency for emergency preparedness, has programmes and exercises to help the community prepare themselves for such emergencies. From the inaugural Exercise Northstar, the planning team has always been scanning the horizon for the latest threat scenarios and adapted them for the exercise scenarios. This has led to a constantly evolving Exercise Northstar as well, from railway bomb incidents (Exercise Northstar V) to Mumbai gunmen style attacks (Exercise Northstar VII).

Interested persons who want to learn about the planning and execution of exercises can contact the Editorial Board to find out more.

EXERCISE NORTHSTAR: TRAINING AN ALERT AND PREPARED COMMUNITY

LTC Wesley Lim, Chief Instructor, Civil Defence Academy
LTC Goh Boon Han, Senior Assistant Director, Operations Department
WO Erwan Bin Talib, Instructing Officer, Civil Defence Academy
Singapore Civil Defence Force

Introduction

Singapore is a country that is spared from natural hazard events such as earthquakes, cyclones, tsunamis etc. Nevertheless, the country is still exposed to anthropogenic hazard events such as fire, pandemic, chemical spill. In any of these events, it is at the community level where the full effects of emergencies are felt, and it is there that definitive achievements in emergency preparedness can be made [1]. The community, regardless of their level of receptivity towards emergency preparedness, lacks direct personal experience in such hazard events [2]. It is therefore important for Singapore Civil Defence Force (SCDF), the lead agency in emergency preparedness, to embark on programmes and exercises that will prepare the community's response and resilience should they be caught in a hazard event.

Exercise Northstar (Ex NS)

The Exercise Northstar (Ex NS) refers to a National level exercise that stress tests the response mechanism of various Government agencies. The first of its series, started in 1997, has been organised and led by SCDF. Over the years, Ex NS has expanded in its scale and took on more elaborated and challenging scenarios. The recent exercises were modelled after events such as the London bombing in 2005 and Mumbai gunmen attack in 2008. While such incidents have not occurred in Singapore, the re-enactment of such scenarios enabled the various Government agencies to validate their respective contingency response plans. It also served as a platform to review the plans through lessons learnt, after the exercises.

Pre-9/11 Ex NS

The pre-9/11 Ex NS [series I, II and III had just been initiated and was a tool to validate a National Response plan – codenamed 'Operations Civil Emergency' (Ops CE)]. SCDF was also then newly appointed as the Incident Manager (IM) for civil emergencies. In the early days of planning, Ex NS had already envisioned nation-wide involvement as a final objective. The Ops CE plan (1st edition) was validated with the inaugural Ex NS I on 3 Jul 1997 with a scenario of a major hazardous material (HazMat) incident. It was a Table-Top Exercise (TTX) involving 17 Government agencies, with an objective to discuss and validate their response strategies for a chain collision involving vehicles transporting Hazmat along on a busy key arterial road. The outcome of the TTX led to a more concerted and established response plan for the management of a major HazMat incident from all participating agencies.

The follow-up for Ex NS I was a full-troop deployment exercise which was achieved via Ex NS II on 27 January 1999. The scenario was a major petrochemical fire incident in an offshore setting. The exercise involved 21 Government agencies, and the objectives were to synchronise the various agencies' response plans and evaluate the challenges in managing a major petrochemical fire incident in an offshore setting.

Post-9/11 Ex NS

On 11 September 2001, the world woke up to a major terrorist attack on United States (US). The high profile attack triggered the security and emergency response organisations world-wide in the enhancement of response plans and capabilities. For SCDF, it was an opportunity to level-up the conduct of Ex NS. Ex NS III, conducted on 12 June 2003, was the first in the series after 9/11. The scenario was premised on a radiation leak and fire situation on board a Nuclear Powered Submarine (NPS). It was a deployment exercise that involved 10 agencies and they had to manage and mitigate a scenario involving a radiation leak and fire onboard a NPS berthed at a naval base. The exercise allowed participating agencies to practise their deployment and response; as well as appreciate the complexity and massive coordination efforts required in the management of an incident involving toxic radioactive materials.

The Ex NS IV, that took place on 11 Jan 2004, was the first exercise in the series to involve the community. The scenario was modelled after the Madrid train incident that took place in 2003. By this time, Singapore had established a public rail transportation system named as the Mass Rapid Transit (MRT) system. The scenario involved a chemical agent attack at Raffles Place MRT Station, which is a busy transportation node in the heart of Singapore's Central Business District (CBD). This deployment exercise, the largest at the time, involved over 800 participants and agencies such as Singapore Police Force (SPF), National Environment Agency (NEA) and Ministry of Health (MOH). The community was engaged in the conduct of In-Place Protection (IPP) for 13 commercial buildings in the vicinity – the first large scale IPP exercise in Singapore.

Figure 1: Ex NS IV: SCDF personnel conducting mass rescue at Raffles Place MRT Station

Figure 2: Ex NS IV: Singapore Police Force Officers providing security coverage

In 2005, the world was shocked at the bold attempt to cripple London's transportation network by a group of suicide bombers who detonated themselves almost simultaneously at various transportation nodes. The incident triggered an urgent need for Singapore to prepare the community for such a scenario. SCDF then made a novel attempt to plan an exercise on Singapore's own rail transit network which mirrored the multiple terrorist attacks on the public transport networks in Madrid (2003) and London (2005) and also involved real and unsuspecting commuters. The Ex NS V, a 3-hour exercise that started at 6.25am on 8 January 2006, involved simultaneous bomb blasts at 5 different transport nodes – Raffles Place, Marina Bay, Dhoby Ghaut, Toa Payoh Mass Rapid Transit (MRT) Stations; and on board a bus at Toa Payoh Bus Interchange. A secondary Chemical Agent (CA) was release at Dhoby Ghaut MRT Station to validate the efficiency of the national emergency response.

Apart from the on-site multi-agency response and mitigation, Ex NS V also involved off-site crisis management. Medical evacuation of mock casualties at various hospitals were exercised to see how hospital Accident & Emergency units coped. At the Family Assistance Center set up for the exercise, psychological support was also rendered for mock role players of family and relatives of victims who had been affected by the incident. The exercise involved a high level of involvement and support of the community, where the activation of Emergency Preparedness Groups at the community, Community Emergency Response Teams of the various transport stations and other volunteers were achieved during the exercise.

Figure 3: Ex NS V: SCDF responders conducting rescue in MRT Train

Figure 4: Ex NS V: Inter-agency coordination and unified response

The Ex NS VI, held on 23 May 2008, was the first ever maritime civil emergency exercise conducted. The scenario setting was on-board the cruise ship, SuperStar Aquarius, and replicated a fire within the ship's galley resulting in a mid-sea evacuation of 857 passengers. More than 1,600 personnel from 12 agencies participated in the exercise. Controllers from various agencies were deployed to observe and evaluate key functional areas of the exercise, such as incident mitigation, evacuation of passengers and casualties. Ex NS VI not only stress tested the collective capabilities of the multiple agencies involved in a large scale maritime incident but also provided the platform to validate the contingency plans for the management of such incidents within Singapore waters.

The scenario for *Ex NS VII* was modelled after the Mumbai gunmen attack in 2008 and involved multiple terrorist attacks. 15 selected role players executed a series of coordinated attacks over a span of three days (6, 7 and 15 July 2009) at iconic and popular tourist attractions. To add challenge to the exercise, the 'attackers' barricaded themselves at a hotel. Members of public in the vicinity were roped in as well to conduct evacuation. This was used as a showcase for the community on the safest way to react should such an incident occur.

Figure 5: Ex NS VII: Gunman attacking civilians

Figure 6: Ex NS VII: SCDF responders conducting mass rescue

As gunmen-style attacks continued to take place at various part of the world, Ex NS VIII on 25 November 2011 involved multiple terrorist attacks on both sea and land targets. The purpose of this exercise was to stretch the responding resources and evaluate the co-operation amongst the sea and land response forces. The scenario involved security forces storming a tanker, hijacked by terrorists with plans to use it as a "floating bomb". On the mainland, an attack was also initiated in the deliberate release of hazardous gases at the Jurong Island Petrochemical Hub, which is home to companies such as ExxonMobil, Shell, Dupont etc. Another attack, involving vehicle bombs were detonated by terrorists at the link bridge of the island to mainland and this was setup to target the members of public who were in the midst of evacuation.

Figure 7: Ex NS VIII: Joint effort between SCDF responders and Company Emergency Response Team (CERT) to mitigate a chemical leak

Figure 8: Ex NS IX: Vehicle bomb explosions at Singapore Sports Hub

Figure 9: Ex NS IX: Gunmen attacking civilians

Figure 10: Ex NS IX: Singapore Police Force officers neutralising gunmen

The most recent Ex NS IX, which took place on 9 May 2015, was held at the newly opened Sports Hub. The Sports Hub was chosen as the exercise location as it was one of the key facilities for Singapore to host the upcoming South East Asian (SEA) Games in 2015. This also allowed responders to validate the contingency plans that had been drawn up for various envisaged scenarios. The scenario for this exercise involved terrorist attacks in the form of vehicle and person-borne improvised explosive devices. While spectators were fleeing the scene, they were cornered by gunmen planted at their exit route. This culminated in a firefight with the security forces. The community filled up the observation areas to witness the exercise scenario at Kallang Wave Mall.

Figure 11: Ex NS IX: SCDF responders conducting mass rescue

Figure 12: Ex NS IX: Joint operations between Singapore Armed Forces and SCDF responders

Conclusion

The Straits Times published an article on the 27 Mar 2016 [3] which looked at the community's reaction towards emergency preparedness. In the article, it was reported that 3 in 4 Singaporeans surveyed believed that it was only a matter of time before a terrorist attack happens in Singapore. However, only a third of them were concerned that insufficient measures has been done to prepare the citizens for the eventuality. Therefore, the majority of the population perceived that there were sufficient preparations for the citizens in times of emergencies.

Although the survey is testimony of the work that SCDF has achieved in preparing the community for such events, the work to prepare the country for emergencies must be ongoing and continually improving. Thus, exercises such as Ex NS are necessary in preparing the community to be alert and prepared in the event of catastrophic incidents. As such, it is vital for SCDF to continue the conduct of Ex NS to prepare the community for such events.

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3 *The Straits Times, 27 Mar 2016. 3 in 4 Singaporeans believe terror strike here 'only a matter of time'.*

Editorial Preview

For the normal citizen who has watched the movies "Backdraft" or "Ladder 49", the sight of a fireman in his turnout gear (TOG) seems to grant them ungodly powers. They would seemingly be able to run into a fire situation with fire bellowing at them, and yet come out of the fire unscathed and having rescued somebody.

Can the fireman's TOG protect him to such an extent depicted in the movies? This article examines the thermal protective performance of SCDF TOG under a realistic testing environment provided by Thermo-Man™, Dupont™.

Interested persons who want to learn about the Thermo-Man™ and the TOG tests can contact the Editorial Board to find out more.

TESTING THERMAL RESISTANCE OF FIREFIGHTER'S TURNOUT GEAR

CPT Chan Jia Hui, Ops Rediness Officer, 3rd SCDF Division HQ
LTA Dinesh Verlachamy, Senior Instructing Officer, Civil Defence Academy
Singapore Civil Defence Force

Mr Kelvin Tan
Dupont Company (Singapore) Pte Ltd

Dr Richard Jin
Dupont China Holding Limited

Introduction

The Turnout Gear in Firefighting

In most dangerous work environments, the goal is to avoid or eliminate hazard as personnel safety is paramount. On the contrary, in firefighting, the principal work activity is hazard engagement. Hence, preparative measures, such as provision of reliable turnout gear (TOG) are crucial to ensure firefighters' safety and well-being. The standard TOG for structural firefighting has three layers of protection: an outer shell, a vapour barrier, and an inner thermal liner. Each of these layers uses a different type of fabric to provide safety to the firefighters. For example, the outer shell, which is the first layer of thermal protection, is designed to withstand direct contact with flame and heat, without degrading or burning. Many materials have been used to construct the outer shell. Each of these products meets the benchmarked standards (NFPA 2112 or EN ISO 11612) and offers comfort and mobility to the wearer.

Risk of Thermal Hazards

Amidst the multiple threats in firefighting, protection from thermal hazards is of primary concern. Thermal hazards can be categorised based on intensity (routine, hazardous / ordinary and emergency [1] , as summarised in Table 1) and type of exposures such as radiant heat, flame, hot surface, molten substances, hot liquid and steam [2]. According to data from the National Fire Protection Association (NFPA), nearly 45,000 firefighters suffered burn injuries in the United States from 1981 to 2013 [3], showing how thermal hazards pose a very real risk to firefighters in their line of work.

Challenges in Firefighting in Singapore

In the Singapore Civil Defence Force (SCDF), all fire emergency responders are equipped with the standard-issue TOG which comprises a turnout jacket, pants, flash hood, helmet, fire gloves and boots. With this set of TOG, the SCDF responder is expected to attend to all types of fire and emergency calls (see Figure 1), ranging from residential unit fires, commercial (high-rise) fires, industrial fires, vegetation fires, vehicle fires, road traffic accidents to other rescue missions like suicide attempt cases. In other words, the TOG has to perform over a wide range of thermal environments in terms of severity / intensity and duration (See Figure 2 and Table 1). For example, tackling a residential unit fire could be a 30-minute operation while a vegetation firefighting operation could last for more than 3 hours. However, the heat fluxes produced in the residential unit fire could be much higher than the vegetation fire, with flashover conditions that produce heat flux in the range of 0.3 to 5.0 cal/cm²sec.[1]

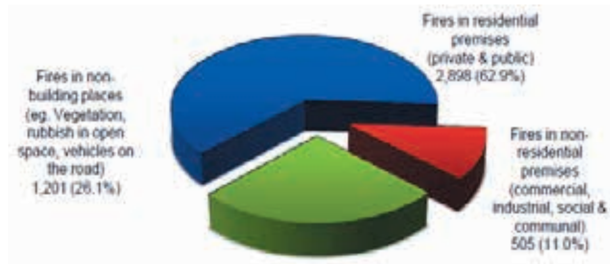

Figure 1: A breakdown of 4,604 fire calls that SCDF responded to in 2015. The fire calls are classified by the type of premises. Different types of premises and nature of calls pose different hazards for firefighters, such as thermal hazard and heat injuries. In addition to that, SCDF also responded to a total of 2,465

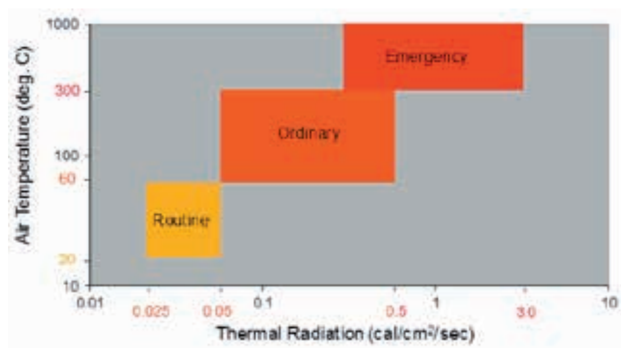

Figure 2: Relationship between increasing thermal radiation and air temperature in room when a structural fire occurs. The TOG has to perform over a wide range of thermal environments in terms of severity / intensity and duration.

1 Heat flux is the rate of heat energy transfer through a given surface per unit time. Any heat flux exceeding 0.04 cal/cm2sec is considered hazardous condition.

Zone	Description / Scenario	Temperature Range (°C)	Thermal Radiation (cal/cm^2sec)
Routine	• Operating hoses or fighting fire from a distance • No special clothing is necessary	20 – 60	0.025 – 0.05
Hazardous /Ordinary	• Similar to ventilating a fire without water support or entering a burning building • “Turnout” uniform is necessary to provide burn protection and to minimise thermal stress	60 - 300	0.05 – 0.6
Emergency	• Flashover occurring • Severe thermal problems and life-threatening injuries	> 300	> 0.6

Table 1: Summary of the 3 key zones of working situations and the various thermal radiation and temperature range respectively.

In view of the operational environment SCDF firefighters work in, and the risks they may face if the TOG is unable to adequately protect them from thermal hazards, it is thus critical that the performance of existing TOG is ensured through rigorous testing for its continual quality and performance. This technical paper thus aims to highlight an advanced instrumented manikin fire test for SCDF TOG, the Dupont™ Thermo-Man™.

Performance Evaluation of TOG

Current Limitations in TOG Evaluation – Skin Burn Injuries and the Thermal Protective Performance (TPP) Test

Thermal hazards may cause burn injuries with impact determined by both time and temperature. The higher the skin temperature, the shorter the time required for skin to blister or burn. As skin temperature exceeds 55°C, the skin will begin to burn at any heat level. Furthermore, prolonged or repeated high thermal exposure will gradually increase clothing temperature. This can cause burns even after the firefighter is no longer exposed to high ambient temperature. As shown in Figure 3, the chances of survival drop exponentially when the body area burn increases to 75%. It is interesting to note that burn injuries in the range of 75% of the body area can result from the continued burning of flammable clothing on the victim’s body. In short, the total area of body burn injury is the key survival factor for burn victims.

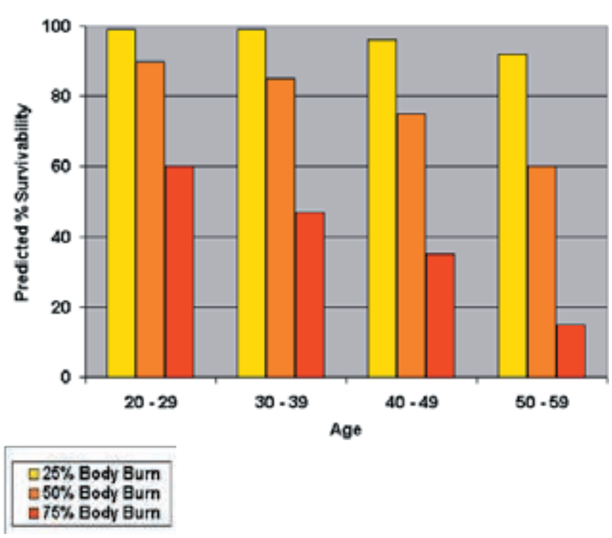

Figure 3: Predicted Survivability (%) versus Age

In the 1950s, Alice Stoll and Maria Chianta [4] used a combination of analytical and experimental techniques to measure the thermal response of single fabric layers over skin[6]. They developed methods to rate the thermal protection offered by a fabric with known properties. Their efforts eventually led to the thermal protective performance (TPP) test, which is the most important laboratory test used to evaluate thermal protective clothing performance today. This includes bench-scale testing of fabric and full scale instrumented manikin assessment of whole garments exposed to simulated flashover conditions. The heat flux histories transmitted through the fabrics and/or the protective thermal clothing is used to calculate the time required to cause a second-degree burn on wearers' bodies. The TPP value is defined as total exposure energy that causes TOG composite to transfer a sufficient amount of heat to elicit a second-degree burn injury (blister) [5].

TPP value (cal/cm^2) = Tolerance time (sec) x Incident Heat Flux (cal/cm^2 sec)

By dividing the TPP value by the fabric basis weight (in g/m^2), the Fabric Failure Factor (FFF) value is obtained, indicating the thermal insulation performance of the fabric [6]. The higher the TPP and the FFF value, the higher the protection factor. The FFF allows for an objective comparison of materials on an equal basis, as it takes the protection/weight ratio into account. However, this test is unable to predict the thermal performance of a garment because TOG's thermal protection does not only derive from a single garment of thermal clothing but by interactions between various protective garments and equipment. For example, thermal protection to the torso and neck region is a function of shirt/uniform, turnout jacket, collar position (up or down), flash hood, SCBA and helmet. To test any single item without the others is a serious limitation of current TPP tests.

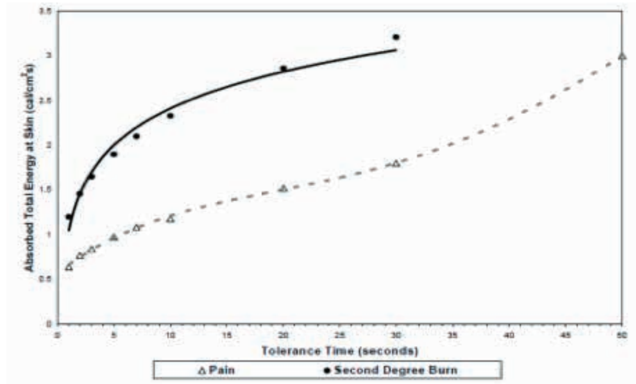

Figure 4: The Stoll curve quantifies the level of heat and the duration of time required for a second-degree burn to occur under a wide range of exposure conditions.

About the Thermo-Man™ Test

The Thermo-Man™ testing facility was opened in Singapore in May 2016, bringing the total number worldwide to five. Facilities were already established in the United States, Switzerland, the United Arab Emirates and Brazil. These five testing facilities enable collaboration with customers and partners in all regions of the world, helping to foster innovation and support the development of more advanced fabrics, fiber technologies and garment designs that can help save lives.

Standing over six feet tall and wired with 122 heat sensors, Thermo-Man™, one of the most advanced thermal burn injury evaluation devices in the world was developed by DuPont™ in 1970 in response to a request from the United States' Government to help find a way to optimise flame-resistant (FR) garment design to better protect armed forces personnel from burns. At the time it was developed, Thermo-Man™ was the first of its kind. It has now become an industry standard for measuring the protective performance of garments and clothing systems under realistic flash fire conditions. Because Thermo-Man™ is used to test full-size garments rather than fabric samples, factors such as garment construction, fabric weight, material type, style, fit and the impact of outerwear and undergarments can be taken into account.

Figure 5: Dupont™ Thermo-Man™ testing Manikin

Thermo-Man™ is equipped with top-notch quality control systems, including:

- National Institute of Standards and Technology (NIST) traceable system calibration of heat flux sensors;
- Control charting to measure system performance; and
- Routine round robin with other testing laboratories

Thermo-Man™ is a certified test according to ASTM F1930 and ISO 13506. It can be also used to certify garments according to NFPA 2112 (UL Certified) or EN ISO 11612.

How It Works

A life-sized manikin is dressed in the test garment and then engulfed in flames generated by 12 propane torches. These torches create a uniform flame and can be used to simulate temperatures ranging from 600°C to 1,000°C. The test simulates the exposure of a garment to a typical industrial flash fire and then predicts the garment's protective performance and integrity against heat and flame experienced during such a typical fire incident.

The Thermo-Man™ system is designed to offer a range of heat fluxes – from 1.0 to 3.0 cal/cm²s /sec – and exposure time of up to 20 seconds. During the test, the 122 heat sensors record the temperature rise on the surface of the manikin at half-second intervals. Data is collected from the sensors both before and after the flames, measuring the heat transmitted from the flames through the test garment to the surface of the body. A sophisticated computer simulation program then calculates:

- The predicted percentage of second and third-degree burns a person might suffer on his or her body under similar conditions;
- The position of the burns and the percentage of burns compared to the total body's surface area; and
- The burn evolution over the measuring time, resulting in the person's chance to survive the incident (in %) in conjunction with the victim's age.

For each set of conditions, multiple test exposures are conducted to achieve a sufficient level of statistical significance. Actual flash fires are unpredictable and can be more or less intense than the conditions created during testing. That's why Thermo-Man® testing is usually performed over a range of heat exposures, from moderate levels to the level required to tax the protective properties of the garments or garment systems being tested. Using this approach, it is possible to identify potential failure mechanisms of the test garments.

Benefits from Thermo-Man™ Testing

Since the 1970s, DuPont™ has conducted more than 10,000 burn exposures using Thermo-Man™ systems. These tests have been conducted for a broad range of fields, including the petroleum, petrochemical and chemical industries, electric and gas utilities, and fire services. Testing has also been conducted for the armed forces of the United States, Germany, Israel and Italy. Thermo-Man™ testing provides valuable information for safety professionals to help them know if they have selected the appropriate fire response gear for the workers in their companies.

The major benefits of Thermo-Man™ include:

- Controllable, reproducible exposure conditions;
- Applicability to a wide variety of products and industries; and
- The ability to simulate other "real-world" factors such as wind

Thermo-Man™ testing can be used to:

- Check garments for minimal compliance versus NFPA 2112 manikin test requirements;
- Check garments against an actual hazard evaluation by varying exposure duration; and
- Test the performance limits of the garments currently being used for FR protection

Application of the Thermo-Man™ testing on SCDF TOG

Objectives and Methodology of Testing

It was not long ago when firefighters still take pride in heavily soot-covered and well-worn clothing as a badge of fire ground experience. Now, with the increased awareness on fire ground toxic and carcinogenic contaminants, firefighters are advised to keep their TOG clean and properly maintained. However, there are concerns that repeated laundering of TOG might affect its fire retardant properties. The TOG might provide excellent initial protection and thermal properties, but their protective performance may deteriorate in prolonged exposure to the harsh physical and environmental factors faced by firefighters.

Hence the main objective of the test is to evaluate SCDF's TOG thermal protection efficiency. At the same time, areas where second or third-degree burns found can also be highlighted for further improvements. Besides that, the Thermo-Man™ test can also evaluate if aged TOG's retains its thermal protection efficiency.

Figure 6: SCDF TOG garment undergoing Thermo-Man™ testing

A TOG garment (10 years old) was provided by SCDF to undergo Thermo-Man™, instrumented manikin fire test (see Figure 6). The TOG was constructed with:-

- Outer Layer – Nomex® Tough (195 g/m^2);
- Moisture Barrier – GoreTex Fireblocker N (140 g/m^2);
- Thermal liner – Nomex® felt (175 g/m^2); and
- Face cloth – 50% Nomex®/ 50% Viscose (125g/m^2),

The Thermo-Man™ test is conducted to benchmark the protection effects with 2cal/ cm^2s heat flux after 8 seconds flame exposure.

Test Results

Figure 7 represents the results of the Thermo-Man™ test of predicted burn injuries obtained from the given sample. All the burn injuries were caused by the unprotected head portion. In other words, the 10 years old SCDF TOG still performs at its best ability to provide thermal protection to its wearer.

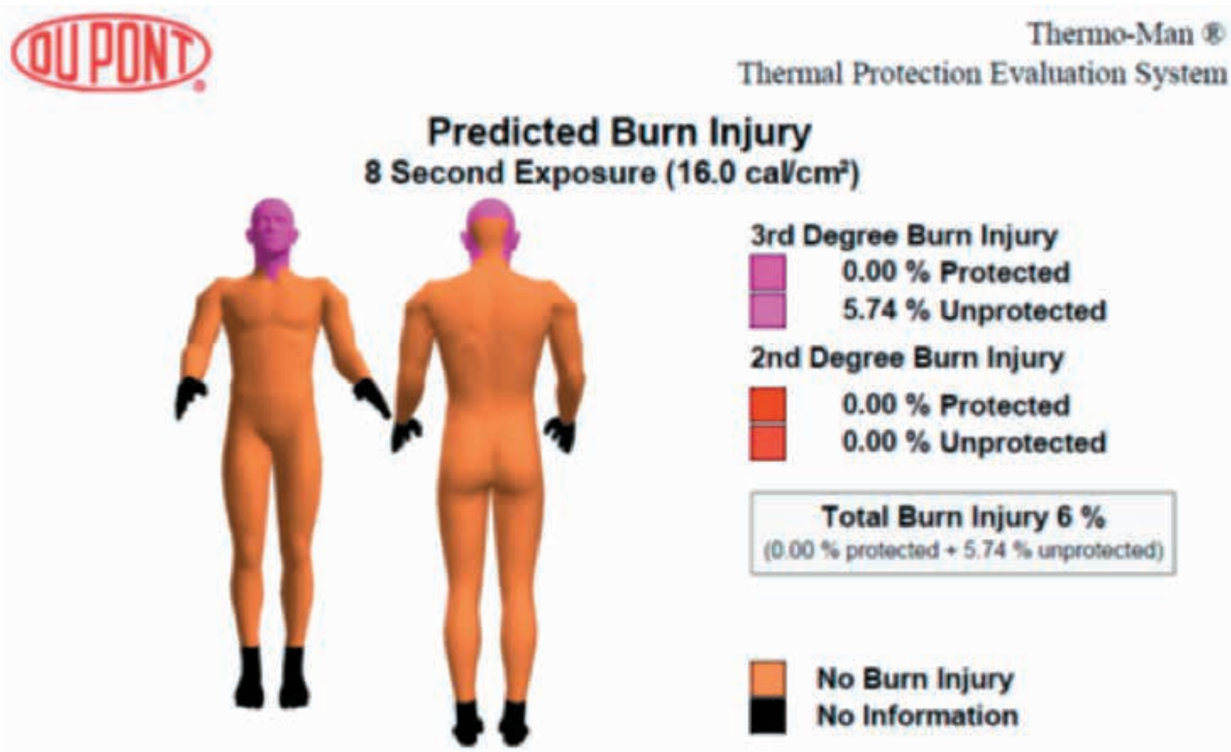

*Figure 7: Thermo-Man™ test results using SCDF TOG. No injuries burn injuries were observed. *There was no head thermal protection for the test.*

Other Applications of the Thermo-Man™ Test

Aside from performance evaluation of TOG, the Thermo-Man™ Test can also be used to raise awareness on proper donning of PPE in firefighting. For example, further tests can be conducted to demonstrate the extent of burn injury that can be inflicted when PPE is improperly worn i.e. not fully zipping the turnout jacket, having a gap between the turnout jacket and the fire glove, unsuitable size fit of the leggings which might expose part of the back torso. Such results can serve as compelling evidence to educate new firefighters and inculcate the importance of proper PPE wear. This can help to promote a culture of safety in the organisation.

Other Considerations in Design/ Selection of TOG

This paper focuses on protection against thermal hazards in firefighting but it is notable that firefighting is a physically and physiologically demanding task. Aside from thermal hazards, there are several other risk factors that firefighters have to face in line of duty. In 2014, Federal Emergency Management Agency (FEMA) did an annual research on firefighter fatalities in the United States of America. The published reports indicated that 91 fire-fighters died while on duty. It also indicated stress/overexertion (Figure 8) as the number one reason for the fatalities.

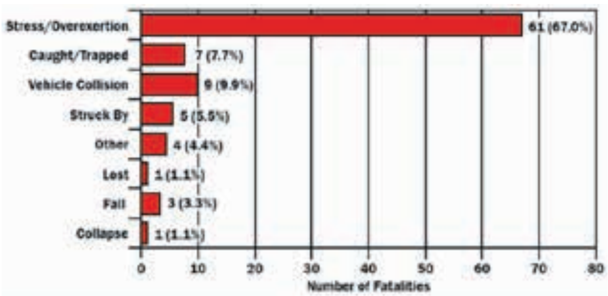

Figure 8: Fatality causes versus Number of fatalities

Stress or overexertion is a general category that includes all firefighter deaths that are cardiac or cerebrovascular in nature such as heart attacks, strokes, and other medical injuries/ conditions due to extreme climatic thermal exposure. Classification of a firefighter fatality in this category does not necessarily indicate that a firefighter was in poor physical condition. From both research and studies conducted, conclusions can be drawn that the current fire-fighting personal protective equipment provides sufficient thermal protection. However, stress/overexertion affects fire-fighters adversely and elder team members are generally the most affected when working in a hot and hostile environment. With the combination of various stressors, the elevation in body temperature has a myriad of effects on the human body, most notably: hastening the onset of muscular fatigue, promoting dehydration, increasing cardiovascular strain and interfering with cognitive function.

Hence, when considering the upgrading or purchasing of TOG, one must also consider many other factors including:

- The work required to be done in the gear;
- Balanced performance;
- Thermal protection;
- Comfort;
- Fabrics' physical strength; and
- Gross weight

Conclusion

From the preliminary testing of SCDF's TOG via the Thermo-Man™ manikin fire test, despite being a used product (10 years old), the TOG is able to withstand the benchmark, 2cal/ cm²s heat flux with an 8 seconds flame exposure. With a brand new TOG, it might be possible for the bunker gear to withstand an exposure time of approximately 12 seconds. More testing will need to be undertaken for more conclusive results.

These results are a first step in practical evaluation and improvement of SCDF TOG. In Singapore's context of firefighting, both heat and humidity are two of the greatest occupational hazards SCDF firefighters face on a daily basis, and it is important to balance protecting the emergency responders and ensuring their functionality. This can be done through reviewing the design, weight and breathability of SCDF TOG to provide maximum protection and comfort. For example, TOG can be further improved by incorporating new fabrics (smart fabrics). Currently, there are also prototypes on smart thermal protective clothing that can feedback wearer's physiological data.

With this technology located in Singapore, there is thus an opportunity for SCDF to review the requirements of a suitable TOG to facilitate optimal performance and safety for its firefighters.

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Editorial Preview

With the number of unattended cooking fires (UCFs) in Singapore contributing 13% to the total number of fire, one may ask: Which target crowd should we target to reduce such fires? Female or male cooks are more likely to cause a UCF. Are those who are absent minded and leave the house more likely to start a UCF? These are some of the hypotheses which will be examined.

Every year, SCDF responds to over 4000 reported fires and attendant fire investigation (FI). One key motivation for FI is to determine the cause of fire so that appropriate measures can be taken to prevent a recurrence. To do this, it was found that an analysis of a collection of fires involving the same or similar entities over time can yield valuable insights that can help to sharpen fire safety and prevention measures.

Interested persons who want to learn about how SCDF utilises data analytics for its work can contact the Editorial Board to find out more.

DATA ANALYTICS IN FIRE INVESTIGATION: TRANSFORMING DATA INTO INSIGHTS

LTC Lim Beng Hui, Commander, Fire Research Unit
CPT Soh Seok Yuen, Fire Engineering Officer, Fire Research Unit
LTA Lim Yew Yee, Fire Forensics Officer, Fire Research Unit
Singapore Civil Defence Force

Background

Data analytics, the science of studying raw data on the basis of deriving insights from that information, has increasingly been employed by a multitude of industries to aid in decision-making. Some data analytics-driven success stories are Miami-Dade Police Department, who was able to crack longstanding cold cases by using historical data to predict areas with higher likelihood of the occurrence of crime and zoom in on possible perpetrators, (IBM 2013[1]) and West Virginia Credit Union, who was able to decrease its loan delinquency ratio by 95%[2].

Data analytics is actually not new in fire investigation. Over a decade ago, the United States Fire Administration (USFA) of the Federal Emergency Management Agency (FEMA) published the second edition of their Fire Data Analysis Handbook (2004[3]) to help the fire service process and make sense of the huge amounts of data that they collect in the course of their operations. The handbook explains how fire departments can better appreciate clues that remain post-fire, optimise resource allocation and even identify areas for improvement through data analytics. The publication also seeks to equip readers with basic knowledge on various statistical and visual tools to show trends or establish relationships. Till today, FEMA periodically shares important insights on selected fire themes and provide possible solutions in the field of fire education, fire research and fire service training[4].

Here at home, the SCDF is also stepping up its use of data analytics to turn data collected from the over 4000 reported fires that it responds to and investigates each year into valuable insights[5]. While some form of analysis had been carried out in the earlier days, those studies were limited to relatively short periods of time to narrow in on defective products and reveal hot spots for incendiary fires. It was only in recent years that more resources have been channelled to perform new and enhanced studies for longer durations as well as collect demographic data in an attempt to establish possible relationships between specific groups of people and certain fires.

Photographic Evidence Analysis

While there are many papers that focus on statistical analysis of fire investigation data, few have ventured beyond numbers, charts and graphs to make sense out of a collection of photographs on similar burnt entities. The SCDF first used this form of analysis to debunk the myth that air conditioning fan coil units (FCU) on standby mode cannot catch fire as the current drawn is extremely low (2014[6]). Beyond claims by the occupants of the room of the affected FCU it was not switched on, how else could it be proven that ignition could occur at FCUs on standby mode? In that study, this was done through a presentation of photographs of several past FCU fires with localised damage and louvers distinctively closed.

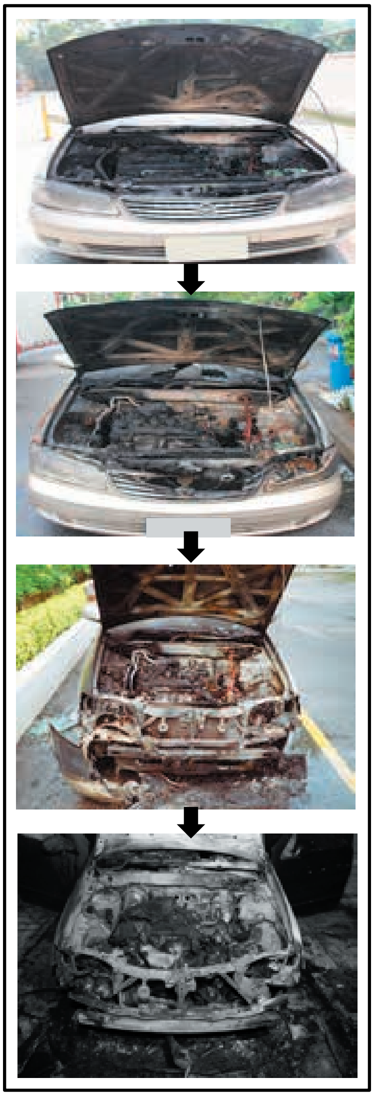

Figure 1: Possible Development of Fires Originating from Engine Compartment

That study also went on to sort the photographs of various FCU fires on the years by the extent of damage; and in so doing, mapped out the possible development of a FCU fire which provided leads as to which specific parts of the FCU could have been problematic. Such a technique could be used for other equipment and provide good indications on the the most probable fire cause .

In recent years, this methodology of photographic analysis was applied to a particular make of car. By sorting the extent of damage, a possible way in which this engine compartment fire could have developed was established as shown in Figure 1. The collection of photographs from the various cases was proof that the fires were not isolated events and warranted the manufacturer to work with the authorities to narrow in on the problematic component. Investigators readily identified the component by examining photographs from a few cases where the fire did not develop significantly. One such case is shown in Figure 2. The engineers from the manufacturers delved deeper and attributed the fire to the failure of the Anti-lock Braking System (ABS), which was cause by excessive water penetration during high pressure car or engine wash. A recall was initiated by the manufacturers which covered other makes, having the same ABS.

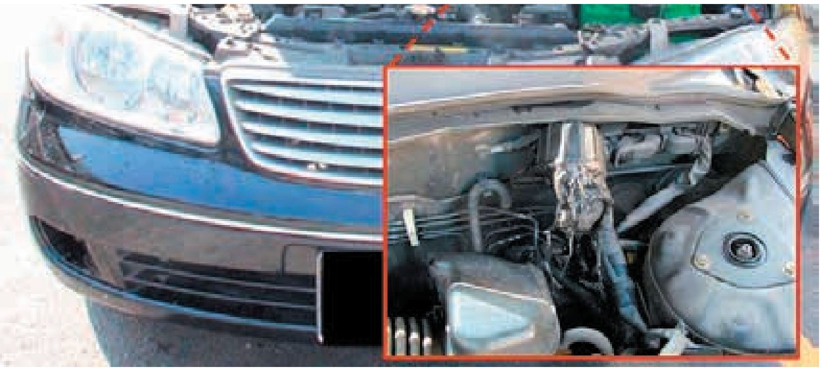

Figure 2: Localised Fire at the ABS

Temporal Analysis

A simple sorting of fire data by month,day and time can yield much insight to the problem at hand. Such an application has been mention in past FEMA publications on themed events e.g. fires which occured on Halloween were found to occur more often in public areas during dinner hours [7] and outdoor fires that fluctuate with the time of the season (2009[8]).

For Singapore, the first application of such an analysis was for refuse chute fires that accounted for a staggering 30% of all reported fires yearly. Although such fires do not pose a major risk, it can be an environmental nuisance to residents and place a strain on emergency firefighting resources. Year-on-year, a peak is noted in either January or February as seen in Figure 3. Transposing this set of data over a lunar calendar provided greater clarity on the situation – refuse chute fires are most prevalent on Chinese New Year (CNY) Eve as shown in Figure 4.

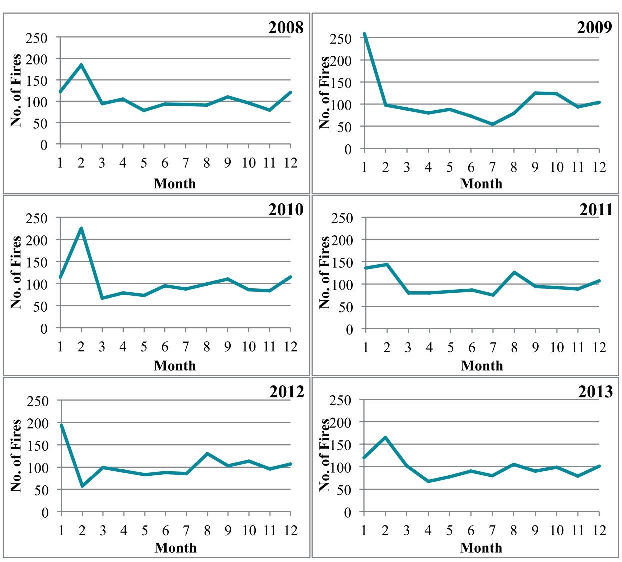

Figure 3: Refuse Chute Fires by Month (2008 – 2013)

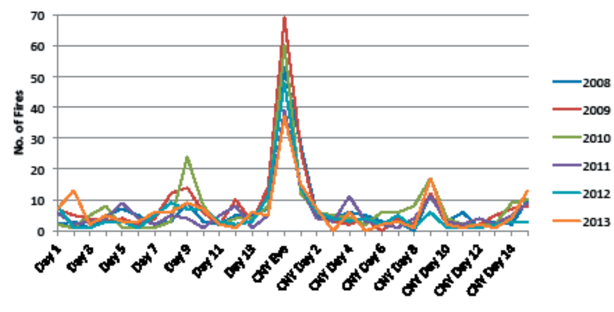

Figure 4: Refuse Chute Fires during CNY Period (2008 – 2013)

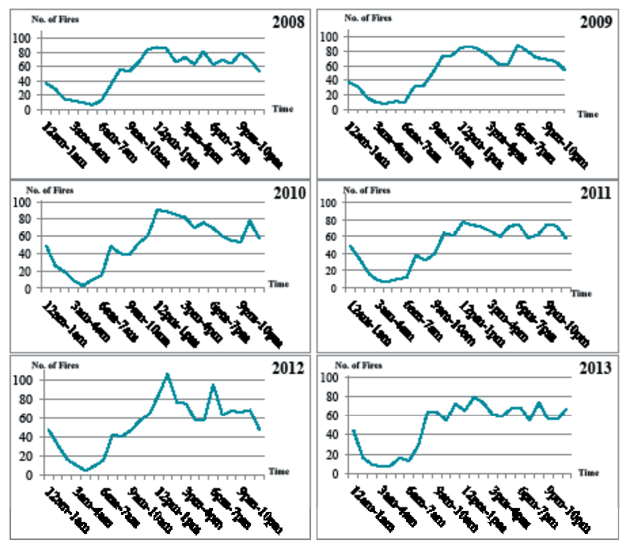

Figure 5: Refuse Chute Fires by Hour of Day (2008 – 2013)

Aside from monthly trends, a study on the distribution of refuse chute fires by hour of the day also provided insights on behavioural patterns. From six years worth of data, shown in Figure 5, a distinct and consistent trend is noted where the number of refuse chute fires dips from midnight to 6 a.m. Thereafter, the numbers rises to a peak in the afternoon between 12 p.m. and 2 p.m. following which the numbers dip till 5 p.m. From 5 p.m. to 7 p.m., a smaller peak was registered.

The annual peak on CNY Eve coincides with the season of traditional Chinese prayers that involves the burning of joss sticks and incense papers; and the daily peaks that correspond to lunch and dinner times strongly suggest that refuse chute fires are a by-product of human behaviour and habits at specific time frames. Tackling the root cause of such fires would require behavioural change, which could possibly be a long-drawn process. Hence, interim fire prevention measures targeted at these time-frames are being explored.

Demographic Analysis

Another fire problem in Singapore clearly associated with human behaviour and habits are unattended cooking fires. Such fires constitute about 13% of all reported fires in Singapore, which amounts to around 400 cases each year (2015[9]). To acquire a better understanding of this perennial problem, demographic analysis was carried out. In consultation the Research and Statistics Division, a customised questionnaire was developed for investigators to obtain pertinent information such as age and educational level. Six months into the launch of the questionnaire, the responses were compiled to acquire some preliminary results for 15 hypotheses on unattended cooking fires (UCFs). Some of the findings for hypotheses are as follow:

Hypothesis 1: Full-time homemakers and unemployed persons tend to have the highest risk of being involved in UCFs

According to the study, working adults contributed to about 45% of UCFs as shown in Figure 6 thereby refuting Hypothesis 1.

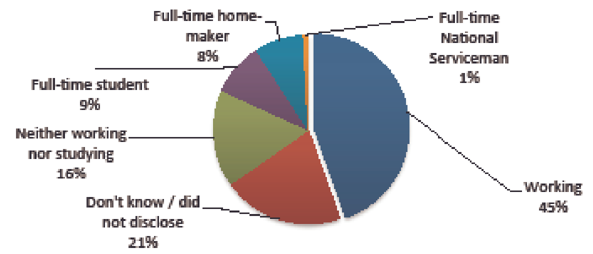

Figure 6: Employment Status of Persons Involved in UCFs

Hypothesis 2: Female cooks tend to be more susceptible to UCFs than male cooks

The number of males involved in UCFs was found to be 18% more than that of females as shown in Figure 7, disproving Hypothesis 2.

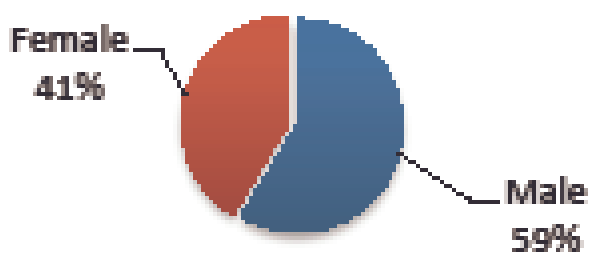

Figure 7: Gender of Persons Involved in UCFs

Hypothesis 3: UCFs are more likely to occur when people cook and leave the residential unit

61% of UCFs involved occupants who were present in their unit as shown in Figure 8. Table 1 presents a detailed breakdown on the causes of their distraction, with resting or sleeping being the top cause of UCFs. Hypothesis 3 was proven to be incorrect

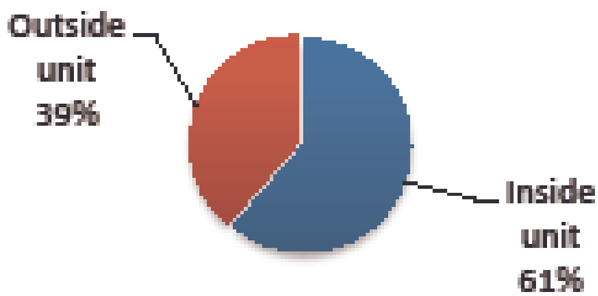

Figure 8 Location of Involved Occupants at Time of Fire

This study on people involved in UCFs highlighted the usefulness of data collection and analysis in develop effective measures rather than basing them on intuition or beliefs. The conventional thinking is that most household cooking in Singapore is performed by housewives and therefore, chances are that women would make up the majority of the 'culprits' in UCFs. This longstanding belief has been proven to be incorrect. Thus education messages for such fires should be consciously extended to cover both genders.

Table 1 – Cause of "Distraction"

	Cause of "Distraction"	Percentage
Inside Unit	Resting / sleeping	41%
	Doing other household chores	9%
	Watching TV	4%
	Playing games	3%
	Communicating with others on phone/ electronics devices	3%
	Attending to children at home	1%
Outside Unit	Went out to shop	21%
	Went out to fetch someone	9%
	Went out to meet someone	8%

Considerations And Limitations

Data analytics is a time-consuming process from the start till the end. The confidence in the trends and insights derived from the analysis is proportional to the amount of data collected.

Hence, a good amount of effort has to be devoted in the data collection and scrubbing process to be certain that findings and conclusions derived from data analytics are accurate and coherent. Similar to the National Fire Incident Reporting System (NFIRS) from the USA, the SCDF has a framework that guides all fire station personnel in their fire reporting process. Data from submitted reports will also be scrubbed at three levels to purge any incorrect or inconsistent data before data analysis is carried out for a selected topic of interest.

While data analysis has the potential to support decision making on matters such as fire prevention measures and allocation of resources, it has to be highlighted that care must always be exercised in the interpretation of the results. A statistically higher outcome does not necessarily mean that the same outcome is to be expected in every case. All facts and circumstantial evidence of the problem or case at hand must be carefully examined and evaluated.

Conclusion

Data analytics has served SCDF well thus far in providing new leads in fire investigation and in sharpening fire prevention measures. For Singapore, data analytics may be a better option, in most instances, over resource-intensive fire tests. Every case is an actual fire that can provide good data on conditions that lead to ignition and fire development. This may be far more realistic and may give more accurate data than any simulated fire. Data analytics, however, is rather reactive in the sense that it requires something to have already happened, and happened a good number of times before one is able to draw sound conclusions and possibly develop counter measures. In addition, one has to exercise caution in the interpretation of results as the circumstances surrounding the problem or case at hand may be different from those encountered in the past.

Fire prevention is no easy feat but data analytics serves to provide a clear understanding of recurrent fire problems so that a targeted approach can be adopted to solve them. Devising effective solutions from data analytics can bring us one step closer to the reduction of occurrence of fires.

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Editorial Preview

SCDF and the French Embassy in Singapore have jointly organised seminars and workshops for emergency responders in the region in the last few years. As a valued strategic partner, the French Embassy in Singapore was then invited to pen an article for this publication. The Paris attacks in France in 2015 took the world by storm, for which the French Embassy in Singapore has graciously agreed to share on the learning that can be extracted from the incidents.

In the months of January and November 2015, the French capital city, Paris suffered two series of terrorist attacks for which the Islamic State has claimed responsibility. These attacks resulted in a complex combination of coordinated actions (shootings, explosions, hostage-taking), which were unprecedented for Paris and represented a real challenge for the emergency services as a whole. The author, Colonel Bruno Ulliac (Refer to biography below) has interviewed his colleagues and extracted the lessons which they have learnt from the rescue operations in Paris, on 13 November 2015.

Interested persons who want to acquire more information about the incident can contact the Editorial Board to find out more.

Colonel Ulliac, from the French Embassy in Singapore is the Regional Adviser for Civil protection for the ASEAN countries. He has been based in Singapore since September 2013. He provides technical assistance and cooperation activities which includes training or workshops, for the 10 ASEAN countries.
From March 2010 to August 2013, Colonel Ulliac Joined the French Ministry of Foreign Affairs (MFA), as an International Expert for civil protection and Fire and Rescue services.

Prior to working at the MFA, Colonel Ulliac held various command and staff positions in Fire and Rescue services. During his career, Colonel Ulliac's responsibilities have included coordination and organization development for the Fire and Rescue services, analysis and cooperation for civil protection programs and operational response as Incident Commander on various emergency situations. He is an UNDAC and EU expert and he has been deployed for various incidents ranging from forest fires to earthquakes and floods..

Colonel Ulliac is a graduate of the French Academy for Fire, Rescue and Civil Protection Officers. He holds a Master Degree in Management of Strategic Information from the Institute of Political Studies of Aix en Provence. He also holds a Master degree in Disaster Risks and Crisis Management from the University of Mulhouse.

LESSONS LEARNT FROM THE PARIS ATTACKS ON 13 NOVEMBER 2015

COL Bruno Ulliac, Regional Adviser for Civil Protection
French Embassy in Singapore

Introduction

The November 13 attacks were the deadliest on French soil since WWII. The terrorists struck at multiple locations at the heart of Paris. In a little over three hours, the nine attackers had killed over 100 people and wounded almost 400. The Paris law enforcement community did a commendable job in responding to coordinated and simultaneous attacks. The death toll would have been much higher if several key decisions had not been made immediately after the attacks began.

The 7 co-ordinated attacks

On November 13, 2015, Paris was attacked in seven different locations (See Figure 1) in 40 minutes. The terrorists targeted the Stade de France, restaurants in the 10th and 11th arrondissements and the Bataclan concert hall. In a little over three hours, the nine attackers killed 130 people, injured 368, and more than 4,000 were psychologically affected by the incident. Hundreds of firefighters and medical teams were mobilized for almost eight hours to carry out extraction, triage and evacuation of people wounded by bullets and blast shrapnel.

Figure 1: Overview of the 7 attack sites in Paris

Overview of Multi-agency rescue efforts

The efficiency of the rescue teams and the successful collaboration between the police units and rescue services helped to neutralize the terrorists and evacuate victims from the Bataclan and other affected places to advanced medical posts, and subsequently to Parisian hospitals. A total of 125 rescue vehicles, 430 rescuers and 21 medical teams from the Fire Brigade of Paris as well as several dozen ambulance teams from the SAMU (Service d'Aide Médicale d'Urgence-France's hospital-based EMS organization), 51 ambulances from several rescue organizations (French Red Cross, Civil Protection, Order of Malta, French Rescue Federation), and backup units from the Ministries of the Interior, Health and Defense worked together with the police for this operation.

Figure 2: Rescuers attending to victims

Co-ordination of Rescue Efforts

Besides the inherent difficulty in managing the high volume of calls within a short period of time, the coordination of treatment, dispersal and transportation of several hundred shooting victims within the same location posed another challenge for the emergency call centers. This included identifying the affected sites, despite the diversity of addresses given by callers, making sense of the information gathered about the threat in order to provide guidance to the front liners, and giving appropriate advice to callers (for e.g., stay put or flee from the location and instructions on how to stop external bleeding).

Challenge of emergency responders

The rescue teams were confronted with two types of threats. Surrounding areas were still under threat, since the terrorists had left the immediate area, but had not been located by the police. There was also a real threat at the Bataclan, where several Fire Brigade rescue teams were confronted with multiple shots, fired towards two of their vehicles. Other Fire Brigade ambulances persisted with their mission despite the difficulty of locating the origin of the fired shots. The challenge then, was to effectively reconcile efficient rescue operations while ensuring ensure responders' safety. The immediate "atmosphere report" given by the initial responding teams helped to guide the incoming teams by informing them of the total number of victims, the number of severely injured, and the nature of the tactical context (e.g., zoning and dangerous roads). For each of the sites where victims were highly dispersed and/or where a significant threat remained (i.e., terrorists were still on site), an initial deployment (forward staging) area was created to act as a safe zone for inter-service coordination. The risk of another attack on the first responders was a major concern. At the Bataclan concert hall, a few rescues were conducted under police protection to bring victims to safety.

Increasing the survivability of victims

Victims of a shooting incident in a civilian environment are much like the wounded on the battlefield. In unsecured areas, the only possible actions are to shelter victims and apply tourniquets. After bringing victims under cover, priority actions were taken based on lessons learned from several previous terrorist attacks and experiences from combat rescue. These actions included: (a) stopping external bleeding, (b) freeing the upper respiratory tract, (c) managing thoracic wounds, (d) ensuring rapid evacuations while providing fluid resuscitation and tranexamic acid (TXA) administration, (e) performing analgesia and (f) preventing hypothermia. Simple initial triage was set up at the onset of evacuations and separated the victims into two categories: critically or not critically injured. This greatly facilitated medical treatment and helped prioritize the evacuations.

Preparation pays off

For many years, the Fire Brigade of Paris has trained its rescue workers on how to use tourniquets and emergency compression bandages. Since the Paris attacks (Charlie Hebdo shootings) in January 2015, the Fire Brigade had enhanced the quality and distribution of bleeding control equipment available in ambulances. Drawing on military experience, a "hemorrhaging in special situations" kit was developed and is currently equipped in all Fire Brigade vehicles, in addition to the standard issue equipment. This kit, which is deployed by all Basic Life Support (BLS) teams, includes two tactical tourniquets (in additional to those in each vehicle's emergency kit), a hemostatic QuickClot combat gauze (See Figure 3) and several types of bandages. Kits from Advanced Life Support (ALS) ambulances include the same equipment, complete with pneumatic tourniquets, needles and tubes for chest decompression, and a perfusion kit. Every rescue vehicle can treat 4-5 victims with severe hemorrhaging depending on the severity of their injuries. Nevertheless, during the attacks on November 13, 2015, rescuers were faced with a large number of victims, many with multiple hemorrhaging lesions. Despite the extra equipment available, the means for controlling hemorrhaging were initially inadequate until the arrival of reinforcement teams due to the large number of casualties.

Figure 3: QuickClot combat gauze

Triage, care and evacuation- The Alpha Red Plan

For most of the critical injuries, BLS medical treatment maneuvers were followed as quickly as possible. It is standard practice in France for the seriously injured to be treated by the ALS teams. Because of the sheer number of victims in the November attacks, the demand for immediate medical teams exceeded the supply. Hence, establishing field triage was imperative. The tactical concept of the Alpha Red plan has been used in Paris since 2007. Under this plan, French pre-hospital triage in mass casualty incidents utilises a four-level scale:

<u>Absolute Urgencies (AU)</u>
-Extreme Urgency (EU)
-First Urgency (U1)

<u>Relative Urgencies (RU)</u>
-Second Urgency (U2)
-Third Urgency (U3)

All patients classified AU are cared for by medical teams (triage, medical maneuvers, fluid resuscitation and TXA). Then, EUs are transported by ALS ambulance and U1s by ALS or BLS ambulances. The separation of RUs into U2s and U3s helped to accelerate evacuations by ensuring the transportation of less seriously wounded patients by large buses that deliver them to different, often more distant, hospitals.

Special complications

Due to the specific characteristics of a mass shooting occurring in a civilian context, the medical teams faced two major constraints. First, a very large proportion of victims were classified as AU in comparison with other types of civilian mass casualty incidents (e.g., terrorist attacks with explosives) and military situations (e.g., victims already equipped with ballistic protection). Secondly, persistent security threats delayed the arrival of backup vehicles and complicated the deployment of triage and evacuations.

The Alpha Red plan turned out to be suitable for these dramatic events, allowing the medical teams deployed at the various sites to adapt their treatment and evacuation of every wounded person according to their wounds, the resources available (e.g., number of ALS ambulances, number of BLS vehicles, backup from large buses), and the nature of the tactical context (e.g., persistent threat, possibility of accessing additional teams). When the evacuation of the critically injured victims was not a critical consideration, both the police protection and the medical capabilities were achieved by deployment of evacuation convoys, which consisted of several ambulances and a police escort. Each ambulance in the convoy provided transportation of 3-4 RUs, or one AU and one RU. A medical team carried out surveillance and treatment during the evacuation of the entire convoy.

Finally, the SINUS system (Système d'Information Numérique Standardisé), a digital system for victim counting and identification in mass casualty incidents, ensured the traceability of the evacuations from multiple locations. SINUS has been used in Paris as well as in other regions of France, on a daily basis and for several years. It includes triage tags, digital watches and computer capture of patient information.

Key learning lessons

New paradigm

There is a need to plan for the unthinkable, and continue to imagine what and how the next threat may present itself. Planning should not be just based on the last event. There is need to conceptualize what future joint exercises and training will look like, make time and commit to them.

Command and control structure

A clear common understanding of the command and control structure is needed by all agencies. The police have the overall responsibility of maintaning safety and security at the incident locations and need to work effectively with other emergency services personnel. Consistent and standard naming protocols are also needed to ensure that the police and the emergency services agencies are using the same language. This is particularly important in the coordination of multiple incident sites.

Resource allocation

The precise allocation of resources, particularly personnel, is very much a key component in the success of such operations. Resources will be in high demand during a high-threat incident, but agencies must plan accordingly to ensure a reserve force is in place and ready to be deployed for any other incidents.

First responders

It is important for agencies to foster a culture of learning amongst first responders, so that they can learn from the good and the bad, without fear of reprisal or judgment. Agencies need to be one step ahead and think about what the first responder needs to be to tackle possible challenges in future.

Social media

There is a strong need for solidarity in times of such crisis. The early use of social media to deliver messages to the public helps minimise duress on emergency services and keep the public informed. The use of social media is becoming an important tool and should be utilised by agencies for intelligence gathering purposes.

Support and well-being

There is a need to ensure that psycho-social support is available and accessible to victims, emergency services personnel and their families. The psychological and social impacts of emergencies can remain dormant and emerge long after the incident has occurred. We need to acknowledge the important role which our agencies and organizations play in raising awareness and improving understanding of psycho-social support.

Medical services integration, coordination and support

The importance of inventory checks and recognising the capacity of medical services in dealing with large scale mass casualty incidents cannot be understated. There is a need to ensure that the necessary agreements between emergency services, hospitals and health providers to respond collectively, if necessary, are in place.

Joint training / tactical training exercises

Regular joint training exercises that involve coordination between the police, the fire fighters and the ambulances should be conducted. Exercises that include participation from health providers should also be conducted regularly to stress test the system. Such training exercises should focus on tactical elements of a high threat event such as regional trauma services, mass casualty, area surveying for active shooters.

Conclusion

As with every disaster, the events on November 13, 2015, have demonstrated the importance of pre-hospital emergency services having efficient and realistic mass casualty plans. This will enable field teams to immediately adapt their response to the specificities of the situation encountered. The quick actions taken by pre-hospital teams during the Paris terrorist attacks contributed to the survival of the wounded, while the coordination between police units, BLS teams, medical teams and trauma centers eventually allowed our healthcare system to provide effective treatment to each casualty.

Editorial Preview

The SCDF and the Hong Kong Fire Services Department (HKFSD) have always had good working relationships, which were spurred on by the signing of a Memorandum of Understanding on 15 December 2009. There has been attachment of SCDF officers to the HKFSD for learning visits, while HKFSD officers have also been attached to, and attended courses at SCDF's Civil Defence Academy.

The building blocks in the training of emergency response crew is important to build the basics and skills of the responders. As such, SCDF and HKFSD place large emphasis in the provision of training requirements and have recently commissioned their new training facilities, the Home Team Tactical Centre (HTTC) in 2015 and the Fire & Ambulance Services Academy (FASA) in 2016 respectively. This article describes the training facilities that were purpose built for HKFSD's environment in FASA.

Interested persons who want to learn about the newly commissioned facilities can contact the Editorial Board to find out more.

AN INTRODUCTION OF THE FIRE AND AMBULANCE SERVICES ACADEMY, HONG KONG FIRE SERVICES DEPARTMENT

Mr Ngai Tak Yung, Commandant, Fire and Ambulance Services Academy
Hong Kong Fire Services Department

Figure 1: Entrance of FASA

Introduction

The Fire and Ambulance Services Academy (FASA), situated at Pak Shing Kok Road, Tseung Kwan O, Hong Kong, was commissioned in January 2016. Constructed at a cost of HK$3.5 billion, FASA is well-equipped with state of art training facilities to offer a wide range of training from foundation fire and ambulance training to advanced techniques in dealing with disasters. It also serves as a breeding ground for firefighters, and ambulance staff, mobilizing & communications and workshop personnel who will be better trained to serve the community. With the integration of fire and ambulance streams' training in the FASA, fire and ambulance personnel will have ample opportunities to be trained together which encourage team building, fosters collaboration, and creates better synergy in responding to emergencies.

Figure 2: Overview of FASA

Training At The Academy

FASA is capable of handling over 500 residential trainees. In addition to provide foundation training for new fire and ambulance recruits and in-service training courses for various grades of serving members, FASA also provides training courses relating to fire and ambulance services for other government departments, private sectors, and its local and overseas counterparts.

Teaching facilities in FASA include a Fire and Ambulance Services Education Centre cum Museum, lecture rooms, an auditorium, a multi-purpose hall, computer rooms, a resource centre, a mock court, a press interview room, a press conference room, law enforcement interview rooms, simulated dangerous goods stores, ambulance practical training rooms, a simulated accident and emergency room and a disinfection room. The new campus also provides physical training facilities which includes a physical training complex with gymnasium, a rescue training pool, an outdoor physical training ground, an adventure training area and a jogging track.

Figure 3: Recruits of FASA on parade

Figure 4: Buildings from left to right: Rescue Training Tower, Drill Tower and Burn House

Specialized Training Facilities

The specialized training facilities in FASA mainly cover emergency scenarios which are relatively complex and large-scale, including incidents related to building, transportation, marine and water, gas plant, aircraft, hazardous materials and structural collapse. All these incidents are possible scenarios encountered by firemen and ambulance crew, and their impact could be relatively serious and widespread. The simulators enable fire and ambulance personnel to receive realistic training in a safe simulated setting, so that they can be better equipped with firefighting and rescue techniques to enhance operational efficiency.

Burn House

The diversity of building materials used, the complexity of building layouts as well as the variety of materials used in furniture and storage in premises in various types of buildings in Hong Kong have increased the challenge of firefighters in carrying out their firefighting and rescue duties. In view of this, advanced indoor live fire training facilities are provided in FASA to practice and enhance their firefighting capability in handling various types of fire incidents. Drawing reference to previous fire incidents, the Burn House was designed to simulate a number of indoor fire scenarios. These include sub-divided units in old buildings, hotels, industrial buildings and karaokes. LPG fueled live fire, high temperature, audio effects and smoke are also available to allow trainees to acquire better firefighting and rescue techniques in a safe and controlled environment.

Figure 5: Live fire training at the Burn House

Rescue Training Tower

Due to the proliferation of high-rise buildings in Hong Kong, HKFSD needs to be prepared for incidents that can occur in different kinds of high-rise buildings. The Rescue Training Tower, a 10-storey building was hence designed with an array of different setups in the tower. These include shopping centre, old residential building, public housing estate, factory and commercial building with curtain wall configurations. The different configurations are built on different floors and at the building façade. There are also training areas where trapped persons in lifts can be simulated. The tower allows for trainees to practice strategies and techniques of firefighting, rescue and casualty handling for various kinds of building configurations. A gondola is also provisioned in the Rescue Training Tower which can also facilitate the specialized training of the High Angle Rescue Team.

Figure 6: Gondola rescue training at Rescue Training Tower

Ambulance Services Training

The Ambulance Services Training Area provides facilities which allow the trainees to go through the entire process that starts from responding to an ambulance call, carrying out patient assessment, administering medical treatment, handing over a patient to hospital staff and conducting disinfection.

Figure 7: Recruit Ambulancemen carrying out training at Simulated Ambulance Compartment

Figure 8: Recruit Ambulancemen carrying out training at A&E Department Simulation Room

Figure 9: The Compartment Fire Behaviour Training (CFBT) Center

During the comprehensive training, the trainees would first receive a call on board the Simulated Ambulance Compartment. The trainees will bring along the equipment to the simulated scene in the Syndicate Room, where they would perform patient treatment as per the Patient Assessment Model practiced by ambulance crew in Hongkong. After receiving initial treatment at scene, the patient will then be transported to the Simulated Ambulance Compartment on a stretcher. Further treatment, stabilization, intervention and examination will be carried out on board the compartment. Lastly, the patient will be conveyed to the A&E Department Simulation Room for handover procedures. The simulated Accident and Emergency Room replicates the environment of a hospital, providing ambulance personnel with realistic and effective training on handing over patients to medical staff of hospital. Trainees will learn how to handle patients with infectious disease which poses major risks to ambulance personnel while carrying out their operational duties. Meanwhile, there is a Disinfection Room which provides a realistic training site for ambulance personnel to practise disinfection procedures. All disinfection procedures will also be practised in the Disinfection Simulation Room.

Compartment Fire Behaviour Training (CFBT)

Firefighters have to deal with various types of building fires and unavoidably face the extreme threats of “flashovers” and “backdraft” during indoor firefighting situations. The multi-storey Compartment Fire Behaviour Training facility allow for simulation of “ventilation”, “flashover” and “backdraft” effects. This facility is envisioned to enhance the response capability and readiness of firefighters who do encounter such scenarios.

CFBT Simulator

The CFBT Simulator is a 3-storey structure which is constructed from 19 numbers of 40-foot freight containers. A total of 4 fire zones are designated on G/F of the compartment and carbonaceous fuel (chipboards) will be burnt in those fire zones. Thermocouples are installed in designated monitoring points to measure and record the temperature during training. The hot and realistic smoke generated from fire zones can be diverted to the 1/F and 2/F by hatches to simulate different kinds of fire scenarios for the trainees to practise different search & rescue and ventilation strategies. Such training helps to enhance the safety and efficiency of fire personnel under extreme circumstances.

Figure 10: 3-storey CFBT Simulator

Backdraft Demonstration Unit

This demonstration unit is a 6m-long structure with fire protection lining and a temperature monitoring system. It is used to demonstrate fire progression and extreme fire behaviours. Trainees are able to witness the various stages of fire development as well as signs and symptoms of extreme fire behaviours such as flashovers and backdraft at a safe distance.

Figure 11: Backdraft Demonstration Unit

Traffic Incident Training

Simulations of Railway Station and Train Tunnel

The entire railway network in Hong Kong is inter-woven by numerous railway lines with numerous underground stations and tunnels. Given the multitude of daily railway commuters in Hong Kong, any incident occurring at an underground railway station or tunnel may pose potential risks of significant loss of lives and properties.

Figure 12: Simulated Railway Station

The Simulated Railway Station and Rail Tunnel provides for a realistic simulation of large-scale railway incidents and train fire. With this facility, firefighters and ambulance personnel can practice the operational procedure, evacuation strategy, firefighting techniques and mass casualty handling required for such a scenario.

Figure 13: Simulated Railway Tunnel and Train Compartment

Figure 14: Simulation exercise on road traffic accident inside tunnel

Road Tunnel

Hong Kong's roads are among the most heavily used in the world. The roads in Hong Kong are interwoven into an extensive network of road tunnels and highways. Given the heavy traffic, any road traffic incident inside a road tunnel or a highway may result in significant loss of lives. The Simulated Road Tunnel and Highways allows for realistic simulation of large-scale road traffic accidents involving heavy vehicle, bus, private car or oil tanker. With this facility, firefighters and ambulance personnel are able to practise rescue techniques on extrication, vehicle stabilization and mass casualty handling with the constraints that will be present for such scenarios.

Fuel and LPG Tank Incident Training

LPG Tank Fire Simulation

Oil Tank Simulator allow for trainees to experience the circumstances they may face in an oil tank fire, thereby strengthening the training of firefighters in this respect. There are a lot of large-scale LPG tanks in Hong Kong. The LPG Tank Simulator provides valuable opportunities for trainees on the proper handling of fire involving an LPG tank.

Figure 15: Simulated LPG Tank Fire

Figure 16: Simulated Fuel Tank Fire

Fugre 18: Simulated Petrol Filling Station Fire

Petrol Filling Station and Vehicle Fire Simulations

There are numerous fuel and LPG filling stations throughout the territory, with many of them being located in densely populated areas. Any incident involving a filling station may cause serious damage to properties and loss of lives. The Fuel and LPG Filling Station Simulators allows for strengthening training on firefighting and rescue operations involving multiple casualties.

Figure 17: Simulated Vehicle Fire

Aquatic Incident Training

Simulation of Vessel Fire

As the interior environment and structure of a ship are different from those of a building, firefighters face far greater challenges when performing firefighting and rescue duties on board a vessel. The Ship Fire Simulator simulates the environment of a four-deck ship, in which the lowest deck is modeled on a cargo ship while the other three decks a cruise liner. There are a number of live fire training compartments in the mock-up ship for simulation of scenarios in passenger compartment, engine room, heated oil piping, etc.

Figure 19: Front view of the Ship Simulator

Figure 20: Rescue exercise with simulation of swift water in force

Figure 21: Aircraft Fire Simulator

Aircraft Incident Training

The Aircraft Fire Simulator features the design of various types of aircrafts, including Airbus A380 and Boeing B767. This provides a more realistic training venue for firefighters and ambulance staff as well as the Mobilization and Communications Group to practise the operational procedures, evacuation strategies and firefighting techniques in aircraft fire and rescue situations. The response capability in handling mass casualty incidents will also be enhanced.

Simulation of Swift Water Rescue

In the past, there were a number of serious flooding incidents in Hong Kong. Swift waters sporadically brought about by heavy rain may lead to loss of civilian lives and endanger rescuers as well. The Swift Water Rescue Simulator, which simulates an outdoor river channel surrounding the Ship Fire Simulator, create artificial swift water effects which allows for honing of trainees' techniques and response capability in swift waters.

Figure 22: HazMat Training Area

HazMat Training

While Hong Kong has relevant legislation in place to regulate the manufacture, conveyance and storage of hazardous materials such as chemicals and radioactive materials, the Department needs to stay alert to HazMat incidents as such incidents may put the lives and properties of the community at risk. The simulated HazMat Training Area provides for a simulated gas leakage chamber, a HazMat laboratory, a dangerous goods store, a chlorine store, etc. Trainees can acquaint themselves with operational strategies, skills of using various detectors and protective equipment, and the sealing and decontamination techniques during HazMat incidents.

Urban Search and Rescue (USAR) Training

The Urban Search and Rescue Training Ground, which simulates building collapse scenarios, provides training on search and rescue operations under adverse circumstances such as landslides and building collapse incidents. An underground concrete conduit is also provided to enable trainees to conduct rescue and casualty handling training in a realistic yet safe environment.

Figure 23: Training at the USAR Training Ground

Figure 24: HAR Training Area

High Angle Rescue (HAR) Training

Various high angle rescue training facilities are provided in the Technical Rescue Training Area, which include a High Angle Rescue Tower, a Simulated Tower Crane and a Simulated Cable Car System for the training of high angle rescue techniques to be employed by rescuers in various scenarios.

Driving Training

The Driving Training Centre in FASA provides an advanced driving training simulator and a designated training ground for emergency driving training. The road network inside FASA is also designed and built to simulate the real driving environment in Hong Kong.

Figure 25: Fire appliance driving training

Figure 26: Ambulance driving training

Conclusion

The provision of various simulators and specialized training facilities at FASA enables HKFSD fire and ambulance personnel to receive a more realistic training environment in a safe simulated setting. Trainees can better equip with fire-fighting and rescue techniques to protect life and property from fire and other calamities.

Editorial Preview

When Singapore Airlines flight SQ 368 caught fire on 27 June 2016 at Changi International Airport, one of the two High Reach Extendable Turrets (HRET), the "Snozzle" was the first fire vehicle to arrive at the scene in just 57 seconds. The fire was subsequently fully extinguished in 90 seconds.

In March 2012, SCDF and the Changi Airport Group (CAG), Airport Emergency Service (AES) signed a Memorandum of Understanding to foster close cooperation for better preparedness in possible crises, and allow for smooth continuity planning in airport operations and passenger facilitation.

HRETs are not so commonly used in conventional aircraft firefighting techniques, with only a small number of airport firefighting units using them. However, they have proven to be useful during occasions when the fire zone is deep seated or inaccessible to firefighters. CAG AES recognizes their potential capabilities and had included two units for its firefighting fleet. The 2 units also complement the arsenal of firefighting vehicles, should SCDF be required to respond to assist AES for any operations. This article describes the capabilities and features of the HRETs.

Interested persons who want to learn more about the HRETs deployed at AES can contact the Editorial Board to find out more.

HIGH REACH EXTENDABLE TURRETS: FEATURES AND CAPABILITES

Toon Jieyao, Operations Commander, Airport Emergency Service
Changi Airport Group (S) Pte Ltd

Introduction

There are times during a medical emergency where an injection makes a difference between life and death for the patient. Likewise, for aircraft fires occurring in areas inaccessible to firefighters or conventional firefighting methods, piercing through the aircraft's fuselage to inject extinguishing agents can vastly improve the effectiveness of firefighting operations.

Changi Airport's Airport Emergency Service (AES) has acquired two High Reach Extendable Turrets (HRET) for its firefighting fleet. These 2 HRETs are capable of piercing an aircraft fuselage to reach inaccessible areas, such as the cargo holds or the electronics bay. The newer of the two, the Austrian-made Rosenbauer "Stinger" HRET, was delivered to Changi Airport in 2016. The older vehicle, the American-made Oshkosh "Snozzle", was delivered to Changi Airport in 2012. Changi Airport scored two firsts for both HRETs; The "Snozzle" is built upon the Oshkosh "Global Striker" chassis and is the first to be operated in Southeast-Asia; while the "Stinger" is built upon the newly designed Rosenbauer "Panther III" chassis, and Changi Airport is the first in the world to operate this new model.

Capabilities of the HRETs

The "Stinger" is equipped with a boom that extends up to 17m, making it taller than the largest passenger aircraft in the world, the Airbus A380. At the forward end of the boom is the monitor and the piercing tip. Unlike older models of the HRET, the monitor of the "Stinger" is able to discharge 6000 liters of water per minute when the boom is stowed, allowing it to be deployed as a primary firefighting vehicle. When the boom is extended, the water discharge drops to 3800 liters per minute. When at rest, the piercing tip is housed in a protective casing for safety and will be deployed when the need arises. The mode of deploying the piercing tip mimics that of the stinging mechanism of a bee, in which once the protective casing is firmly on the aircraft fuselage, the piercing tip will be extended pneumatically. As such, the vehicle is nicknamed "Stinger". There are also thermal imaging and colour cameras at the tip of the boom to allow the operator to perform more accurate piercing operations.

The "Stinger" is powered by a Volvo engine which generates 700 horse-power (hp) with a 6-gear automatic gearbox. At its fully laden weight of 39 tons, the "Stinger" accelerates from 0 to 80 km/h in about 32 seconds, and

Figure 1: Changi Airport's HRETs poised in action, with the piercing tips deployed. The Rosenbauer "Stinger" is on the left, and the Oshkosh "Snozzle" is on the right.

boasts a top speed of between 115-120 km/h. It is able to achieve its targeted response time of 2 minutes to any location on the runway, as stipulated by international regulations. It carries a load of 12,000 liters of water, 1500 liters of AFFF foam solution and a variety of rescue and firefighting equipment. Due to the topography of Changi Airport, there may be a need for its firefighting vehicles to go off-road, should an aircraft undershoot, overshoot the runway, or veer off the sides of the runway. The "Stinger's" all-wheel axle system is attached to the chassis by means of a flexible suspension system. Shock absorbers with progressive coil springs ensure the "Stinger" can travel across any terrain. To enhance its off-road feature, the "Stinger" has differential and inter-axle locks. The overall design of the vehicle has been improved with better axle load distribution and a lowered center of gravity.

The older vehicle, the "Snozzle", operates in a similar fashion as the "Stinger". Powered by a Deutz engine, the drive and operational performance of the vehicle is very much similar to the "Stinger". The main difference is the way the piercing is carried out. Unlike the "Stinger", where the piercing tip is stowed in its casing and deployed pneumatically into the aircraft fuselage, the piercing tip of the "Snozzle" is deployed by hydraulics, using the force of the boom to drive the piercing tip into the aircraft fuselage. In terms of vehicle performance, the "Snozzle" is comparable with the "Stinger", but its monitor output lags behind the "Stinger" at only 3000 liters per minute when stowed. However, it was the best available vehicle in the industry at the time of procurement.

Both HRETs in Changi Airport have the ability to be operated by just one person. With the steering wheel located at the center of each vehicle, the operator has a clear vision of his surroundings. The firefighting controls are all within reach of the operator to minimize additional movements. Unlike older models of fire vehicles where multiple buttons and switches overwhelm the operator, both HRETs' operations are mostly executed by one-touch buttons or switches. The "Stinger" took it one step further by introducing a "joystick within a joystick", eliminating a separate boom control present in the "Snozzle". The fire pump of each vehicle is activated by the Power Take Off which allow both vehicles to conduct firefighting operations on the move.

Safety Features

With the advancement of technology, Changi Airport's "Stinger" is packed with advanced safety features. Unlike its predecessors, the main cabin of the "Stinger" is constructed from high-strength, extruded aluminum profiles and sandwich panels. The cabin is certified with the ECE R-29-3 certification, which dictates the requirements of structural integrity to be met in a series of actual crash tests. Previous structural integrity tests were largely based on computer simulations. Also, the "Stinger" has four cameras placed at strategic points around the vehicle, giving the operator a bird's eye view of the vehicle's surroundings. When making turns at high speeds or on a wet surface, the "Stinger's" Roll Stability Control (RSC) function regulates the tire spins to ensure it does not overturn. The tires are also fitted with tire pressure warning devices to alert the operator should the tire(s) be underinflated. The "Stinger" is also equipped with a data logging function for maintenance and investigation purposes.

HRET Operations at Changi Aiport

The HRET is used at major airports around the world; at Los Angeles, Manchester, Beijing and Copenhagen, to name a few. In 2006, the HRET was used at Philadelphia International Airport to extinguish a fire in a freighter aircraft by piercing the fuselage to reach the burning cargo containers. Piercing operations are destructive to the aircraft fuselage, and as such Changi Airport is mindful of the potential economic losses for the affected airline should piercing be carried out. As such, there are strict training regimes and operating procedures in place to ensure that piercing operations are conducted based on well-informed decisions. As part of the operating procedures, the command to pierce the aircraft will come from the Operations Commander, or the Duty Officer, in the absence of the former.

The command to pierce will only take place after a thorough assessment had been made on the affected aircraft. Thankfully at Changi Airport, there has not been a need to activate the piercing tool prior to the time of writing.

Apart from aircraft firefighting operations, the HRET is also used for firefighting at Changi Airport's fuel farm, known as Changi Airport Fuel Hydrant Installation (CAFHI). There are 16 fuel tanks at CAFHI, each holding about 5 million liters of JET A1 fuel on average. As AES will be the first responder to CAFHI in the event of a fuel tank fire, the HRET will be among the resources to be deployed. With the fuel tanks towering at 14 meters, the extended height of the HRET (17 metres) is sufficient to reach the top of the tanks to be able to flood the affected areas with extinguishing media.

Conceptualisation, design and purchase of the HRETs

Before the integration of the HRETs into Changi Airport's AES fleet, the main fire stations along both runways in Changi Airport operated with 4 standard foam tenders each, giving a total of 48,000 liters of water per fire station. This amount far exceeds the international requirement of 32,300 liters of water for firefighting operations. Changi Airport aims to be a global air-cargo hub, and as such, there has been a corresponding increase of freighter aircraft serving Changi Airport for both scheduled and non-scheduled flights. This increase, coupled with the projected expansion of Changi Airport, AES Changi has resulted in a need to invest in more advanced technology to enhance AES's existing capabilities. Study visits were conducted to various airports globally to understand the operational complexities and effectiveness of operating the HRET. Eventually, Changi Airport proceeded to add the HRET to its fleet.

For each HRET, it took the AES project teams almost 2 years to identify, design and work with suppliers for the acquisition of the vehicle. As part of the project milestones, the project team for each vehicle made trips to Oshkosh, USA and Linz, Austria for the design review and subsequently, the factory acceptance tests. These trips were critical to ensure that the tender specifications and international requirements were strictly adhered to before the manufacturing phase. Testing of the operational functions of the vehicle was also conducted before it was shipped to Singapore. These tests included pump discharge test, acceleration test, top speed test, brakes test and the tilt test. Both the HRETs had their factory acceptance tests conducted during the winter months. Despite the stability tests of the vehicles being conducted on wet and icy surfaces, both HRETs passed the stability tests without issues.

As airport vehicles, both HRETs comply with international requirements for airport operations. The major regulations include those of the International Civil Aviation Organisation (ICAO), the US Federal Aviation Administration (FAA) and the National Fire Protection Association (NFPA).

Conclusion

Today, both HRETs stand proud at Changi Airport's fire stations, entrusted with the noble responsibility of the safety of passengers and aircraft that visit Singapore.

RACE FOR RESPONDERS 2016

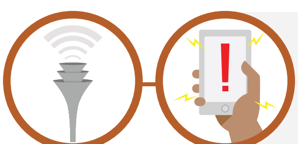
It has been SCDF's dream to conduct a race to foster fellowship between responders from around the world and concurrently raise awareness of the job of emergency responders. This became a reality with our inaugural event, the 'Race for Responders' (R4R) held on 10th November 2016. The run took the international participants through iconic landmarks in Singapore. Some SCDF personnel even ran alongside the participants in their firefighting bunker gear to fit the theme of 'First Responders'.

Being the inaugural run, the general public was not involved this year. In subsequent R4Rs, we hope to see the general public running alongside our very own lifesavers. We also aim to spice up the experience by including obstacles themed in the spirit of emergency services.

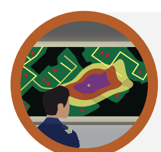
Watch out for R4R 2017!

Enhanced HazMat Capabilities

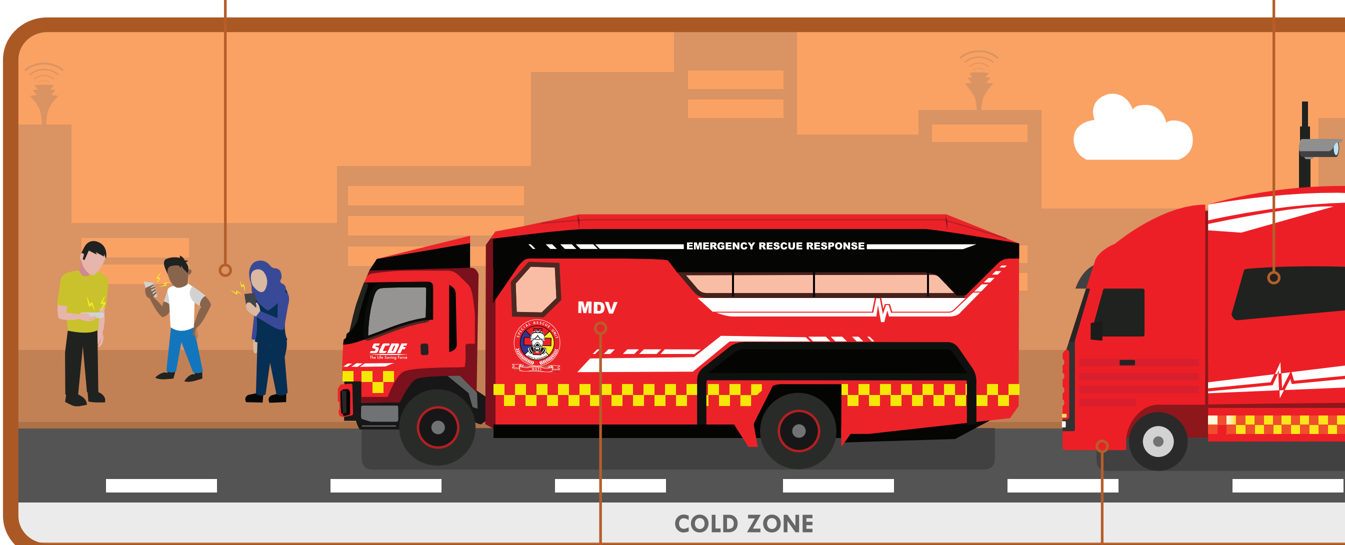
Singapore's status as a regional biochemical hub requires that it remains operationally capable and ready to deal with any CBR-related threats. As terrorism remains a constant threat, the Force has also enhanced its capabilities to effectively mitigate against all incidents.



Public Warning System 2 (PWS2)
SCDF is exploring chemical sensors and camera-equipped sirens as part of the Public Warning System (PWS) 2 project. In addition, next-generation notification technologies will be utilized to quickly warn the public of incidents.



HazMat Incident Management System 2 (HIMS2)
The enhanced Hazmat Incident Management System (HIMS) 2 will continue to serve as a mission-critical command and control system to aid on-scene commanders. HIMS2 will also have the capability to do 3D plume modelling.warn the public of incidents.



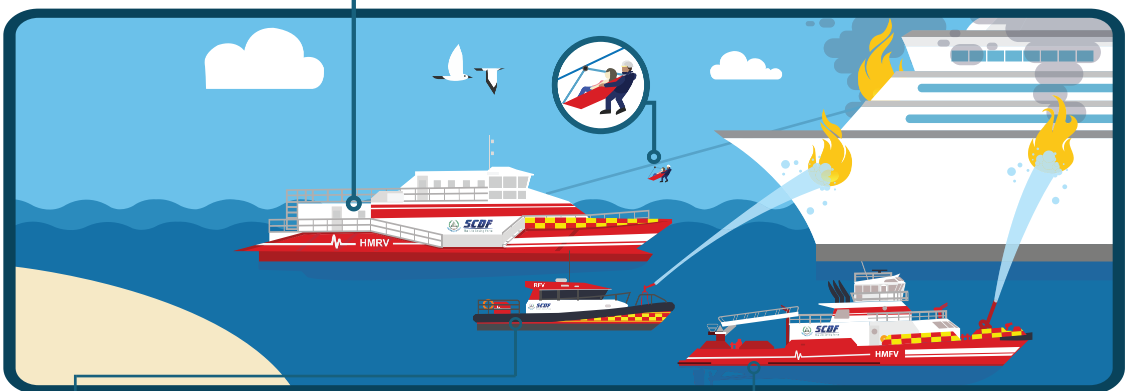
Mass Decontamination Vehicle (MDV)
The MDV allows for the concurrent decontamination of both ambulatory and non-ambulatory casualties while increasing the decontamination capabilities.

Next-Gen Hazmat Control Vehicle (HCV)
The HCV is deployed for the identification of hazardous substances, assessment of contamination and to determine the mitigation approach for the incident. With new detection technologies, communications equipment and vehicle-in-vehicle concept, it is highly capable.

Robust Marine Response

Singapore is a bustling maritime port which handles one of the world's busiest ports. With SCDF appointed as the incident manager of all CBR threats, the Force will need to enhance its maritime capabilities.

Heavy Marine Rescue Vessel (HMRV)
The Heavy Marine Rescue Vessel (HMRV) allows SCDF to carry out the evacuation of mass casualties as well as complex marine rescue incidents. Armed with Fi-Fi Class 1 equivalent external fire-fighting capabilities, the HMRV is also a fire-fighting vessel.

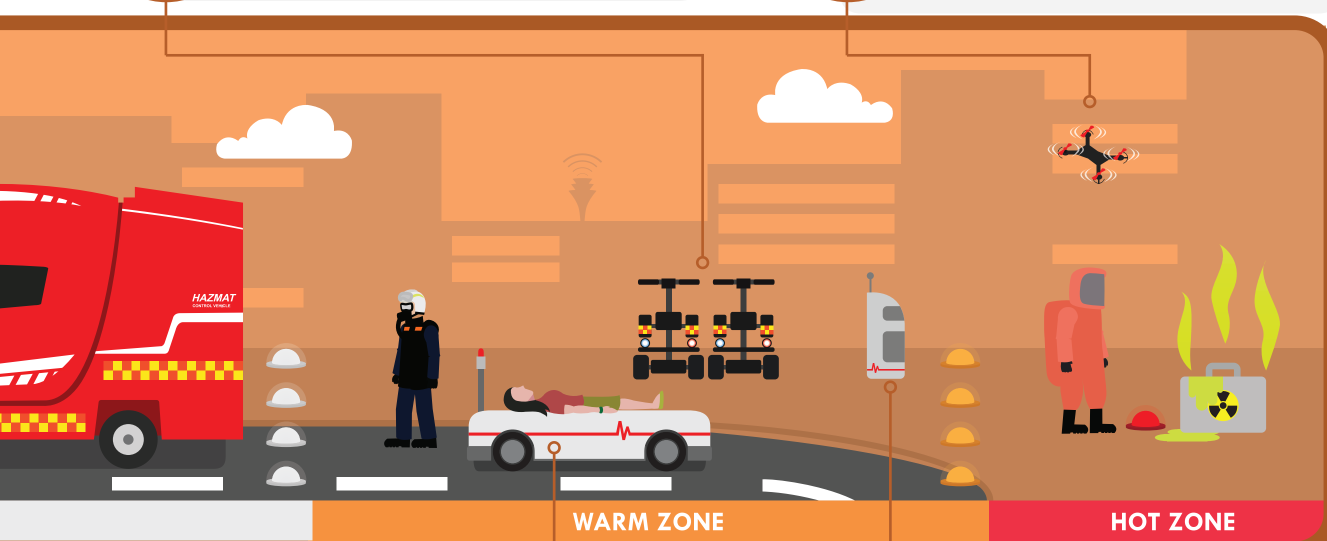


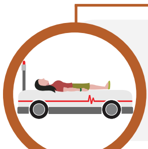
Rapid Response Fire Vessel (RFV)
The Rapid Response Fire Vessels (RFV) provides speedy operational coverage and is equipped with a water monitor and shallow draft to handle small fire incidents on its own. For larger incidents, the high speed vessel is capable of arrive on-site to provide timely information to subsequent responding vessels.

Heavy Marine Fire Vessel (HMFV)
The flagship of the SCDF Marine Command fleet, the Heavy Marine Fire Vessel (HMFV) is designed with heavy fire-fighting capabilities to handle the worst case scenarios within Singapore Waters. The vessel is also equipped with command and control facilities to allow it to function as a forward command post.

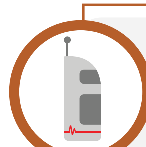
Mobile Transporter
A mobile electric vehicle to carry SCDF personnel and allows them to cover large areas quickly while also detecting toxicity levels in the air and sending back information to the control vehicle (HCV) wirelessly.

Unmanned Aerial Vehicle (HazMat)
It transmits images and remote detection of chemical agent, radiological agent and TICs. It also incorporates swarming capability whereby multiple aerial devices will interact with each other to effectively map out the area of contamination.





Mobile Casualty Machine
To increase the effectiveness of casualty conveyance, SCDF is actively looking into introducingrobots to quickly convey casualties out of disaster zones.



Chemical Standoff Detector
Standoff chemical detection system is designed for early warning, real time visualization and monitoring of chemical clouds from a safe distance. Such system will complement our existing point-source detectors, in enhancing SCDF's overall monitoring capability.

Editorial Preview

For those who have gone out on field camps for 1 to 2 weeks at one go, when given a choice between dry powder baths or a nice cool shower, one tends to choose a wet, cool shower. Wet showers as compared to dry powder baths conventionally tend to give a better cleansing experience and clears out dirt faster.

During chemical agent incidents however, SCDF responder utilises the dry decontamination technique for its responders wearing Nuclear, Biological and Chemical suits to decontaminate. Such a technique has its constraints in terms of time taken and the capacity it can offer.

With wet decontamination offering a faster and cleaner decontamination experience, the challenge was in testing the suits to ensure that wet decontamination would not cause agents to be exposed to the responders whilst doing wet decontamination. This article documents the developmental process of an alternative method of wet decontamination of NBC suits.

Interested persons who want to learn about the alternative method can contact the Editorial Board to find out more.

DEVELOPMENT OF AN ALTERNATIVE DECONTAMINATION PROCEDURE

MAJ Mak Chee Hoe Kenneth, Senior Staff Officer, HazMat Department
Singapore Civil Defence Force

Introduction

In today's heightened security climate, frontline responders from most fire and rescue services are trained, equipped and expected to operate in hazardous environments. The same applies to the frontline responders in SCDF. SCDF's responders are all trained and personally-issued with Nuclear, Biological and Chemical (NBC) suits as their Personal Protective Equipment (PPE), so that they can be adequately protected when responding to such incidents.

During a Chemical Agent (CA) attack, responders have to be properly decontaminated whenever they exit the contaminated zones. Decontamination is an integral process as it removes the harmful contaminants (gases, liquids or solids) from the PPE, hence preventing responders from being exposed to the contaminants. The technique of dry decontamination of NBC suits was adopted from the military many years ago and has been used in SCDF since then. Although dry decontamination is considered an effective method in removing the contaminants, it has several constraints and limitations involved.

Through experimentation and partnership with the Singapore Ministry of Home Affairs' Office of the Chief Science & Technology Officer (OCSTO), the SCDF has developed an alternative procedure for decontamination: wet decontamination.

Existing Decontamination Process and Limitations

In the existing decontamination process, responders in NBC suits are required to decontaminate themselves using the "dry decontamination method" after they have concluded their tasks in a contaminated environment. This involves the use of the Fuller's earth decontamination gloves. Fuller's earth is a clay material which has the ability to absorb contaminants, oil and grease off the NBC suit. Dry decontamination is a common practice worldwide, especially in military settings where water is scarce and difficult to transport. The procedure is critical to prevent cross-contamination between a wearer and the contaminated NBC suit.

Based on the SCDF's concept of operations, a designated dry decontamination lane is set up for the responders in NBC suits (see Figure 1). The responders will first move into a dam decon pit (see Figure 2) to dust their NBC suits with the decontamination gloves, before doffing off their NBC suits.

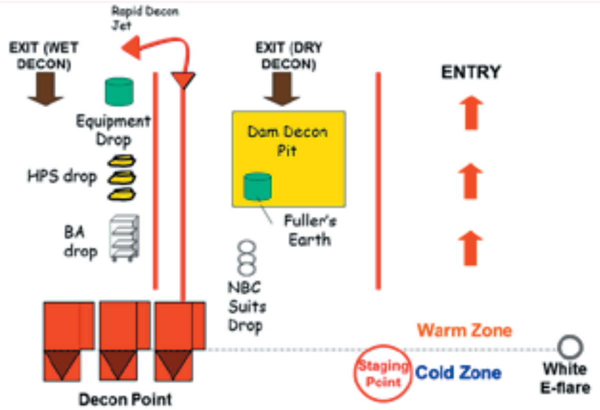


Figure 1: Existing decontamination area setup for CA incidents

Figure 2: A dam decon pit being set up at a CA exercise

During trainings and exercises, it has been observed that delays often occur at the dry decontamination area. The delays were mainly due to the time taken for the responders to decontaminate the NBC suit, which is approximately 3 minutes for each responder to be fully decontaminated. The capacity of the dam decon pit, which can accommodate only 4 to 5 responders each time, was another contributing factor to the delays. An alternative procedure for decontamination was developed to overcome these limitations. The possibility of using wet decontamination for NBC suits was thus surfaced, and a series of experiments and trials were conducted to determine its viability.

NBC Suit Used by SCDF

A fundamental consideration for the viability of wet decontamination is the ability of the NBC suit to withstand the process. Currently, the one-piece Saratoga[1] 6-hour Chemical Protective Coverall is issued to all frontline responders in SCDF. The suit, lined with a layer of activated carbon, can be used for up to 6 hours in a contaminated environment (see Figures 3 and 4) [1].

The outer shell fabric of the suit is made from Polyamide and undergoes water repellence treatment. Based on the product specifications obtained from the manufacturer, the suit can withstand wet decontamination without compromising the functions of the suit. An uncontaminated suit can also be washed and dried up to 6 times. The water repellence properties of the suit therefore makes it possible for responders wearing such NBC suits to undergo shower decontamination.

Apart from the suit, the complete NBC PPE includes a respiratory protective facemask that is connected to a powered air-purifying respirator (PAPR) to enhance the comfort level of the wearer. Each PAPR is in turn fitted with 2 Chemical, Biological, Radiological and Nuclear (CBRN filter canisters for the filtration of contaminated air (See Figure 5 for the complete PPE).

1 Saratoga 6-hour Chemical Protective Coverall is manufactured by BLÜCHER GmbH. The outer layer (shell fabric) is impregnated with water and oil repellency treatment.

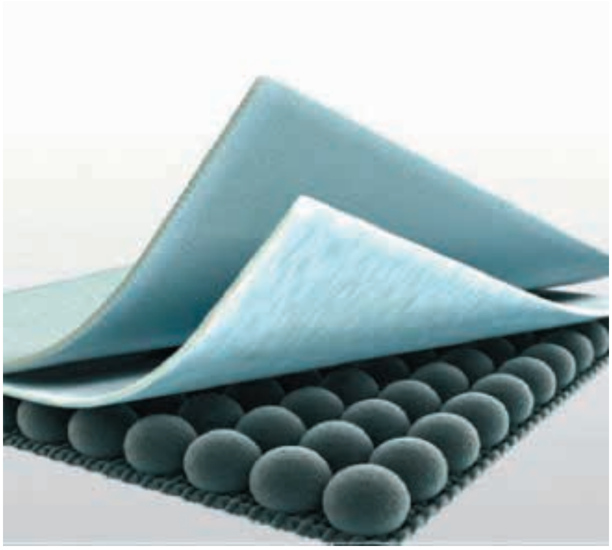


Figure 3: A layer of activated carbon spheres

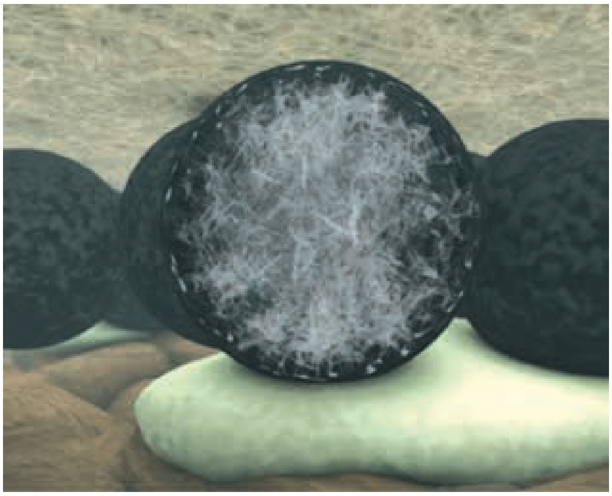


Figure 4: Cross-section of a carbon sphere where the white grids indicate adsorbent of CA

Figure 5: A responder wearing the Saratoga 6-hour Chemical Protective Coverall and the PAPR with canisters mounted on his back

Wet Decontamination Trial

Water serves as a good agent for the removal of chemical agent contaminants from the suit. To validate the water repellence properties provided by the NBC suit manufacturer, SCDF conducted a wet decontamination trial on it, using a fully-charged Portaflex – a portable decontamination shower system with four shower legs that provide 360° decontamination. The shower legs become rigid under pressure and form a stable frame for the contaminated personnel to walk through (see Figure 6). The Portaflex does not require any manning and can be set up quickly in 45 seconds. This served to replicate the actual conditions of wet decontamination, under which personnel would go through.

Figure 6: A fully-charged Portaflex shower, forming a frame by the four shower legs

During the trial, 20 responders donned the NBC suit, together with the facemask fitted with CBRN filter canisters, rubber protective gloves and fire top boots (see Figure 7). Each responder stayed in the Portaflex shower for 15 seconds. No water was observed to have seeped into the NBC suit and subsequently, inspections of the suit revealed that water did not penetrate the suit. This suggested that the safety of any responder undergoing this procedure in an actual incident would not be compromised. The water repellence properties of the NBC suit were therefore proven which paved the way for the next step in the development of a comprehensive wet decontamination procedure.

Figure 7: A responder donned in NBC suit undergoing wet decontamination

Testing of CBRN Filter Canisters by OCSTO

Having established the water repellence properties of the NBC suit, the next step was to find out if CBRN filter canisters for the filtration of contaminated air would result in the release of trapped chemicals when water was introduced. For this portion, SCDF collaborated with the Singapore Ministry of Home Affairs' Office of the Chief Science & Technology Officer (OCSTO).

The exact same set of test [2] were conducted for different types of simulants and concentration levels. Each set of test involved spiking the filter canisters, which

Figure 8: A Tenax mesh was put at the air outlet of the PAPR before the experiment. The filter canisters were then spiked before rinsing under running tap water to simulate wet decon.

were attached to a PAPR, with simulants of toxic industrial chemicals, nerve agents and blister agents respectively. The PAPR was then left running at the highest speed for 2 hours for each simulant. Subsequently, the filter canisters were placed under running tap water for 20 seconds while the PAPR was still running. After the PAPR was switched off in each experiment, a Tenax mesh, which was placed at the air outlet of the PAPR blower before the experiment, was removed and analysed for traces of the simulants. (See Figure 8 for the experiment procedure).

The test concluded that wet decontamination of the PAPR would not cause chemicals, trapped in the CBRN filter canisters, to be released back to the user. This was provided that the concentrations of the chemicals did not exceed the maximum specified concentration that could be used on the canisters, i.e., 5,000 parts per million (ppm).

Development of the Wet Decontamination Procedure

Having established that the NBC suit and the CBRN filter canisters were capable of undergoing wet decontamination, a procedure had to be established for responders in NBC suits to undergo wet decontamination. This involved the replacement of the dry decontamination procedure with wet decontamination using the Portaflex. This would allow the removal of a dedicated dry decontamination lane, and all responders would instead proceed to the wet decontamination lane to be decontaminated (see Figure 9). To facilitate this procedure, the Portaflex will be stowed in the HazMat Mitigation Vehicle (HMV) and set up by the HazMat Incident Team (HIT) during an operation.

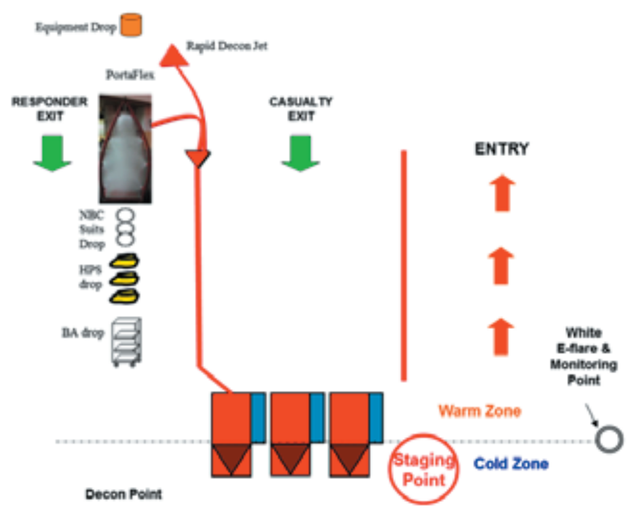


Figure 9: Revised decontamination area setup for CA incidents

Based on the wet decontamination conducted earlier, a responder would be able to complete the decontamination process in just 15 seconds, without compromising his safety.

Assuming that there are 100 responders in NBC suits in a single incident, the amount of time saved exceeds 60% (refer to Table 1), thereby facilitating the transition of an operation into the recovery phase.

	Turns needed	Time needed
Dry Decon (5 responders in 1 pit)	100/5 = 20 turns	20 x 2 mins = 40 mins
Wet Decon (using 2 Portaflex)	continuous	(100 x 15 secs) / 2 = 12.5 mins

Table 1: Time illustrations between the dry and wet decontamination methods

In summary, Table 2 shows the comparisons between the dry and wet decontamination procedures:

	Dry Decon	Wet Decon
Decon Material	Fuller's Earth	Water
Equipment	Dam Decon Pit	Portaflex
Time Required to Decon	2 min per responder	15 sec per responder
Lane Set-up	Need to set up a dry decon lane for responder donning the NBC suits and wet decon lane for chemical encapsulated suits.	No separate decon lanes required. A single wet decon lane for chemical encapsulated suits and NBC suits can be set up.
Procedure	Responder needs to go through several steps for the dry decon.	Responder only goes through the Portaflex.

Table 2: Comparisons between the dry and wet decontamination methods

Conclusion

The developmental process of the wet decontamination procedure demonstrates the SCDF's efforts at innovating through experimentation and partnership. Having identified the limitations of the existing dry decontamination procedure, an alternative solution in the form of wet decontamination was developed through experimentation. The SCDF's partnership with OCSTO further enhanced the development process with clinical analysis. The result is a streamlined procedure that allows responders to decontaminate themselves faster, with a simpler set-up. The need for consumables such as the Fuller's earth decontamination gloves has also been removed. As a new procedure that simplifies, streamlines and standardises the decontamination process of responders, it is hoped that this developmental process proves instructive to further attempts at iterative innovation by SCDF.

References

1 www.blucher.com

2 Phua Xu Mei, Su Hui Yun. Evaluation study on wet decontamination of powered air purifying respirator. OCSTO, 2016

SINGAPORE CIVIL DEFENCE

SCDF

The Life Saving Force