

行政院所屬各機關因公出國人員報告書（出國類別：考察）

參加第八屆國際消防設備技術交流展覽  
會及學術研討會議暨參訪中國大陸建築  
防火及消防科研重要機構單位考察報告

出國人 服務機關：內政部建築研究所

職 稱：副所長

姓 名：丁育群

職 稱：副研究員

姓 名：王鵬智

出國地點：中國大陸

出國時間：八十九年十月八至八十九年十月十八日

報告日期：中華民國九十年元月

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## 第壹章 考察緣起

本項赴大陸地區計畫係依內政部八十八年七月六日台(八八)內會字第八八〇二六四九號函轉行政院八十八年七月一日台八十八忠授一字第〇五五九〇號函核定之本所單位預算，核定派員赴大陸進行合作研究計畫或參加大陸地區舉辦之國際性學術會議；本計畫原訂於八十八年十月派員參加由中國科技大學主辦之「一九九九城市火災安全國際會議」並發表論文，因逢國內發生九二一地震，本所為辦理該震害調查分析，協助災區重建，無法參加該會議計畫，爰延至八十九年執行。適逢大陸地區於八十九年十月十七日至二十日於北京國家農業展覽館舉辦「第八屆國際消防設備技術交流展覽會及學術研討會議」，該會議籌備委員會來函，邀請本所丁副所長育群參加該國際會議並發表論文；經審慎評估，乃撰擬「台灣地區建築防火材料現況與展望(The Perspective and Recent Development of Building Fire Protection Materials in Taiwan)」報告乙篇投稿(如附錄一)。

我國投入建築防火研究已多年，並具相當成效；惟考諸各先進國家在建築防火的研究成果，我國在建築防火的領域仍有相當研發空間，同時，國際間建築防火研究漸有合作與整合的趨勢，大陸投入建築防火領域之研究業有多年，並有多項全尺寸實驗之設備與經驗，本所刻正規劃建築防火實驗室，恰可藉由本次參加國際研討會之機會，實地考察大陸地區防火實驗室之設備並交流經驗，作為我國規劃相關設施、設備之參考。

一、 依據：行政院核定計畫：

1. 內政部建築研究所建築防火科技發展方案中程綱要計畫--建築物防火安全技術開發與應用研究五年計畫
2. 內政部建築研究所建築實驗設施設置計畫(建築防火實驗群設施設備規劃)

## 二、計畫內容：

1. 參加「第八屆國際消防設備技術交流展覽會及學術研討會議」發表論文報告，並與各國代表交流。
2. 蒐集大陸地區最近防火研究活動資訊報告及國際合作計畫成果報告等資料。
3. 蒐集大陸地區建築性能防火法規、防火工程設計、技術基準有關發展動向資料。
4. 蒐集大陸地區建築材料、耐火構造測試實驗室設施設備及人員技術有關資料。

## 第貳章 考察行程及概要

### 第一節 訪問行程

本次奉派赴大陸考察成員、時間及訪問概要簡述如下。

#### 一、考察人員名單

姓名	職稱	專長
丁育群	副所長	都市與建築防災規劃、防火設計、營建法規
王鵬智	副研究員	建築防火、營建法規、建築節能設計

#### 二、考察時間

民國八十九年十月八日至十月十八日。

#### 三、考察行程概要

為配合本所防火研究需求，本次考察特別選定中國大陸各單位中，從事建築防火研究以及防火實驗相關之單位，其中以公安部所屬消防科學研究所為主要參訪考察重點機關，因時間關係，特選定上海所、四川所以及天津所為對象，本次訪問大陸各消防科學研究所，係以內政部建築研究所身分往訪，感謝上海所邱副所長洪芳、蔣主任為民，四川所副所長、藍副處長彬、王主任炯，天津所韓副所長占先、賈主任宜普、倪副主任照鵬等人熱忱接待，並介紹提供許多寶貴資料；此外並順道參訪中國建築科學研究院防火研究所，受到李所長引擎的熱烈招待；同時為了解中國大陸建管行政作業概況，及建築師執業情形，由建設部建築管理司質量技術處吳慧娟處長安排，而有機會與建築管理司張副司長魯風，以及建設部執業資格註冊中心註冊處李文濤處長，交換兩岸建築管理及建築師業務心得。最主要還要感謝中國消防協會的王秘書長根堂、周秘書久經的協助聯絡，方始本次行程得以順利完成。另外由於主辦「第八屆國際消防設備技術交流展覽會及學術研討會議」單位要求，為加快主

辦單位的審查程序，本所丁副所長特以財團法人中華建築中心常務董事名稱投稿，謹此說明。

本次訪問之行程概要詳如表一。

表一 大陸地區考察行程一覽表

日期	拜訪單位	接待人員	活動內容	取得資料
10月 9日	上海消防 科學研究 所	邱副所長洪 芳、蔣主任為民	介紹上海消防科學研究 所研究主題與方向	上海所簡介資 料
10月 11日	四川消防 科學研究 所	藍副處長彬、王 主任炯	介紹四川消防科學研究 所研究主題與方向、中國 建築防火材料檢測制度	高層建築火災 實驗塔、地下 街商場建築火 災實驗資料
10月 12日	國家防火 建材質量 監督檢驗 中心	李副所長風	參觀耐火建築構件、防火 建築材料檢測設備	防火門、防火 建材實驗設施 與設備、2000 年中國防火建 材產品技術手 冊
10月 13日	中國建築 科學研究 院	建築防火研究 所李引擎所長	介紹中國建築科學研究 院建築防火所業務與實 驗設備	簡介資料、

10月 16日	天津消防科學研究所、國家固定滅火系統和耐火構件質量監督檢驗測試中心	韓副所長占先、賈主任宜普	介紹天津消防科學研究所研究主題與方向、參觀國家固定滅火系統和耐火構件檢測設備	簡介資料、
10月 17日	建設部建築管理司；	張副司長魯風、吳處長慧娟	介紹建設部建築管理司業務與建築師相關業務	工程建設與建築業法規彙編、中國工程建設標準全文檢索系統、註冊建築師文件彙編
10月 18日	China Fire 2000 國際研討會	中國消防協會	出席研討會並發表論文；  返程(北京→香港→台北)	學術研討會論文集

## 第參章 大陸建築防火研究發展概況

中國大陸現有 4 個消防科學研究所和 4 個附屬在消防科研院所的國家級消防產品質量檢測中心。包括：天津消防科學研究所、國家固定滅火系統和耐火構件質量監督檢驗測試中心、國家消防工程技術研究中心、公安部消防局火災原因技術鑑定中心；上海消防研究所、國家消防裝備質量監督檢驗測試中心；瀋陽消防研究所、國家消防電子產品質量監督檢驗測試中心、公安部消防局電氣火災原因鑑定中心；四川消防研究所、國家防火建築材料質量監督檢驗測試中心。這四個研究所在火災理論、工程消防、消防法規、消防裝備、滅火技術、火場防護技術、滅火理論、火因鑑定、消防通訊、火災探測報警、電氣火災建築火災理論、材料阻燃技術及建築防火應用技術等方向研究中，取得了多項科研成果，達到了 90 年代初國際同類產品的先進水準，儼然成為大陸重要消防科學實驗基地，確有足供我國建築防火研究參考者。

### 一、天津消防研究所及國家固定滅火系統和耐火構件質量監督檢驗測試中心：

主要研究火災理論、工程消防應用技術、火災分析鑑定技術、滅火劑、阻燃與防火材料、建築防火技術，是世界上規模較大的消防科研基地之一，設有 5000 立方米的滅火實驗油罐。“國家消防工程技術研究中心”、“公安部消防局火災原因技術鑑定中心”、“全國消防標準化技術委員會第一、二、三、八分技術委員會”、“全國自動消防系統工程標準化委員會”和中國消防協會學術刊物《消防科技》編輯部等機構附屬在該所。國家固定滅火系統和耐火構件質量監督檢驗測試中心主要負責國內外滅火藥劑、耐火構件和固定滅火系統及零組件等消防產品檢測任務和負責 ISO/TC21、ISO/TC92/SC2 的中國



對口工作。

## 二、瀋陽消防研究所及國家消防電子產品質量監督檢驗測試中心

主要從事消防電子科學技術研究、電氣火災原因技術鑑定、消防電子產品與系統工程標準化技術研究和產品質量監督檢驗工作，也是全中國電氣火災、消防通訊、火災探測報警技術和消防電子技術資訊開發與應用研究中心。“公安部消防局電氣火災原因技術鑑定中心”

“全國消防標準化技術委員會第六分技術委員會”、ISO/TC21/SC3 和 IEC/TC11/SC15D 的中國對口辦公室等均設在該所。國家消防電子產品質量監督檢驗測試中心主要負責國內外各種火災探測器、火災報警控制器、消防通訊設備、應急照明器具、火災警報器等 18 種消防電子產品檢測任務。

## 三、上海消防研究所及國家消防裝備質量監督檢驗測試中心

主要研究消防裝備技術、消防員火場防護搶險救生技術、滅火戰術、技術，滅火機理和滅火理論，飛機、船舶、車輛等交通工具火災原因鑑定試驗技術，消防裝備質量檢測技術和消防裝備標準技術的研究和開發。“全國消防標準化技術委員會第四、五分技術委員會”、ISO/TC21/SC2 的國內對口辦公室、“上海市化學物品及火災危險性標準化技術委員會”以及上海市消防協會的幾個專業委員會都附屬在該所。國家消防裝備質量監督檢驗測試中心主要負責滅火器、消防車泵和器具等檢測任務，被國家商檢局認可為消防裝備實驗室。

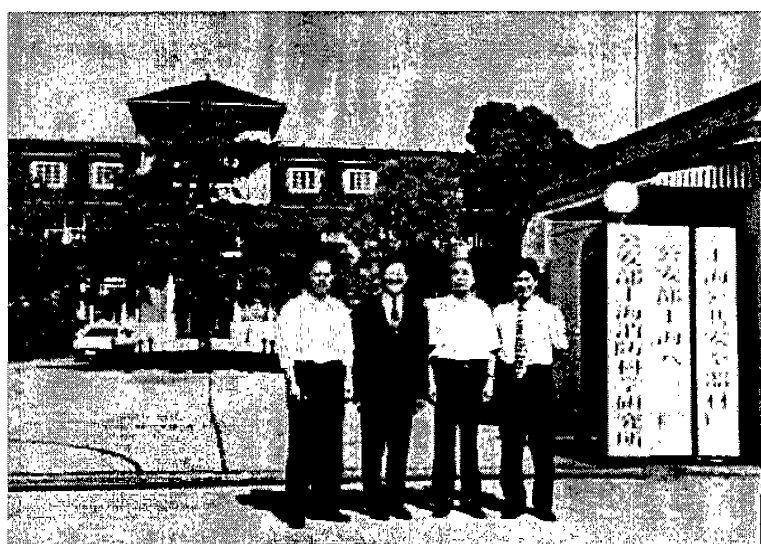
## 四、四川消防研究所及國家防火建築材料質量監督檢驗測試中心

主要研究建築火災理論、建築結構防火技術、建築火災燒損鑑定技術、高層建築防排煙技術、自動噴水滅火技術、防火保護及阻燃技術、材料燃燒煙氣毒性、新型防火建築構（配）件和防火建築材料開發、防火建築材料檢測以及工程防火標準、規範、技術等。該所是 ISO/TC92/SC1、5C3 和 SC4 的中國對口單位，也是“全國消防標準

化技術委員會第七分技術委員會”、國家標準《高層民用建築設計防火規範》管理工作的附屬單位。國家防火建築材料監督檢驗測試中心負責國內外建築材料、建築構（配）件、防火塗料和塑膠等防火建築材料檢測任務。

本次參訪單位限於時間關係，主要以上海消防科學研究所、四川消防科學研究所、以及天津消防科學研究所為對象，以下謹就上述三個科研院所與中國建築科學研究院建築防火研究所業務內容與研究方向簡要介紹。

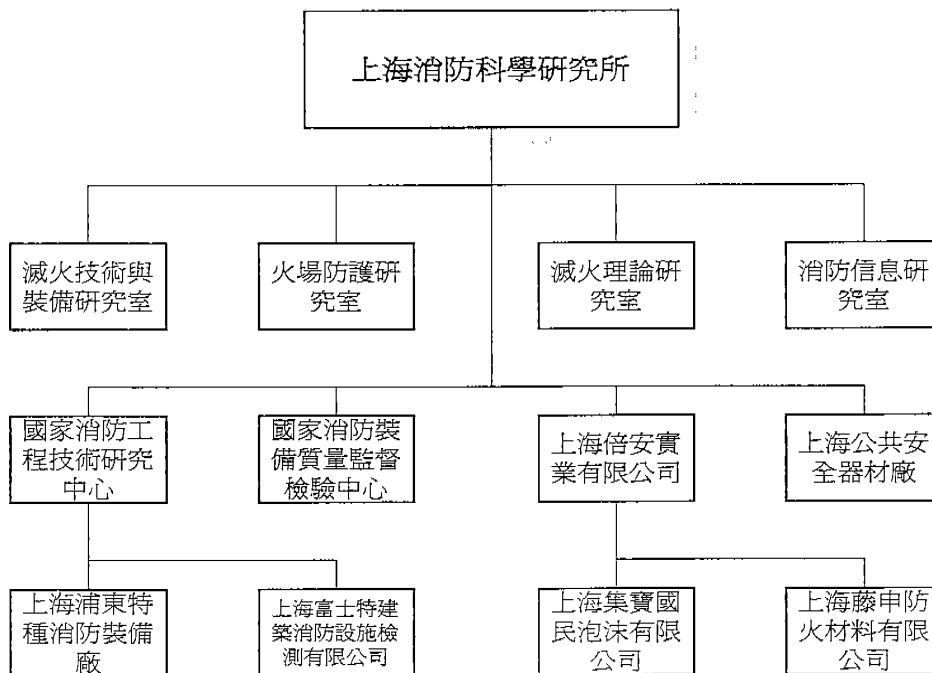
### 第一節 上海消防科學研究所



圖一 上海科學研究所外與邱副所長合影

上海消防科學研究所成立於一九六五年，是公安部直屬的技術警察單位，現任所長胡傳平。全所現有職工 980 餘人，其中技術人員 500 餘人，主要負責大陸國內公安消防部隊裝備的應用研究、國家消防裝備的質量監督檢驗任務和消防裝備技術，包括高層建築、地下工程、石油化工、能源、交通等領域的新技術的研究和開發。一九八七

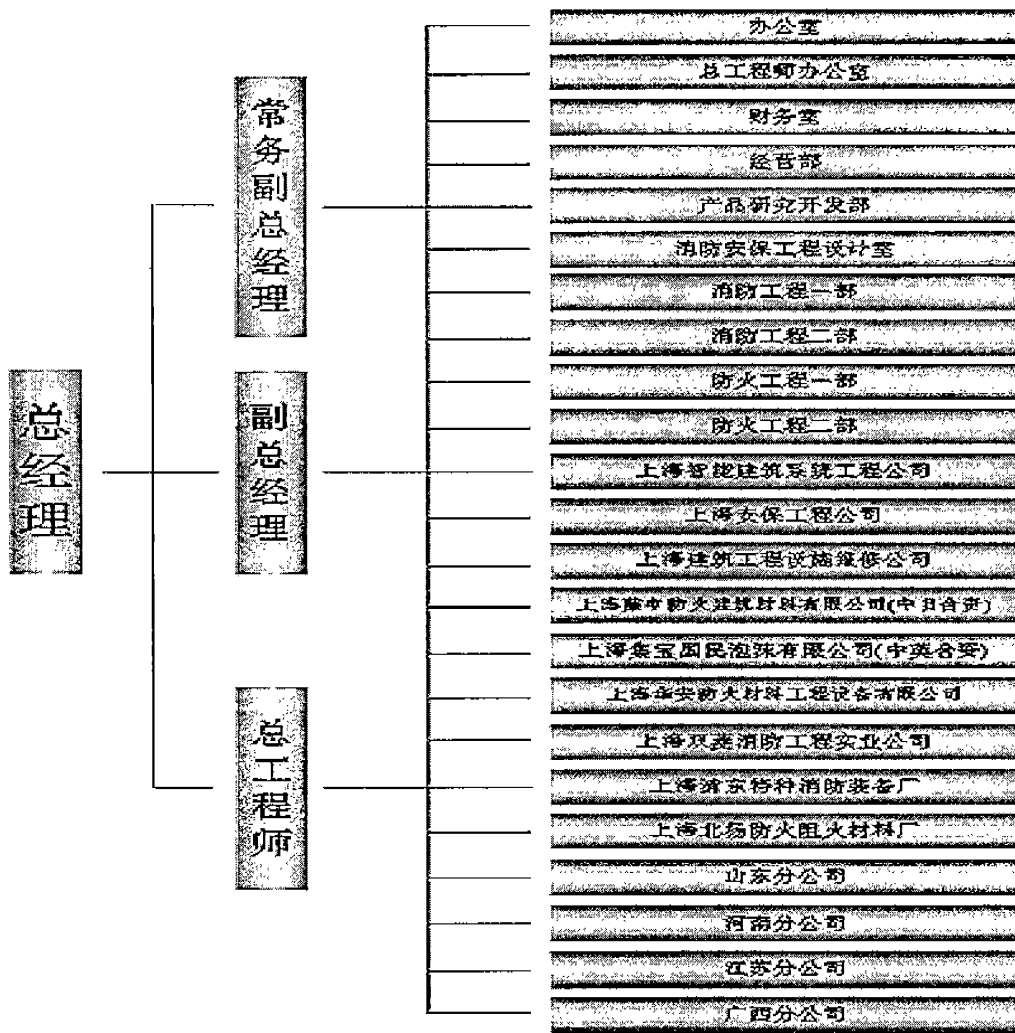
年通過中國國家審定建立的國家消防裝備質量監督檢驗中心是國家級的消防裝備質量監督檢驗機構，近年來又被批准為國家商檢局消防裝備認可實驗室，中國汽車總公司汽車新產品定型試驗單位，上海市消防產品質檢單位，主要負責消防車、泵、滅火器具、消防介面、水帶、搶險救生器材等產品的國家抽檢、產品認證、生產許可證發證檢驗、新產品和改型產品的定型試驗、仲裁檢驗，進出口商品檢驗以及其他消防產品的委託檢驗。在上海地區還負責地區性的各類消防產品的檢驗測試。一九九五年經國家科委批准，成立了國家消防工程技術研究中心上海分中心，主要負責消防裝備技術的研究和新技術產業開發，消防科技成果的轉化，提高消防新技術產品工藝和裝備研究開發的中試生產能力，提高科研成果的成熟性、配套化、產業化和工程化水準。



圖二上海消防科學研究所組織圖

為適應市場經濟的發展，由單純科研型向科研、生產、經營、服務型轉變，該所近年來逐步形成了一支水準較高的技術經營服務隊伍和經濟實體。科技人員積極貫徹消防科技，從事適合消防工作需要的消防車、消防艇、消防槍、炮等消防裝備技術和消防戰鬥服、指揮服、消防頭盔、空氣呼吸器等防護裝備技術的研究工作，研製開發了遙控消防炮滅火系統，中、低壓供水系統，液壓破拆工具、搶險救援系列裝備器材，還充分發揮本所人才和技術力量，研製了多種乾粉、泡沫滅火劑。為滿足中國大陸電力、冶金、石油化工等企業高層建築和地下工程電纜防火的需要，還研製了不同類型的電纜防火阻火產品。應用於高層建築、計算機房、倉庫等特殊環境的纜式火災探測報警系統的研究也達到了國際同類產品的水準，這些產品和技術在消防實際應用中發揮了顯著的社會效益。

該所下屬的上海消防研究所工程技術實業總公司，是以該所技術力量為依託，面向中國經濟建設保衛工作從事消防工程、技術服務的經濟實體。總公司下設技術、質量管理部門，消防、防火、安保工程業務部門和華安防火材料廠、雙菱報警設備廠、北楊防火材料廠三個聯營廠，上海集寶國民泡沫公司和上海藤申防火建築材料公司二個中外合資公司。總公司走向市場經濟以來，實行其所謂技、工、貿一體化，從事多方位的消防技術服務，已逐步形成了一支技術力量較強的設計、調試、施工隊伍和加工、生產企業。



圖三 上海消防研究所工程技術實業總公司組織架構圖

### 實驗室簡介

上海所內現有綜合樓 5000 餘平方米，建有物理性能、微量物證、滅火機理、燃燒特性、遙控技術、煙氣流動模似、水力特性、紅外鐳射等四十多個試驗室。在上海萊莊地區建有 2500 餘平方米的檢測、試驗基地和 6000 餘平方米的試驗場地，同時在上海浦東地區征地 30 餘畝，建有 4000 平方米車間的中試產品生產基地——上海浦東特種消防裝備廠，所內擁有各種先進的試驗、檢測儀器設備。近年來開通了

E-mail 和 Internet 互聯網、美國 Dialog 資料庫、上海資訊網等，為快速傳遞資訊創造了條件。

## 科技成果

上海消防科學研究所科技成果專案（包括著作）如下：基礎理論研究專案“火災煙氣流動水力模化的研究”、國家八·五科技攻關專案“高層建築滅火救災移動式綜合裝備系統的研究”、部隊戰術技術應用研究專案“高層與遠距離火場供水與滅火應用技術的研究”、標準制訂專案“GA137—1996《消防梯通用技術條件》”以及三本科技專著《建築滅火器配置設計手冊》、《消防車在結構與使用》和《桑塔納轎車使用與維修》，標準制訂專案“GA138—1996《消防斧》”、“GA139—1996《滅火器箱》”和兩本科技專著《消防車的常見故障與維修》、《國產輕型汽車的使用與維修》。

## 科技動態

根據一九九八年公安部科學技術研究計劃（消防部份）任務的指令，上海所負責該計劃內有關專案的課題組按科研專案進度執行表的具體要求進行，特別是其所謂的國家“九五”攻關專案和國家“八六三”計劃專案，都攻克關鍵技術難點，取得了階段性的成果。國家“九五”攻關專案專題“地下與大空間建築火災滅火救援特種裝備技術”已進入中評估階段。該所獨立負責的子專題兩項，第一項“遠端遙控移動式消防炮”，包括“壓縮空氣泡沫滅火系統”和“移動式消防炮”，前者基本完成了機架、發動機、燃油系統、離合器、油門操縱系統，取力器及傳動裝置的組裝。後者完成了大流量移動炮 60L/S 水炮、64L/S 泡沫炮（手動式）的設計並正在加工，大流量移動式遠控炮（氣動式）已完成設計。該項計劃今年底組織鑑定。第二項“特

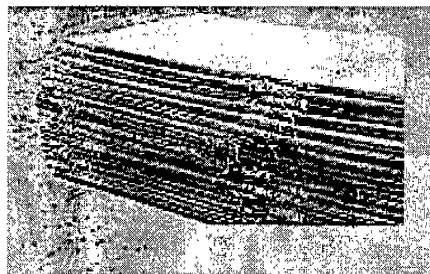
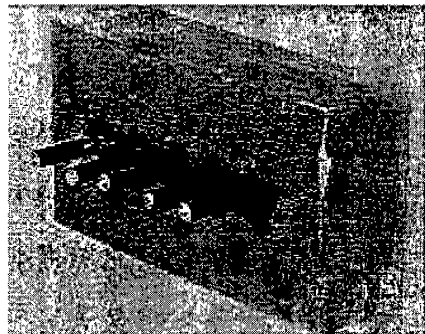
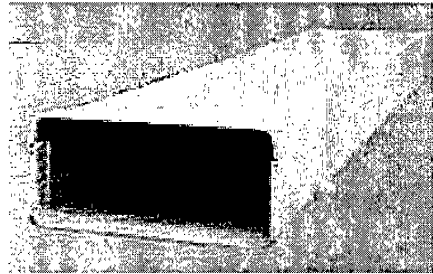
種救援裝備的研製”，包括“全密封消防防化服”和“移動式排煙設備”。九五”專案中上海所負責的子專題“細水霧流場特性對滅火效果影響的研究”已完成細水霧系統試驗裝置和噴頭的設計、加工，正著手進行試驗，提出優化特性參數；“地下商業街火災煙氣流動特性模化與仿真技術的研究”正進行水力模化試驗，已建立數學模型離散化方法，完成了電腦軟體的介面編制，計算程式和動畫的實現預計今年（2000）年10月份完成。國家“八六三”專案“消防機器人”已完成圖紙設計，正在進行樣機試製加工。建設部下達的“遠控消防炮滅火系統設計規範”專案，現已完成徵求意見稿，正在中國範圍內徵求意見。計劃年底完成送審稿。上海市各部委專案“自走式消防炮”和“消防炮遠端柔性控制系統”，目前正處於專案的最後衝刺階段。公安部專案“消防員防護服整體熱防護性能評價研究”，目前已完成大量試驗，撰寫完技術文件。另外尚有兩個專案“自動化大功率消防水泵檢驗裝置的研究”和“消防車水力系統連續運轉檢驗裝置的研究”。計劃今年底完成的“手提式滅火器採用國際標準質量控制新技術研究”和“消防過濾式自救呼吸器標準檢測技術及裝置的研究”，以及明後年計劃鑑定的專案、標準類專案都在進行中。二氧化碳滅火系統作為一種優良的滅火手段，在工業發達國家應用相當廣泛。它具有長期使用不變質、滅火效率高、電氣絕緣性好、無毒、無水漬損失、不破壞臭氧層等特點，被廣泛應用於電腦房、集控室、通訊機房、高低壓配電室、檔案館、珍寶庫等重要場所。該所及所屬的浦東特種消防裝備廠，在通過對國內外技術資料進行充分調研和深入分析的基礎上，根據高壓二氧化碳滅火系統國家消防工程設計規範和系統組建產品標準的要求，經過多次試驗研究，成功研製出G25型（40L）、2型（68L）高壓二氧化碳滅火系統，並通過國家固定滅火系統和耐火構件質量監督檢驗精試中心的檢測。

## 企業單位

### 上海倍安實業有限公司

上海倍安實業有限公司（原上海消防研究所工程技術實業總公司）是上海消防科學研究所與上海公共安全器材廠（公安部八二二廠）共同投資組建的技術先導型集團公司。主要從事高層建築、石油化工、能源交通等領域的消防、安保新技術產品的開發、生產和銷售；消防、安保工程的設計、安裝、調試、維修服務；並專業從事化工、機電、消防、安保產品進出口貿易業務。上海消防研究所工程技術實業總公司是專職從事智慧建築系統集成、火災自動報警、自動滅火、防火及安保系統工程承包，新產品、新材料開發生產經銷，集技工貿于一體的實業公司（國有企業），公司有高中技術人員 66 名，其中研究員 4 名、副研究員 11 名，享受政府津貼的專家 5 名。

該公司自 1976 年負責毛○○紀念堂消防工程任務起，在高層商貿辦公樓、賓館酒店、名勝古迹陵園、體育場館、航空港、港口、大中型電廠、地下工程、現代廠房等衆多領域承接了各種類型的消防、安保系統工程及其他服務專案，積累了豐富的技術經驗，具有綜合性的技術優勢，能提供從系統設計、設備供貨、施工安裝、開通調試、技術培訓及長期保養維修的綜合性服務。公司曾獲得上海市消防局首批頒發的甲級火災自動報警系統、甲級自動噴淋滅火系統、



圖四 各種防火阻料產品



甲級氣體滅火系統消防工程施工許可證；以及上海市公安局首批頒發的公共安全防範工程壹級設計施工資格證書；並先後獲得江蘇省、河南省、山東省、廣西省等消防局頒發的消防工程設施施工安裝許可證。經營範圍包括：智慧建築系統集成、火災自動報警、自動滅火、防火處理及電視監控、防盜、廣播音響等系統工程設計、施工、調試、開通與維修。滅火藥劑、防火材料、消防設備的開發、生產、經銷。

### 上海北楊防火阻火材料廠

上海北楊防火阻火材料廠具有三十多年歷史，是由上海消防科學研究所與上海北楊實業公司聯合創辦的一家主要從事防火、阻燃材料研究、開發防火、報警、自動滅火工程的設計安裝施工專業廠。該廠依託上海消防科學研究所，具有消防領域中門類齊全的各學科專門人才作技術後盾。目前該廠已研製開發了膨脹型防火包、無機耐火隔板、槽盒、通風管道、防火套管、無機自動防火門、纜線報警控制設備及多種防火塗料、有機防火塗料、無機防火塗料，多種阻燃劑等防火阻火材料及產品。這產品已在國內許多電力、冶金、化工、紡織等大型企業及賓館大樓獲得廣泛應用。該廠除了具有較強的研究、生產能力外，還擁有一支訓練有素長期從事防火工程安裝施工的隊伍。該廠長期以來一直從事電纜防火、建築防火工程勘察、設計、施工；對防火工程積累了豐富的經驗。從事電纜貫穿孔洞的封堵、電纜表面的防火塗料塗刷、電纜的其他防火保護，以及建築內部的防火分隔及防火保護。

## 第二節 四川消防科學研究所



圖五 四川科學研究所

四川消防科學研究所是公安部直屬的四個消防研究所之一。始建於1963年，其前身為公安部消防科學研究所，1965年從北京遷建於舉世聞名的都江堰水利樞紐工程近旁。經過三十多年的建設和發展，四川消防研究所據悉現已成為集科、工、貿於一體的專業骨幹科研實體，擁有一支經驗豐富，勇於創新，專業配套的科技隊伍和一批先進的科研實驗設備。公安部四川消防研究所(以下簡稱四川所)現有專業技術人員103名，包括建築、化學化工、機械、電子、材料、儀器儀錶、電腦、外語等多種專業人材。四川所是從事建築防火科學研究的專業研究所，主要負責公安部下達的指令性科研專案，同時也負責四川省科委下達的專案和承接中國各地方單位或企業委託或聯合研究的專案。在建築火災理論、建築結構防火技術、建築火災燒損鑑定技術、高層建築防排煙技術、自動噴水滅火技術、材料防火保護及阻燃技術、材料燃燒煙氣毒性評估與研究、新型防火建築構(配)件和防火建築材料開發、防火建築材料檢測以及工程防火標準、規範的制定等領域取得了豐碩的成果。

四川所在國內最早創建了建築構件（包括梁、板、柱、牆）耐火試驗裝置、自動灑水滅火系統試驗裝置、常見易燃易爆氣體爆炸濃度和爆炸壓力試驗裝置、材料燃燒性檢測裝置，建立了中國唯一的材料產煙毒性評價和九種煙氣成份分析試驗裝置。並先後建立了高層火災試驗塔、地下商業街火災試驗室，擁有先進的 PE 公司熱分析儀 PSC、TG、DTA 和 PE 公司的錐形量熱計，可以負責建築防火科學的各個領域的研究、火災危險性評價和防火產品的研製開發。



圖六 四川科研所高層建築火災實驗塔與地下商場實驗室

四川所亦是中國國內率先開發研製和推廣四種溫標的玻璃泡自動灑水噴頭、濕式報警閥門、水流指示器、壓力開關、水力警鈴、防火塗料、防火玻璃和防煙垂壁的單位。其他產品還有阻燃塑膠、阻燃電纜槽盒、阻燃木材、防火堵料、耐火包等產品，這一系列產品投放市場以來，為中國消防工程應用發揮了巨大作用。

國家授權具有第三方公正性的國家防火建築材料質量監督檢測中心附屬四川所，並負責對中國的防火建築材料、構(配)件和防火塗料類

產品的質量監督抽查檢驗、相關產品的定型鑑定檢驗、生產許可證的發證檢驗、進出口產品的質量評價檢驗以及國家標準、行業標準的制、修訂工作。

根據該所的業務特點和工程建設的需要，國家科技部和公安部分別批准該所成立了國家消防工程技術研究中心四川分中心和公安部消防局建築物火災燒損鑑定技術研究中心。受四川省消防總隊委託，成立了四川省天府建築消防設施檢測中心。

四川所是國際標準化組織 ISO/TC92/SC1、SC3 及 SC4 的對口單位，同時是中國工程防火防爆委員會、中國消防標準化技術委員會第七分技術委員會、防火建材技術委員會、中國消防協會建築防火專業委員會以及國家標準《高層民用建築設計防火規範》和《自動噴水滅火系統施工及驗收規範》管理工作的附屬單位，與國內外該領域、專家有著廣泛的聯繫和密切的技術交流與合作。



圖七 四川消防科學研究所外與該所人員合影

國家防火建築材料質量監督檢驗中心（NCFM）

國家防火建築材料質量監督檢驗中心是經國家質量技術監督局和公安部批准建立，於1987年經國家技術監督局正式驗收並授權成爲中國首批具有第三方公正性地位的、法定的國家級產品質量監督檢驗機構。授權負責：各類防火建築材料產品、耐火建築構(配)件產品和各類防火塗料產品的質量監督檢驗以及建築材料的燃燒性能分級檢驗。1990年通過了國家技術監督局的計量認證，1993年通過了國家技術監督局組織的實驗室和計量復查驗收，1998年又通過了國家質量技術監督局和中國實驗室國家認可委員會組織實施的“實驗室認可”、“計量認證”和“中心復查的“三合一”復查驗收。國家防火建材質檢中心行政上受公安部消防局直接領導，檢驗業務受國家質量技術監督局質量監督以及公安部科技局、消防局的指導。

目前，中心的組織機構爲一科一部三室，即：技術管理科、技術發展部、耐火建築構(配)件檢驗室、防火塗料檢驗室、防火建材檢驗室，擁有建築面積三千多平方米，儀器設備130多台套，固定資產近人民幣1千萬元。

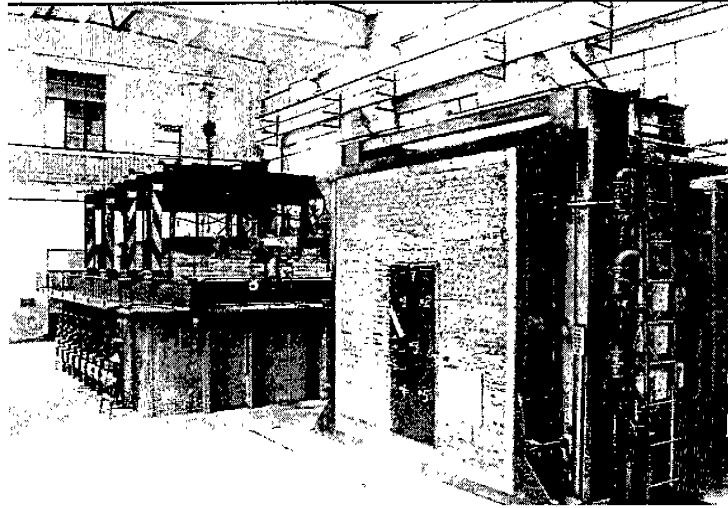
爲了完成質檢中心的技術執法工作，中心確立了“科學檢驗、公正評價、熱情服務、求實創新”的十六字質量方針。國家防火建材質檢中心除了負責檢驗任務外，還從事建材燃燒性能和防火材料相關標準的制、修訂或標準化技術對口、檢驗技術和檢驗設備的研究開發以及對地方消防監督機關人員培訓等工作。以下針對檢驗室工作簡介：

#### 1. 耐火建築構（配）件檢驗室：

耐火建築構（配）件檢驗室內檢驗項目包括：

- 構件耐火性能(梁、板、柱、牆、吊頂)
- 鋼質-木質防火門
- 防火卷簾

- 鋼質防火窗
- 防火閘
- 排煙防火閘
- 防火排煙風機
- 防火封堵材料(有機、無機堵料、阻火包、阻火圈、密封條等)



圖八 防火門試驗爐、柱構件試驗爐

- 鋼結構防火塗料
- 預應力混凝土防火塗料
- 防火玻璃
- 電纜防火槽盒、橋架
- 其他各類耐火建築構配件

## 2. 防火塗料檢驗室

防火塗料檢驗室檢測項目包括：

- 飾面型防火塗料
- 電纜防火塗料
- 阻燃和耐火電線、電纜

- 其他各類防火塗料



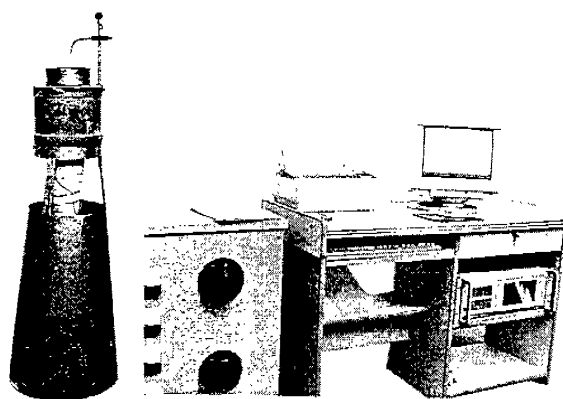
圖九 塗料大板控制室

### 3. 防火建材檢驗室

防火建材檢驗室負責業務如下：

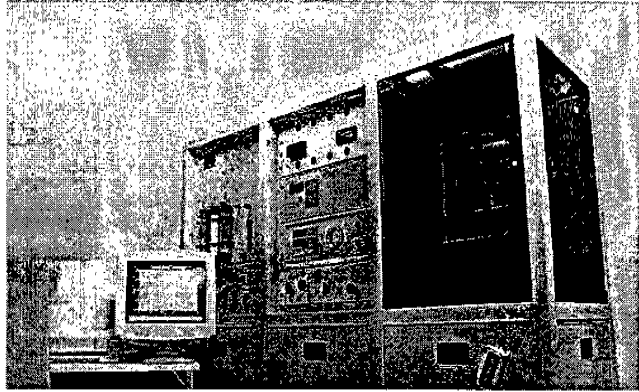
#### 一、檢測專案

- 建築材料燃燒性能分級檢驗
- 不燃性建築材料 A 級
- 難燃性建築材料 B1 級
- 可燃性建築材料 B2 級
- 煙密度
- 輻射通量
- 熱值
- 釋放熱量
- 煙氣毒性
- 各類阻燃劑



圖九 不燃性試驗設備

- 難燃電線電纜塑膠套管
- 阻燃窗簾幕布、織物
- 阻燃鋪地材料
- 阻燃泡沫塑料
- 難燃塑膠建材
- 輕質防火板材
- 耐火紙面石膏板
- 難燃刨花板
- 不燃性無機複合防火板
- 其他各類防火建築材料



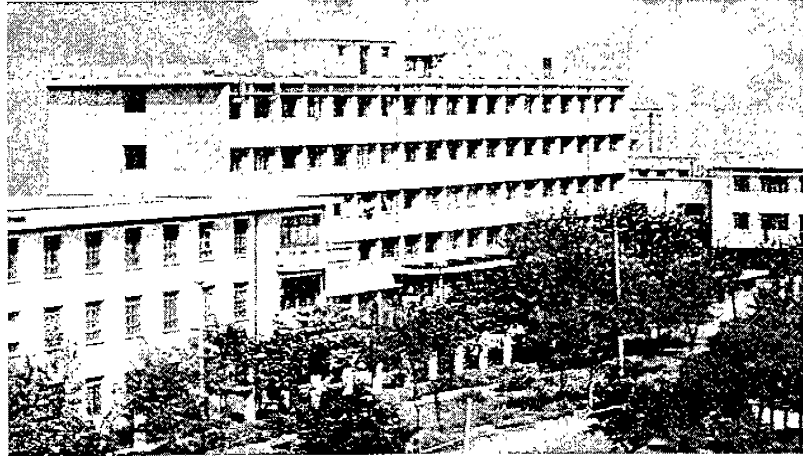
圖十 錐形量熱計

#### 國家消防工程技術中心四川分中心

國家消防工程技術研究中心（四川分中心）是建築防火及阻燃材料研究、開發、生產的專業機構，依託於公安部四川消防研究所。分中心於1996年經國家科委批准組建運行，其主管部門為公安部。四川分中心設開發部、工程部、系統測試部和辦公室，下設相應實體。現有：成都都江防火塗料廠，成都天府消防科技開發工程公司和四川消防科學研究所都江堰實驗工廠等三個經濟實體。隨著國家科技體制改革的深入，為使消防事業持續發展，研究所於一九九八年對消防工程分中心下屬的經濟實體實行了統一管理、統一運作。



### 第三節 天津消防科學研究所



圖十一 天津科學研究所

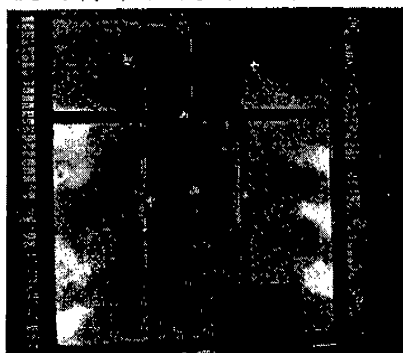
天津消防科學研究所成立於1965年，是以研究火災基礎理論，工程消防技術和建築防火技術為主的、是中國國內規模最大的綜合性消防科研機構。現有在職職工288人，其中高級技術人員70人，中級技術人員106人。該所由所本部和消防試驗場兩部分組成。所本部位於南開區衛津南路92號，占地37畝，建築面積2000平方公尺是從事科研、檢測和管理的主要場所；消防試驗場位於西青區王蘭莊，占地86畝，建築面積10600平方公尺是從事消防試驗和產品生產的主要場所。該所是ISO/TC21和ISO/TC92/SC2、“國家消防工程技術研究中心”、“國家固定滅火系統和耐火構件質量監督檢測中心”、“國家商檢局工程消防產品認可實驗室”、“公安部消防局火因技術鑑定中心”等的技術對口和附屬單位。經國家科委批准，該所自1996年開始組建“國家消防工程技術研究中心”。“中心”主要從事消防工程技術的綜合、集成、優化研究，固定消防系統新技術成果的產業化開發，國家重點消防工程的論證、審查以及為全行業提供包括資訊諮詢、人員培訓等各種開放式服務。該“中心”的成立，對整個消防行業的發展產生重要的保障、支援和推動作用。該所目前的

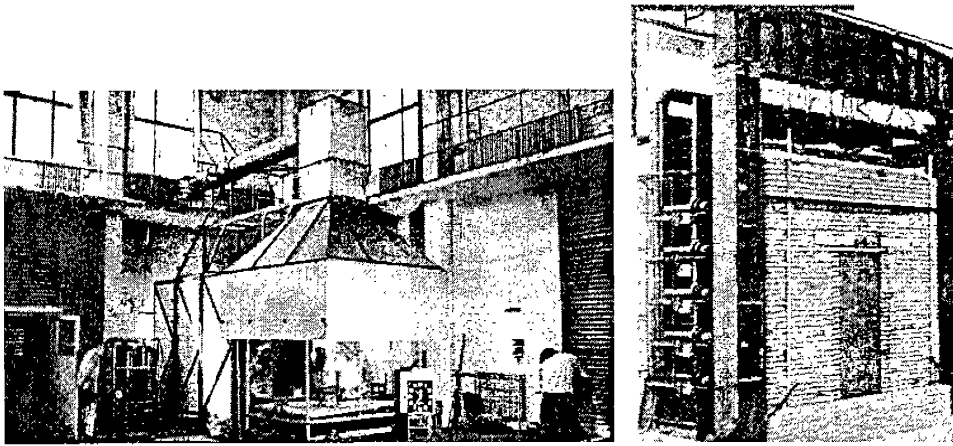
業務範圍主要有科研、檢測和開發三個方面。

在科研方面，天津所主要從事火災基礎理論、防火及防爆技術、火災實驗技術、火場勘察和火因鑑定技術；固定滅火系統及其應用技術；滅火劑、阻燃劑和阻燃、防火材料；建築防火構、配件及其建築防火技術；消防標準和規範以及消防軟件科學等方面的研究。在檢測方面，國家固定滅火系統和耐火構件質量監督檢測中心擔負著各種滅火劑、固定滅火系統及零部件和建築防火構、配件的質量性能檢測。在開發方面，主要從事各種固定滅火系統、滅火劑、阻燃劑和阻燃、防火材料、建築防火構、配件產品的開發生產；承攬各類消防工程的設計、施工任務；從事技術諮詢、技術轉讓和技術服務等技術推廣活動。

#### 服務項目

各種固定滅火系統及零部件、滅火劑和建築防火構、配件的質量性能檢測；物質火災危險性參數和材料防火、阻燃性能的測試；提供各種固定滅火系統及零部件產品；負責各類消防工程的設計、施工；提供各種新型滅火劑、阻燃劑、阻燃和防火材料、防火塗料和各類耐火構件產品；提供國內外消防技術及產品資訊；從事各種技術諮詢、技術轉讓和技術服務。





圖十二 天津所防火試驗設備

### 國家固定滅火系統和耐火構件質量監督檢驗中心

國家固定滅火系統和耐火構件質量監督檢驗中心（天津消防科學研究所檢測中心，以下簡稱“質檢中心”）是經國家質量技術監督局驗收並依法授權的、具有第三方公正地位的消防產品質量監督檢驗機構。該質檢中心也是經國家進出口商品檢驗局認可的進出口工程消防產品認可實驗室。質檢中心附屬於天津消防科學研究所，是非營利性的技術服務事業單位，在行政上受公安部消防局領導，檢驗業務受國家質量技術監督局監督司領導，進出口檢驗業務受國家進出口商品檢驗局領導。質檢中心於1988年經原國家標準局驗收合格，1989年國家質量技術監督局批准該中心頒發《國家固定滅火系統和耐火構件質量監督檢驗測試中心認可證書》；於1990年經國家計量認證合格並頒發證書；於1993年12月經國家質量技術監督局複驗合格。質檢中心於1993年通過了中國國家進出口商品檢驗局“國家進出口商品檢驗局工程消防產品認可實驗室”的認證審查；於1998年12月通過中國實驗室國家認可委員會“三合一”驗收（實驗室認可、國家質檢中心審查認可和計量認證）；國家質量技術監督局於1999年3月10日發出質技監局批准該中心實驗室認可。質檢中心現有工作人員53

人，主要檢驗設備 300 餘台（套），實驗室及附屬建築約 500 平方米，建有完善的質量體系，滿足獨立從事檢驗工作的需要。

質檢中心的主要任務是：固定滅火系統及零部件、耐火構配件、防火材料和消防藥劑等消防產品的各類檢驗；有關承檢產品的國家標準和行業標準的制、修訂；檢驗技術和檢驗設備的研究；ISO/TC21/SC5、SC6、SC8、ISO/TC92/SC2 的國內對口工作。

質檢中心具有按現行國際標準、國家標準、行業標準和企業標準對承檢產品進行全項檢驗的能力，同時還可提供檢驗技術和檢驗設備的技術諮詢。

#### 第四節 中國建築科學研究院建築防火研究所



圖十三 建科院大樓

成立於 1953 年的中國建築科學研究院目前是中国最大的綜合性建築科學研究機構（如圖十三）。現有職工 1296 人，其中科學院院士 1 名，工程院院士 1 名，教授級高級工程師 96 人，高級工程師 259 人。全院擁有 79 個研究領域和 70 多個試驗室。兩年前從事改企轉制，中國建築科學研究院作為科技型企業進入中共中央企業工作委員會，改企轉制前是建設部直屬的最大的

的建設行業綜合性研究與開發機構，下設十個專業研究所（分院、中心）和中國建築技術開發總公司及建築設計院，四個國家級質檢中心和八個經國家有關部委批准成立的國家和行業中心（單位）依託在該院。另外，建設部所屬北京建築機械綜合研究所在該次改企轉制中併入該院。建科院已與 30 多個國家和地區的有關機構建立有科技合作關係。中國性的二級以上學會 35 個、三級學會 20 個設在或附屬在該院。建科院的主要任務是：面向中國的建設事業，以建築工程為主要研究對象，以應用研究和開發研究為主，致力於解決中國工程建設中的技術關鍵問題；負責編制與管理中國主要的工程建設技術標準和規範；從事行業所需的共性、基礎性、公益性技術研究；負責建築工程、空調設備、電梯和化學建材的質量監督核對總和測試任務。主要專業領域有住宅體系及產品、智慧化建築、建築結構、工程抗震與防災減災、地基基礎與城市地下空間、建築 CAD、建築環境與節能、建築機械與施工、新型化學建材、建築裝修等。建科院作為建設行業科技先導和技術依託，通過院下屬的建築設計院、中國建築技術開發總公司、六個中試與研發基地，積極推進科技成果工程化和產業化。僅

99年通過科技成果轉化進入市場實現的合同額即達人民幣5億元以上，人均產值近50萬元，上繳國家稅收1760萬元。從建院至今，該院共完成科研成果1640項；主編並頒佈的國家和行業標準297項，獲得國家和省部級獎勵421項。

中國建築科學研究院下設機構有：

建築結構研究所、地基基礎研究所、工程抗震研究所、空氣調節研究所、建築物理研究所、建築工程材料及製品研究所、建築機械化研究分院、建築設計研究院、電子計算中心、建築防火研究所、建築裝修研究所、住宅產業研究設計中心、科技幹部培訓中心等十三個單位。

中國建築科學研究院管理的公司有：

中國建築技術開發總公司、凱勃建設監理公司、中碩發展有限公司(香港)等三個公司。

經國家批准，依託在中國建築科學研究院的機構有：

國家建築工程技術研究中心、國家建築工程質量監督檢驗中心、國家空調設備質量監督檢驗中心、國家電梯質量監督檢驗中心、國家化學建材測試中心、建工測試部、建設部防災研究中心、建設部建築工程標準技術對口單位、建設部空調淨化設備標準技術對口單位等機構。

本次考察主要以建築防火研究所為主，其研究領域與成果簡要介紹如下：

## 建築防火研究所

研究領域：

- 1、 建築構、配件的耐火性能

- 2、 建築材料對火反應的綜合性能
- 3、 高層及公共建築防煙、排煙
- 4、 建築物防火監控與自救系統
- 5、 防火改造與火災後的結構處理

**主要成果及代表工程：**

- 1、 防火塗料耐久性能的研究
- 2、 有機建材煙氣互理分析研究
- 3、 主編國家規範《建築內部裝修設計防火規範》
- 4、 紡織織物阻燃劑的研製
- 5、 樓梯間正壓送風系統的設計計算
- 6、 氣體滅火系統排放工況的類比計算
- 7、 智慧型通用火災報警控制器
- 8、 火災後建築結構受損狀態的評估與修復處理技術
- 9、 建築材料、結構構件、防火閥門等的防火特性檢驗測定
- 10、 建築防火系統工程的設計、安裝和調試
- 11、 北京仟村百貨商場的消防系統工程
- 12、 北京寶鼎廣場消防系統工程
- 13、 北京建威大廈消防系統工程
- 14、 深圳深業中心大廈空調系統工程
- 15、 深圳華佳廣場空調系統工程
- 16、 深圳航都大廈空調系統工程
- 17、 深圳集浩花園空調和防排煙系統工程

**防火所完成的科研成果目錄**

科研成果名稱	完成時間
高層建築防火技術研究方向與技術論證	1987
中央黨校禮堂主體結構火災損壞情況檢測及評定	1988
硬質阻燃可彎塑膠電線套管	1989
建築材料耐火性能及防火措施的研究	1990
PC—1500 自動噴水滅火系統設計計算程式	1991
小型自動報警滅火控制裝置	1991
木材快速熱解/燃燒特性研究	1991
薄型防火塗料的研製	1992
ZSTD—15XXY 型易熔合金自動噴頭研製	1992
菱鎂製品改性添加劑的研製與製品性能測試方法的研究	1994
高層建築防、排煙正壓送風及其測試技術的研究	1994
高層建築消防樓梯間防火排煙系統風量風值的實驗研究	1994
高層建築構件耐火性能研究	1995
火災報警系統圖形顯示和處理軟體	1995
織物阻燃劑的研製	1995
有機建材煙氣毒理分析研究	1996
城市火災危險性評估與防治對策的研究	1997
難燃性試驗裝置的研究	1997
火災後建築構件損傷程度評估方法的研究	1997
建築構件耐火試驗爐內正壓穩定性的研究	1997
點型光電感煙探測器的研究與開發	1998



## 第肆章 第八屆國際消防設備技術交流展覽會及學術 研討會概要

### 第一節 第八屆國際消防設備技術交流展覽會



圖十四 第八屆國際消防設備技

第八屆國際消防設備技術交流展覽會係由中國消防協會主辦、香港彙顯展覽有限公司協辦，美國消防協會（NFPA）作為支援單位，於2000年10月17日北京中國農業展覽館盛大開幕。參加人員包括來自美國、德國、法國、澳大利亞、韓國、新加坡，香港特別行政區、澳門特別行政區、以及我國等地消防組織和消防協會的代表。中國消防協會理事長胡之光致開幕詞提到：本屆展覽會是在人類即將邁入21世紀時，在北京舉辦的一次消防盛會。新的世紀將是一個科學技術更加迅速發展的時代，這必將為全球消防事業帶來前所未有的機遇，眾多新技術的運用，使我們的消防產品更為適用、更加可靠，使滅火救援工作更加簡捷、更為有效，從而給人民群眾帶來更多的安全。

本屆展覽會舉辦之時適逢世紀之交，突出了“消防新技術、新產品”的主題，展出內容包括新型的火災探測及報警設備、自動滅火系統、高效滅火劑及其設備、各類消防車、破拆工具以及消防員個人防護裝備等22大類消防產品。據統計，共有來自美國、加拿大、德國、英

國、法國、奧地利、芬蘭、匈牙利、俄羅斯、日本、韓國和香港特別行政區以及我國的 40 多家消防企業和大陸地區 175 家消防企事業單位參加展覽會，彙集了當前各類先進消防產品和消防科研成果。



圖十五 展覽會展示之各類消防設備

本屆展覽會期間還將首次舉行消防學術研討會，邀請國內外消防專家作 10 場專題學術報告。為各界提高火災的預防和撲救能力提供互相交流、學習以及技術貿易洽談的機會，同時還舉辦 11 場消防新技術報告會。

## 第二節 學術研討會

本次國際研討會係於2000年10月18日假北京長城飯店舉行，研討主題為：面向新世紀的消防科技與消防產品，共有來自美、德、加、台灣以及香港等國專家學者，發表十一篇論文，對消防技術以及建築防火科技皆有深入見解。研討會日程表如下：

### 學術研討會日程表 SYMPOSIUM PROGRAMME

- 8:00 to 9:00 Delegate Registration  
代表註冊
- 9:00 to 9:10 Symposium's Opening Celemony  
研討會開幕式  
Host: Mr. Liu Shipu, Vice President of China Fire Protection Association  
主持人：劉式浦 中國消防協會副理事長  
Welcoming Address  
致歡迎詞  
Mr. Hu Zhiguang, President of China Fire Protection Association  
中國消防協會胡之光理事長
- 9:10 to 9:40 NFPA's Global Reach and Our Diverse Efforts in Protecting People and Property From Hazards  
美國消防協會的全球發展和為保護人民生命財產免受各種危害而進行的努力  
Mr. George D. Miller, President and Chief Executive Officer, National Fire Protection Association  
美國消防協會總裁兼首席執行官 喬治·米勒先生

Mr. Martin Reiss, Chairman, Board of Directors, NFPA

美國消防協會董事會主席 馬丁·賴斯先生

- 9:40 to 10:10 The Fire Protection Code Writing Process in the United States-A Property Loss Prevention Perspective  
從防止財產損失的觀點來談美國消防規範和標準制定體系

Mr. Cheng Yao, Technical Advisor and Far East Operations Representative Vice President, Manager of

Research-Retired, Factory Mutual Research Corporation

美國 FM 研究所科技顧問兼遠東業務代表

美國 FM 研究所原副總裁兼研究所主任 姚崢先生

- 10:10 to 10:40 The Planned New Hong Kong Fire Services Communication Centre

香港新世紀緊急通訊及指揮中心

Mr. LAM Chunman, Chief Fire Officer, Hong Kong Fire Services Department

香港特別行政區消防處消防總長 林振敏先生

- 10:40 to 10:55 Tea Break 休會/茶點
- 10:55 to 11:25 The Perspective and Recent Development of Fire Safety Regulations for Building Materials in Taiwan  
臺灣地區建築防火材料法規現況與展望

Mr. Yuh Chyurn Ding, Director, Architecture & Building Center, Taiwan

台灣中華建築中心常務董事 丁育群先生

Mr. Peng Chih Wang, Associate Researcher, Architecture & Building Center, Taiwan

台灣中華建築中心副研究員 王鵬智先生

- 11:25 to 11:55 Study on High Pressure Water Mist Fire Extinguishing System  
 高壓細水霧系統的研究  
 Mr. Li BaoLi , Senior Engineer , Head of Division of Technology Development , The Tianjing Fire Research Institute of The Public Security Ministry  
 公安部天津消防研究所技術開發部主任 高級工程師 李保利先生
- Mr. Tian Liang , Senior Engineer , Vice Director of Department of Science and Technology , The Tianjing Fire Research Institute of The Public Security Ministry  
 公安部天津消防研究所科技處處長 高級工程師 田亮先生
- 12:00 to 13:30 Lunch/Break 午餐/休息
- 13:30 to 14:00 Host : Mr. Wu Qihong , Senior Engineer , Standing Member of China Fire Protection Association  
 主持人：吳啓鴻 中國消防協會常務理事 高級工程師  
 Introduction of German Industrial Standardization for Fire Fighting  
 德國消防工業標準簡介  
 Mr. Wolfgang Schmitz , Member of the European and International Standardization Committee , The President of Schmitz GmbH  
 歐洲國際標準委員會委員 施密茨公司董事長 沃爾夫岡·施密茨先生

- 14:00 to 14:30 21st Century Compressed Air Foam  
Fire-fighting Technology  
21 世紀壓縮空氣泡沫滅火技術  
Mr. Ping Li Yen, Fire Marshall/Fire Investigator, Arcadia  
Fire  
Department, Arcadia, California, U. S. A  
美國洛杉磯阿凱迪亞市消防局副局長 閻秉立先生
- 14:30 to 15:00 Development and Deployment of FIRECAMTM  
FIRECAMTM 的開發與應用  
Mr. David Yung, Ph. D., Senior Research Officer, Fire Risk  
Management Programme, Institute for Research in  
Construction, National Research Council of Canada  
加拿大國家建築研究院 (NRC) 建築研究所火災危險性管理專案  
計劃 高級研究員 博士 容天霖先生  
Mr. Nouredine Benichou, Fire Risk Management Program,  
National Research Council of Canada  
加拿大國家建築研究院 (NRC) 火災危險性管理專案 N. 本尼  
舟先生
- 15:00 to 15:15 Tea Break 休會/茶點
- 15:15 to 15:45 Chinese Fire Product Market and the Trend  
of Fire Industry Development  
中國的消防產品市場與消防產業發展趨勢  
Mr. Yin Tielin, Deputy Director, Senior Engineer, Fire  
Prevention Equipment Trade Administration Office, The  
Public Security Ministry

公安部消防產品行業管理辦公室副主任 高級工程師 尹

鐵林先生

- 15:45 to 16:15 Fire Safety and Infrastructure  
Construction in the Development of  
the Western China  
中國西部大開發的消防安全與消防基礎設施建設  
Mr. Lian Yu, Director, Senior Engineer, The Fire Fighting  
Bureau of Xinjiang Uyghur Autonomous Region  
新疆維吾爾自治區消防局局長 高級工程師 廉鈺先生
- 16:15 to 16:45 Fire Robot—A Good Helper of the Fireman  
消防機器人—消防員的好幫手  
Mr. Hu Chuanping, Professor, Director, Shanghai Fire  
Research Institute  
公安部上海消防研究所所長 研究員 胡傳平先生

各發表論文內容詳如附錄二。

## 第五章 考察心得

進行為期十一天的考察活動，並於國際研討會中發表文章後，深覺建築防火的研究與發展工作，確實逐步邁入世界合作的階段。而大陸在建築防火領域的基礎研究精神、研究開發與實務工程應用的結合、以及廣大的市場經濟需求，給我們十分深刻的印象。比較值得我們學習或相互交流的有：

### 一、 加強基礎理論的實驗與驗證，提高防火工程技術水準

由本次考察發現，大陸各消防科學研究所，在防火領域的研發工作，大多依照科技項目任務要求執行，對各種國內外防火產品與技術，均在理論分析基礎上，進行全面性的調查與比對，同時經過反覆試驗研究與充分的科學論證。

### 二、 落實防火產品的研究發展與實務結合

大陸地區由於制度的不同，各研究單位下屬有事業單位，負責產品與技術的推廣與營運，因此其所從事之研發項目與產品、技術，皆緊密的與實務工程結合。依此，各科研院所所提之研究專案，必是市場所需，即以經濟導向。除了自給財源外，對於防火工程實務也有一定的刺激作用。

### 三、 促進全尺寸火災實驗的經驗交流

此次所參訪之科研單位，大多為國家重點發展的實驗室，兼負大陸國家消防設備、防火材料、構件，品質檢測驗證之責。因此，已具備許多大尺寸防火試驗的經驗，同時，大陸十分重視國際合作，各種試驗皆有邀請國外知名專家學者參與，對全尺寸實驗有足夠的經驗，倘能適時交流學習，這對我國將於台南歸仁所設置的防火實驗群，尤其是全尺寸及地下街火、煙的實驗部分，將有助益。



#### 四、 觀摩建築防火材料檢測驗證制度、制定完善防火法規

我國在建築防火材料的檢測認證制度方面，已有一定程度的運作，尤其在耐燃材料、耐火構件、防火門等之檢測認證，尚稱上軌道。然而，目前國際間對於建築物防火系統的檢測，包羅萬象，如防火阻絕、填充材料的檢測，梁、柱、牆等防火構材的檢測，甚至煙控設備、防火防煙閘門等產品之檢測，皆待進一步研究與執行。大陸廣大的市場，在加入 WTO 之後，如何整併兩岸技術，確是值得探討的課題。

#### 五、 舉辦國際或兩岸學術研討會，促進彼此防火工程技術的提昇

此次藉著參加國際研討會期間，有機會了解大陸在防火工程上的研究現況，我們很驚訝其邁入國際潮流的腳步，而大陸各科研單位領導人員，對國際學術合作與技術交流的熱衷，尤其令我們佩服，在投入國際組織人力的分配，像 ISO、CIB 等國際組織皆有對口單位。據悉四川省消防科學研究所，已得到 NFPA 授權，並完成 Life Safety Code 的翻譯工作，其實這些資源如果能夠進一步整合，在防火領域的研究方面，則可節省許多時間與人力。因此，若能適時舉辦兩岸或國際學術研討會，促進兩岸交流，相信對我國防火研究工作必有十分助益。也可藉以提昇我國防火工程技術水準。

## 附錄一

### **The Perspective and Recent Development of Fire Safety Regulations for Building Materials in Taiwan**

Yuh-Chyurn, Ding  
Director  
CABC, Taiwan

Peng-Chih, Wang  
Associate Researcher  
CABC, Taiwan

#### **SUMMARY**

The main regulations of fire safety for building materials in Taiwan involve both of Building law and Fire law. Building law is mainly for administration of building materials which are fixed and attached to the elements of construction, such as fire windows & fire doors and noncombustible materials. Fire laws are to specify for curtains, clothing screen and carpets those are affiliated to the elements of buildings and are movable. In this paper, fire safety regulations relative to building materials in Taiwan are introduced. Definition and categories of fire-resistant materials are first related, then further exploring the operating conditions of corrective laws and inspection institution of test of fire-resistant material and administrative institution.

#### **INTRODUCTION**

In Taiwan, vigorous development of construction business caused by economic fast growth makes buildings tend to the trend of large scale, specific structures and complicate equipment. Meanwhile, under the situation of quick expansion of population, there's an enormous pressure on the work of building control administration. Especially in recent years, fire cases are kept pouring for domestic buildings, causing serious damage of properties and loss of life, and also giving terrible teachings and burdens for the society and individuals.

In recent years, the Government has paid more attentions to stand up for public safety, and also the public conscience for safe consuming has risen. Building fire safety has become one of the main tasks concerned with quality of social safe. Therefore, using fire proof building materials is also a policy for fire safety that is commonly learned. Not only in public places, but also in private houses, for interior finishing, it is noticed if fire proof materials are used. In the past that no one concerned about fire-resistant materials, at present,

utilizing fire-resistant building materials becomes the main subject. Meanwhile, it is mostly concerned and respected by the Authority and the construction business circle.

The main regulations of fire safety for building materials in Taiwan involve both of Building law and Fire law. Building law is mainly for administration of building materials which are fixed and attached to the elements of construction, such as fire resistant structure, fire windows & doors and noncombustible materials. Fire laws are to specify for curtains, clothing screen and carpets those are affiliated to the elements of buildings and are movable. In this paper, fire safety regulations relative to building materials in Taiwan are introduced. Definition and categories of fire-resistant materials are first related, then further exploring the operating conditions of corrective laws and inspection institution of test of fire-resistant material and administrative institution. The resource and manpower of the Government and none-government should be integrated to promote development and application of fire-resistant material, in order to setting up a complete system for fire safety of building materials.

## **DEFINITION AND TYPES OF FIRE--RESISTANT MATERIAL**

### **Definition of fire-resistant material**

The meaning of “fire-resistant material” is a general term. In simple words, All that possesses performance of fire-resistant can be “fire-resistant material”. Fire-resistant function means that under procedure of specified test conditions, one material possesses functions of fire prevention and fire protection. By reference of ISO’s standard, common functions of fire-resistant are divided into three types based on different specified test conditions and procedure as follows:

- Flame retardancy: function that material can prevent from kindling by tiny fire source (such as cigarette butts and matches) or flames fast burning.
- Fire retardancy: function that material is uneasy to ignite when fire with flames or at high temperature during from initial to long term and produces ability to limit heat and smog.

- Fire- resistance: function that material, component and structure can sustain integrity, stability and insulation at high temperature after flickering and burning.

According to those related above, fire-resistant materials can mean the total title for three materials such as Flame retardant, fire resistance and fire- proof. On regulations in Taiwan , there are different limitations such as scale, usage and scope for using fire-resistant materials of construction to prevent from fire occurring. Meanwhile, fire-resistant materials of these buildings shall accord to specification identified by regulations or construction materials with fire- resistant function are products validated by the Government.

### **Types of fire-resistant materials**

Based on fire resistant functions related above, fire-resistant materials can be divided into materials such as flame retardant, fire-retardant and fire resistant.

### **Flame retardant materials (finishing materials )**

By regulation 11 of amended articles for fire code of 1995, according to occupancy and floor areas, administrators of buildings whose ground floors reach up to 11 floors, underground buildings and locations specified by central authority (as table 1) shall use Flame retardant articles attached by Flame Retardant marks. Flame retardant articles related above or other material without attached marks can't be sold or exhibited. And flame retardant marks related shall have function of flame retardant certified by central authority. Based on main points to be validated for function of Flame retardant, kinds of articles of flames-retardant include as follows:

- a. Carpets: carpets such as shuttle-knitted, direct cluster, synthetic fiber carpets, men-made turf and ground flat layers.
- b. Curtains: cloth curtains (including common curtains, up leaf type/ lateral type of shutters)
- c. Cloth screens: cloth screens for usage of stages or studio.
- d. Advantage plate for show: plywood for show or for advantage.

- e. Other Flame retardant articles that mean size below 12 millimeters of execution canvas.

### **Fire retardant materials (fixing-up materials of fire resistance)**

By article 88 of Building Technical Regulations, internal fixing-up material (as fire retardant materials of fixing-up) such as noncombustion materials, fire-resistance materials and fire-resistant boards shall be used on internal walls and ceilings of buildings for specific purposes (as table 2).

1. Non-combustion materials ( grade 1 material of fire retardant )
  - Based on item 24, article 1 of construction design execution of building technical regulations, non-combustion materials include cement concrete, brick, or hollow brick, tile, artificial stone, asbestos product, aluminum, glass, mineral wool, glass fiber, pottery product, mortar, lime and other same materials certified by center authority.
  - Based on CNS, grade 1 material of fire-resistance means a kind of material that is uneasy to produce thick smog and gas, with smog coefficient of its unit area under 30, and has no bad phenomenon such as transformation, dissolution and chaps at high temperature.
2. fire-resistance plaster (grade 2 material of fire-resistance)
  - In Building Technique Regulation there's no definition for fire-retardant plaster, but in article 88 of design & construction section, two items of cast plaster and wood cement plaster are included by type of bracket.
  - Based on CNS, grade 2 material of fire-resistance means the material whose burn speed is very slow, with little combustion phenomenon when initial fire occurs. Smog coefficient of its unit area is under 60, and it has no bad phenomenon such as transformation, dissolution and chaps at high temperature.
3. fire-resistance material ( grade 3 material of fire-resistance )
  - Based on article 25, item 1 of construction design & construction section for Building Technique Regulation, fire-resistance material means materials such as plywood, fiber plaster of fire-resistance,

Table 1 Limited locations to use Flame retardant materials in Taiwan

Types	Occupancy	Floor areas offered for that purpose	reference
(1)	Theaters, cinema, dance hall, sing-song houses, hair-dresses, massage locations, video tapes running places (MTV), Karaoke (KTV), bars, pubs.	All.	
(2)	Bowling alley, billiard alley, assembly houses, fitness & leisure centers, inner-golf exercise places with screen type, amusement places.	All	
(3)	Tour hotels, restaurants, inns, reception houses (with bedroom).	All	
(4)	Shopping centers, markets, department stores, supermarkets, showrooms.	Floor area over 300 m <sup>2</sup>	
(5)	Dinner halls, eating houses, coffee shops, teahouses.	Floor area over 300 m <sup>2</sup>	
(6)	Hospitals, sanatoriums, rest-homes, convalescent hospitals, children farewell facilities, kindergarten, nursing houses, nursing centers, special school for the deaf, blind, handicapped.	Floor area over 200 m <sup>2</sup>	Hospital shall have patient rooms.
(7)	Sans, public bathrooms.	All	
(8)	Libraries, museum, art galleries, showrooms, history info houses, memorial houses	Floor area over 500 m <sup>2</sup>	
(9)	Cram schools, training schools.	Floor area over 200m <sup>2</sup>	
(10)	The places such as movie studios and TV relay places.	All.	
(11)	Buildings in execution (for use of inhabiting except urban plan area.) and other working articles such top sheds of station's platforms, saving tank body and products of chemical industry.	All.	

Source from: Main points to certify Flame Retardant Material, Fire Control Office, Ministry of Interior.

Table2: Limitation to use Flame retardant materials in Building Technique Regulation in Taiwan

Occupancy	Specific floor area for that occupancy		Inner fix-up materials	
	Fire-resistant building Building of Fire-proof structure	Building of none fire-proof structure	Room for living or parts for that purpose	Passage and hallway to ground
(1) Theater, cinema, show place, showroom, assembly room.			Fire-retardant plaster of non-combustion (Cast plaster, wood cement plaster)	Fire-retardant plaster of non-combustion
(2) Buildings such as hospital, hotel, rest-room, children welfare facilities	All		Fire-retardant plaster	
(3) Shopping center, market, office, showroom, night club, bar, tavern, dance hall, amusement place, public bathroom, restaurant, etc.				
(4) Underground floor, underground working articles for usage of (1)(3)	All			
(5) Parking space, automobile repair shop	All		Fire-retardant plaster of non-combustion	
(6) Room for living without widows	All			
(7) Rooms to use burn equipment	Residents	Parts above 2 floors (except top floor)		
	Non-residents	All		
(8) Floors above 11 stores	Parts with fire-proof divisions each under 200 m <sup>2</sup>		None-combustion materials	
	Parts with fire-proof divisions each under 500 m <sup>2</sup>			
(9) Underground building	Those whose areas of fire-proof divisions is divided based on above 100m <sup>2</sup> and under 200 m <sup>2</sup> .		Fire-retardant plaster of non-combustion	Noncombustion materials
	Those whose areas of fire-proof divisions is divided based on above 100m <sup>2</sup> and under 200m <sup>2</sup> .		None-combustion materials	

Source from: Building Technique Regulation

- cast plaster and other same materials identified by central authority.
- Based on CNS, grade 3 material of fire- resistance means the material whose burn speed is very slow, with little combustion phenomenon when initial fire occurs. Smog coefficient of its unit area is under 120, and it has no bad phenomenon such as transformation, dissolution and chaps at high temperature.

**Materials of fire- resistance ( materials of fire- resistant structure )**

To prevent from fire's burn expansion and favorable to escape, besides limiting inner fix-up materials for buildings of specific purpose, buildings are specified to has divisions of fire- resistant, enhancing public safety of buildings. Construction of divisions of fire- resistant means fire- resistant structure and door/window of fire- resistant in time efficiency of fire resistant. Fire- resistant Structure includes main structures such as pillars, beams, walls, floors, roof parts and stairs. Time efficiency means combustible time of inspecting structure body 's stress able to load at combustible temperature that test structure are put on stimulated fire place. Types and definition of structure of fire- resistant and door/window of fire- resistant are instructed as follows.

**(1) Structure of fire- resistant**

Based on law of article 69 of design & construction section for Building Technique Regulation, buildings shown on Table 3 whose floors or area are over 300 square-meters shall be buildings with structure of fire- resistant or buildings with fire- resistant. Main structures of building with structure of fire- resistant (including pillars, beams, walls, floor boards and roof parts) and stairs structure shall at least accord to time efficiency of fire- resistant and structure specified by article 70 of design & construction section of Building Technique Regulation, referring to Table 4. Besides, there are specification into details for main structures such as pillars, beams, walls and floor-boards specified for time efficiency of fire- resistant with 1 to 3 hours in article 71 to article 74 of design & construction section of Building Technique Regulation.



Table 3 Buildings in Taiwan shall be those with fire- resistant or those with fire- resistant structure

Category	Occupancy	Fire- resistant building		Fire- resistant structure
		Limitation of stores	Limitation of total floor area	
(1)	Theater, cinema, show room, assembly room, showroom, etc.	Floors except ground floor Floors over 3 stories	1. Audience seats are over 200 m <sup>2</sup> . 2. Outdoor audience seats are over 1000 m <sup>2</sup> .	Limitation of floor areas
(2)	Hospital, hotel, assemble residents, dormitory, rest- house, children welfare facilities, etc	Floors over 3 stories		Floor area of 2 <sup>nd</sup> stories is over 300 m <sup>2</sup> . Hospital shall be with patient rooms.
(3)	School, office, gym, museum, art gallery, library, inner swimming pool, etc	Floors over 3 stories		Over 2,000 m <sup>2</sup>
(4)	Shopping center, market, show room, night club, dancing hall, restaurant, liquor shop, public bath room, food shop, bowling house, roller- skated room, etc.	Floors over 3 stories	Over 3,000 m <sup>2</sup>	Those which area of 2 <sup>nd</sup> floor is over 500 m <sup>2</sup> .
(5)	Warehouse, plant, etc.		Total floor areas above 2 stories is over 300 m <sup>2</sup>	Over 1,500 square meters ( plants not including )
(6)	Garage, repair shop, movie studio, TV relay room, etc.	Floors over 3 stories		Over 150 square meters
(7)	Store place for dangerous things	Specified by HJA according to kinds of dangerous articles and storage quantity.		

Source from: as Table 2.

Table 4 classification of fire- resistance function for fire- resistant structure in Taiwan

1. Main structure	walls				Column	Floor board	Beams	Roofs
	Separate wall	Exterior walls		Parts outside fire- proof zoom				
		Load-bearing walls	None-load-bearing walls					
Each floor under 4 stories from top	One hour	One hour	One hour	30 min.	One hour	One hour	One hour	30 min.
Each floor from floor 4 to floor 14, counting from top	One hour	One hour	One hour	30 min.	Two hour	Two hour	Two hour	30 min.
Each floor over floor 15 from top	One hour	Two hour	One hour	30 min.	Three hour	Three hour	Three hour	30 min.
2. stairs structure								
Stairs structure shall be as follows:								
1. Made by reinforced concrete or steel reinforced concrete.								
2. Made by none- reinforced concrete or brick, stone, cement and hollow brick.								
3. Others with similar function as above identified by the authority.								

Source from: as Table 2.

## **RELATIVE REGULATIONS OF FIRE-RESISTANT BUILDING MATERIALS**

Fire-resistant materials can be divided into two regulations system of accreditation and administration (as Table 5) to explore. Among them, flame- retardant materials belong to administrative scope of Fire Laws. And fire- retardant materials and fire-resistant materials are under control of Building Law system. Meanwhile, relative laws for materials test are specified to fix standards announced by Standard and Inspection Bureau of Economy Department. Relative laws for flame- retardant materials, fire-resistance materials and fire-resistant materials are probed in the section.

Table 5 Relative laws of accreditation and administration for construction fire-resistant materials in Taiwan

Kinds of materials	Laws for test and accreditation	Administrative laws
Flame- retardant materials (decoration materials)	<ol style="list-style-type: none"> <li>1. Fire Law.</li> <li>2. Main points to take effects for accreditation of flame- retardant function.</li> <li>3. Test Standard for Flame- Retardant Function.</li> </ol>	<ol style="list-style-type: none"> <li>1. Fire Law</li> <li>2. Details to take effects for Fire Laws.</li> <li>3. Main points to take effects for accreditation of flame- retardant function.</li> </ol>
Fire- retardant materials (finishing materials)	<ol style="list-style-type: none"> <li>1. Standard laws.</li> <li>2. Announcement of Standard and Inspection Bureau of Economy Department.</li> <li>3. Building Technique Regulations.</li> <li>4. Main points to apply for accreditation of new skills, new equipment, new materials of construction. (Note 1)</li> </ol>	<ol style="list-style-type: none"> <li>1. Building Law.</li> <li>2. Main points to take effects for accreditation of flame- retardant function.</li> <li>3. Rules of signing up and application of buildings for public safety inspection.</li> <li>4. Improving regulation for means of egress and fire control equipment of old buildings.</li> <li>5. Administrative measures for inner fix-up of buildings</li> </ol>
Fire- resistance materials (structure element of fire- resistant/ door/window of fire- resistant)	<ol style="list-style-type: none"> <li>1. Standard laws.</li> <li>2. Announcement of Standard and Inspection Bureau of Economy Department.</li> <li>3. Announcement of Standard and Inspection Bureau of Economy Department. (Note 2)</li> </ol>	<ol style="list-style-type: none"> <li>1. Building laws.</li> <li>2. Main points to take effects for accreditation of flame- retardant function.</li> <li>3. Rules of signing up and application of buildings for public safety inspection.</li> <li>4. Improving measures for refuge facilities of fire- proof and fire control equipment of old buildings.</li> </ol>
Note 1: fire- retardant materials that are none test items to take effects announced by Standard and Test Bureau are available.		
Note 2: fire- resistant structure and materials such as fire- resistant coverings and partitions are available.		

Source from: "Test and administration of fire- retardant materials used for Japanese buildings, 1997, Economy Department.

## **CURRENT ADMINISTRATION SYSTEM AND INSPECTION ACCREDITATION FOR FIRE- RESISTANT MATERIALS**

### **Organization Structure of Administration System and Inspection Accreditation for Construction Fire-resistant materials**

Building materials of fire-resistant, from production to application on buildings, can basically be divided into six stages. They are setting up standards, applying for identification, inspecting, evaluating, certifying, and issuing marks, see Table 6.

### **Procedure to apply for examining identification for fire-resistant building materials**

#### **(1) Application for examining identification for flame- retardant materials**

For flame- retardant materials, Fire Control Office of Interior Ministry takes responsibility for function identification of flame- retardant and institution for inspection system, govern identification application, go into evaluating and certifying flame- retardant functions as well as tasks of issuing marks and quality control. For inspection, institution or unit specified by fire control institute of central authority takes charge. Procedure of its identification application for flame- retardant functions is as Figure 1.

#### **(2) Application for examining identification for fire- resistance materials**

Fire -- resistance materials and fire- resistant door are products to be examined by announcement of SIB, Economy Ministry. Others not by announcement shall be examined and identified by CPA of Interior Ministry. Its application procedure for examining identification is as drawing 2.

#### **(3) Application for examining identification for fire-resistant materials**

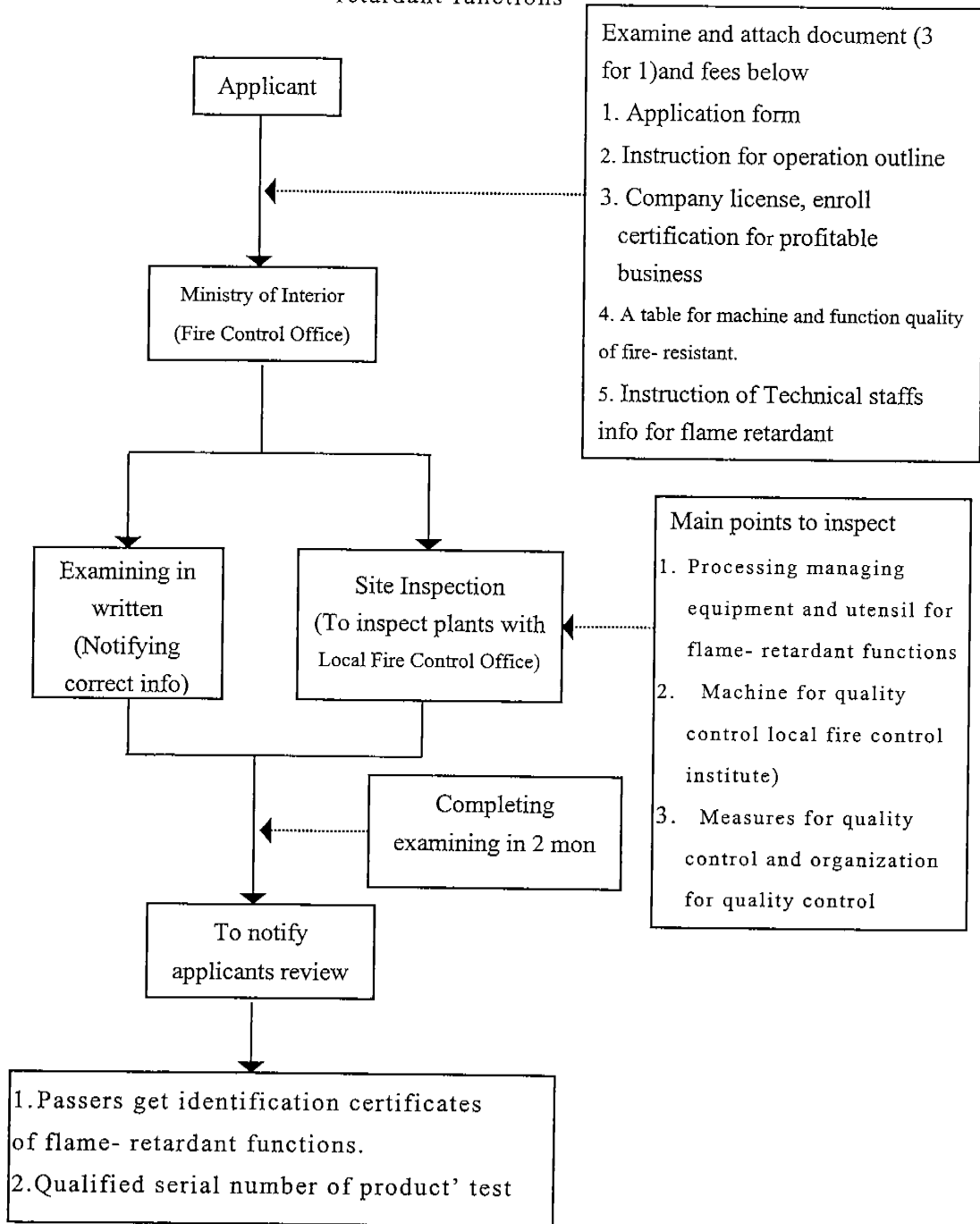
Fire-resistant materials such as fire- resistant covering and separate spans of fire- resistant structure shall be examined and identified by CPA of Interior Ministry.

Table 6: Organization Structure of Administration System and Inspection Accreditation for Fire-resistant materials

Material' title	Unit	Authority set up standards	Authority to apply	Authority to inspect	Authority to evaluate	Authority to certify	Authority to issue marks
(1) flame-retardant materials		Fire Control Office	Fire control Office	Institution/group specified by Fire control Office	Fire control Office	Fire control Office	Fire control Office
(2) fire-retardant materials	1. Items to be inspected by announcement of SIB	SIB( Standard and Inspection Bureau )	SIB	1.SIB 2.Center of plastic development	SIB	SIB	SIB
	2. Others	CPA	CPA(Chinese Architecture & Building Center)	Institution/group specified by CPA	Examining squad of fire-resistant materials of review committee for building technique	CPA	Note 1
(3) fire-resistant materials	1. fire door	SIB	SIB	Construction Research institute, interior Ministry	SIB	SIB	SIB
	2. Fire- resistant structure	CPA	CPA(Chinese Architecture & Building Center)	Institution/group specified by CPA	Examining squad of fire-resistant materials of review committee for building technique	CPA	--
Note 1: Certification only issued by CPA							

Source from: as Table 5

Figure 1 Procedure of its identification application for flame-retardant functions



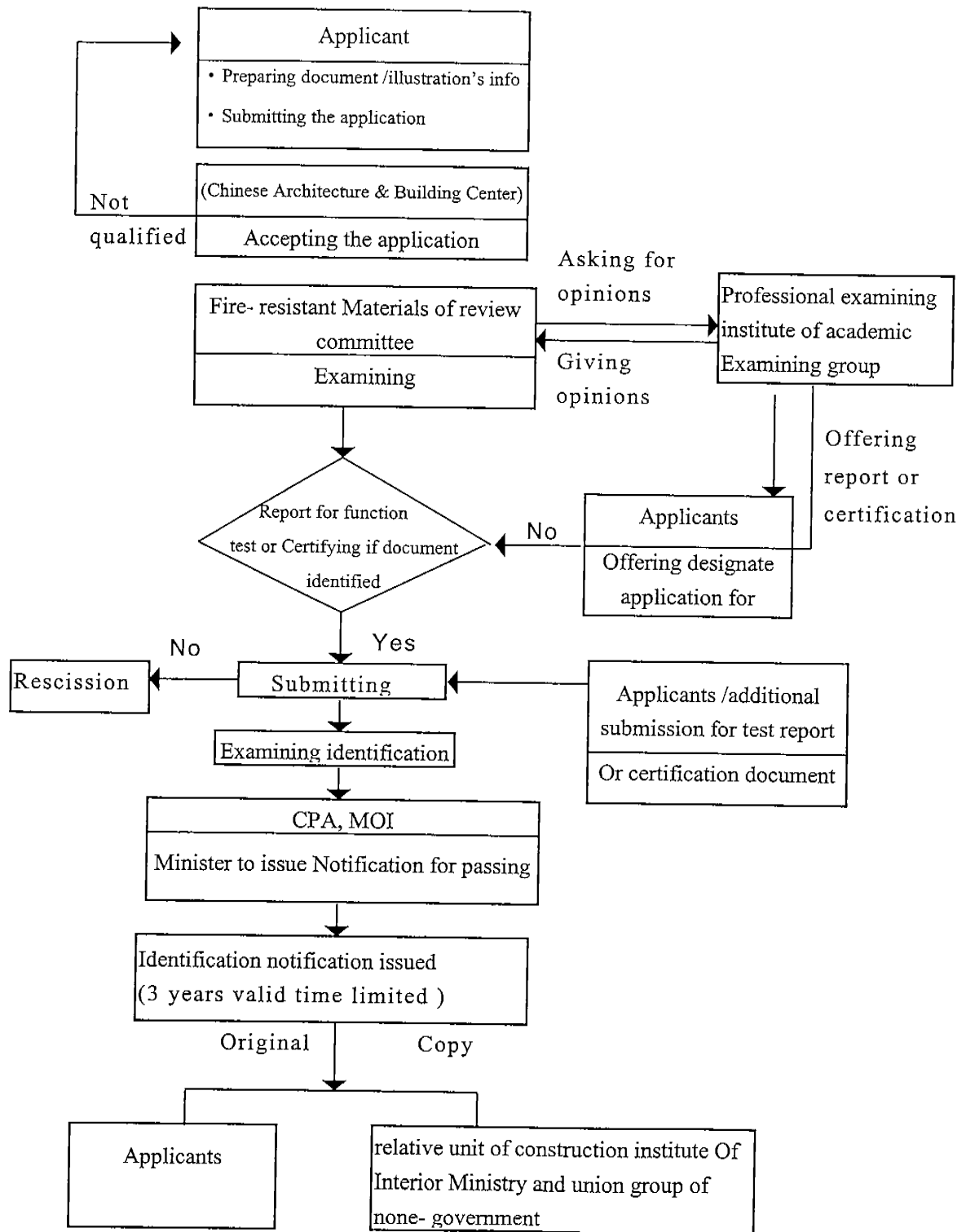
Source from: Fire Control Office, main points to take effects for function identification for flame-proof.

Before applying for examining, applicants shall first designate an academic group or institute for testing fire-resistant functions, then preparing application form and document/ illustrations and applying to central authority. Construction institute of central authority shall list them in detail, and notify applicants to supplement or correct if there's any unqualified points in examining case. After collecting all information, CPA of Interior Ministry shall transmit the case applying for examining to examining squad for fire-resistant materials of review committee for Building Technique Regulation for evaluating.

When examining and evaluating, examining squad shall ask applicants for test analyses, test report of testing institute or opinion signed by relative institute for certain item if necessary. The result after examining shall be notified applicants in written and identification certificate shall be issued. In the certificate, identified contents, scope to suit and valid time limit. Fire-resistant construction materials identified by central construction authority shall register in identified product collection of construction fire-resistant of Interior Ministry" and be identified announced.



Figure 2 Application Procedure for Examining Identification of Construction's New Skills, New Labor Laws, New Equipment and New Materials



## REVIEW OF CURRENT CONDITION AND PROSPECTIVE

Usage of Construction fire-resistant materials is a basic measure for carrying out fire-resistant goal of “preventing buildings from fire occurred and fire expanding for fire-resistant buildings”. Regulations of construction fire-resistant in Taiwan are still sound, but fire-resistant institution is not perfect because of uncertain relative laws of authority, shortage of test equipment, and no data base of fire-resistant materials. Issues are reviewed as follows:

### Review for issues of present condition

#### 1. For flame-retardant decorating materials:

Authority of Interior Ministry (Fire Control Office) has announced to take effects on “Main Points for Identifying Flame-retardant Functions”. Facing that the public asked the Government soon to control flame-retardant materials, some relative business shall be established, such as to designate relative institution, school, and group to assist technique work of examining. Meanwhile, Authority also need to set up regulations for operating procedure and test standard for identification of flame-retardant function and issue of flame-retardant marks and setup of examining unit and its capability for identification.

#### 2. Fire-retardant finishing materials and fire-resistant structure materials

(1) Specification and inspection of fire-resistance fix-up and fire-resistant structure materials are mainly specified in Building laws and relative sub-laws. Examining measures and basic standard of functions are based on national standard. If there's no suitable item in technique rules and national standards, they can be based on article 4 of Building Technique Regulation general rules set up on April 9, 1997, “Certifying its specification through test and reporting to central authority for reference. Meanwhile, its test work shall be clearly specified, and institute, school or group

identified by authority to take care. But concrete specified measures for function examining basic standard of fire-resistant construction materials, identification operating procedure and marks issue shall be further set up. Measures of relative administration shall be set up for follow-up tracing administration.

- (2) Specified in article 3/4 of general principle of Building Technique Regulation Rules, with national standard, specification and function of construction materials are mainly based on. And in chapter 3 of articles of construction fire-resistant, there are no ensured articles to specify for structure, component and inner material of fire-resistant ( fire-resistance ), test measures, and function basic standard based on item of national standard. That makes Clients indecisive and law executors have no certain rules to test.
- (3) All the Limitation of using construction fire-resistant materials aren't forced to be passing authority' approval. Without examining identification, fire-resistant function of construction materials can not be controlled only for design executing by rules of specification.
- (4) Although present regulations for fire-resistant are sound, laws is difficult to be carry out efficiently without local technique specification test standard and institution policy needed by industries.
- (5) Functions of construction fire-resistant materials cannot completely fit into system of construction administration.
- (6) There's no complete and sound institution for test, and existing fire-resistant policy and projects aren't easy to execute thoroughly.

#### **Future work prospective**

To explore issue thoroughly, the main cause for issue of domestic construction fire-resistant is there's no examining identification institution. In the present, the public expects the Government soon to control fire-resistant construction materials, most important of all, authority shall quickly establish examining identification institution for construction fire-resistant materials,

1. Making efforts on setting (amending) relative fire- resistant specification, taking effects for localization.
2. Authorizing juridical institution, taking effects examining identification work.
3. Developing new products of fire-resistant materials, enhancing fire-resistant functions.
4. Intensifying administration institution of examining and certifying, ensuring public safety.
5. Respecting assistance and rewards, invigorating production system.
6. Establishing the public's common view through promoting education.

## **CONCLUSION**

For maintaining public safety, reducing people wound and killed in fire, and enhancing safety quality of construction fire- resistant, relative units of the Government have constantly improved for policy regulations and institution. In the future, besides going on intensifying exist foundation, aggressive participation from every circle from academy, research, and industry is needed. Therefore, according to the resolution by Technique Meeting of National Material Technology, Technology Consultant Team of The Executive Yuan assists Research Institute of Construction of Interior Ministry to start the promotion for planning work of fire-resistant materials. Collecting common view from every circle, they will provide each working unit with suggestion of working plans. The promotion work will start from items with feasible main points, then gradually expanding. In one word for those related above, for long term of promotion goal of construction fire-resistant materials, the four items below shall be aggressively taken into actions.

1. Thoroughly reviewing about fire- resistant function regulation of materials (component, structure) of laws for construction and fire control, view of performance-based design, setting up specification and rules suitable for the public's needs.

2. Setting up identification system and correlative institute for fire-resistant material examining authorized and guarded by the Government, governed by national identification system self-run by those of non-government.
3. Ensuring tactic policy to develop applicable technology, collecting resource from research institute, aggressively investing in development and production of fire-resistant materials with high quality, low cost and multi-function (including functions such as environmental protection, operating convenience and endurance.)
4. Strategically rewarding domestic manufacturers to part in developing and producing potential products, assisting to develop competition capability to be internationalized

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## NFPA'S Global Reach and Our Diverse Efforts in Protecting People and Property from hazard

**George:** Thank you, It is my great pleasure to attend CHINA FIRE 2000 with my good friend Martin ("Mickey") Reiss, president of Rolf Jensen and Associates, and the chairman of NFPA's Board of Directors. On behalf of NFPA's 70,000 members worldwide, we thank you for this wonderful opportunity.

It is truly a privilege to be in Beijing again. Although many miles separate our countries, the United States and China have in common the threat of uncontrolled fire — as do all nations. Fire protection must remain a top priority for every government, and for every citizen. Through our respective missions and work, CFPA and NFPA share a commitment to reducing the incidence of fires not just in our own countries, but also around the world.

That commitment brings us all here together today. We are honored to be invited by CFPA Secretary — General Wang Gentang, and Mickey and I are pleased to further NFPA's agreement with CFPA to work cooperatively in pursuit of reducing the burden of fire. Thank you.

**Mickey:** I, too, wish to thank Mr. Wang for his kind invitation to speak today.

George and I have been fortunate enough to spend time together in Beijing on several previous occasions, speaking at CHINA FIRE in 1996 and in 1998. We are delighted to represent the NFPA, and bring with us the best wishes of NFPA's entire Board of Directors and Officers.

George and I have been friends and colleagues for nearly a decade and our work together through NFPA has give us several opportunities to travel over the years, as well as occasions to make joint presentations. We've settled into what we call the "Huntley — Brinkley Report" presentation style for these talks, named for the early broadcasters who pioneered TV news in the U.S. We enjoy giving this tandem-type of presentation, and we hope you will too.

Let me start off today by giving you some background on my career. I've been in the fire protection business for over 30 years. Throughout that time I have been a strong advocate of both NFPA's technical activities and public education outreach. A longtime volunteer in NFPA's consensus code— and standard—development process, I've also served on NFPA's board of directors since 1991 and am an active member of the board of trustees for The Fire Protection Research Foundation. And since its inception, I've been a member of NFPA's International Advisory Council.

I am president of Rolf Jensen & Associates (RJA), which is an international fire protection engineering and consulting firm. Recent projects in China and Asia include the General

Motors and Daewoo Office Tower in Shanghai, Convention Center expansion and the Central Station Project in Hong Kong and the tallest buildings Petronas Towers in Malaysia. RJA is a good example of how the private sector utilizes NFPA codes and standards on these projects. I see it first—hand in my work; every day, the engineers at RJA make decisions influenced by or based on the requirements that come from NFPA's open consensus process. The value of that unique process is brought to bear day in and day out in companies all over the world, as the users count on the documents' accuracy, timeliness and comprehensiveness.

Consensus codes are just one of the qualities that have drawn me to NFPA and kept me involved. I'm also a longtime supporter of NFPA's educational efforts, and I share this interest with my wife Rhea. In fact, the NFPA Teacher of the Year Award is named for Rhea, which is an honor for our family. George and I will talk more about safety education later on today, particularly for the world's aging population.

The work of the Research Foundation is also very important to me. The Foundation, which is a subsidiary of NFPA, is the world's only charitable fire research institution. For nearly two decades the Foundation has been an impressive catalyst for independent fire research, addressing crucial issues such as risk, new technology, and even human responses. The end results of the Foundation's research projects are utilized throughout the world and frequently influence the technical committee decisions within NFPA's code — and standard — making system.

That's a quick review of my career and affiliation with NFPA. George is going to talk about his background next, but before he starts let me just say that his tenure as NFPA's president has been entirely successful, with many important accomplishments to his credit. In particular, he has taken a global view of fire safety and that is the reason that we are here today. Cooperation between the United States and China fire services and engineering communities has been one of his highest priorities. George had already achieved an impressive military career when he came to NFPA, but that hasn't stopped him from forging yet another leadership role. I'll let George tell you about it.

**George:** Thank you, Mickey. It's true that my work history has been somewhat varied, but the continuous thread throughout my career has always been my interest in public service. I spent most of my adult life in the U. S. defense forces, serving in a variety of capacities in the United States Air Force before retiring after 34 years as Lt. General. During my tenure in the Air Force, I served as a pilot certified in 15 different types of aircraft. Having served at every level of command from squadron commander through wing and division commander, my last assignment was as the vice commander—in—chief of the Strategic Air Command. I wanted a change after retiring from the Air Force, but I continued to be drawn to a role that suited my sense of patriotism, so I joined the U. S. Olympic Committee as executive director. Among my experiences there, I enjoyed learning the finer arts of fundraising, a

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new skill that has served me well in the years since. Following the USOC, I was named president of the Morris Animal Foundation, from which I was recruited to become NFPA's president and chairman of the Fire Protection Research Foundation, just referred to by my friend Mickey.

My role within NFPA has been a wonderful opportunity to continue a career of public service as well as to grow personally. Throughout my career I've had an appreciation for the value of standards, the critical need for research and the important role of training, so it wasn't much of a stretch to come to NFPA where these are among the core values of our association.

I've been privileged to extend my NFPA role to serve in a variety of outside capacities.

Among these has been the exciting challenge of serving as chairman of the Confederation of Fire Protection Associations International, which functions to facilitate international cooperation in many important areas dealing with fire prevention. And, of course, I am proud to represent NFPA at important world meetings and other events, such as this meeting here in Beijing.

Today, Mickey and I plan to tell you about NFPA and some of the top areas of interest in fire protection. Mickey, why don't you start?

**Mickey:** NFPA's mission is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating scientifically — based consensus codes and standards, research, training, and education.

For the first 100 years, NFPA focused its mission largely on fire and electrical safety, and the mission statement specified only those areas.

One of the most exciting accomplishments I've been involved with during my tenure on NFPA's board of directors is the decision a couple of years ago to formally expand NFPA's mission statement to better articulate the work our organization actually does day—to—day. The new mission statement just recited for you clearly states NFPA's global reach and our diverse efforts in protecting people and property from hazards, including but not limited to fire.

**George:** Mickey makes an important point. NFPA continues to focus on preventing fire losses, and the vast majority of our codes, standards and educational materials address fire as a priority. However, NFPA is also a world leader in electrical safety and life safety, and we are now in the process of developing our organization's first building code.

In fact, NFPA's efforts extend far beyond fire safety. For example, we have codes and standards that address many other topics, such as carbon monoxide exposure protection, disaster management, and hazardous materials response and confined space rescue. Our training programs address fire safety but they also deal with other important subjects including occupational health and safety. In addition, NFPA's educational activities have



extended beyond fire safety for some years now. RISK WATCH'S, the first school-based, comprehensive injury-prevention curriculum, and REMEMBERING WHEN'S, an exciting new concept that combines fall prevention with fire prevention for older adults, are already being implemented.

NFPA's expertise in electrical safety goes back more than 100 years. The National Electrical Code or NEC is the industry standard for electrical safety and is the most widely used and accepted code for electrical installations in the world. The NEC has been translated for use in numerous countries, including in Asia.

The Life Safety Code has been in use for more than 90 years, protecting new and existing building occupants from dangers that would prohibit their ability to safely escape in an emergency. Like the NEC, the Life Safety Code has been translated and is in use around the world, and both codes are used virtually everywhere in the U. S. On this past Monday morning, we had the pleasure of signing an agreement with China Fire Protection Association that will allow translation of this document to the fire services and engineering organizations in China. We are very proud of this agreement.

**George:** As you know, NFPA is a nonprofit membership organization and we are non-governmental; therefore we exist solely to promote our mission. This can be a blessing as well as a burden. It is a blessing in that we can focus on the work at hand without being unduly influenced by the needs of stockholders or other corporate distractions.

However, NFPA is not a charity and resources are not as plentiful in the nonprofit sector, so keeping an eye on the bottom line is essential. We must function as a business even though we are dedicated to public service.

NFPA's nonprofit status has never wavered in 104 years. It was in 1896 that NFPA was founded, based on the need for standardized automatic fire sprinkler systems. That first sprinkler standard has evolved into what is now known as NFPA 13, Which is used around the globe (including here, in China by organizations such as RJA).

NFPA's founders were visionaries. The work they did in those early years has been critical to the battle against fire. Automatic fire detection and suppression technology are the key to preventing large fire losses — saving lives in particular. In the United States, the biggest loss of life from fire occurs in residential occupancies. We've seen the fire death rate fall dramatically in the 20 or so years since home smoke detection equipment became the norm. The next step will be increasing the availability and use of residential fire sprinkler systems. These are our best bet for making another dramatic reduction in deaths and injuries from fire. And this technology can be applied anywhere in the world.

**Mickey:** As important as NFPA 13, the NEC and the Life Safety Code are, it is the process through which they are developed that makes them viable and timely. All NFPA codes and standards are developed through NFPA's unique open consensus process, which allows for the input and participation of all who are interested — in any occupation, in any country. I

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sincerely believe open consensus is the best way to produce safety codes and standards, no matter where in the world they are used, and I know George agrees with me. This process allows the NFPA codes and standards to contain the latest state — of — the — art in technological advances.

Codes and standards have been called the "lifblood" of NFPA, and in many ways this is a fair assessment. As a daily user of these documents in my own work, I can personally attest to the critical need for timely, accurate and comprehensive voluntary standards in our society. NFPA documents have helped make many parts of the world safer from fire, and the process through which our codes and standards are developed is critical to ensuring that these lifesaving requirements are applicable throughout the world.

Open consensus is true consensus, and NFPA is the only code-making group that is using open consensus to develop a full set of codes for the built environment. The building code that George mentioned a moment ago will be one of the anchor documents of that set. The NEC will be the other, with important fire, plumbing, energy, fuel gas and other critical codes completing the set.

One of the valuable aspects of NFPA's consensus process is that we actively seek cooperation and participation from other organizations. NFPA makes it a priority to stay involved with international activities, including our agreement with CFPA. In addition, some of the other groups with which we work are the International Association for Fire Safety Science, the International Council for Research and Innovation in Building and Construction, the International Electrotechnical Commission and International Standardization Organization, and the International Technical Committee for the Prevention and Extinction of Fire.

We also work closely with other domestic organizations, most of which also operate in an international arena. As one example, NFPA recently entered into an agreement with the International Association of Plumbing and Mechanical Officials to work together on the development of consensus plumbing and mechanical codes. You may be familiar with IAPMO, as it's known, because they are currently working with China Association of Engineering Construction and Standardization on plumbing product certification.

**George:** Although our full name sounds like we are a U. S. organization, NFPA is actually international in scope, activity and deed. We have about 70,000 members, from dozens of countries around the world. Our 300 codes and standards are used all over the globe, frequently translated into the local language. A network of 6,000 volunteers who are experts in their own right develops them, and written to protect the lives and property of people from all walks of life.

NFPA's documents are accepted and followed throughout Asia, Europe, the Middle East and across North and South America. Here in China, NFPA's partnership with CFPA has helped facilitate the translation of NFPA's important requirements. We hope we can continue and even expand this joint effort.

One of the important parts of my work as NFPA President has been focusing on global standards. The current world economic climate is stormy at best, and anyone who wants to stay competitive must become a diligent student of international trade. The issue here is what makes a standard international. NFPA has had to work to dispel the myth that we are simply a national standards developing organization — that just isn't so. It is entirely possible that this myth is perpetuated by those who would like to see NFPA and others shut out as global standards development organizations.

There are those who have taken the position that only the ISO (International Standards Organization) or IEC (International Electrotechnical Commission) are truly global SDOs. June Ling, a colleague of mine at the American Society of Mechanical Engineers, refuted that point well a few years ago when she defined what makes a standard truly global. In her article Ms. Ling said, "The true test of an international standard is fair and open access to the standards development process and its record of success in meeting international market and safety needs."

Her definition clearly includes NFPA's open consensus process, and the 300 codes and standards developed within that process. And others concur. I recently listened to a speech given by the Deputy Under Secretary-for Technology in the U. S. Department of Commerce. He explained to his audience that there is tacit agreement that if a standard is used globally, it is essentially international. "In fact, the World Trade Organization does not specify ISO or IEC as international standards," he explained. Too often ISO standards reflect a European bias which works to the detriment of large nations like China and the US which have perfectly good standards.

With the advent of the Internet, NFPA's international status has become much easier to see. The World Wide Web has made it possible for people all over the globe to stay in close touch with NFPA activities, be they technical, research or educational. NFPA is currently in the process of examining a variety of applications that will make interaction among technical committee members simple and travel-free, saving money and time for all involved. We are constantly adding new information to our Web sites, making it easier for those who are interested in NFPA to stay involved and active.

The Internet has positively affected conducting business internationally too. E-Business is critical aspect of any organization's ability to stay competitive and NFPA is no exception. For some time now, we have been aggressively working to ensure that NFPA's codes and standards are available online to meet the needs of those whose primary resource is the computer. Just this year we added a brand new Web site called "NECDIRECT," which allows those in the electrical field and others interested in electrical safety to access information about the NEC, code requirements, and much more. We are also in the early stages of looking at electronic training programs. These are the wave of the future, and they are within our reach.

**Mickey:** One of the most exciting things about the Internet today is that it has opened the doors to expanded learning opportunities. George and I want to spend some time now talking about NFPA's public education outreach.

This is one of the most visible aspects of NFPA's mission. NFPA codes and standards protect people behind the scene, but there is prevention work that goes on at the grassroots —or very basic—level that is also critical to reducing fire losses.

NFPA's commitment to public safety dates back to our founding 104 years ago, but it has grown exponentially in recent years. Our philosophy about prevention and safety messages is really pretty simple: We believe in positive, consistent and technically accurate messages, exposing as many people as we possibly can, in all segments of society.

This approach to public education has served people well. Learn Not to Burn®, NFPA's original fire safety curriculum, is used in a quarter million schools in the U. S. , but it is also used nationwide in Canada and in parts of Great Britain. Another core component of NFPA's fire safety outreach has been sponsorship of Fire Prevention Week , which we've done for three—quarters of a century. Our official role is to create a structure for community—based implementation of comprehensive safety information. We do this by galvanizing the energy within fire departments, schools and other safety advocate groups to help spread fire prevention messages.

For most of NFPA's early history, public education outreach was focused solely on fire. But on NFPA's 100th anniversary, we took an unprecedented step and broadened NFPA's reach by establishing the first comprehensive, school—based injury prevention curriculum. It's called "Risk Watch" and it teaches school—age children how to take action to protect themselves from the leading causes of childhood injury, one of which is fire. To achieve this, NFPA teamed up with an impressive group of technical advisors from among the most authoritative injury prevention organizations. After only a couple of years in the field, Risk Watch® is already widely accepted in the educational and public health fields and support for and interest in it is growing.

The world's population is aging and the needs of this group are frequently different than for others. In the United States, older people suffer the highest fire death rates of any population group. One of the most important new activities for NFPA is a safety curriculum for older adults called "Remembering When™."

This new teaching tool combines the two leading causes of injury for older adults — falls and fire —and addresses them in a curriculum that was specifically designed to appeal to this age group. "Remembering When™" uses games and activities that embrace popular events from bygone days as an incentive to get people talking about simple prevention methods and to learn what they can do to avoid injury. It is designed to be used in group or individual settings, by trained instructors as well as by home aides. "Remembering When™" is an important achievement for NFPA, as it marks the first time we've developed a curriculum targeted solely at adults.

**George:** NFPA embarked on this program for older adults as a direct result of research findings that told us that's where we need to focus our efforts. Research is one of the core elements of NFPA's mission, and is critical to helping us understand the behavior of fire and the significant factors that lead to death and property.

The collection and analysis of data is an important aspect of research and NFPA maintains one of the world's most extensive fire experience databases. This research serves as an important guide not only to NFPA's public education initiatives, but also to the technical committees that write the codes. NFPA produces dozens of annual reports and special studies on a wide variety of fire issues and these are disseminated among the fire, engineering and insurance industries, as well as within the news media.

In addition, NFPA is fortunate to maintain the Charles S. Morgan Technical Library, which has one of the largest collections of information relevant to the fire problem.

**Mickey:** One of the important roles of NFPA's research activities is to provide benchmarks for our progress in reducing fire losses. Although the United States has seen an important downward trend in fires and fire deaths over the past several decades, our country still suffers one of the highest fire death rates in the industrial world. What has changed significantly is that extremely large, or catastrophic, fires don't occur as often as they once did. In the past, extraordinarily large fires frequently took the lives of scores of people at one time.

Many of these historic incidents are well known — perhaps you're familiar with them. There were structural fires: The Triangle Shirtwaist Factory Fire (146 dead), the Iroquois Theater Fire (602 dead), the Cocoanut Grove Fire (492 dead); and there were horrendous losses in ship fires: the General Slocum Excursion Steamer (1,030 dead) and the S. S. Grandcamp (468 dead); tragic tent fires killed nearly 500 in India and 146 in the State of Connecticut; and there were conflagrations, such as the earthquake and fire that hit San Francisco, killing 492.

These tragic incidents represent more than just numbers and names. Fortunately, the hard lessons learned in all of the fires I just mentioned have contributed to a safer world today. In many cases, such as with the Triangle Shirtwaist factory, the fires led directly to new or improved codes and standards, protecting the lives of those who would follow the victims.

Although we rarely see fire deaths of this magnitude any longer, NFPA continues to research significant fire incidents through its Fire Investigations Department. As part of our mission, we fund the independent investigation of technically significant fire losses in order to document the lessons learned.

We don't investigate the fires to find fault or lay blame; that is for the other authorities to do. Rather, we want to learn what went wrong and what went right. The findings from NFPA fire investigations are broadly distributed, including through NFPA's Web site.

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Certainly the fire service community is interested in the results, but so are many others. The findings are shared with technical committees, which frequently incorporate the results into code requirements.

It is through this sort of effort and many others that NFPA can provide a leadership role in reducing the burden of unwanted fire.

**George:** Our presentation is drawing to a close. I think it is fitting to end on a note that I believe is optimistic.

When I visit this part of the world I can't help but be impressed with the culture and history of your enchanting region. There is such a rich collection of artifacts and architectures, works of art and fine craftsmanship—so much to protect and so much to lose should fire strike. We share in common a desire to protect not only the people who are dear to us, but also the symbols of our heritage and the fine things that provide inspiration, or comfort, or simply the pleasure of enjoyment. Preserving our cultural heritage is one of the most valuable aspects of fire protection.

Fire is a threat to nearly any type of structure, old or new. While modern technology improves the level of protection we can build in to new construction, it is not necessarily as easily applied in historically significant structures. NFPA has a proposed code in development that addresses fire protection of these special occupancies, NFPA 914, Code for Fire Protection of Historic Structures. Mickey is a member of the NFPA Cultural Resources Committee that has developed this code. Once it is approved, it will provide important guidance on protection these enduring and beloved treasures for the benefit of all mankind.

**Mickey:** It would be easy to talk on and on about NFPA, but George has chosen an excellent stopping place. This is a good example of the state-of-the-art codes and standards that are developed through NFPA's process and their far-reaching affects.

It also underscores that no matter how far apart we are geographically, there are values and beliefs that inexplicably join us. When NFPA and CPFA signed an agreement 5 years ago, we couldn't know what would lie ahead for our organizations.

I am pleased to say that our combined efforts continue to be valuable and productive today. George and I are committed to working closely with CPFA and others here in China to ensure that NFPA's codes, standards and other resources are properly translated to make them useful references in your culture and society. Personally, I have had the great opportunity to renew old friendships and make new friends on my trips to China and am honored to be part of the cooperation between our two great nations.

**George:** Mickey's got it right. Not only is our agreement of mutual benefit to our respective associations, it is important progress in the daily battle against fire. Together, NFPA and CPFA, along with others, can make a real difference in fire safety.

Again, we sincerely thank you for the opportunity to join you today, and we look forward to a long future of cooperation and collaboration in the interest of protecting people from fire in our own countries and around the world.

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## Study on High Pressure Water Mist Fire Extinguishing System

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**Abstract:** This article briefly introduces the history of water mist system and its breakthrough for the sprinkler system. The mechanism of water mist formation, mechanism of fire extinguishing, capability of fire extinguishing, application area and the cost comparison to gas system and sprinkler system of water mist system is described according to the full scale test for the two phases flux high pressure pre-installation water mist system developed by TFRI. The possibility of being alternative to halon is determined, moreover, the prospect of engineering application is showcased.

**Keywords:** water mist extinguishing system nozzle

Since ancient time, it has well known that water possesses the capability of putting out fire. Among fire extinguishing systems, sprinkler system, therefore, has the longest history of more than one hundred years. During this period of time the key part, i. e. the sprinkler head, has been improved dramatically at following respects: 1) integration of detecting and spraying; 2) improvement of thermal sensitive parts; 3) improvement of water flux rate, operation pressure, water distribution and water momentum. However, it is the diameter of water mist (including the diameter of water spray particle) within 1—2mm that has not been made a breakthrough. Subsequently, the serious problems such as a great consumption of water, water damage and unexpected operation etc. become inevitable and formidable. In 1940s water mist system was applied on ship. Nevertheless, water mist system was frustrated in research because the sprinkler technology was in fashion. In 1990s, along with the technology progressing, the fire concept changing and the halon-oriented problems, the water mist technology is appealed to be used.

In early 1990s, Finland, USA and Canada developed the water mist system. The related design, installation and standardized document was put forward in 1993 and the Standard for Water Mist System (NFPA750) was publicized officially in 1996 by Water Mist System NFPA Technical Committee being comprised of manufacturer, developing and engineering sector, insurance company, legislation institution and representatives of clients.

After the signature of Montreal Protocol China staged the research on alternative system of halon 1301 and 1211. The water mist system, low pressure CO<sub>2</sub> system, fast sprinkler system and Inergen system are the promising alternative systems of halon. Among them, the water mist system is superior to halon system in terms of fire extinguishing capability, cost and side effects after release, moreover, as agent of the system water is obtained easily and cheaply. Additionally, in respect of the protected object, applied area and fire extinguishing behavior this system is almost the same with halon system. It is evident that this system possesses the effects of cooling the protected area and preventing dust. Compared to sprinkler system, water mist system is characterized by small amount of water consumption, little water damage, convenience in installation and pool relief. This system is one of the widely used alternative system among the developed countries. Its application in civil building, flammable liquid storage and electric appliance room is under researching. Water mist system research is the key project in China. It is believed that domestic manufactured water mist system will stage to market and related technical standard and



design construction code will publicized soon. The water mist system is a promising system in engineering due to not only its alternation in formation comparing to the traditional sprinkler system but also its substantial improvement in its spray pattern, fog formation principle, fire extinguishing mechanism, capability of fire extinguishing and application scope.

### 1. classification of water mist system

The water mist system can be divided into 5 categories and subdivided into 14 kinds in terms of operation pressure, flow phases, application ways, operation ways and installation ways. It is high pressure two phases pre—installation mist system that our TFRI developed. But for special explanation the followings refer to this system.

### 2. water mist formation principle

The nozzle is the important part because it can transform water to fog. It consists of the sprinkler frame, filter net etc (see figure 1). After water and N<sub>2</sub> enter the nozzle through the filter net, under the pressure high velocity appears in the spiral space. When the two phases flux get to the outlet of the nozzle, they will be smashed and jet out. The distribution of diameter of the water mist measured by FAM laser apparatus under the condition of nozzle (1MC6MB—1.4) pressure of 0.4 MPa~1.2 MPa illustrated in Table 1.

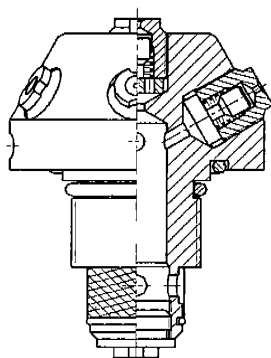


Figure 1 nozzle

Table 1

Operation pressure(MPa)	D <sub>32</sub> (μm)	D <sub>v0.5</sub> (μm)
0.4	105.4	111.8
0.5	76.7	98.7
0.6	73.7	95.7
0.7	65.3	86.7
0.8	63.3	67.1
0.9	60.9	81.3
1.0	57.5	72.9
1.1	56.7	74.5
1.2	54.2	73.4

### 3. water mist system formation

The WMU150 water mist system which is a two phases flux system consists of N<sub>2</sub> cylinder, water cylinders, control valve, cylinder shelf, pipe, nozzle, alarm controller and detector. (see figure 2, function of parts and main parameter illustrate in Table 2 )

Table 2

	components	function	parameter
1	N <sub>2</sub> cylinder	high pressure N <sub>2</sub> storage	volume 50 L, operation pressure 15 MPa
2	water cylinders	water storage	volume 50 L, operation pressure 15 MPa
3	tee	separation of gas and water (gas in and water out)	operation pressure 15 MPa

4	controlling valve	manual, electric start and on-off circulation; pressure adjusting, gas and water mixture proportion controlling	control up to 3 groups of WMU150 cylinder, operation pressure 15 MPa, maximum flux rate 45L/min
5	nozzle	water mist formation and fire extinguishing	Open type, $K_{liquid} = 1.4$ , operation pressure 0 MPa—5.5 MPa
6	alarm controller	In addition to the functions of normal controller, it possesses the function of programming carrying out in different ways according to the protected object	AC220V or DC24V
7	detector	detect the fire development	water/explosion proof, high temperature resisting

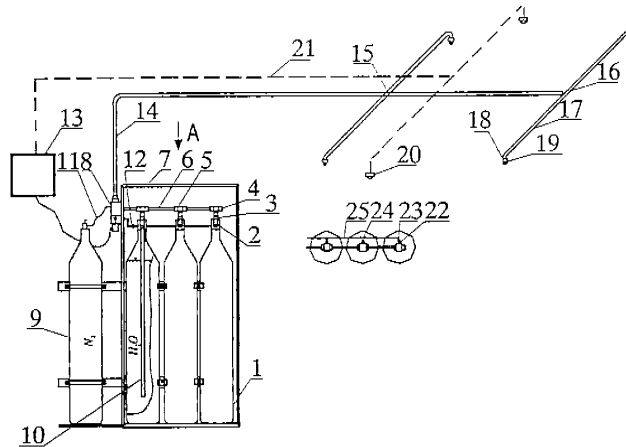


Figure 2 Layout for high pressure water mist system

**4. fire extinguishing mechanism of water mist**

There are many ways to be carried out to the protected object such as extinguishing, suppression, controlling fire/temperature and dust prevention. Its mechanism is as follows:

a. efficient heat absorbing

The water mist can be totally evaporated in fire due to its diameter at the range of  $40 \mu\text{m}$ — $200 \mu\text{m}$ . The surface area of the mist is 1 700 times as big as normal water drop. The heat absorbing power of the fog released from each nozzle is 300 kW assuming that the evaporation potential heat at  $100^\circ\text{C}$  is 2 257 kJ/kg.

b. suffocate

After the water mist system operation, water mist will be transformed to vapor quickly and the volume will expand dramatically to expel air out. Subsequently, an obstacle around the burning substance will form to prevent fresh air from entering. The fire will be suffocated when the oxygen concentration is low enough.

c. heat radiation obstructing

The vapor keep the burning substance, flame and smoke plume separate from adjacent goods preventing the fire from spread.

### 5. scope of application, application area and cost

The scope of application of water mist system is determined by the diameter of water mist and the mechanism of fire extinguishing. However, as for traditional sprinkler system enough water momentum is required to compensate the buoyancy of heated gas and smoke plume and delivery enough amount of water to the surface of the burning object. Therefore, the sprinkler system has the ability of putting out fire by cooling and reducing the vaporization rate. Thus, the mechanism of the sprinkler system determine its scope of application that it is feasible for solid fire but can not apply to liquid fire and electric appliance fire. In terms of the mechanism of fire extinguishing the water mist system is totally different from the sprinkler system though it is developed from the sprinkler system, i. e. , cooling, suffocating and separating adjacent object from fire. The water mist system can put out fire whatever.

Moreover, compared to the gas system water mist system is convenience for engineering and daily maintenance and more cheaper because pressure in the water storage cylinder is normal at stand-by condition. Additionally, the test conducted by ABB Stromberg Research Center indicate that the system possesses good performance of electric insulation. The application area of this system is as follows: Class A fire, Class B fires, Class C fires, and Electrical equipment fires.

According to code in China, it is required that transfer room and high/low voltage electrical equipment room should be protected by halon 1200, 1301 or CO<sub>2</sub> full flood system. Almost every building contains such two kind places, so the halon quantity used in those places is quite considerable. Such place is a focal point to replace halon by non-halon. Generally, the volume of such place is relatively smaller (200 m<sup>3</sup>—500 m<sup>3</sup>) and better closed, there is no other combustible products except transformer and electrical chamber. It is quite suitable for water mist system applying in such place. Take a 1000KVA internal transformer (the size is 2 230 mm×1 595 mm×2 610 mm, the oil weights 1 485 kg, the room is 7 m×7 m×5.1 m) as example, the transformer is protected respectively by halon 1211, 1301, high pressure CO<sub>2</sub>, sprinkler system and water mist system, the comparison for agent usage and the engineering cost can be seen in table 3 (without the alarm system).

Table 3

	System type	The agent consumption	Mine equipment	Main pipe (mm)	The factor of engineering cost
1	Halon 1211	94 kg	2×40 L agent cylinder	DN50	1.0
2	Halon 1301	83 kg	2×40 L agent cylinder	DN50	1.7
3	High CO <sub>2</sub>	482 kg	11×70 L agent cylinder	DN50	2.7
4	Water sprinkler	20 m <sup>3</sup>	Water pool 20 m <sup>3</sup> , two 18.5 kw pump, a deluge valve set	DN80	2.0
5	Water mist	Water: 150 L N <sub>2</sub> : 50 L	3 water cylinder, 1 N <sub>2</sub> cylinder, 1 control valve	φ20	0.8

### 6. The typical full scale fire extinguishing test

To select 315 kVA oil-immersing electrical transformer as the protected object, put in the center of combustion test room (7 m×7 m×3.5 m), shown as figure3, beneath the transformer there is a 1.8 m×1.0 m×0.15 m steel oil-plate to simulate oil collecting pit. At first, the oil tank of the transformer is filled with water and the surface of the water is 15

cm below the top of the oil tank. Then, pour 30 L oil into the oil tank and splash the surface of the transformer evenly with 9 L transformer oil. The extinguishing System used is the WMU150 type water mist system developed by TFR1. The water store amount is  $3 \times 50$  L while  $N_2$  pressure is 12.5 MPa. The nozzles are installed under the roof (the roof is 3.5 m high), the spacing between the nozzles in horizontal is  $2.2 \text{ m} \times 2.2 \text{ m}$ . The nozzles are developed by TFR1 and the type is 1MC6MB-1.4. Four nozzles in all.

Use 4 of cotton yarn ball soaked with 100 mL of gasoline and placed at the bottom of transformer, four points in diagonal. The pre-ignition time is 108 s, the highest temperature is up to  $195^\circ\text{C}$  at the roof. When the temperature rises to  $220^\circ\text{C}$  the system begin to spray mist, the temperature drops rapidly. After 25 s the temperature is about  $100^\circ\text{C}$ , radiation heat reduces 56%. By that time there no flame can be seen. When another 20 s passed the temperature dropped to  $60^\circ\text{C}$ , the radiation heat reduced 30%. The system sprays water mist continually for 10 min to prevent re-ignite. After the fire been put out, the result can be found that the oil in transformer was not burned, the oil poured on the surface of the transformer consumed about 30%, the transformer and oil tank was not damaged and deformed. Conduct full-scale fire extinguishing test. Measuring point arrangement: see table 4 and figure 4.

Table 1-4

Test parameter	Temperature ( $^\circ\text{C}$ )						Pressure (MPa)			Radiation heat kcal/ $\text{m}^2/\text{h}$
	T11	T12	T13	T14	T15	T16	P12	P13	P14	F1
Test point location	Near the 4 nozzles	The top of transformer			middle of transformer		inlet of control valve	Inlet of cylinder	Inlet of nozzle	At the corner, 1.4 m high

7. Analysis for the test result

- 1) The water mist entering fire area absorb heat quickly and lower the temperature. The generated large quantity of vapors can prevent combustibles from fresh air, cut off oxygen supply and suffocate the fire. In addition, the capacity of insulating radiation heat is extraordinary;
- 2) The water used in fire fighting is very little. At the same fire extinguishing time the water amount used by mist system is only 5% of that of water sprinkler system;
- 3) The curves of temperature-time, pressure-time, and radiation heat-time are shown in figure 5, figure 6.

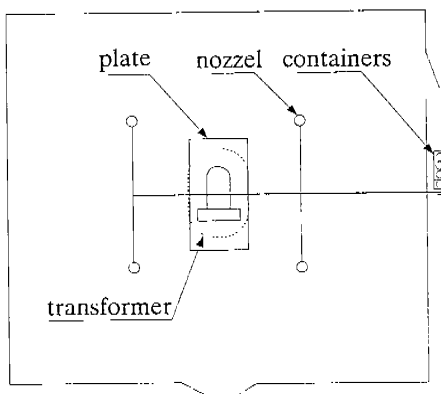


Figure 3 The arrangement of the test

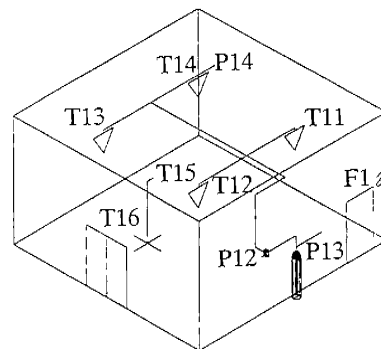


Figure 4 The test room and the arrangement of the measuring points

(T—temperature; P—pressure; F—fradiation heat; triangle—nozzle)

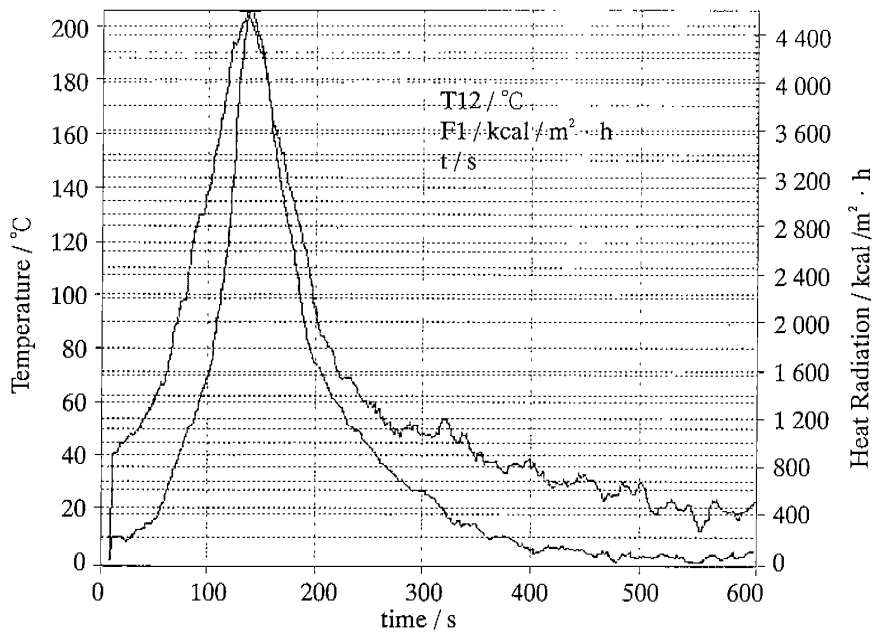


Figure 5 the curves for temperature, radiate heat—time

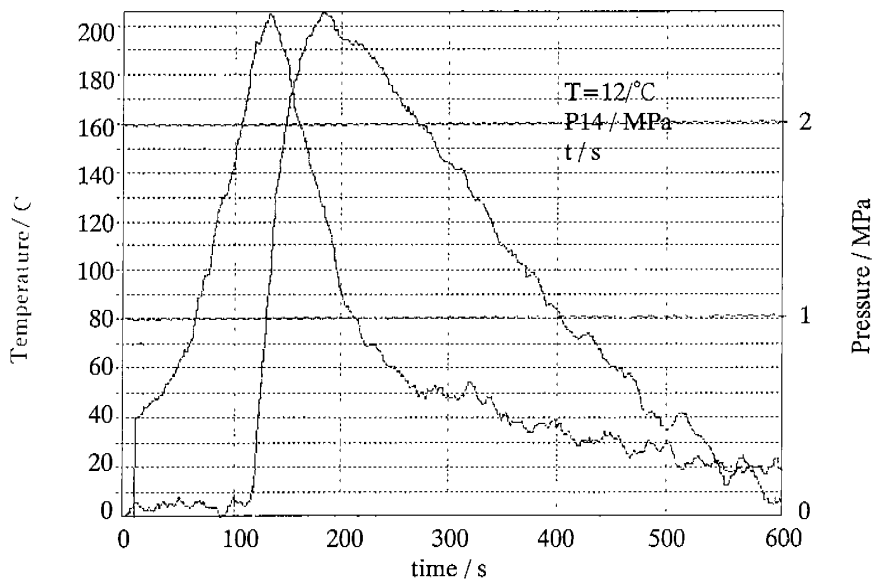


Figure 6 the curves for temperature, pressure—time

### 8. Conclusion

- 1) WMU 150 type high—pressure mist system (with gas—liquid phase in one pipe) can

- protect a closure of 250 m<sup>3</sup>. According to measurement, the general diameters of the water mist droplets are within 40 μm~150 μm.
- 2) Take water as fire extinguishing agent, the system can put out Class B fires quickly and effectively, such as diesel fire, transformer oil fire and gasoline fire.
  - 3) This system can be used as alternative system to halon, its proportion of cost—performance is better than that of halon system and CO<sub>2</sub> system.
  - 4) The system is suitable for protecting internal oil—immersed power transformer.
  - 5) The loss caused by water mist is very light, without any harm and pollution to human being, protection object and environment.

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## Development and Deployment of FIRECAM<sup>(TM)</sup> \*

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**ABSTRACT** Many countries in the world, including Canada, are moving towards the more flexible performance — based building regulations and away from the present restrictive prescription — based regulations. Performance — based regulations allow the designers and building officials the freedom to come up with innovative designs that will provide a level of safety that satisfies the objectives established by the regulations. Such innovative designs often lead to lower fire protection costs. The implementation of performance — based building regulations can be facilitated by the development of engineering tools that can help assess the overall fire safety performance of a building.

### 1 Fire Models to Support the Introduction of Performance—Based Codes

To support the introduction of performance — based codes, many research organizations around the world are developing computer models that can help designers predict how fire and smoke develop in a compartment and spread to other compartments in a building.<sup>[1]</sup> These models include both field and zone models. The field models divide a compartment into many cells and compute, using computational fluid dynamics (CFD), the thermal and flow conditions in each cell. These models provide detailed information in a compartment but are computationally intensive and require a lot of computer time even with the fastest computers. An example of the field models is the JASMINE model that was developed by the Fire Research Station in the U. K. <sup>[2]</sup>

Different from the field models, the zone models divide a fire compartment into a number of characteristic zones, such as the upper hot layer, the lower cold layer, the fire plume and the compartment boundary. The conditions in each zone are modelled separately and then linked together through fluid dynamics and heat transfer equations. This approach simplifies the intensity of computation and allows previously developed models, such as plume models or ceiling jet models, to be applied. A notable model of this type is the CFAST model that was developed by the National Institute of Standards and Technology (NIST) in the U. S. <sup>[3]</sup> Other more comprehensive models that predict not only the fire and smoke spread in a building, but also the expected risk to life of the occupants, are also being developed. These risk assessment models combine the interaction of fire growth, smoke spread, occupant response and evacuation, and fire department response to assess the expected risk to life of the occupants. Two such models that are being developed are the CESARE—RISK<sup>[4]</sup> that is being developed at the Victoria University of Technology in Australia and FIRECAM<sup>(TM)</sup><sup>[5]</sup>

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at the National Research Council of Canada (NRC).

## **2 Development of FIRECAM<sup>(TM)</sup> and other Risk Assessment Models at NRC**

To provide a tool that can assess the overall fire safety performance of a building, NRC is developing a computer fire risk – cost assessment model called FIRECAM<sup>(TM)</sup> (Fire Risk Evaluation and Cost Assessment Model). The model can assess both the expected risks to life of the occupants in a building, as well as the expected costs of fire protection and fire losses in the building. Therefore, the model can be used to identify cost – effective fire safety designs that provide a level of safety that is required by the code (performance – based code), or alternative designs that provide a level of safety that is equivalent to that of a code – compliant design (prescription – based code). The model is being developed in partnership with the Public Works and Government Services Canada (PWGSC) and the Department of National Defence Canada (DND).

To undertake the evaluation of fire risks and losses, FIRECAM<sup>(TM)</sup> simulates the ignition of a fire in various locations in a building, the development of the fire, smoke and fire spread, occupant response and evacuation, and fire department response. These calculations are performed by a number of submodels interacting with each other. There are nine submodels that are run repeatedly in a loop to obtain the expected risk to life values and the expected fire losses from a set of probable fire scenarios that may occur in a building. The computer model also includes three optional submodels that can be run if the building fire characteristics and fire department response are not considered typical or if fire costs are required. One submodel is run only once to obtain the failure probability values of boundary elements. FIRECAM<sup>(TM)</sup> is the only comprehensive model in the world that includes the probability of fire spread in a building, the response of the fire department and the estimate of fire costs, in addition to the typical modelling of fire growth, smoke spread and human response and evacuation.

FIRECAM<sup>(TM)</sup> uses statistical data to predict the probability of occurrence of fire scenarios, such as the type of fire that may occur or the reliability of fire detectors. Mathematical models are used to predict the time – dependent development of fire scenarios, such as the development and spread of a fire and the evacuation of occupants in a building. The life hazard posed to the occupants by a fire scenario is calculated based on how quickly the fire develops and how quickly the occupants evacuate the building for that scenario. The life hazard calculated for a scenario multiplied by the probability of that scenario gives the risk to life from that scenario. The overall expected risk to life to the occupants is the cumulative sum of all risks from all probable fire scenarios that may occur in a building. Similarly, the overall expected fire cost is the sum of fire protection costs (both capital and maintenance) and the cumulative sum of all fire losses from all probable fire scenarios in a building.

Another research group at NRC, in partnership with the DND, is developing a new computer model to evaluate fire protection systems for light industrial buildings, with the



primary focus on warehouses and aircraft hangers. FIERAsystem (Fire Evaluation and Risk Assessment system), is based on a framework that allows designers to establish objectives, select possible fire scenarios, and evaluate the impact of each scenario on life safety and property protection. The framework leads the user through a series of steps in setting up the problem, including defining building and occupant characteristics, and specifying fire safety objectives and appropriate performance criteria for fire and smoke spread, occupant safety, property protection, continuity of operations, and environmental protection. Potential fire scenarios are then selected from a list, along with active and passive fire protection options to be evaluated.

### **3 Deployment of FIRECAM<sup>(TM)</sup>**

Over the past decade, NRC, in partnership with PWGSC, has been developing a version of FIRECAM<sup>(TM)</sup> for PWGSC's use. The model, FIRECAM<sup>(TM)</sup> – Office Model, allows designers and regulators to evaluate the impact of various design options on life safety and property protection for office buildings. PWGSC owns most of the Canadian federal government buildings. The model will help PWGSC to identify cost-effective fire-safety designs for these buildings.

To help evaluate the performance of FIRECAM<sup>(TM)</sup> before its actual use, PWGSC has formed a number of task groups across Canada during the past three years. Groups were formed in Halifax, Montreal, Ottawa, Toronto, Winnipeg, Edmonton and Vancouver. Each task group consisted of PWGSC regional staff, fire consultants, building and fire department officials. Task group members were provided with the computer program as well as the necessary training, education and guidance. They learned how to apply the model as a fire safety assessment tool, interpret its results and understand its capabilities and limitations. The objectives of the evaluations were: a) to assess FIRECAM<sup>(TM)</sup> in order to determine whether its predictions were reasonable and realistic for applications to office buildings; and b) to provide constructive comments and recommendations for improving FIRECAM<sup>(TM)</sup> if there were any areas requiring improvement.

Real and fictitious case buildings were used in the exercise and numerous runs were conducted. For each building, a base fire safety design case was established and then one fire safety design parameter was changed at a time to determine the impact. In later runs, multiple parameters were changed to determine the impact of tradeoffs and additions. After each run, the members presented and discussed their results. At the end, they concluded that the predictions by the model in general were reasonable. In a few situations when the results differed from users' expectations, these differences were discussed and resolved. This is an important step in gaining the confidence of users and, ultimately, their acceptance and adoption of this program. Feedback gained from this comprehensive evaluation process also led to improvements in the computer program.

Following the evaluation of FIRECAM<sup>(TM)</sup> through PWGSC's task groups, NRC plans to release the FIRECAM<sup>(TM)</sup> — General Model by November 2001. The target date of November 2001 is set to allow sufficient time to fix bugs that may be identified through the current evaluation by PWGSC through March 2001. The executable module, the user's manual and the system model document will be available. Other reference material can be obtained from NRC Publications. NRC will not provide any technical support. However, training workshops may be provided at the request of the users and at full cost recovery. Users take full responsibility when they use FIRECAM<sup>(TM)</sup>.

For those parties interested in developing the model further for their specific use, NRC could enter into a collaboration agreement that will allow the model to be further developed. For example, if Tianjin Fire Research Institute (TFRI) wants to develop FIRECAM<sup>(TM)</sup> further for use in China, a research collaboration could be setup between TFRI and NRC. The collaboration will allow TFRI to carry out the required research and development work, with the support by NRC researchers, to make FIRECAM<sup>(TM)</sup> applicable in China. Such collaboration will benefit both organizations; allowing China to have the use of FIRECAM<sup>(TM)</sup> and allowing NRC's FIRECAM<sup>(TM)</sup> to have a wider application.

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## The Planned New Hong Kong Fire Services Communication Centre

LAM Chun—man

*(Hong Kong Fire Services Department)*

The Hong Kong Fire Services Department (FSD) is an emergency service in the Hong Kong Special Administrative Region. It is responsible for protecting lives and properties in case of fire or other calamities, giving advice on fire protection matters, as well as providing an emergency ambulance service for the sick and injured.

The Hong Kong Fire Services has about 8,500 fire and ambulance personnel and 800 civilian staff. It is under the leadership of the Director of Fire Services and is assisted by a Deputy Director.

Based on different areas of work, the department is divided into seven commands. There are three operational fire commands, namely, Hong Kong, Kowloon and the New Territories; two fire protection commands, which are the Licensing and Control Command and Fire Safety Command, an Ambulance Command, and the Headquarters Command which is mainly responsible for policies, training, mobilizing and communication, resources and planning etc.

Each operational fire Command is led by a Chief Fire Officer. There are about 4 to 5 divisions in each Command and each division has 4 to 7 fire stations.

In 1999, the Fire Services responded to 43,564 fire calls and 21,035 special service calls.

Fires are generally classified into five categories, from No. 1 to No. 5 Alarm according to their severity. Fire appliance attendance is determined on the basis of the fire alarm.

The normal initial attendance is a No. 1 Alarm attended by 4 fire appliances and one ambulance. But responding to places of high fire or life risks such as hospitals, dangerous goods storage or tunnels, the Department will turn out more fire appliances or ambulances depending on the nature of the risk and we classify these fire calls as No. 2 Alarm.

In 1999, careless handling or disposal of cigarette ends, joss sticks, children playing with matches and candles remains the major causes of fires, amounting to 6,238 cases, representing 14.3% of the total fire calls. This was followed by incidents involving the preparation of food and electrical faults. Unwanted alarms generated from faulty automatic alarm systems contributed to about 58.7 per cent of the total number of fire calls. In 1999, fires claimed 29 lives and 577 injuries. 3,652 persons were rescued in fires.

Special service calls cover a wide range of incidents including traffic and industrial accidents, lift incidents, gas leakage, landslides, flooding, house collapse and others where lives are at risk. About 34% of special services calls amounting to 7,064 cases were people shut in lifts, 505 cases were leakage of flammable liquid or gas and 344 cases of traffic accident were also handled by the Department.

Since 1992, the Department published its performance pledge informing the public of the

standard of service they can expect. The target response times for calls to fires in buildings are six minutes for built-up areas and 23 minutes for areas of more dispersed risk and isolated developments. The Department pledges to reach 92.5 % of total building fire calls within these targets.

To enable the Department to meet the performance pledge, fire stations have to be strategically provided to cover the risks. The need of a fire station is determined by an assessment of the risk category of the areas it serves. For this purpose, the Hong Kong Fire Services has developed a Risk Category System. A penalty points system based on factors such as population, intensity of land use, type of buildings, gross floor area utilization of different uses of buildings, height of buildings etc. , is adopted in determining the risk level of the areas concerned. Expected changes in any of these factors for the next ten years will also be taken into consideration.

The resulting penalty points will then be categorized into 5 levels of risk, from Cat. A to Cat. E, which forms the bases of a graded response time. Category A or B risk areas are either industrial or densely populated, and a response time of 6 minutes to reach the scene of incidents has to be achieved. For Category C to E risk areas, the response times vary from 9 to 23 minutes. Additional fire stations will be needed in areas where fire appliances cannot normally reach within the graded response time.

The Department recognizes that prevention is better than cure. While the Department has good fire fighting capabilities, an effective implementation of fire protection policy and adequate provision of fire service installations in buildings are equally important. In this connection, the Licensing and Control Command and the Fire Safety Command will prescribe fire service installations in new or existing buildings and licensed premises according to regulations.

For old buildings where the standard of fire service installation provisions is not up to the present day standard, the Hong Kong Fire Services has introduced legislation and devised a phased program for owners or occupiers of these buildings to retrofit their buildings with new fire systems or equipment. The staff in Fire Safety Command will provide technical advice to these building owners and adopt a pragmatic approach in assisting the upgrading work.

Fire Services installations are hardware in fire safety. What is more important is the software which is human behavior. Thus, promoting public fire safety awareness is of paramount importance. In 1997, we launched a Fire Safety Ambassador Scheme as a major fire prevention education program. Fire Safety Ambassadors are taught with basic fire protection principles and fire safety messages. In turn, they will assist in spreading these messages to their friends and relatives. They will also assist in reporting fire hazards to the Fire Services for follow up action. Currently, about 11,600 Fire Safety Ambassadors have been recruited and the Department plans to recruit up to 15,000 ambassadors by the end of the year.

With adequate fire fighting resources, appropriate built-in fire protection systems and high public awareness in fire safety, the Hong Kong Fire Services believes there will be less tragic fires. The following table shows the no. of major fires and fatalities in the past few years.

Year	No. 3 Alarm & Above	Fatalities	Injuries
1996	39	65+(1)	611+(37)
1997	26	47	589+(16)
1998	32	14	711+(19)
1999	19	29	577+(18)
( ) Fire Services Members			

Nevertheless, the continuous rapid development in Hong Kong will result in an increase of fire calls despite most of them are unwanted alarms or small fires. The prompt dispatch of fire fighting resources to scene of incident requires an effective and efficient mobilization and communication system. The existing mobilizing system was commissioned in April 1991, and will reach its designed handling capacity in 2002. To ensure the Department will continue to provide an efficient emergency service, an in-house review was carried out in 1998 and followed by a comprehensive consultancy study. The study identified the following deficiencies and recommended replacing the existing system for the following reasons:

(i) its capacity has been stretched to the limits and cannot support vast data and image transmissions;

(ii) it cannot provide accurate and updated data to facilitate the searching process for dispatch efficiently;

(iii) it has limited integration capability and is incompatible with other supporting systems;

(iv) it will reach its serviceable life in 2002 and can no longer be effectively maintained beyond 2003;

(v) it cannot effectively cope with the projected growth in call volume beyond 2003.

To replace the existing system, it was proposed to develop a new communication and mobilizing system, namely, the Third Generation Mobilizing System (TGMS) to be commissioned in 2003. The new system will adopt an open platform design with graphic working environment. It will have a larger capacity, enhancement in various mobilizing activities and resource identification and also flexibility for further upgrading in handling the projected growth in call volume in the following 10 years to improve the pledged dispatch time for fire and ambulance services. The TGMS will comprise the following main systems:

(i) Computerised Mobilising System (CMS)—it will be a high-power system built on an open platform with pre-emptive multi-tasking functionality to cope with the projected workload during the lifespan of TGMS;

(ii) Telephone System — the system with Computer Telephony Integration (CTI) technology will facilitate Automatic Call Distribution. Through the Calling Line

Identification System (CLIS), address information of the caller using lined telephone network could be readily retrieved to help speedy identification of incident address;

(iii) Automatic Vehicle Location System (AVLS) — it will provide accurate location data of all FSD mobile resources, such as vehicles and fireboats, automatically;

(iv) Geographic Information System (GIS) — the system working with AVLS and CMS will indicate on digitised map the nearest available fire and ambulance resources to any reported address of incident for efficient mobilisation;

(v) Wireless Digital Network (WDN) — this network will provide effective data and image transmission for AVLS and Mobile Data Terminals installed in emergency vehicles;

(vi) Mobile Data Terminals — these terminals will be installed in all fire and ambulance vehicles to receive and despatch incident information through WDN;

(vii) Information Management System — it will integrate with all systems for records logging, analysis, resource management, etc.; and

(viii) Other supporting systems — they include the Security System, the Fault Indication Management System, the Intercom System, the Uninterruptible Power Supply System, the Telecommunication Network, etc.

TGMS will enable the Department to enhance its performance and handle the projected growth of emergency calls up to and including year 2013. It will also help improve fire — fighting and rescue operations in the following ways:

(i) accurate and efficient resources deployment — TGMS will identify and locate real time fire and ambulance resources automatically for immediate dispatch to the scenes of incidents. It helps to achieve more accurate incident tasking and optimize resource management;

(ii) accurate incident address — Fire Services Communication Centre (FSCC) staff can easily ascertain through CLIS incident address for timely dispatch of fire and ambulance resources and it minimizes mis — reception of the reported address;

(iii) direct and effective operational information exchange — Vital operational information/data, such as caller's information, chemical data, location of hydrants and public utilities, building information, vehicle access, incident details, etc. can be accurately exchanged between FSCC and the resources at scene for effective management of fire — fighting and rescue operations;

(iv) enhanced flexibility in resources identification and mobilisation — through open platform design, CMS allows easy programme development and enhancement and has the flexibility to meet future operational requirements and demand for continuous improvement in fire and emergency ambulance services;

(v) no additional staffing resources — TGMS will enable console operators to cope with the increase in the number of calls without the need for additional staffing resources.

It is estimated that the non — recurrent cost of the replacement system will be about HK \$ 690 million i. e. US \$ 85M. Subject to satisfactory site acceptance test, system reliability

tests and phase—in parallel run, it is planned to commission the TGMS in 2003.

We expect there will be a steadily increasing call volumes for both fire and emergency ambulance services in the coming years and we see there are two striking forces in the public's expectation. One is the demand for continuous improvement of public services, and the other one, the most important of all, is the need to provide a cost effective public service. We believe that the provision of an effective communication and control system with latest technology and equipment will help us to meet the challenges in the new millennium by

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( I ) promoting our performance in responding to emergency calls as the mobilizing and arriving time of the emergency resources will be reduced;

( II ) optimizing utilization of available emergency resources by virtue of its precise appliance location ability; and

( III ) addressing the public's expectations — the delivery and maintenance of an efficient and cost effective essential service.

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## Fire Robot — A Good Heiper of the Fireman

Hu Chuanping

(*Shanghai Fire Research Institute*)

**ABSTRACT** Based on the requirement of fire fighting, this paper discuss the necessity of extinguishing, detecting, washing and neutralizing, breaking and rescuing work of the fire robot, as well as all kinds of the functions of it in the diversified hazardous places. Different fire robots are classified here. Both the foreign history and present development and the domestic development of the fire robot are discussed here. It also analyze the conditions for the development of the fire robot in our country and put forward the developing target and direction.

**KEY WORDS** Fire robot, fire fighting, research and development, applying

### 1 Summarization

Life is precious, when many people are fortunate enough to be saved by the firemen from the fire, the firemen's own lives is on the verge of death. Every year, thousands upon thousands fire fighters are injured and dead in the fires all over the world. To put out the fire as soon as possible, prevent the spread of the fire and find the fire source, the close range extinguishing method is the best way to raise the extinguishing efficiency. But, sometimes the fires are too violent to close. Processing a chemical hazardous incident, the situation of the fire scene is quite complicated, the toxicity, causticity, flammability and explosibility, or the radioactivity of the leakage is more dangerous for the firemen.

Who can help the fire fighters do better in the chemical hazardous incidents, as well as extinguishing the fire, saving the lives? And who can go instead of the fire fighters to receive the threat against their lives? Fire robot.

### 2 The present development of the foreign fire fighting robot

USA and former Soviet Russia have made the research of the fire robot earlier than other countries in the world have. And later, British, Japan, France and Germany have started to research this technique one after another. Japan has applied the most robots into practice. In 1980s, Japan has developed at most five types of self-propelled fire robot, and they are equipped separately to the fire department of Tokyo, Osaka, etc.. This robot, which uses the gas engine or eletromotor as the power, equipped with the driving wheels or the track-laying gear, can climb and surmount obstacles. The fire monitor, which it's equipped with, has a large jet current, and can turn round pitching, right-and-left. It also mounts a gas fire detector and a video monitor equipment. The maximum distance controlled by the cable or wireless control is 100 m(150 m). Another type of robot is the detecting and rescuing robot, besides the gas fire detector and the video monitor equipment, they are also equipped



with the manipulator, which can deal with the hazardous materials by the remote control. USA has developed the intelligentized rescuing robots controlled by the sensation, such as the "Dante 2" was used to detect the active volcano in Alaska, the RM1 — 9 remote controlled fire robot caught a homicide, and so on. The fire robot, developed by the fire department of Arizona, equipped with the breaking—in tool and fire fighting lance, which can break and spray at the same time.

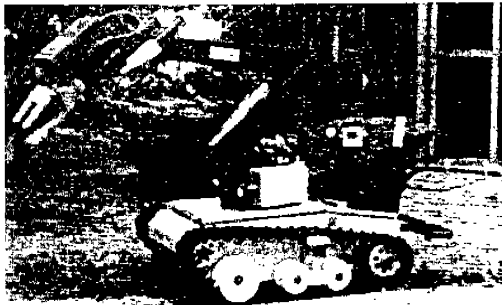
The RO — VEH remote controlled fire vehicle, produced by the British intelligentized Security Company, has been equipped into the middle and west fire department. It is equipped with a track—laying or wheeled running gear, so it can climb the stairs, and the cable or a self—equipped accumulator supplies the power. It is wire controlled and also mounted the fire monitor, video camera and thermal camera. In 1985, the British Midwest fire department and the Firma SAS company jointly developed a fire robot, refitted from a Hunter III motor, equipped with two manipulators, fire fighting lance, detector (temperature, chemical materials, radiation), technical video camera, infrared equipment. The manipulators are used to open and close the valve, move the goods or open the door.

The Peter tractor factory of Former Soviet Russia and the fire research institute of Ministry of internal affairs have jointly developed a fire robot, which has the vision function, equipped with the fire fighting lance, photoelectricity probe and technical video camera, etc. In the world, the research of the fire robot can be classified into three phases (three periods), the first period: the program controlled fire robot; the second period: the sensory fire robot; and the third period: intelligentized fire robot. At present, the developed countries are expediting to develop the different applied fire robot of the second type and the basic intelligentized fire robot, and they are also commencing to research the advanced intelligentized fire robot. In some developed countries, the fire robot research has been placed in the national technique development program, and has been regarded as the main guarantee of the economic development. Fig. 1 shows the pictures of fire robot from France and Japan.

### **3 The classification and main technical characteristic of the fire robot**

For the convenience for the research and exploration of the fire robot, the fire robot can be classified as follows on the basis of the needs of the actual combat.

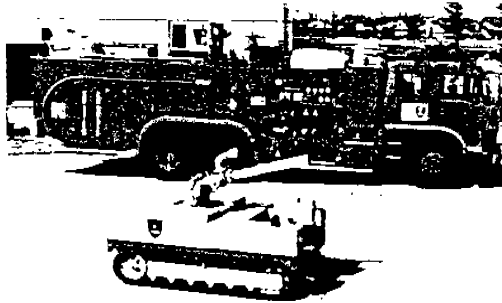
- (1) Classified by the main functions
  - a. Fire extinguishing robot
  - b. Fire detecting robot
  - c. Hazardous leakage detecting robot
  - d. Break—in robot
  - e. Rescuing robot
  - f. Multifunctional robot



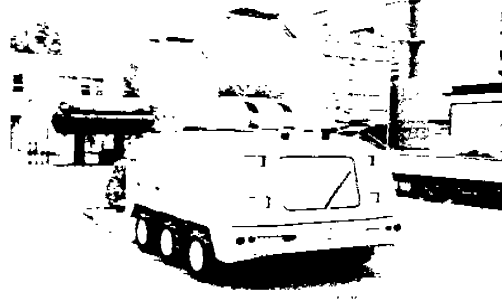
Tracked Rescuing Robot (France)



Wheeled Fire Fighting Robot (France)



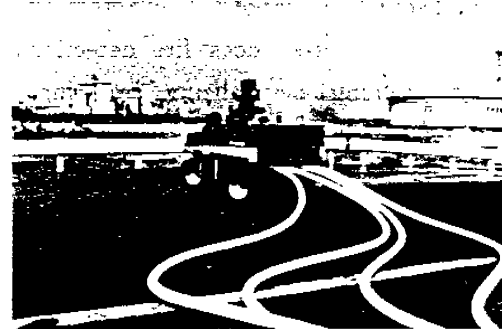
Tracked Fire Fighting Robot (Japan)



Wheeled Fire Detecting Robot (Japan)



Wire Controlled Wheeled Fire Fighting Robot (Japan)



Wireless Controlled Wheeled Fire Fighting Robot (Japan)



" Mother Car" Carrying the Sun Robot the Scene (Japan)



The Sun Robot Moving onto the Ground (Japan)

Fig. 1 Fire Robot from France and Japan

- (2) Classified by the walking modes
  - a. Wheeled fire robot
  - b. Track—laying fire robot
  - c. Track—laying wheeled running fire robot
  - d. Suction cup running fire robot
- (3) Classified by the control modes
  - a. Wire controlled fire robot
  - b. Wireless controlled fire robot
  - c. Self—adaptive fire robot
- (4) Classified by the intelligentized standards
  - a. Program controlled fire robot
  - b. Computer aided controlled sensory fire robot
  - c. Intelligentized fire robot
- (5) Classified by the sense functions
  - a. Vision fire robot
  - b. Olfactory fire robot
  - c. Thermal sensation fire robot
  - d. Tactual fire robot

The fire robot often does fire detection, hazardous chemicals detection, extinguishing, cooling, washing, neutralizing, breaking, rescuing, opening and closing the valve, moving and plugging under a badly flammable and explosible environment, which has high temperature, strong thermal radiation, smog complicated land forms, many obstacles and chemical corrosion. Consequently, as a specified used fire robot, it should have one or some of the running or self—protection functions as follows.

- a. Climbing gradient, ladder and surmounting obstacles
- b. Heat resistance and thermal radiation resistance
- c. Water proof
- d. Explosion proof
- e. Chemical corrosion prevention
- f. Electromagnetism anti—interference quality
- g. Remote control quality

#### **4 Fire robot research and development in our country**

Shanghai fire research institute is the fire outfit research unit of our fire brigade. Since the end of the 1980s, with the support of the Ministry of Public Security, it has engaged in many researches on the remote controlled fire monitor system, the main part of the fire robot, and on the relative experiment technique. It solves the problem of the engineering application of the remote controlled monitor system on the oil wharf and other relative places. Presently,

this production has been successfully applied in many domestic oil wharves, petroleum tank areas, hangars and so on. The relative productions has held the 80% share of the domestic market, the engineering application technique and productions are all matured. It lays a solid foundation for our research of the fire robot. In August 1998, "the self-propelled fire monitor" (six-wheeled fire extinguishing robot), developed by the Shanghai fire research institute and registered by the Shanghai Science Committee, was passed by the expert certification. The next year, "the track-laying fire extinguishing robot" was also successfully developed. On June 24th, 2000, the national "863" item, "the track-laying wheeled fire extinguishing and detecting robot" has been favorably developed by Shanghai fire research institute, Shanghai Jiao Tong university and Shanghai fire bureau, and has passed the national acceptance.

#### 4.1 Six-wheeled fire extinguishing robot

Six-wheeled fire robot is composed of a hanging six-wheeled running gear, a remote controlled fire monitor, a detection system of environment and internal temperature of the vehicle, a atomizing cooling self-protection system, a water and foam fire-extinguishing agent supplied system, a wired power supplying and controlling system. It can go deep into the key place of the fire scene, can use the extinguish agent and transported by the supplying system, and can spray and extinguish, wash and neutralize under the command of the rear operator. The straight stream spray and atomization can be converted each other through the replacement of the nozzle of the monitor. It has good ability of climbing gradient and surmounting obstacles, and the rate of flow is large, the effect of the atomizing cooling self-protection is quite good. Chart 1 is the performance indexes of the six-wheeled fire robot. Fig. 1 is the pictures of six wheels fire fighting robot.

The improvement of the six-wheeled fire robot is now in progress, the self-equipped engine will replace the wired power, and the wired control will be replaced by the wireless control, the hydraulic pressure motor will go instead of the electric motor. The intrinsic merits of the improved six-wheeled fire robot will be kept on, the running and operating flexibility and the fire fighting practicability will be further increased.

**Chart 1 the performance indexes of the six-wheeled fire robot**

Items		Indexes
Effectively controlled running length		$\geq 100$ m
Running speed m/s	Go head	$\geq 1$
	Back up	$\geq 0.5$
The gradient of climbing ladder		$\geq 30^\circ$
The height of surmounting the vertical obstacles		$\geq 250$ mm
The rated flow of the fire monitor		32 L/s

The rated working pressure of the fire monitor		0.8 MPa
The range of the monitor	water	$\geq 52$ m
	foam	$\geq 48$ m
The angle of the fire monitor	horizontal	$-60^{\circ} \sim +60^{\circ}$
	pitching	$-10^{\circ} \sim +70^{\circ}$
Continuously working time in the environment of 200°C, and 0.8W/cm <sup>2</sup> heat radiation		$\geq 0.5$ h
Continuously water proof time		$\geq 0.5$ h
The stability of the working posture		Can not be overturned in the travelling, climbing ladder and slope, surmounting the obstacles and spraying process

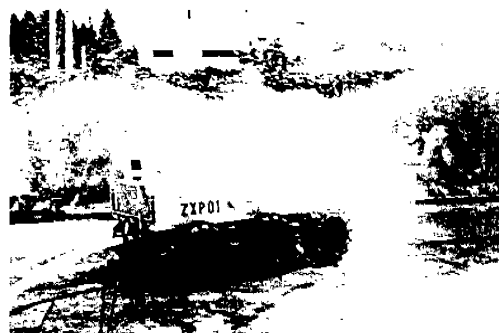


Fig. 2 Six wheels Fire Fighting Robot Developed By SFRI

#### 4.2 The track-laying fire extinguishing robot

The main function of the track-laying fire-extinguishing robot is the same as the six-wheeled fire robot. But the running gear is replaced by the track-laying, and the power is supplied by the self-equipped diesel motor, the running gear and the remote controlled fire monitor have been driven by the hydraulic pressure system, the controlled mode is the wireless control. The main performance indexes are as Chart 2. Fig. 3 is the pictures of tracked fighting robot.

Chart 2 the performance indexes of the track-laying fire-extinguishing robot

Items		Indexes
Engine	Type	Perkins103-13KH
	Power	13.8/2400 kW/rpm
Running speed	Go ahead	$\geq 2.8$ km/h
	Back up	$\geq 2.8$ km/h

The ability of the climbing slope		$\geq 28^\circ$	
The height of surmounting the vertical obstacles		$\geq 160$ mm	
Maximal necessary flow of the fire monitor		50 L/s	
The range of the monitor (discharging pressure 0.8 MPa)	32 L/s	Foam	$\geq 48$ m
		Water	$\geq 52$ m
	48 L/S	Foam	$\geq 60$ m
		water	$\geq 65$ m
The angle of the fire monitor	horizontal		$\pm 90^\circ$
	pitching		$0^\circ \sim +70^\circ$
Controlled length	$\geq 150$ m		
Mass	$\leq 1500$ kg		
Exterior sizes length×width×height	2300 mm×1060 mm×1470 mm		
Notice: The fire monitor can spray and atomize by the remote control			

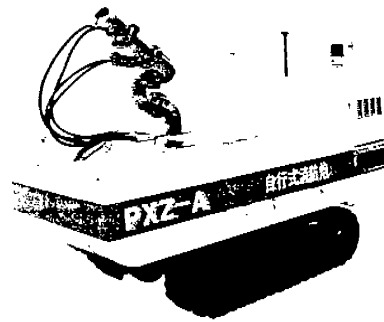
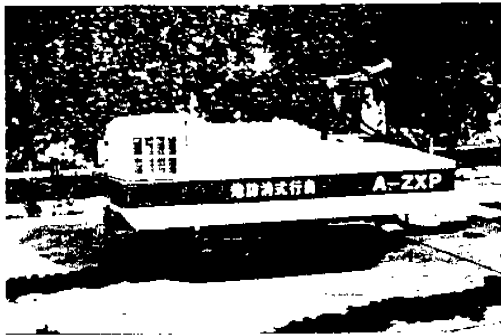


Fig. 3 Tracked Fire Fighting Robot Developed By SFRI

4.3 The track—laying wheeled extinguishing and detecting robot

The track — laying wheeled extinguishing and detecting robot consists of a remote — controlled fire monitor, a flammable and explosive gas detection system, a tracking—laying wheeled running gear, a graphic detection and transmission system, a positive anti — explosion system, a remote graphic monitor system, a atomizing cooling self — protection system, a light alarm system, a remote computer control system, and a expert auxiliary decision system. Under the control of the salvager, it can enter the flammable, explosible and poisonous scene of the dangerous incident and fire by itself, and complete a series of extinguishing and chemical rescuing work. The main functions are as follows:

- Goes deep into the dangerous place through the remote control, and surmounts the vertical channel obstacles and the slope.
- Works safely in the environment that is full of the poisonous, flammable and explosible

gas.

- Works continually in the environment of strong thermal radiation created by the fire source.
- Detects the character and concentration of the leaking gas at real time.
- Controls the spray direction of the fire monitor flexibly to extinguish, cool or dilute and wash, neutralize.
- Approaches the center area of the incident to surveil of the situation of the disaster and transfers the dynamic images of it.
- Provides the expert auxiliary decision of the rescue command.
- Has the cooling and self—protection function.

Chart 3 is the performance indexes of the track—laying wheeled fire extinguishing and detecting robot. Fig. 4 is the pictures of the track—laying wheeled fire extinguishing and detecting robot.

**Chart 3 the performance indexes of the track—laying wheeled fire extinguishing and detecting robot**

Items	Indexes
The length of the remote control, data, and graphic transmission	$\geq 100$ m
The usual types of detected poisonous gases	CO, H <sub>2</sub> S, HCN, SO <sub>2</sub> , NH <sub>3</sub> , CL <sub>2</sub> , NO <sub>2</sub>
The usual types of detected flammable and explosible gases	CO, gasoline, beneze
Remote monitor performance	Take and transmit the situation of the disaster and fire through the CCD and other specified optics system
The follow of the monitor	30 L/s
The range of the monitor	$\geq 52$ m
The follow of the foam monitor	32 L/s
The range of the foam monitor	$\geq 48$ m
The angle of the aclinic circumgyration of the fire monitor	$\pm 120^\circ$
The angle of the fluctuating pitching of the fire monitor	$-10^\circ \sim 80^\circ$
Climbing gradient	$\geq 30^\circ$
The height of surmounting the vertical obstacles	$\geq 250$ mm
The maximal running speed	$\geq 50$ m/min, can turn round and retroact
Swerve radius	$\leq 3$ m
Heat resistance quality	Can continuously work 1 hour in the non—anti—explosion state and the 5 kW/m <sup>2</sup> intensity of heat radiation
Water proof quality	Rain prevention

The positive anti — explosion system	Air supply pressure	0.45 MPa~ 0.85 MPa
	Ventilation time	10 min
	Normal pressure	300 Pa±30 Pa
	Alarm pressure	150 Pa±15 Pa
	Minimal pressure	60 Pa±15 Pa
	Anti—explosion	ExpDe II BT4
The expert auxiliary decision system		Provide auxiliary decision for the extinguishing, protection of the firemen, anti—explosion, early process,etc.
Simulated fire ground examining conditions		The prototype can successfully go through the simulated fire ground with the conditions of minitype fire, water sprinkle, obstacles, and slopes to discharge the water or foam, and pass the examination of the comprehensive performance.

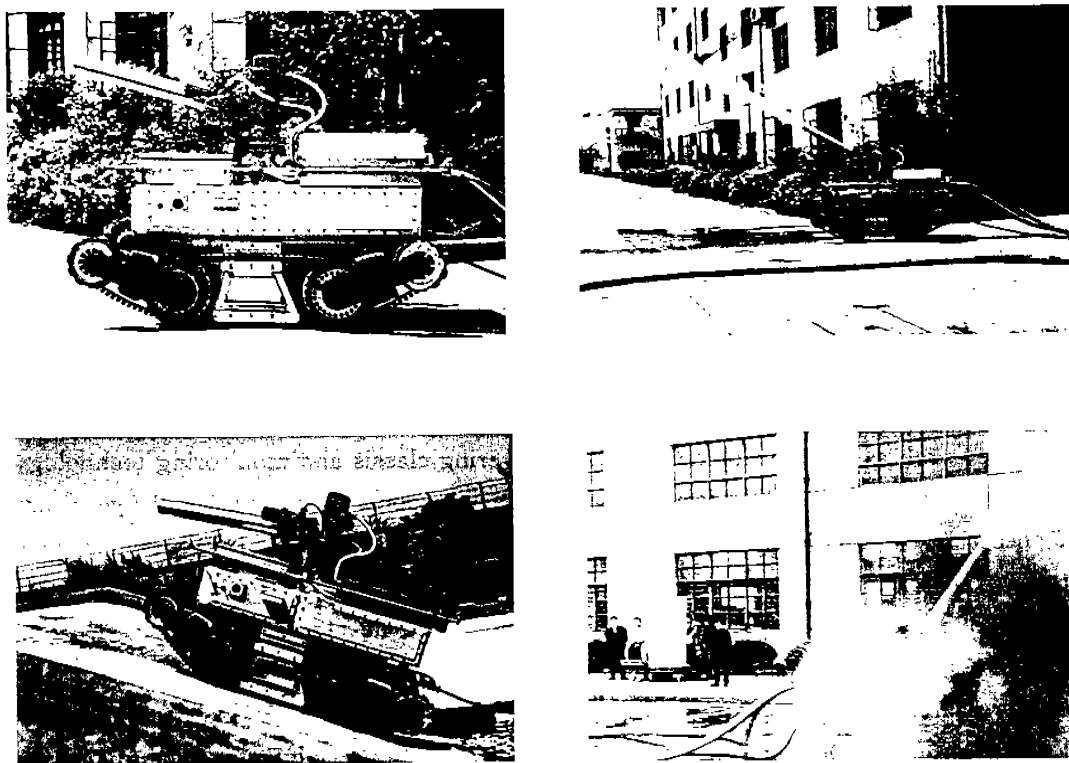


Fig. 4 Track—laying Wheeled Extinguishing and Detecting Robot

5 The development base and prospect of the fire robot in Chinese.

In Chinese, there are about 30 colleges and universities and research institutes engaging in the research of the various robots. Since 1971, we have obtained gratifying achievement on the sensory identification, operation, moving technique, man — machine interfacing technique, intelligentizing technique of the robot. Some of these achievements, such as the



industrial assembly, welding, spray painting, carrying, crack detection, underwater working and process surveying robots have come into the practical stage. The technique of some control and transmission elements is close to the advanced world levels. It creates a good environment for the overall development of the fire robot of our country.

In recent years, most of the relative government departments have supported the research of the fire robot. The three types of robots, developed by us as introduced above, were completed with the support of those departments. We believe that they will keep on supporting the research and development of the fire robot during the "Ten • Five" period. At the same time, we are also pleased to see that all over the country more and more fire officers and fighters have realized the importance of the fire robot, and the market demand of fire robot has formed.

We think that the research of the fire robot of our country should be simple at first and then come into being complicated. It should be popularized and researched at the same time, and should be followed in order and advanced step by step, and improved constantly. We can develop the breaking, rescuing and multifunctional fire robot base on the completed fire extinguishing robot and the fire—detecting robot step by step. The control mode can come into using the wired or wireless remote program control, and then work up the self—adapted fire robot. We can use the successful experience of the fire robot of the developed countries for reference. We should combine the existing industry and technical bases, fully use the techniques of the relative institutes, universities, enterprises and the users, strengthen the international technique communication and business cooperation, and rapidly shorten the disparity between the developed countries and us in this field. The development of the fire robot should make the most use of the matured technique, and pay attention to the necessary technique, such as the development of the delivering classis and monitoring technology, to ensure the dependability and practicability of the fire robot. The next 5 to 10 years are the best occasion for the development of the fire robot of our country. We must make great efforts to increase the level of the series, standards, technical quality and tactics utility of the fire robot, and make it reach the present level of the developed countries.

We believe that in the near future, a government supported fire robot industry, participated by the research institutes, enterprises and extended users, will be flourishing in Chinese. It takes the large international market as the head, the high—technique as the guide, and its target is to save the lives of the fire fighters, increase the fighting ability and reduce the loss in the fires.

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## **Fire Safety and Infrastructure Construction in the Development of the Western China**

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On Jan. 19, 2000, the State Council held the western areas development conference in Beijing, which marked the overall start of the develop — the — west strategy. It is an important decision formulated by the Central Party Committee headed by Jiang Zeming General Secretary of the CCCP according to Deng Xiaoping's strategic thoughts "Liangge Daju" on modernization construction. It makes great influence on reviving the central and western areas economy, promotes deeper development of the country's economy, but also realizes the blueprint of modernization construction of china to carry out the strategic decision.

### **1 The focal points on the strategic decision of the development of western China**

The State Development Planning Commission noted in The Report on Implementation of the Develop — the — West Strategy that it is a systematic project with great scale and a hard historical task to carry out the development of the western China.

The State Council parley set five major tasks for the country:

1. Develop infrastructure projects, such as highways, railways, airports, and natural gas pipelines, water resources and communications.
2. Protect and improve the environment Measures must be taken to strengthen ecological environment protection and construction, and to change the situation of soil erosion to harness vegetation and dissertation.
3. Adjust industrial structures and expand the tertiary industry, including tourism. This is the key of western development.
  - (1) Adjust and optimize the agriculture structure, promote livestock husbandry and raise farmers' income.
  - (2) Develop and protect resources rationally, raise the benefits of resource exploitation and using.
  - (3) Speed up the steps of adjusting industry and reorganizing structure.
  - (4) Expand the tertiary industry, especially tourism.
4. Develop undertakings in science, technology and education, and more quickly nurture the development of trained personnel.
5. Make greater efforts in reform and opening up of the western regions.

The new thoughts and mechanisms should be studied in new situations. Directed by Deng Xiaoping's theory on the primary stage of socialism, the western areas should expedite

reforms, develop a diversified economy, improve the investment environment, and absorb more capital, technology and management experience from local and overseas investors in various ways. Also great efforts should be made in developing collective, individual and private economy in western areas.

In order to start the develop — the — west strategy; the Government formulated four favorable policies.

- (1) Assign funds of sixty per cent as a target for foreign capital use in the western areas.
- (2) Permit western cities to issue the infrastructure lottery bickers.
- (3) Expand the scale of local enterprises' issuing debentures.
- (4) Try to establish an industrial investment fund in western areas. To take advantage of foreign investment indirectly, the project asked for loans from international financial organizations, foreign Governments, and international commercial banks, and assigned the loans to western municipal administration in small parts.

## **2 Fire Safety and infrastructure conditions in western areas**

### **2.1 The basic conditions in western areas**

There are ten provinces, regions and municipalities. Shanxi, Gansu, Qinghai Sichuan, Guizhou, Yunnan provinces, Xinjiang Uygur, Tibet and Ningxia Hui autonomous regions and Chongqing Municipality. The vast west, covering 5.4 million square kilometers, makes up about 56 per cent of the country's total land and accommodates 23 per cent of the nation's population, which totaling 285 million people. It also has 50 per cent of China's natural resources and 77.75 per cent of the waterpower. More than 80 per cent of minority nationalities are concentrated in the western areas, and continental borders.

Because of History and questions of nature, the economic gap between the western and eastern areas is still wide. In 1998 the western gross domestic product (GDP) only held 15 per cent of the nation, and only five provinces (cities) reached 100 billion—yuan (Table 1). The per capital GNP of the west is only 40 per cent of the east. In 2000 March, Chinese Academy of Social Sciences published a comprehensive capacity list of 31 provinces and regions for the sustained development (table 2).

These 10 provinces and regions in western areas are all listed in the end. The comprehensive capacity is very low and the industry structure is distributed unevenly in the western eastern areas.

(Table 1)

target	Chongqing	Sichuan	Guizhou	Yunan	Tibet	Shanxi	Gansu	Qinbai	Ningxia	Xinjiang	western areas total/average
area(10000 square kilometre)	8.24	48.5	17.61	39.4	120	19.5	45.4	72.23	6.64	166	538
population (10000)	3060	8493	3658	4144	252	3596	2519	503	538	1747	28510
GDP(100 million Yuan)	1434.5	3580.3	843.5	1793.1	91.2	1410.5	869.8	218.6	227.3	1115	11583.8
GDP growth rate(per cent.)	8.50	9.10	8.60	8		9.30	9.20	9	8.50	7.30	
per capita GDP (Yuan)	4702	4231	2323	4353	3736	3937	3470	4377	4258	6435	4231
workers' average wage (Yuan per person)	6433	6577	5775	7667	10987	3029	6809	8011	6822	7121	7223
city dweller per capita income (Yuan)	5466.6	5127.1	4565.4	6042.8	5438	4220.2	4009.6	4240.1	4112.4	5000.8	4822.3
farmer & herdsman's per capita income (Yuan)	1720.5	1789.2	1334.5	1387.2	1231.5	1405.6	1393	1424.8	1721.2	1600.3	1500
local revenue (100 million Yuan)	71.7	197.3	65.3	168.2	3.6	93.3	54	12.8	17.8	65.4	748.8
per capita local revenue (Yuan)	232.3	232.3	178.5	405.9	142.9	259.5	214.4	254.5	330.9	374.4	262.6
local expenditure (100 million Yuan)	125.8	320.9	133.1	328	45.3	166.2	125.3	44.1	45.1	146	1479.8
fixed assets investment (100 million Yuan) (exclude collective and individual in urban & rural areas)	379.5	863.5	203.9	490.4	38.4	421	247.8	98.9	88.6	432	3264.1
Volume of the foreign investment (10000 dollars)	43107	37248	4535	14568		30010	3864		1856	2167	137355
international tourism reception (10000 persons)	16.34	29.06	15.13	76.09	9.64	54.05	10.24	1.66	0.51	16.29	229.01
volume of the tourism income (100 million dollars)	0.88	0.84	0.48	2.61	0.33	2.47	0.3	0.03	0.01	0.82	8.77

(Table 2)

region	total capacity	assets	debt	comprehensive capacity
Beijing	64.07	59.84	17.67	42.17
Tianjing	57.38	57.13	21.69	35.74
Hebei	45.59	30.12	20.88	9.24
Liaoning	49.57	41.77	22.49	19.28
Shanghai	65.86	69.08	17.27	51.81
Jiangsu	54.46	55.42	14.06	41.36
Zhejiang	53.41	55.42	15.66	39.76
Fujian	51.99	51.41	15.66	35.76
Shandong	50.11	42.97	17.69	25.28
Guangdong	55.87	59.44	12.05	47.39
Guangxi	42	23.29	34.94	-11.65
Hainan	46.18	32.13	33.33	-1.2
Shanxi	38.27	17.27	39.36	-22.09
Inner Mongolia	41.1	18.17	46.18	-27.71
Jilin	48.02	30.52	27.31	3.21
Heilongjiang	49.1	36.55	28.11	8.44
Anhui	45.09	12.29	28.92	-16.63
Jiangxi	45.27	23.69	32.53	-8.84
Henan	45.3	20.88	29.32	-8.44
Hubei	48.78	26.1	11.65	14.45
Hunan	47.05	29.72	17.27	12.45
Chongqing	39.91	18.07	37.35	-19.28
Sichuan	40.4	22.49	37.75	-15.26
Guizhou	33.94	15.26	64.26	-49
Yunnan	39.58	22.89	44.58	-21.69
Tibet	33.69	24	51.41	-27.31
Shanxi	40.82	20.88	36.95	-16.07
Gansu	26.25	12.85	59.04	-46.19
Qinghai	35.2	18.88	61.45	-42.57
Ningxia	35.6	12.45	56.22	-43.77
Xinjiang	42.63	26.51	41.37	-14.86

## 2.2 Fire safety and infrastructure conditions in western areas

Since China adopted reform and opening — up policies two decades ago, the fire fighting facilities have made repaid progress. Public fire fighting equipment constructions, such as the civil fire brigade, fire station, fire corresponding, fire watersupply, are now beginning to take shape. Most big cities have formulated their own fire—fighting plan and are putting it into effect, with a 20,000 people and 1,000—fire engines public security team. They play an important role in fire fighting control and rescue, making a greater contribution to the safety of the nation and it's people.

The supervising work of fire protection has already formed a legal system including local fire — protection laws, administrative regulations of government and standard documents. The work is carried out under the base of “The Fire—Protection Laws of PRC”(abbreviated: The Fire — Protection Laws), putting the safety responsibility of Government and corporation units into effect, the managements of important units and dangerous chemistry goods, and many kinds of drum boating education in Fire — Protection. The legal system has been founded with the leading of Fire—protection laws though zealous enforcing socialization fire work, with regards the aspect of putting out the fire and rescuing the fire conscientiously and the training of applied subjects. Thus they show their idea of “Exercise for Ready”. A lot of special equipments of demolishing, plugging holes, saving lives and rescuing have been bought. They seek the guiding ideology actively to meet the needs of the development of social economy. This ideology is as follows: the emphasis on putting out the fire and developing through many functions and methods. But because of the reasons of history and the limited conditions, there is still a distance between West and East in the level of development. It hasn't sited the needs of development of the whole national economy and socialist market economy. The overall ability against fire disaster is low, main characters are:

(1) The economic development of the western area is slow and the Government is in short finance so it puts little supports on fire — protection woke. Some provinces receive only millions of Yuan every year in fire—protection, so that this condition makes the public fire—protection equipment short of supplies. (Table 3)

(Table 3)

province/ region	total number of cities		cities with fire fighting planning		number of fire hydrants						number of fire stations			cities with direct equipments for fire alarms		number of fire engines						
	1997	1998	1997	1998	1997			1998			1997	1998	1997	1998	actual	proper	newly	1997	1998	actual	proper	newly
					actual	proper	newly	actual	proper	newly												
Chongqing	4	1	1	1	2712	5622	2979	267	23	53	23	0	1	1	91	266	101	10				
Sichuan	12	13	2	11	4806	13033	5814	1038	77	177	88	11	3	4	192	310	202	10				
Guizhou	3	3	2	3	346	3345	440	94	15	31	15	0	2	2	40	112	16	6				
Yunnan	4	4	4	4	2054	4471	2625	571	26	56	29	3	2	2	108	165	125	17				
Tibet	1	1	1	1	156	713	156	0	2	10	2	0	1	1	10	12	12	2				
Shanxi	7	7	1	1	1103	8054	1497	394	23	51	25	2	5	5	121	176	117	23				
Gansu	5	5	0	1	479	4717	485	6	15	32	15	0	1	1	67	181	69	2				
Qinhuai	1	1	0	1	350	1660	423	73	7	13	7	0	1	1	29	35	31	2				
Ningxia	2	3	2	3	894	2242	958	64	16	22	16	0	2	2	61	67	63	2				
Xinjiang	2	2	2	2	326	3837	480	154	6	19	9	3	1	1	50	133	51	1				
western total	41	40	15	28	13226	47694	15887	2661	210	467	229	19	19	20	772	1517	817	55				
nation <sup>a</sup> total	229	231	157	195	145914	328235	176298	30384	1359	2840	1450	165	165	171	5740	8361	6161	721				
western/ nation	17.90%	17.32%	9.55%	14.36%	9.06%	14.53%	9.01%	8.76%	15.45%	17.69%	15.79%	20.90%	11.52%	11.70%	13.45%	18.14%	13.10%	10.30%				



We can see that existing number of fire hydrants was only 33 per cent of the due number, fire stations about 49 per cent and the fire engine about 55.8 per cent. The rate of debt is higher than the average number for the whole nation.

(2) Police Fire—protection organizations and fire fighters are fewer. There are only 27966 fire fighters in the western area but this is only 23 per cent of the fire fighters for the whole country. The number of the fire fighters in Gansu, Ningxia, Qinghai and Xinjiang provinces are all fewer than 2000. Taking Xinjiang for example; there are 45 fire brigades and 55 departments. About 40 to 50 per cent of the towns and cities have no fire brigade and departments and also no rescuing and supervising work. Meanwhile, because the western area is the main area for the minority nationalities and the staff is limited, the number of fire fighter of minority nationalities is far away from the needs of the work. That makes the development of this work be interfered and restricted.

(3) One of the main reasons of lower development is the people's language, character, and customs, it is difficult for us to carry out social drum beating education about fire protection, especially in the poor and multinational areas. The fire—protection work is confused, and the ability of self—rescuing is weak. So the rate of fire disasters is higher and the damage is heavy. From the statistics of the fire disaster in the year of 99, the rate the fire disaster is about 14.02 per cent of the whole number in the country, the dead about 21.5 per cent, the injuries about 22.62 per cent and the direct damage to the economy is about 20.62 per cent. (Table 4)

The table of the statistics about fire—disasters shows; the fire disasters caused by careless productive and normal life is about one third of the whole number of the country. Not putting out the fire effectively is also the main factor of causing fire damage.

(4) Local insufficient fire—protection laws influence the safety of the social fire—protection work directly. According to the survey, in the 80s, there was not a local laws, from 90s to the time of publishing “the Fire—Protection Laws”, some “Fire—Protection Regulations” and “Fire—Protection Punishment Rules” came into beings. But from the analysis of content and effect, there were few substantive provisions, especially about the responsibility of the government and corporation units on fire protection, setting up the public fire—protection equipments and constructing regularly. The responsibility of the fire—protection insufficient and irregular and the work of controlling the fire and administrative work through laws are not carried out in an all—round way resulting in the slow development of the fire—protection work and the weak ability to restrict the damage and audients.



### **3 The counter measure and the imagination of fire — protection safety under the circumstances of the development of western China**

The development of western China is a historical decision by the Government carrying out the economic development of the western areas. The safety of fire—protection is one of the main contents of the exploitation. Holding this historical opportunity of western exploitation and pushing the development of the fire protection actively, we must carry out "the fire—protection law" and "the outline of fire—protection reform and development" seriously and merge the fire—protection work into the exploitation plan of every province in the west. 6 goals should be realized:

- To establish the idea of serving the western exploitation through fire—protection work and to provide a good social safety environment.
- To carry out the responsibility of fire—protection of the government and corporation units.
- To put more finance into the fire—protection work and control the fire—protection regulations of the cities. The establishment of the public fire—protection equipments and building the fire—protection station.
- To enforce the vocational and the quality construction and develop many kinds of fire brigades for improving the efficiency of fire prevention and putting out the fire.
- To carry out many kinds of social drum beating education about fire—protection to spread the knowledge of fire—protection and improve the realization about this work.
- To enforce the construction of fire—protection laws for the administrative work.

The development of western China is a systematic project, on which each province's (gnomes); magistratrate has worked out a general program to implement. The public security and fire fighting services setup with other concerning departments haze cooperation participation and focus on the following work:

(I). Catch the opportunity of infrastructure construction, which is one of the important strategies in the west development, boost and carry out the city fire planning and public fire installation construction. City planning is the unified plan and concrete arrangement, which defines the city's nature, scope, and the orientation of the development, makes rational use of the city's land and coordinates the city's layout and each construction. City planning is the foundation of building and ordering the city, and the important means of city construction and the macro—administration. City fire planning is an important element, concerning the city fire fighting security distribution, the supply of water for fire fighting, fire station, etc. It also includes the capacity to plan against natural disasters; good or bad fire fighting security environment, long—term development, and so on. City economic construction and social development will not function effusively without this assurance provided by city Government public infrastructure. The work of the city in fire fighting in the west has lagged behind for a long time. New debts go before old ones. The stagnancy of fire fighting planning is one of the problems (See table 3).

Statistics show that the public fire fighting installations in the western cities are all in debt and the integrative function is in a bad condition, which has serious effects on the supervision of fire fighting and carrying out fire — extinguishing tasks. Take Urumqi, Xinjiang for example; the number of fire stations is less than 40% of the number planned. The fire Hydrants only cover 1/7 of the requirements. In this case, the overall layout is off balance, the command system of communication of fire fighting drops behind, and the public fire — fighting installation construction falls far behind the standard of modern city construction. As regards this point, Xinjiang is adopting measures and putting forward the slogan “Where there is the construction and transformation of city roads, there is the building of a fire hydrant”. Meanwhile the “mini — fire — fighting — station ” has been built also. Therefore we must attach importance to the planning of city fire fighting, of which “timely formulating, government approval and the NPC’s consideration of moderate advances” is all primary to the western fire workers. The public installation construction of fire fighting is the key to practical city fire planning. So the whole western workers of fire fighting must “build roads and construct bridges” in order to take the construction of the city public fire installation into the building of “fast traffic lane”.

(II) Raising funds in many ways, solving the big questions of affecting fire utilities and development. Apart from the Government at different levels increasing the investment of vocational work of fire fighting, first of all, striving for the Government policy appearing and imposing the construction tax on complete fire equipment, which will increase and improve the specialized fire equipment for vehicle installation, emergency rescue, and dealing with incidents of dangerous articles.

In order to control the special fund to special use, we adopt the operating ways that the local financial department sets up a special organization. The institution of public security and fire fighting applies for it and the Government considers and makes purchases.

Secondly, the Government puts forward the concerning policy that encourages the large and medium state — owned enterprises, national groups and individual enterprises to aid utilities of fire — fighting financially. The capital can be expended before paying taxes. The fires vehicles of fire fighting which make use of this fund to purchase can be signed by these enterprises.

Thirdly, establishing the developing fund for the development of fire scientific teleology is to attract the investment of fire factories of production. fire — fighting construction enterprises home and abroad, and to support the dissemination of higher scientific technology of fire — fighting security skill, the production of fire products. the propaganda education of public security and fire — fighting in poor areas, and the education of fire — fighting schools.

Fourthly, we take advantage of national preferable tax policy so as to attract the foreign tradesman and eastern foreign internment enterprises to develop the safety technology and products for fire fighting. For instance, we have more appropriate measures than that in the east concerning the other conditions and the degree of opening to the market for the

restricted items and the items requiring the limited stock proportion for the foreign investors. Eastern foreign tradesmen invest again to the west, the proportion for the foreign investors is over 25%, and they enjoy the same treatment as the foreign in investment enterprises. From Jan 1st, 2000, the National Tax Administration encourages the foreign trade enterprises to invest in the middle and western regions of China and levy the tax to less than 15% compared to original enterprises tax, as thin 2 years after the correct preferable policy ends.

The main contents of scientific technology and products of fire—fighting are the gas fire—extinguishing equipment, the series of fire extinguishers, the safety monitors and fire—extinguishing systems of long distance transportation of gas and oil, and the automatic alarming equipment of fire, etc. Therefore these products can be sold to the west of Asia through the western region, and facilitate the circulation of international trade market.

(III) The supervisors and management of fire fighting must serve for the development of western China.

The public security and fire—fighting organizations at different levels need to improve the recognition of the position and function of fire—fighting in the construction of western China, and to strive to work to advance, with good service in terms of strict administrative laws. As to this point, the transformation of two respects must be realized:

One respect, the transformation of management styles. To analyze the working patterns of present management which aren't adaptable to construction. To discover malpractice, separate the "combining departments", proceed from "simplifying the sequence and transferring power to lower levels, simplifying the formalities, shortening the time". To accept the vocational fire—fighting work unitarily, open the working process and promise to serve society, appoint the social supervisors, and increase the openers of the work, and change the operating of "bellows" into "Sun Light" project. As for "Hot Point" projects, "the interest of common people" projects, that key projects, we must serve to the doorstep, so as to make it convenient for people and investors and set a good image of administrative law enforcement.

The other aspect: the transformation in realizing the appropriate level and quality of supervisors and management.

Firstly, to improve the vocational quality of fire—fighting supervisors now possible through training. Furthermore, to take the workable administration according to the law as the core, and take two classes of chief group and detachment as important, to standardize the process and examination of law enforcement so as to make the supervising work of fire—fighting more civilized, highly efficient and standardized. Meanwhile, to avoid fatal fire incidents to the fire fighters. In the form of carrying out various incidents under control, to remove the serious hidden fire dangers, to beautify the environment and conditions of social security of fire—fighting, and to ensure the security of fire—fighting effectively both in public gathering places and the units and other places where the fatal fire can easily happen.

(IV). Put the emphasis on the education and importance of the fire—fighting talents.

First, enroll more mesa students into the fire—fighting institutions now available in the west. The training of minority fire—fighting takes should be the most important issue on the agenda. Several measures should be taken:

State institutions should be responsible for the university education and provinces (the autonomous region), in charge of the training school and technical secondary school education. Minority students have the preparatory courses in the local institution and specialized courses in the fire—fighting institutions. The aim is to do our best to train many middle and high rank fire—fighting talents of ethnic minorities in a short period of time. These recruits should possess the knowledge of modern fire—fighting management. Second, absorb more outstanding graduates from colleges and universities into the army in the west. Third, adopt a double—direction distribution of fire—fighting recruits, namely, to select prominent fire—fighting cadres from western regions and send them to the east in order to learn the advanced management there and select those prominent from eastern region and send them to the west on purpose of defusing advanced management experience. Fourthly, take advantage of the three current fire—fighting schools in the west and carry out degree education, which chiefly aims at raising the cultural levels of fire—fighting cadres and developing further education for the cadres of minority nationalities.

(V) Strengthen the work of investigation and research of information and establish tanks of synthetically information and data of fire control.

Provide scientific basis of fire control for the develop—the—west strategy to collect various kinds of information of the development of western china, maintain close links with the Government administrative department of economy. Master the local construction of key projects and make preparations to provide services for them. Establish the sense of studying new problems emerging from the enforcement of the development strategy. Make clear the principled bounds of what should be done and what shouldn't be done for some problems with general characters. Be sure of economic information, such as local resources, situations, large and medium sized construction projects invested in by state—owned and foreign enterprises, the construction project that are introduced from other provinces and are bound to the local enterprises, the scale of investment, the trend of local economy, the conditions of development and basic situation of cities' fire control. According to the whole situation of the development in Xinjiang, and on the basis of the projects of development and construction, put forward voluntarily by each prefecture, each city and various professions, the Development Planning Committee has established the construction project tanks of the development of Xinjiang with overall balance, selecting and determination. The project tanks consist of major and ordinary project tanks and the project tanks for attracting merchants and funds. By using computers, the Fire Department of Public Security has set up files of synthetical information of fire control and data files to store and edit the information, including the fields that are connected with fire control, Key projects, projects of attracting

merchants and funds, and also the local trend of development of fire—fighting, fire danger class, the measures, programmes, the power of fire brigade and equipment of fire prevention. Then the information can be used and retrieved up whenever and wherever you go. It is convenient not only for work, but for the masses.

(VI) Develop various kinds of professional teams of fire control.

Firstly, voluntarily develop various kinds of professional teams of fire control and compulsory organizations of fire control. The Government, the union of a few enterprises or the local people, can run them. The main problem is to solve the staff's pay, the expense of the equipment and daily duties. Some large counties, which grow a lot of cotton, have set up professional groups of fire control, and cotton and kapok companies largely provide vehicles and equipment. Some enterprises with good benefits run by counties are responsible for the staff's pay and the pay is under the centralized management of the counties' Public Security Bureau. Local organizations of public security fire control take the charge of the staff's training and guidance. All these measures have brought good social effect. In some places, joint defense of public, in some places, joint defense of public security teams are responsible for the duty of fire control.

Secondly, according to the current situation of paramilitary management, the Production and Construction Military Units of Xinjiang regard the regiments of farming and animal husbandry as units, and develop the teams, classes and groups of fire control in the battalions, companies and platoons of military units, and equip them with light fire control equipment, such as minor fire apparatus with water tanks. They have all changed the current situation that there have been no teams of fire control for a long time in the system of military units.

(VII) Closely depending on the Governments at different levels, and under the leadership of the Government, make full use of the role of staff officers and assistants of fire control, carry out firmly the system of job responsibility of social fire control and encourage shape the development of western areas.

The organizations of public security fire control are both the functional departments of the Government and the organ of social administration, so it must administer the policies by law, when involved in the key projects and other jobs of fire control. All levels of the organizations of public security fire control must at first consult and serve beforehand in order to solve all the problems during the period of designing and demonstrating. Meanwhile, when coming across some specific problems, they must be good at explaining work to the Government in reasonable time, carry out carefully reports on some important and special topics, and the system of asking for instructions, and also carry out necessary working procedures according to the administrative executing laws. Be sure that the executing law is based on the facts and the procedures of executing laws are proper. Moreover, organizations of public security fire control of the ten western provinces and cities should enforce the horizontal contact and communication, and deliberate and solve the

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problems with general characters in time to improve the work. We must investigate and prosecute common and violent crimes and educate the masses by the laws and rules in the development of western China. By checking, training and educating in various forms, we try to promote the settlement of the system of the whole people's fire control and improve the social ability of resisting fire. We are trying to establish a good surrounding of social security fire control for the development of western China.

(VIII) Suggestions:

1. The National Fire Department must strengthen the micro—coordination and guidance to the transregional key projects and put forward the standards and explanation for the technical problems in the key projects, for example, the project of "conveying gas from western to eastern China covers more than ten provinces and nearly 100 billion renmin Yuan has been invested. Be sure that the organizations of public security control participate in the pre—demonstration examination and appraisal of design: the entering into the cities and houses with a vast number of natural gas pipelines, the building of natural gas stations, the construction of department stores of super size; rescue work of disasters on highways or high—quality roads and in the tunnels of mountains. These things mentioned above are all new subjects for the organizations of public security fire control that need to be addressed.
  2. National Bureau of Fire Fighting holds conferences on fire control of western China in a timely fashion. Study new problems and situations in the development and construction, seek unity of thinking and put forward corresponding countermeasures to guide the work of fire control in the development of western China. The National Bureau of Fire—fighting should especially coordinate and solve the key problems among different professions and departments, such as national construction, economy and trade, industry and commerce, petroleum and railway. There are two current outstanding problems in Xinjiang
2. One is permissive conveying of dangerous chemical goods in transit. Not only the organizations of public security fire control, but also the department of communication is handling the procedures of permissive conveying of dangerous chemical goods. Although their appellations are different, the operations and requirements are almost the same. The other is the civil use of hydrocarbon fuel. In 1995, the Ministry of Public Security, the Ministry of Labour and the Ministry of Construction published the document [1995] No. 97 and made it clear that hydrocarbon fuel can only be used in industry. However, in 1997 the Ministry of Agriculture, the State Planning Committee and the State Economy and Trade Committee published the No. 30 document that popularized the use of hydrocarbon fuel. In the same year, the Ministry of Agriculture also published the professional standard of the document "CIVIL USE OF HYDROCARBON FUELS". As a result of the fact that the problems mentioned above haven't been straightened out or standardized by higher authorities, the work among different departments has overlapped, some contradictions have appeared. It has brought difficult problems to executing laws at grass—roots level and the masses have expressed their doubts and opinions for the administrative authorities' cross



management of inflammable and explosive substances.

3. The country made efforts and take favoured policies to western areas in setting up public security and fire — fighting organization and staff establishment. If any town or country has no such organizations, the Government will set up them, especially in the remote but important districts.

The supervising work of fire protection should serve for the work of development economy and the exploitation construction rapidly and conveniently.

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## China's Fire Product Market and the Development Trend of Fire Industry

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After the policy of reform and opening-up has been carried out for over twenty years, China economic system is changing from planned economy to market economy. Fire products also changed from planned allocation to commercial market, gradually being brought into the line with the world. Under market economic system, fire products market has undergone a development of growing out of nothing, getting from small to big. Now we have stridden into the door of 21st century, the state of China's fire product market, its existing problems, and what measures we should take to greet the opportunities and challenges of 21st century have become problems requiring our attention and research.

### **1 China's fire product market is in a period of flourish development.**

#### 1.1 The drive of the development of fire product market

1.1.1 The reform of economic system is the primary drive of the development of fire fighting products market. Since China carried out economic system reform at the end of 1970s, with the deepening of reform and opening-up and the gradual establishment socialist market economic system, China's national economy has been growing continuously and stably. As a part of national economy, fire product market is also developing rapidly.

1.1.2 In comparison with the fast growth of economic construction, the social overall fire defending capacity still lags behind. The object reality requires the development of fire industry and the growth, maturity and advancement of fire product market. With the continuous expanding of city construction scale, people's material and cultural life keeps improving. The increase of material and the wide development and application of new energies, new materials and new equipment have resulted in the distinct increase of fire disasters. According to the analysis of China's fire disasters in the past few years, the most serious fire disasters happened in such public places as department stores and hotels, petrochemical and inflammable and explosive places, often result in massive injury, death and huge property loss. It has caused bad influence to social stability. The experience and lessons tell us that in the meantime of the rapid development of economic construction, measures should be taken as soon as possible to change the situation of social low overall fire defending capacity resulted from factors as remainders of long formed city planning and industry layout, backward fire fighting facilities and poor condition of constructions' fire fighting establishment. It will enable the fire safety level be suited to the level of economic

development. It puts forward a demand to the quick growth of fire industry and fire product market. Fire product market is an inevitable result of social economic development as well as a demand to guarantee of the persistent social economy.

1. 1. 3 The strengthening of fire legal system has provided a reliable guarantee for the stable growth of fire product market. In "Fire Regulations of the People's Republic of China" issued in 1984 and "Fire Law of the People's Republic of China" issued in 1998, fire products are listed in the safety product category, which promotes the issuing of other necessary laws, regulations and standards and lays a solid foundation for the continuous development of fire products. By now China has issued 209 national standards and industry standards on fire. 180 of them are compulsory standards and 29 commendatory standards. There are also 26 regulations issued by the ministry. The construction of fire legal system ensures the continuous and stable growth of fire product market.

1. 1. 4 The competition mechanism between enterprises in market economy is the impetus of the development of fire product market. Since the reform and opening—up being carried out, under the guidance of new industry policies, fire product enterprises have increased considerably. In order to get higher market share, enterprises set off increasingly drastic competitions in the respects of variety, property, quality and service, which promote the quick growth of fire industry and fire product market.

1. 1. 5 The social demand for fire products is changing gradually from passive to positive, which mobilizes the development of fire product market. During the deficit economy, as the fire did not form a great pressure to society, most of the social needs for fire products are limited to the passive demands under laws. With the development of economy, the people's material life improves gradually. The demand of life quality, especially the demand for safety products is becoming higher and higher. In some rapidly growing areas and cities, lots of fire fighting equipment has entered people's houses gradually. The raising of people's safety awareness generates the desire of initiative requirement for fire safety. With the issuing of Fire Law, the responsibilities of governments of different level in fire protection is further clarified, the leadership of the governments to fire work is strengthened, and the investment to city fire safety security facilities has grown year by year. To ensure the fire investment and spend money for safety is not only the safety engineering of safeguarding economic construction, but also the image engineering of government to the public. The knowledge is becoming the consensus of governments in all levels. The change from the passive demand to positive demand provides the huge potential to promote the development of fire product market.

## 1. 2 The situation of the development of current fire product market

### 1. 2. 1 The development of enterprise and industry.

At the initial period of reform and opening—up, there were about over 100 enterprises that produced fire products. After 20 years' development, there are more than 3000 enterprises.

Large — scale enterprises with over one hundred million Yuan annual output value keep arising. Enterprises also change from simply state owned and collective owned enterprises to a variety of economic forms, including private business, collective owned enterprise, state owned enterprise, joint venture and wholly foreign funded enterprise. Scientific and modernized management model has been set up in lots of enterprises. A group of national key enterprises in military industry, mechanics, aviation and chemistry, nuclear industry etc enter into fire product industry, which enhances the structural level of fire products and expedites the initial formation of economy of scale. Fire industry has become an important component of social public safety industry that plays an active role in the development of national economy.

#### 1. 2. 2 The development of fire products.

At present, China's production enterprises have been able to produce a large variety of fire engine, fire pump, fire boat, and fire detecting alarm equipment, fixed extinguishing fire equipment, fire extinguisher, extinguishing agent and fireproof door, including 21 types over 300 varieties 3000 specifications, which can meet the basic need of fire—prevention and fire fighting. While the technique of products improves tremendously, the technical content of products keeps growing. Elevating fire truck, fire forcible entry tool and other products that used to rely on import has mostly been produced domestically. The technical level of some main fire products have been close to or reached the world advanced level. The fire alarm products develop from multi — line system to general line system, from simply traditional on — off smoke — sensitive and temperature — sensitive sensor technique to intelligent detector with imitation quantity, multi — sense and multi — criterion. The improvement of chassis of fire engine and equipment technique, especially the techniques of fire pump, has greatly raised the technical capacity of fire engine. The temperature sensitivity and precision of the sprinkler with glass bulb also increased considerably. The bulb's diameter has also developed from the initial 8mm, 5 mm to the world level 3mm.

#### 1. 2. 3 The fire market situation.

Fire product market has waved farewell to the period of deficit economy. The products can meet the basic demand of market in terms of types and quantities. The supply of some products is even larger than demand. A buyer's market has taken shape. The market competition is increasingly intense. High—tech national fire products have got more market shares than the initial period of reform and opening—up. The technical content of products is higher and the export is increasing year by year. Currently the annual output of domestic extinguisher is some 8 million, about 30% for export. The annual output of fire engines is 1500 or so, about 4% both for export and import. In 1999 the sales volume of domestic fire alarm products is about 1. 8 million, fire alarm detectors imported are about 1. 2 million. The market occupancy rate is some 60%, which is a great improvement compared with the past.

#### 1. 2. 4 The entry systems on permitting to enter the market. Currently there are four

systems for the fire products on permitting to enter the market: 1. Registration management system of the list of fire vehicles; 2. Management system of production license; 3. Certification management system; 4. Compulsory examination system. These four systems on entry the market involve all kinds of fire products. Each kind of fire products should follow its corresponding management system. As to imported products, the kinds of products that follow certification system domestically should follow the equivalent certification system. Other imported products should follow the compulsory examination regulation.

## **2 The problems in fire product market and fire industry and the solutions**

The current fire product market has many problems that mainly show in: 1. The problems of excessive numbers, decentralized production, disordered management and low quality of products that exist in some enterprises. (The scale of many enterprises is small and cannot produce in large scale. The management of enterprises is rather disordered. The production technology is quite low which results in the poor quality of a number of fire products. ). The structure of products in some enterprises is not fully rational; 2. The manufacturing technique of many products is still rather low; some production technology is rather backward, having a certain distance with the international advanced level; 3. Modern enterprise mechanism has not taken shape. Enterprises lacks the ability of blazing new tails; 4. The disordering competition of fire product market still exists in many respects. The market is not very satisfactory, which hindered the development of enterprises.

According to the common laws of economic development, the various problems in current fire product market has a distinct feature of social economic transformation. China is in a period of transition from planned economy to market economy. In the view of the basic law of epistemology, the various problems emerged in the transition period have relatively inevitability. One of the problems arisen in China's planned economy is deficit economy. The types and quantities of the products at that time can not meet the demand of market. With the gradual establishment of market economy, resource allocation is transforming according to the need of market. The number of enterprises is increasing greatly and the types and quantities of products are also increasing. During this period social need for the types and quantities of fire products is satisfied to a certain degree. On the other hand, due to the relative stagnation of the construction of legal system and market regulations, there appears the phenomenon of extensive management of enterprises and disordered market competition. From the view of the history of international economy development, many countries faced such problems as excessive enterprises, irrational industry and product structure as well as poor quality during the period of the economy development. It is certainly that the problems in the fire product market during the period of economic transformation can be solved step by step. It is analyzed from the view of the social need changing law that the social need is unlimited. What to be solved is not only for the problem of whether there is or not, but also

for the problem of whether the quality is good or not. After the problem of deficiency in the quantities and types of products is solved, the market will definitely keep bringing forward newer and higher demands on the quality, property and type of products. Then the market structure with the current problems and the disordered market environment cannot continue to meet the higher market demand. Therefore the critical problem to be solved at present is the conflict of production relations and the development of productive force. In the light of the experience of some developed countries, in order to solve the problems gradually in this period, the legal construction of market is strengthened, the market environment regularized, and the enterprises led to the road of orderly competition. After decades of evolution, with the adjustment of market need, they achieved the current industrial structure whose principle part is large groups or multinational companies with famous brand products. China, as a socialist country, has the capacity and superiority in adapting production relations to the development of productive force positively. In the process of changing from planned economy to market economy, China's social management mechanism that restricts the development of productive force is being changed. The problems existing in the period of social transformation will gradually be solved. If the problem is correctly realized and the social development rules are followed, the current problems in the fire product market can be solved and the economic transformation period can be shortened enormously through establishing and carrying out corresponding management measures.

In the light of the actual condition of fire product enterprises, the domestic fire products lacks competitive power compared with the imported products of the same kind. It is caused by the poor product technology, low reliability of the product performance, and uneven level of the quality of a batch of products. The improving measures include 1. To put in efforts in quality control and administration, or called to improve the "software"; 2. To devote more time and energy to the development of production equipment, or called to improve the "hardware". However, there are some internal causes that result in enterprises' incapability to solve the problem of low competitive power. From the objective view, because the excessive number of enterprises of the same kind, the products provided are combined with high quality and low quality, the market share is divided too many, the products produced in large scale can not be guaranteed to sell. Meanwhile, the unsatisfactory market environment and inadequate capital also make most enterprises unwilling to undertake large-scale technical renovation and more capital investment. Even the few investments cannot receive the anticipated result. From the subjective view, facing the gradual formation of market economy and the increasingly fierce competition, most enterprises are still under the inert influence of planned economy or waiting for the favorable turn of the market environment. They lack the initiative of studying the market rules and self-improving. Therefore, the current key task is to further encourage competition and expedite the environment administration.

In view of the above analysis, several measures to solve the problems will be put forward

here for discussion:

2.1 To change the old ideas, adjust and improve the management mechanism of fire product industry. Based on the requirement of the central Party on the reform of organizations, to change the function of government and further separate the function of government and enterprises. To follow the development rules of market economy, change the current management pattern of the governmental authorities to fire products and strengthen the micro adjustment and supervision function of public security organs and fire departments to the fire product industry. To develop evaluation system and fire industry organizations or sector associations, bringing their adjustment and management functions to the industry into full play. To establish a "scientific, fair, honest and effective" fire product supervision mechanism, a "scientific, fair and authoritative" fire product evaluation system and a industry self-disciplinary mechanism "obeying the laws and regulations, restricting oneself and supervising each other", all of which are in accordance with the development of socialist market economy. Under the standardized management of laws and regulations, supervision, evaluation and self-discipline can interact, adjust each other and complement each other. An effective supervision and management system of fire products come into being, which will promote the establishment of a unified, open, competitive and orderly fire product market and provide a fine development environment for enterprises, accelerating their development toward intensive and modernized enterprises.

2.2 To strengthen the legal system construction, make out industry policy and regularize the fire product market. To give full play to the functions of police and fire fighting organizations, industry evaluation system and industry association organizations. To make a scientific study and reasoning on the problems and suggestion arisen during the process of supervision, products evaluation and industry self-discipline and make corresponding laws, regulations and industry policies. To take strong measures against fake and inferior products, rationalize the market system, leading the enterprises toward intensive management and modernization and eliminate the enterprises with extensive management, poor equipment and low technology. To solve the problems of irrational structure of industry, enterprise and product so as to provide a fine market competition environment for the fire production enterprises.

2.3 To fulfil the gradual transfer of the emphasis of supervision of fire products. To change the emphasis of supervision to the application field, according to the convention of the international enterprises of the same kind and the quality feature of our industry. To strengthen the supervision of the fire products used in projects and the coordination and cooperation of the three parts of fire organizations — — construction examination, fire prevention supervision and product supervision. To reinforce the examination of the selection of products used in the construction, adding the regulation of random inspection in the construction site. To ensure the initial opening and continual opening rate of different kinds of fire fighting system in the examination upon the completion of the construction and

the supervision in different stages of the usage. To enhance the real time and actual effect of supervision and change the current situation of market full of fake and inferior fire products and the low quality of fire protection project design and construction.

2.4 To strengthen the renovation mechanism of enterprises, enhance market competitive power of products. To set more freedom to enterprises in policy, continue to enforce the market competition, and promote the enterprise's survival and development capacity in competition environment. The renovation mechanism is the essential guarantee for an enterprise to put itself in an invincible position under a competition environment. The renovation mechanism includes the renovation in production, technique and management. Fire production enterprises can only rely on strengthening renovation mechanism, increasing investment in renovation, putting in efforts in the quality and property of products, creating their famous brand products and key products and strengthening post—sell service, aiming at enlarging the market share in order to vitalize the enterprises to adapt themselves to the changes of market.

### **3 The opportunities and challenges of the fire product market**

In the 21 st century, the fire product market has enormous potential and the completion is even more intense. With the development of economy and science, all kinds of buildings with more and more complicated functions arise by large numbers, and modern petroleum, chemistry enterprises increase quickly and the transportation industries such as highway, railway, shipping, aviation also develop rapidly. All of these greatly increase the possibility of fire disaster and aggravate the result of fire disaster. Therefore, there are new changes in the aim of the fire fighting safety protection. It also brings about many new topics and higher demand to fire protection work. Under the new historical situation, the development of fire product market needs to be fit to and meet the demand of fire fighting work. With the enlargement of the development space of fire product market there will be higher and higher demand in the variety, property and quality of fire products. Only when the fire production enterprises strengthened their renovation ability and develop new products with high technical content that can meet the requirement of market and can they adapt themselves to the development of market.

Soon China will join World Trade Organization (WTO). As a member of WTO, China will enjoy more advantages when participating in the international competition on equal basis, developing China's market economy and rationalizing the resources. Joining WTO will also help activate China's fire product market, bringing both opportunities and challenges to China's fire enterprises. Due to the reduction of import tariff, some fire engine production enterprises will be able to import chassis of the trucks considering their better quality, so that they can improve the quality and property of fire engines and enhance their market competitive power. Fire alarming electronic products will face the challenge caused by the influx of foreign product with the reduction of tariff. The enterprises with low output and



small market occupancy rate will face even greater challenges. Therefore with the approaching of the date of joining WTO, enterprises should attach importance to the deepening of reform and establishing modernized enterprise system and management mechanism that can meet the need of socialist market economy. There is an urgent need to accelerate the strategic reorganization of enterprises and develop specialized and social coordination system, rationalizing the economic scale and encouraging the development of many big powerful enterprises and groups. Through establishing of renovation system, raising the developing capacity of enterprises, reforming the traditional fire industry and prompting famous brand strategy, we can develop a new high — tech fire industry and increase the power of fire production enterprises in international competition and greet the challenge of the 21<sup>st</sup> century.

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## 21<sup>st</sup> Century Compressed Air Foam Fire Fighting Technology

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• **Slide 1**

Introduction

• **Slide 2**

Today, we will talk about Class A foam for fire suppression. How many of you currently use Class A foam to put out fires?

How many here have a clear understanding of what it is and how it works?

Why all the fuss about Class A foam? Today, it is the hot topic in the U. S. fire service and it's going to be the hot topic in the Chinese fire service.

• **Slide 3**

We will discuss Class A foam the chemical — why it works — Class A foam proportioning systems — compressed air foam systems — and how you can effectively fight fire with Class A foam.

• **Slide 4**

### FIRE SERVICE TRADITION

In the U. S. , tradition rules the fire service. It doesn't matter if it's municipal or rural, paid or volunteer, structural or wild land. We all think the same way ..... "if it isn't broke, why bother trying to fix it; or, we've been doing it this way for two hundred years, why change now?"

In 1980, there were only a few fire departments in the U. S. that utilized hydraulic rescue tools.

Now, over 90% of our fire departments have hydraulic rescue tools. They will tell you that they can't do their job without them.

In the 1970's, the fire service had just begun using self-contained breathing apparatus, now it's use is mandatory in all U. S. fire departments. But many then were reluctant to use it, even though it could save their lives, because it wasn't traditional.

In the early '80's we began using gasoline powered PPV or positive pressure ventilation fans to clear smoke and heat out of buildings so that firefighters could better do their job of finding and extinguishing the fire. In the early '90's, these fans became common equipment on fire apparatus.

It typically takes between 10 to 15 years for new technology to be accepted into the mainstream of the fire service. Class A foam, or compressed air foam in particular, is now where hydraulic rescue tools were in 1985. We know with certainty that it is for real, and in five years, the vast majority of new fire trucks will be equipped with compressed air foam systems.

• **Slide 5**

So, why spend your money on Class A foam hardware and concentrate?

For a minimal expense, you can double the effectiveness of your water, your fire truck and your manpower.

For a more significant expense, you can increase their effectiveness up to 5 times with a compressed air foam system. The research has been done and is still being done to scientifically quantify these claims.

• **Slide 6**

Many of you do your jobs with limited resources, in the way of manpower and water supply. Class A foam will help you do your job more effectively and with reduced risk to the well-being of your firefighters.

With compressed air foam, you can apply a blanket of foam to structures that are in the path of a wildfire. This can be done hours before the fire passes through, allowing your firefighters ample time to evacuate the area. There are protein-based foams that last over 24 hours as a fire barrier. These have been used successfully in the southern California wildfires in the past few years.

• **Slide 7**

A major benefit in using Class A foam is safety. Some of the reasons why it provides enhanced safety:

1. With compressed air foam, you can effectively fight most structure fires from the exterior.
2. You can do a better job in reduced manpower situations.
3. Class A foam puts the fire out faster. Your firefighters spend less time in dangerous situations.
4. A compressed air foam system will discharge foam up to 40 meters from a hand-held hose, or 60 meters from a master stream. You can reach the fire from a greater distance.

How does Class A foam effect the environment?

1. The quicker a fire goes out, the less pollution it creates.
  2. The less water you pour onto a fire, the less will run off to contaminate the environment.
- Foam solution itself is not a harmful material, it is simply synthetic detergent, like dishwashing liquid.

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**• Slide 8**

The current rage in the U. S. fire service is "customer service". There are many ways that the fire service can serve its customers. If we do a better job of putting out fires and saving property by using Class A foam, it only stands to reason that we are providing better customer service.

**• Slide 9**

We all must be fiscally responsible in our jobs as public servants.

Class A foam itself is not an expensive proposition. By adding a foam proportioner to a new fire truck, you add 5 to 10% to the overall cost and you at least double its effectiveness as a firefighting tool.

If you add a compressed air foam system to a fire truck, you add 15—20% to the overall cost and by so doing, you increase its effectiveness as a firefighting tool from 5 to 10 times.

It doesn't take an accountant to figure out that there is a good return on this investment.

**• Slide 10**

Let's talk about why foam works.

Water in and of itself does a pretty good job of extinguishing fires, right?

The biggest problem with water is its surface tension; or, its inability to penetrate and wet fuels. The second problem is that water does not cling to fuels; it tends to bounce off.

How do we make foam?

When we add foam concentrate to water, we are making foam solution. As you know, most Class B foams are mixed at ratios of 3 to 6%. Class A foams are mixed at 3% to 1%. There is much less chemical in Class A foam than Class B foam.

Foam concentrate is composed primarily of synthetic detergent, which is a surface active agent, or surfactant. It is very similar in composition to liquid dishwashing soap.

When you add air, or aerate the foam solution, the result is what we call finished foam, or bubbles if you prefer.

**SURFACE TENSION DEMO**

You can see how plain water beads—up on the cardboard. The water with less than 1% foam concentrate content is readily absorbed. The surface—active agent, or surfactant in the foam concentrate breaks—down the surface tension of the water.

Any of you who have fought an interior structure fire have seen how water runs off the fuel surfaces. This run off is wasted water, and occurs even when you use fog streams. Most of the water runs out the door.

**• Slide 11**

Foam concentrate does not extinguish fires. It is still the water in the finished foam that puts out the fire. The foam only allows the water to do its job more efficiently.

Finished foam, particularly compressed air foam, provides the most finely divided water particles you can apply. A stream of these particles, when applied to an interior fire, converts to steam much faster than a fog stream, allowing rapid absorption of the heat and quicker knock-down.

When you apply finished foam, not only are you using an extinguishing agent with the increased ability to wet the fuels; it also has the ability to cling to the fuels and release the water into the fuel in a controlled fashion. This allows the water to do its job better in putting out the fire.

Finished foam, as you know, is white. You can see where you have applied your extinguishing agent. This opaque surface reflects heat. If you apply a blanket of foam to a fire exposure, you get the dual benefit of insulation and heat reflection. This provides you wild land fire fighters great advantage in protecting structures in the path of a fire and also in creating fire lines.

• **Slide 12**

How do we make foam with a fire truck?

You already have a water pump and fire hose. You need a means to get foam concentrate into the fire stream and air into the foam solution.

The best way to make foam solution is with a foam proportioner. These devices put precise amounts of foam concentrate into a water stream.

The least expensive way to make bubbles is to batch mix foam solution in the water tank by simply adding foam concentrate and then use an aspirating nozzle. These normally consists of a shut-off valve, a venturi and air vents around the vacuum end of the venturi that allow air into the foam solution stream. The down-sides to batch mixing are the difficulty in keeping an uninterrupted supply of foam to the pump and the foam can be hard on pump seals.

• **Slide 13**

Foam proportioners come in both manual and automatic versions.

• **Slide 14**

Manual types include pump suction side proportioners, in-line eductors, bypass eductors, around-the-pump proportioners and manual injection types. For the most part, these apparatus are either obsolete or too inaccurate for use with Class A foam.

• **Slide 15**

Automatic types include balanced pressure bladder systems such as the Robwen Flow-Mix

(describe bladder, venturi, metering valve).

The most popular proportioner used on US fire trucks is the electronic direct injection type, which uses a flow sensor and a microprocessor to accurately inject very precise amounts of concentrate into the water stream. These are marketed under the Foam Pro brand name.

• **Slide 16**

A compressed air foam system or CAFS adds an air compressor to the foam system that injects compressed air into the fire stream. Foam is then formed in the fire hose prior to discharge through a nozzle.

• **Slide 17**

A CAFS consists of a water pump, foam proportioner, air compressor, check valves in the water and air lines to prevent back—flow, a means to control the air pressure as it is injected into the fire stream, fire hose and a nozzle.

• **Slide 18**

A good CAFS includes a system to automatically adjust the air pressure to match the water pressure at any given moment. This makes the system more operator friendly. The air and water pressures must be close to equal for the machine to operate effectively.

The mix of air to foam solution is called the foam "expansion ratio". A mix of one gallon of air in one gallon of solution would be a 1 to 1 expansion ratio. This ratio is adjustable, providing varying expansion rates to do different jobs on the fireground.

• **Slide 19**

Why are CAFS better than nozzle aspirating foam systems?

They use lower percentages of foam concentrate. .3— .5% for CAFS, .5—1% for NAFS.

A CAFS makes very small, strong, consistent bubbles. A NAFS makes bubbles of all sizes that are fragile, some solution remains un—aerated.

As we previously mentioned, you can adjust the foam expansion ratio with a CAFS to suit the task at hand. Expansion rates typically vary from 3:1 which is a very wet foam to 15:1 which is a dry, fluffy foam.

A fire hose holding CAF is full of mostly air and weighs less than 1/2 of a hose full of water or solution. This makes the hose easy to maneuver, firefighter fatigue is significantly reduced.

CAF is simply more effective in controlling and extinguishing all types of fires (except alcohol and polar solvents).

Increased stream reach.

Lighter hose lines, less than 1/2 the weight of the same hose full of water.

You have a source of compressed air to operate air tools, fill tires, anything you may use

compressed air for.

You can use a CAFS with Class B foam. Never mix concentrates.

You don't need expensive nozzles with a CAFS, only a ball valve shut-off with a smooth tip or no tip.

Disadvantages include:

There are extra components and controls that require special training.

Hose kinks easier when it is full of air. We still see descent flows with kinks.

• **Slide 20**

Added safety precautions must be taken with a CAFS.

Since air (and foam) compresses in the fire hose, the initial nozzle reaction can be significant. Precautions include bracing and opening the nozzle slowly.

Slug flow is what we call the effect of water and air in a hose without any foam concentrate.

The result is a jumpy hose and nozzle. Simple precautions eliminate this potential problem.

• **Slide 21**

There are many tactical advantages using CAFS.

A 1" CAF stream for wildland use discharges approximately 75 liters per minute of foam solution and 300 cubic meters per minute of air, producing 300 liters per minute of finished foam.

As we mentioned earlier, foam clings to fuels; there is less water runoff. You will use approximately one-fifth the amount of water on the same job.

Hoselines are lighter and fires are extinguished quicker. This results in reduced firefighter fatigue and increased safety.

• **Slide 22**

Today, we are going to demonstrate the Pneumax model 70-35-GP CAFS unit. This is the smallest unit we offer, yet it includes all the important features. If you compare the Pneumax unit to the Snuffer offered by W. S. Darley, you will notice many differences, which include:

Automatic pressure balancing vs manual

Water pressures up to 11 bar vs 8 bar for Snuffer

All brass and bronze plumbing and valves vs rubber hose and plastic valves

A pneumatic priming system primes the water pump quickly. The Snuffer has no primer as standard.

The Pneumax unit has tank-to-pump and tank fill valves for connection to your water tank. The Snuffer does not have these valves.

A Robwen proportioner which designed for fire suppression and is of all metal construction vs a plastic dosi-matic which is designed and produced to put medicine into water for cattle

that is provided on the Snuffer.

Gates Poly Chain drive system vs common vee belts (slippage)

See for yourself the difference in quality.

**Ping—Li Yen Chinese American**

Fire Marshall/Fire Investigator

Arcadia Fire Department

Arcadia, California, U. S. A.

Vice President/Chief Engineer

Fountain Fire Protection Inc.

Sow Gabriel, California, U. S. A

California State Fire Marshal's Office

Certified Fire Marshal

Fire Instructor

Fire Investigator

California State, Government's Office of Emergency Services

Certified Hazardous Materials Emergency Response Incident Commander

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## **The Fire Protection Code Writing Process in the United States A Property Loss Prevention Perspective**

**Cheng Yao**

*(Factory Mutual Research Corporation)*

### **The Fire Protection Code Writing Process in the US — A Property Loss Prevention Perspective (Draft 8)**

The first time I spoke to an audience in China on fire protection, I was invited by Mr. Wu Qihon to talk about "Fire Protection Research in Factory Mutual Research Corporation" in the Tianjin Science Conference Hall in 1979. Since then, I have been invited back several times to give technical seminars in Tianjin, Shanghai, Chengdu, Shenyang and Guanzhou. It is a great honor for me to be invited again today to speak in front of this distinguished group of old and new friends.

You have just heard from Mr. Miller and Mr. Reiss about the NFPA's consensus codes and standards and how they are being used worldwide by an engineering consulting firm. I am going to start with a brief review of the overall environment of fire protection management in the USA, under the rule of market economy. It includes

- Fire protection and building codes (standards) making process
- Product testing and certification process
- Codes and standards enforcement system

I will then talk about how FM Global and Factory Mutual Research work within this environment to solve an industry's or an individual customer's property loss prevention problems.

### **Three types of fire protection and building code writing processes in the US**

There are three processes followed in the development of fire, property protection and building codes.

1) The first is the consensus code writing process such as the one followed by the National Fire Protection Association (NFPA), a nonprofit, non-government membership organization, which has existed for 104 years.

All NFPA codes and standards are developed through an open consensus process, which allows for the input and participation of all those interested. This process allows the NFPA codes and standards to contain state-of-the-art technological advances. This process enables the Codes and Standards that are developed to meet the market and safety needs of society. About 6000 volunteers who are experts in their own right, representing the following groups, are involved in the Technical Committees that have the primary responsibility for developing the NFPA codes and standards:

- Manufacturers of equipment and materials
- Trade associations
- Property owners or companies in the user industry group
- Code enforcers/authorities having jurisdiction (Federal inspectors, state fire Marshals, town building inspectors, town fire inspectors)
- Insurance companies
- Testing laboratories
- Research and scientific organizations
- Architects and engineers involved in construction,
- Consulting companies
- Government bodies (e. g. , Navy, Air Force, GSA, Dept. of Energy, etc. )

The development of a new standard can be recommended by anyone within or outside the NFPA. Each technical committee develops a proposal, solicits comments and modifies the proposal based on the comments. The proposal is then voted on by the membership of the NFPA. This is followed by a vote by the Standards Council. New codes take between 2–3 years to develop, i. e. , after opportunities for public proposals and comments and all the relevant technical data have been collected. The development and generation of additional technical data is often done and/or funded by interested groups outside of the NFPA consensus process. Existing codes are revised every 2–5 years based on the knowledge and developments during that period. NFPA publishes 300 codes and standards. FM Global and Factory Mutual Research are involved with approximately 120 NFPA codes primarily in the area of property loss prevention.

2) The second is the code writing process followed by the code enforcers. Historically, in the U. S. there were three main Building Code Organizations whose membership is comprised only of building code officials. The Organizations and their Codes are:

- Building Officials and Code Administrators (BOCA) — develops the BOCA National Code which is effective mostly in the Northeastern Region of the United States
- International Conference of Building Officials (ICBO) — develops the Uniform Building Code adopted mostly in the Western Region of the United States
- Southern Building Code Congress International (SBCCI) — develops the Standard Building Code adopted in the Southern Region of the United States.

In 1994, the three Building Code organizations formed the International Code Council (ICC) with the objective of publishing an International Building Code (IBC) and the International Fire code (IFC) in the spring of 2000. The IBC is a consolidation of the three building codes. The process used by the Building Officials is not a consensus process like NFPA's. While any interested party may make comments and recommendations for changes in the building codes, only code enforcement authorities vote on the proposals.

3) The third process is followed by insurance organizations such as FM Global. For over 165 years the company has worked toward reducing property losses from fires and other perils

such as flood, typhoon and earthquake for its insured worldwide. FM Global develops its own Property Loss Prevention Data Sheets. These Data Sheets are based upon the research and testing conducted by Factory Mutual Research as well as FM Global's experience in reducing losses and preventing fires. The knowledge and technical data that are included in its property loss prevention data sheets are followed and valued highly by industry, code enforcement agencies and other insurance companies.

The FM Global staff that develops these Data Sheets consists of about 30 full time engineers who are experts in various fields of property loss prevention and fire protection. This group currently maintains about 350 data sheets. About 17 NFPA standards are referenced in these data sheets. At the same time these and other FM Global engineers participate in approximately 100 Codes through about 70 technical committees of the NFPA's consensus code writing process. FM Global Property Loss Prevention Data Sheets has 50 data sheets that deal with protecting building construction from man-made and natural disasters. They cover most areas relating to property loss prevention that is covered by all three building codes and some additional areas. In some cases FM Global's requirements are stricter than the requirements of the codes.

Other insurance groups in the U. S. adopt NFPA codes and standards and occasionally FM Data Sheets, but often with their own interpretation.

### **A Major Change**

Currently, there is a major change underway in the United States regarding Codes and Standards. As a result of the formation of the International Code Congress (ICC), they announced that all Codes for the built environment would be included as a part of the International Building Code. What this meant was that in addition to the structural elements always included in the Code, the IBC would now contain the electrical, heating, ventilation, air conditioning, plumbing and life safety codes currently promulgated by other organizations such as NFPA that use a consensus process. As the ICC did not announce any intention to convert their rules regarding voting to allow the development of a full consensus process, concern arose over the ability of building officials to promulgate a Code covering such a wide range of crucial technologies.

As a result of this concern, the NFPA has undertaken an initiative to develop a single set of consensus Codes — including a structural code. It is expected that this family of codes will continue to encompass the knowledge, expertise and innovation from both the private and government sectors. Building officials have been invited to be participate in this development. It is our belief that the consensus process is the best way to develop the most sound, technically advanced Codes and Standards. Thus, FM Global is supporting the NFPA's effort in this regard.

### **Code Enforcement in USA**

In the U. S. , code enforcement authorities (federal inspectors, state fire marshals, town building inspectors, town fire inspectors) from individual states determine which Building Codes will be followed in their states. Each state votes on the Building Code it will adopt. Local town building inspectors then enforce the building codes for buildings within their jurisdiction. Fire codes are enforced by state fire marshals and by the local town fire inspectors. Federal inspectors are responsible for enforcing fire codes only on federal properties such as national parks, federal buildings, Navy, Air Force, etc.

A key part of the ability for enforcers to accept designs for fire protection and building construction is the availability of products that have been certified by a recognized, independent testing laboratory. In the United States, the oldest best recognized laboratories are Underwriters Laboratories (a. k. a. UL) and Factory Mutual Research Corporation (a. k. a. FM).

#### **Product Testing and Certification Process in the US**

The certification process in the U. S. is similar to the process in use by most countries. A certification/testing organization evaluates products to verify conformance with recognized national or international standards. The certification/testing organization's ability to conduct tests in accordance with accepted practices is verified by accrediting organizations such as OSHA (Occupational Safety and Health Administration), ANSI (American National Standards Institute) and ICBO (International Conference of Building Officials). Manufacturers of the approved product(s) are authorized by the certification organization to place a recognized certification mark on the product label. The certification mark is a registered mark that is recognized by the authorities having jurisdiction over the location where the product is installed. An AHJ would include the state or local building/electrical inspector, fire marshal, government organization, etc.

In Factory Mutual Research, the Product Approval Testing (Certification) Standard usually results from a test protocol developed from scientific research. Comments on the standard are sought from jurisdictions, industry users, manufacturers, industry groups, other testing and certifying organizations, and government agencies. The standard is then modified and published. Factory Mutual Research then works with other organizations such as American National Standards Institute (ANSI) to have our product approval testing standard accepted by their organization.

Frequently, Factory Mutual Research Approval testing standards reference standards and codes adopted by ANSI and the NFPA which imply that the code can be met by using Factory Mutual Research Approved products for those codes. Frequently architects and building construction specifiers will recommend the use of Factory Mutual Research Approved products for specific applications.

If a product passes the tests required in the Standard and if the manufacturer has sufficient rigor in their own quality standards at the manufacturing plants, the product is approved.

The manufacturer is then entitled to use the Laboratory's mark on the approved product and the advertising associated with it. The laboratories publish a listing of products that have passed their tests.

The acceptance of FM Approved product according to Factory Mutual Research Approval Standards and/or UL listed product for equipment installed in their jurisdictions is up to the discretion of the jurisdictions. However, they usually recognize the laboratory through OSHA (Occupation Safety and Hazard Administration) certification process.

**Factory Mutual Research and FM Global. Company objective: Reduce losses and prevent fires**

Factory Mutual Research is a nonprofit scientific research corporation, affiliated with FM Global. As a world renowned research and scientific organization, Factory Mutual Research undertakes research into:

- fire protection methods — developing new technology sprinkler systems;
- flammability of building and plant equipment construction materials, liquids, vapors and gases — developed the Fire Propagation Apparatus; and
- structures of buildings and machines — resisting fire and natural disasters.

Factory Mutual Research works with FM Global's engineering staff to develop Property Loss Prevention Data Sheets relating to such things as:

- installation of fire protection equipment
- use and storage of flammable liquids and gases, and
- construction of buildings

These data sheets recommend using Factory Mutual Research Approved products because the research and testing data references in the data sheets are usually collected using Factory Mutual Research Approved products.

Factory Mutual Research develops product Approval standards based on

- lessons learned from losses
- requests from manufacturers and trade organizations
- experience within the industry, and
- knowledge developed through research and testing.

Some areas of Factory Mutual Research approval standards development are

- automatic sprinkler systems • water mist systems • hose and piping • fire pumps • roofing assemblies • building materials • plastics used in semiconductor manufacturing • alarm and signaling • electrical equipment used in hazardous locations, etc.

Factory Mutual Research's historical participation in NFPA Codes and Standards activities  
Factory Mutual Research participates in the code/standards writing process of national bodies, sharing our research and scientific knowledge in the development of national standards and codes like the NFPA by contributing:

- our unique knowledge of the engineering behind loss reduction and fire prevention

- our knowledge of losses and the reasons behind the losses in various industries
- the research and testing we have done in those areas

While Factory Mutual Research develops its product Approval standards and data sheets based on its scientific knowledge and the losses due to fire and natural hazards in industry, it participates in the consensus process of code development to:

- harmonize the codes by participating in code development meetings
- incorporate our research and knowledge into the development of the code
- learn from and share technical knowledge with manufacturers, trade associations, industry, code enforcers (authorities having jurisdiction), architects, engineers, other testing laboratories
- facilitate widespread acceptance of cost effective solutions towards preventing losses
- improve fire code enforcement throughout the country since code enforcement authorities accept codes such as the NFPA code

Bringing all the affected parties together raises the flow of information among the participants. It helps define the problem, understand the pros and cons of potential solutions, and then develops agreement on those solutions that are best for society.

#### **Real World Case Studies to Illustrate How the Consensus Process Works**

Early Suppression Fast Response (ESFR) sprinkler

The development of the Early Suppression Fast Response (ESFR) sprinkler is an example of how Factory Mutual Research saw a need for the development of a fire suppression solution for higher storage racks and higher hazard commodities, e. g. , expanded plastics and uncartoned commodities without the use of in-rack sprinklers. The process followed was

- Under our continuous long-range research program, FMRC developed fire suppression technology in 1982 after our success in the development of residential sprinklers and large drop sprinkler systems.
- FMRC undertook the ESFR research program, and introduced the ESFR concept to 24 sprinkler manufacturers worldwide in 1983.
- Worked with seven manufacturers in the development of a commercial prototype ESFR sprinkler.
- In 1984, the National Fire Protection Research Foundation (NFPRF) announced plans to seek public funding to initiate a two-part Quick Response Sprinkler (QRS) Project. FMRC worked with the Group 1 - Technical Advisory Committee of the QRS project in 1986 to obtain the large-scale fire test data for the development of the installation standards for ESFR sprinkler systems.
- In 1986, FMRC circulated a draft approval standard for the ESFR sprinkler for public review based on the capabilities of the prototype selected for the large-scale fire test series. In 1987, FMRC developed the installation standards for ESFR sprinklers, Data Sheet 2-2.
- This knowledge and research was then shared through the consensus process with the

NFPA technical committee. The NFPA adopted the ESFR technology and included the installation rules for the use of ESFR sprinklers in the 1989 edition of NFPA 13.

Under the sponsorship of sprinkler manufacturers, many models of the ESFR sprinkler have been developed, including the K-14 and K-25 models. The industries or occupancies this type of sprinkler helps to protect has expanded to 13.7 m high ceilings in storage areas without the use of in-rack sprinklers for specific commodities. New development of models is continuing to provide fire protection solutions for new commodities. Up to date, Factory Mutual Research has conducted 160 full-scale fire tests with ESFR sprinklers of different K factors.

This is just one example of the collaboration between research, industry, manufacturers, insurers and code authorities working together to benefit industry and further the science of loss reduction and fire suppression.

#### **Protection of Clean Rooms for Semiconductor Manufacturing Facilities**

An FM data sheet was originally written in 1980 to protect clean rooms and was revised in 1986 and in 1991. As the semiconductor manufacturing facilities expanded and increased in complexity, FM Data Sheet 7-7 had to follow. In 1993, long before the large losses in the semiconductor manufacturing facilities in Taiwan and elsewhere, FM Global initiated a research program to investigate the semiconductor clean room fire hazards. We found that the primary fire hazards were originated on clean room wet benches and the sprinkler system was not a viable method of suppressing the wet bench fires in the early stage with an acceptable loss. The solution was to build wet benches with truly fire safe plastics that require no protection. When fire hazards exist on a wet bench, a Factory Mutual Research Approved wet bench protection system should be used. Several water mist and gaseous systems are found to be effective for wet bench protection.

To find some truly fire safe plastics for wet benches, the Factory Mutual Research team used the Fire Propagation Apparatus (FPA), developed originally in the 1970's by Factory Mutual Research. The FPA was used to test advanced plastics, which will not burn or emit excessive smoke even when exposed to a large fire source. A test protocol, Factory Mutual Research Approval Standard 4910, was developed to evaluate advanced plastics for wet bench application. Based on these research results a major revision was made on FM Data Sheet 7-7 in 1997.

Last December, the ASTM recognized the FPA as the Test Method Standard E2058 Measurement of Synthetic Polymer Material Flammability. The FPA has also been incorporated into a proposed standard by the NFPA - NFPA 287, Measurement of Flammability of Material in Clean Rooms. This standard is currently going through the public comment process and final approval is expected later this year.

The NFPA technical committee on clean rooms was formed in 1988. NFPA Standard 318 on Clean Rooms was adopted in 1991. NFPA 318 has also adopted various portions of Factory

Mutual Research's approach on loss prevention in semiconductor fabs and included as Appendix material references to Factory Mutual Research Approval Standard 4910.

**Final Remarks**

- There are three types of fire protection and building code writing processes in the US.
- NFPA codes and standards are developed through an open consensus process, which allows for the input and participation — including voting rights — of all those interested.
- NFPA consensus codes and standards are generally adopted and enforced by state fire marshals and by the local town fire inspection staff. Federal inspectors are responsible for enforcing fire codes only on federal properties.
- Each state votes on the Building Code and usually the Fire Protection and Life Safety Codes it will adopt. Local town building inspectors then enforce the Building Codes for buildings within their jurisdiction.
- Consensus codes and standards in the US have always been adopted on the basis of their technical merit. Building Codes have largely been accepted on a geographic basis.
- Implementation of such codes and the process of setting codes and standards through a consensus process would accelerate the development of the market economy and promote the development of the science and technology.

The economic environment in the US encourages free competition in business, science and code enforcement in all sectors of the economy as well as the support of diverse points of view. This leads to the encouragement of creative ideas, the development of innovative products and the growth of the economy.

**Fire Protection Codes and Standards in the USA — The Players**

Players	Owner	Insur	CdWrtg	CdEnf	PrdStd	PrdCert	Res	Test	Conslt	Insp	Eng'g
Large Corp and Comp.	*						*				
Self Insured Comp.	*	*	*		*					*	
Insurance											
FM Insurance		*	*	*						*	
Other Insurance Companies		*		*					*	*	
Fire Prot. Prod. Manuf'cturers							*	*			*
Codes and Standards											
NFPA — Consensus Codes			*								
BOCA National Code			*								
Uniform Building Code			*								
Standard Building Code			*								
3rd Party Res and Product Testing											
Factory Mutual Research					*	*	*	*	*		
UL					*	*		*			



SWR		*	*	*
Eng'g & Consulting Companies				
RJI			*	*
CSA			*	*
Federal Government				
GSA	*			
NIST				
FEMA				
Military				
Nucleau				
Local Government				
Fire Services		*		
Building Inspectors		*		*
Authorities having Jurisdiction		*		*

### Honors and Awards

- Fire Detection Institute — Board of Directors, 1973—1992
- National Research Council Evaluation Panel for Fire Research in the National Bureau of Standards ( now NIST), 1981—1987
- Society of Fire Protection Engineering — The Arthur B. Guise Medal in recognition of the eminent achievements in advancing the science of fire protection engineering — 1997
- International Association of Fire Safety and Science — Award in recognition of his considerable contribution into cooperation between Russian and international fire safety science communities, 1997

Industry in general and the fire protection community are all benefiting from his contributions during his 30—year career in fire protection research and engineering.

### Biographical Data

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Cheng Yao received his B. S. degree in Mechanical Engineering from the Taiwan College of Engineering (now National Cheng—Kung University) and his M. S. degree in Mechanical Engineering from Purdue University in 1957. He joined Factory Mutual Research Corporation (FMRC) in 1967, following 10 years of research and development in steam—generating units and air pollution control equipment.

At FMRC, he initiated numerous fire and explosion research activities, and for many years led FMRC's applied research. He was elected Vice President in 1986 and managed all of FMRC's research and large—scale testing activities until his retirement on July 1, 1996. He

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is now an independent consultant and has been retained by FMRC on a part-time basis as a Technical Advisor and Far East Operations Representative.

**Technical Achievements**

Mr. Yao is an internationally recognized authority on sprinkler technology research. He created the basic concept and assumed the overall responsibility for the research and development of the Large Drop sprinkler (1971–1980) and ESFR (Early Response Fast Response) sprinkler (1984–1989). He had also modeled the leakage of Halon 1301 through enclosure openings in 1967, and pioneered the dynamic approach to explosion (deflagration) venting research and engineering design in 1969.

## **Introduction of German Industrial Standardization for Fire Fighting(Outline)**

**Wolfgang Schmitz**  
(*Schmitz GmbH*)

1. The mark of the German Industrial Standardization Organization (DIN)
2. Who is DIN?
3. Introduction of the statute § 1, paragraph 2 (about the purpose of DIN)
4. Principles of the standardization works
5. Structure of DIN
6. Documents in the course of standardization works
7. Emergence of a DIN standard
8. Emergence of an European standard
9. Importance of different countries in the vote of European standardization works
10. Financial position of DIN
11. Information service of DIN database
12. Some examples of electronic media
13. The first DIN standard
14. The first standard of the world—emerged in China
15. The DIN data
16. The development of DIN
17. The professional standardization committee for fire fighting
  - 1) Who needs standards for fire fighting?
  - 2) For what does man need standards for fire fighting?
18. Structure of the professional standardization committee for fire fighting
19. Introduction of FB 192 working group

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