

出國報告（出國類別：其他）

## 參加美國AIHA國際研討會 並參加展示活動

服務機關：行政院勞工委員會勞工安全衛生研究所

姓名職稱：陳春萬研究員、王順志副研究員

派赴國家：美國(芝加哥)

出國期間：95年5月12日至5月19日

報告日期：95年8月

# 摘要

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關 鍵 詞：研發成果展示、工業通風、奈米研究

內容：

本次行程主要為參加2006年美國工業衛生研討暨展覽會(AIHce 2006)，展出本所工業通風研究成果，包括新型氣簾式化學氣櫃、氣簾輔助系統、吹吸式氣罩、新型分徑採樣器、摺疊式負壓隔離艙，並發表本所有關通風及奈米微粒相關研究論文。已順利完成展覽工作，成功的讓台灣及本所形象透過攤位名字[Taiwan IOSH]，讓參觀者留下深刻印象，吸引超過400人次參觀攤位，超過30人次表示對本所產品有興趣，所發表之論文也可國際職業衛生研究相匹配，也與各國職業衛生從業人員交流，充分展現勞工委員會勞工安全衛生研究所之成果。

本次行程所展出及報告之通風研究成果，讓各國與會人員驚奇，紛紛表示興趣及希望更進一步索取資料，研究經驗應該會對各國控制預防提供非常有用之參考資料。就分享並與各國參與人員交流台灣職業安全衛生經驗，展現並推廣本所研究成果，此次行程有很好的表現。

# 目次

|                         |    |
|-------------------------|----|
| 摘要 .....                | 1  |
| 目次 .....                | 11 |
| 壹、目的 .....              | 1  |
| 貳、過程 .....              | 2  |
| 一、展示規劃—展覽品與攤位 .....     | 2  |
| 二、攤位佈置與展覽品運送 .....      | 6  |
| 三、實際展出工作 .....          | 11 |
| 四、論文發表 .....            | 15 |
| 參、心得 .....              | 17 |
| 肆、建議事項 .....            | 19 |
| 附錄一 展覽品之說明海報 .....      | 20 |
| 附錄二 研討會發表有關奈米微粒論文 ..... | 23 |

# 壹、目的

台灣在職業衛生上之研究，已經逐漸獲得成效，雖然透過論文發表，已讓世界各國職業衛生從業人員參考，但只侷限於部分學者，並無法有效呈現台灣之研究能量，若是能透過有系統的介紹，將可讓更多世界各國職業衛生人員，清楚台灣工業通風之研究成果。

再者台灣應該適度的參與國際的交流活動，與其他國家分享台灣過去的執行經驗，也共同為未來可能面臨之問題共同討論解決。安全衛生雖然不是國際事務上主要議題，但若相關從業人員互相交流，也可增加台灣之能見度，特別是台灣近年來在安全衛生之努力經驗，若能適度讓國際相關領域人士了解，可增加國際上對台灣之了解，而參與研討及展示活動經驗，也可增加國際上之經驗，增加本所研發能量。

參與大型國際安全衛生活動，促進研發成果及技術國際交流及行銷，為本所當前工作方向之一；經核定同意本所參加2006年美國AIHce展示活動後，透過多次內部討論，整個活動的目的在於藉由參與國際大型安全衛生活動，主動分享本所近年重要研發成果，增進本所國際知名度並尋求技術交流合作，建立未來研發成果行銷國際之管道。

## 貳、過程

美國工業衛生研討暨展覽會 ( American Industrial Hygiene Conference & Exposition, 以下以簡稱 AIHce 2006代替 ) 是美國工業衛生年度盛會，由於美國國力強盛，也匯集了世界各國的工業衛生的關注，再加上美國認證工業衛生師 ( certificated Industrial Hygienist, CIH ) 再教育認證制度 ( continuous education certification )，工業衛生專業人員必須不斷更新獲得專業知識，取得足夠之學分數 ( credits ) 才能獲得專業技能的持續認可。因此，全美工安衛人員有很高的意願參加此一盛會，也獲得世界各國之重視，本項大會仍是目前全世界在環境職業安全衛生最受重視的活動之一。近幾年每年都超過5000人參加，發表論文超過400篇，再加上專題演講、討論會、圓桌會議、各項分組會議，使得活動多采多姿，而所辦理之工業衛生展覽，近年也都超過400家廠商共相盛舉，各種最新發展的儀器設備都會有展示，包括偵測、控制、防護設備等，藉由參加AIHce的展覽機會，我們可展示本所的研究成果，也可交換各國工業衛生最新的發展經驗。

### 一、展示規劃—展覽品與攤位

2006年AIHce選在美國芝加哥舉辦，且同時舉辦VENT 2006，時間定於95年5月13日-18日。工業通風為2006年研討會主要議題之一，因此將AIHce 2006與VENT 2006一起舉辦。本所對於工業通風已有多多年研究經驗，也發表多篇國際論文，例如

1. R. F. HUANG, S. Y. LIN, S.-Y. JAN, R. H. HSIEH, Y.-K. CHEN, C.-W. CHEN, W.-Y. YEH, C.-P. CHANG, T.-S. SHIH, C.-C. CHEN,

- 2005; “Aerodynamic Characteristics and Design Guidelines of Push–Pull Ventilation Systems”, *Annals of Occupational Hygiene* 49(1):1-15
2. Rong Fung Huang, Gene Shin Liu, Shin Yi Lin, Yu-Kang Chen, Shun-Chih Wang, Chiung-Yu Peng, Wen-Yu Yeh, Chun-Wann Chen, Cheng-Ping Chang, 2004; "Development and Characterization of a Wake-Controlled Exterior Hood", *Journal of Occupational and Environmental Hygiene*, 1: 769–778
  3. Rong Fung Huang, Gene Shin Liu, Yu-Kang Chen, Wen-Yu Yeh, Chun-Wann Chen, Chih-Chieh Chen, 2004; “Effects of Flange Size on Dividing Streamlines of Exterior Hoods in Cross Drafts”, *Journal of Occupational and Environmental Hygiene*, 1(5):283 - 288
  4. Chung, K.C., Yang, C.Y., Chen, C.W., 2003; "The Effect of the Size of Openings on Contaminant Control Between Two Adjacent Spaces With Differing Air Pressures", *American Ind. Hyg. Assoc. J.*, 64(6):792-798
  5. Huang, R.F., Sir, S.Y., Chen, Y.K., Yeh, W. Y., Chen, C.W., Chen, C.C., 2001; “Capture Envelopes Of Rectangular Hoods In Cross Drafts American”, *Ind. Hyg. Assoc. J.*, 62(10):563-572
  6. Huang, R.F., Chen, J.L., Chen, Y.K., Chen, C.C., Chen, C.W., Yeh, W. Y., 2001; “The Capture Envelope Of A Flanged Circular Hood In Cross Drafts”, *American Ind. Hyg. Assoc. J.*, 62(2):199-207

其中第5篇 “ Capture Envelopes of Rectangular Hoods in Cross Drafts ” 更獲得AIHce 2002年之The Best Engineering Paper Award(The American Industrial Hygiene Association)。因此對於工業通風主題，剛好可讓本所有效呈現展示研究成果。

為有效呈現研究成果，因此選定有模型或實體之研究成果，並且為突顯本所工業通風成果及配合大會主題，展品規劃以通風研究

成果為主，其他研究成果為輔之考量，經內部討論決定以3項本所重要工業通風研究成果做為主要展示項目，分別為

- 吹吸式氣罩
- 新型氣簾式化學氣櫃
- 氣簾輔助系統

另本所去年參與AIHce 2005所展示之研發成果新型分徑採樣器及摺疊式負壓隔離艙相當受到參觀者之重視，因此也繼續展出。

規劃之展示品，都已經商品化、或已有商品雛型、或有展示模型，例如吹吸式氣罩，利用煙霧產生器及雷射光頁，可讓參觀者清楚看到通風之流場，提供一種最吸引人，最直接的成果展示。

對於展示品之介紹，過去都有發表之學術論文，但為求有效吸引參觀者，且必須讓參觀者快速掌握展出成果，也提供簡易直接之介紹內容，並且儘量利用圖片內容來說明，因此對於展出品之宣傳單，經過研發人員之斟酌後，再經同仁審慎的一再確認內容，送請本所外籍顧問修訂英文，並送交專業設計公司製作宣傳單張。

另為增加展覽之動感，吸引更多注意，展覽時規劃透過電腦及投影機播放簡介影片，除特別製作展品之介紹影片，也可播放本所及台灣相關之介紹。對於展出說明資料及影片，為求讓參觀者更深入對本所研發成果認識，展出時透過DVD提供更詳細解說資料，除了每項展品解說外，也將本所20分鐘英文簡介置入其中。

由於工業通風展示品，都有模型或實體說明，需要較大之展示空間，另展覽會場攤位安排，若僅租用1-2個單元(10英尺X10英尺)，必須與其他單位併排，也就是只有一個展示面，若租用4個單元(20英尺X20英尺)，將可獲得獨立空間，也就可明顯突顯展示之攤位。因此為展示通風研究成果及展出效果，本所在AIHce 2006租用20英尺X20英尺之攤位，主辦單位提供本所之位置圖如圖1。

雖然本所之正式名稱為行政院勞工委員會勞工安全衛生研究所，但參加國外展出，不易被確認，為呈現本所為來自台灣的研究單位，採用本所簡稱[Taiwan IOSH]，讓國外參觀者一眼就看出是來自台灣比擬美國NIOSH(National Institute for Occupational Safety and Health)的研究單位。

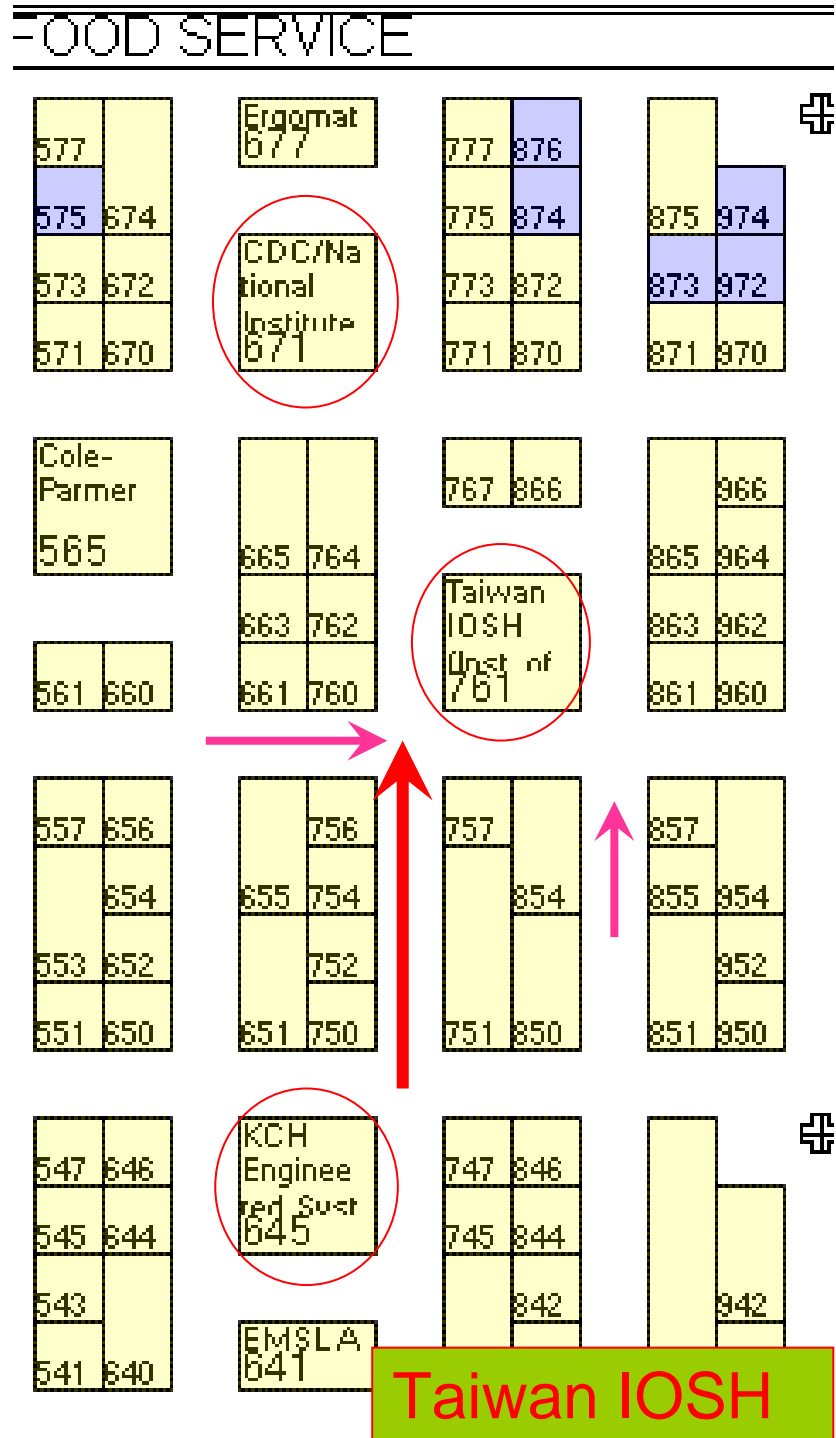


圖1 AIHce 2006主辦單位提供本所(Taiwan IOSH)位置圖



## 二、攤位佈置與展覽品運送

對於20英尺X20英尺之攤位，四面都可展出，標準佈置方式如圖2，為一開放空間，但因本所此次展出之通風模型，必須有適當遮擋，避免環境氣流影響(如人員走動、空調等)，如此方式並不恰當。且此種佈置方式，因有懸空及支撐問題，布置費用高，因此必須另行規劃。



圖2 標準20英尺X20英尺展示空間佈置圖

考慮實際需求與經費，認為一般圖3之20英尺X10英尺之佈置方式，剛好可提供本所此次展出之佈置。可利用後面看板來擺放工業通風模型(流場可視化模型)，而其他展示空間，可擺設商談桌及化學氣櫃實體及提供影片播放影幕。



圖3 一般20英尺X10英尺展示空間佈置圖

因此展出攤位整體規劃如圖4，本次AIHce 2006於芝加哥舉行，芝加哥是全世界有名的高樓都市，也曾擁有世界第一高樓希爾斯大樓，現階段世界第一高樓為台灣101大樓，因此本所攤位特別選用101大樓照片來佈置攤位，再配合台灣之空照圖，吸引所有參觀者。

為強化展出效果以及突顯來自台灣之研究機構，展出時採用2部筆記型電腦播放介紹DVD，利用投影機及投影影幕，而為吸引參觀者目光，建立參觀者印象，在攤位四周都佈置大型台灣空照圖或101大樓照片，並且標示Taiwan IOSH。

為節省經費考量，因大型照片、播放系統租用或輸出費用相當高，因此預計都由台灣帶到美國，因此在規劃攤位佈置前也一併設計佈置影像。

由於展出工業通風模型與實體，體積相當大，因此若採取傳統空運方式，費用將非常驚人，但若採取海運方式，費用可適當節省，但必須提早規劃。為節省經費，本次展出提早規劃，提早準

備，配合展出之運送期程及海運時間，將展出品包裝運送。

對於配合主辦單位之佈置，也配合佈置之規劃，早期即向主辦單位確認，如此可享早期預定之折扣。

大會允許佈置時間為3天，雖然本所有許多展出模型與實體，但考量出國成本，規劃展出前1天整天進行佈置，應可順利完成佈置。為確認裝潢及佈置租用狀況，也為確認所運送之展出品已順利運抵展場，本次出國安排行程，當地時間5月13日(展出前2天)到達後，即先進展場確認是否所有準備已定位，而於展出前1天(5月14日)完成佈置。

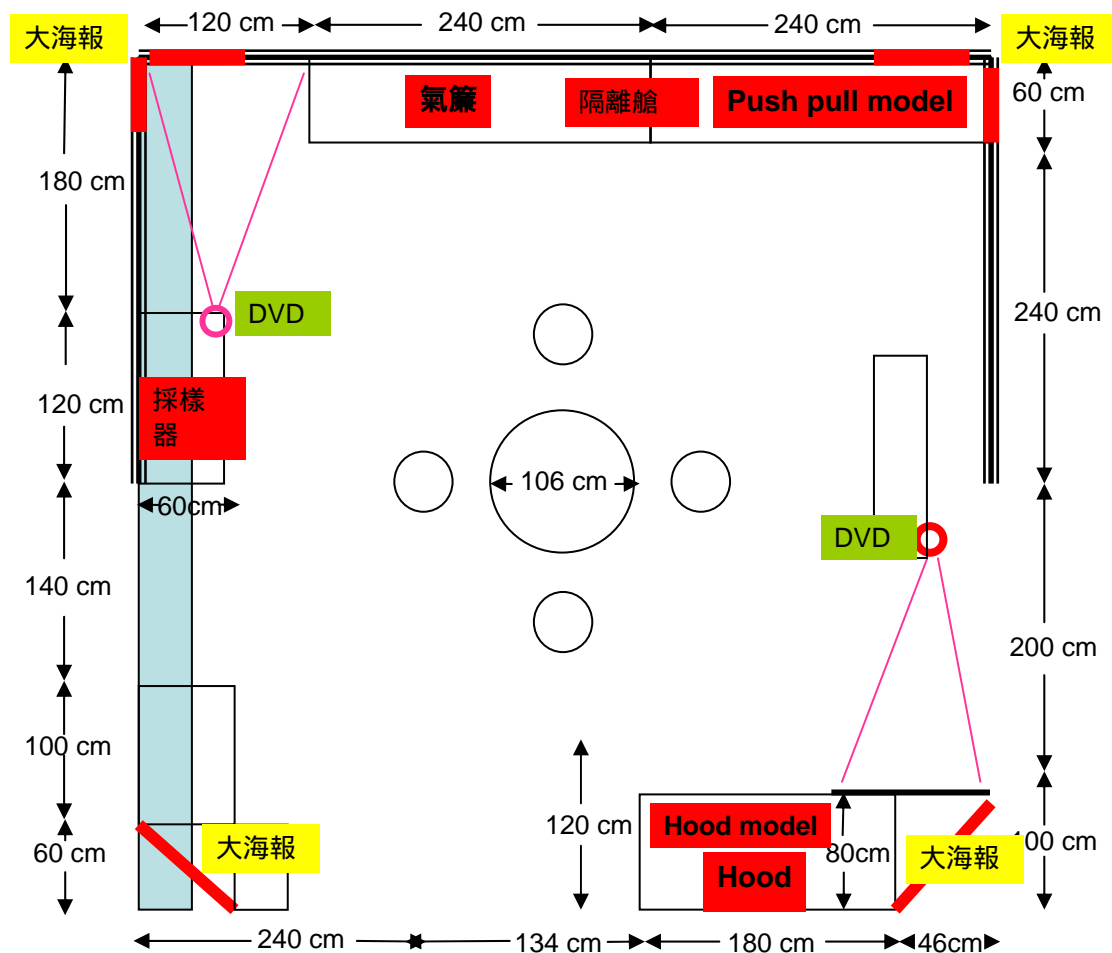


圖4 展示空間佈置規劃圖

本次行程5月13日到達美國芝加哥後，即進入展覽場確認運送之3大木箱(每箱約長2公尺，寬1公尺，高2公尺，約200公斤重)都已到達，並與台灣前往參加研討會之學者學生約定，5月14日協助佈置。佈置情形如圖5，幸運的有許多教授與學生協助幫忙，大家合力佈置攤位，將展覽品順利組裝完成。



圖5 展示空間開始與佈置情形

最後完成佈置情形如圖6，將化學氣櫃實體，吹吸型氣罩模型，氣簾輔助系統模型，DVD播放系統，攤位大型海報，依計畫安排在適當位置。由於本所攤位背後有看板隔開，為吸引由後方走到往前參觀者，在隔間看板上也佈置[Taiwan IOSH]—台灣空罩圖及101照片如圖7，吸引參觀者目光。



圖6 展示空間佈置完成圖



圖7 展示空間背景佈置完成圖

### 三、實際展出工作

此次AIHce 2006之攤位有很完整空間，同時間可允許多組人員為參觀者解說，安排上化學氣櫃實體，吹吸型氣罩模型，氣簾輔助系統模型各有一名解說人員，也就是同一時間最好有3名解說員，除負責這3項主要展品之說明外，也可互相支援DVD播放系統、摺疊式負壓隔離艙、新型分徑採樣器、甚至對台灣有興趣之參觀者進行解說。

雖然本所實際前往AIHce 2006工作人員有限，但因有台灣前往參加研討會之教授與學生幫忙，雖然同一時間必須有多位解說員，彼此互相支援下，也順利為400位各國參觀者解說。

為求說明內容相同，此次產生之成果都有解說小海報如附錄一，展出人員或義務解說之學校教授與學生，都可參考解說，也可提供參觀者參考。

展出期間，由於本所所採用之流場可視化如圖8，以及台灣空照圖與101大樓圖，攤位一直吸引參觀者注意，很多參觀者特別再帶朋友來參觀，也有與本所解說人員熱烈討論，對於過去曾展示過之新型分徑粉塵採樣器、摺疊式負壓隔離艙，也與本所通風研究成果一樣，也受到很多之詢問，甚至希望能夠直接帶產品回家，只是限於規定與現況，無法完全配合。估計有400多位各國參觀者參觀本所攤位，也有30多位人員表示希望購買本所所展出之研發成果。

特別是在展出期間，本所商請合作開發新型化學氣櫃之台灣科技大學機械系之黃榮芳教授，於研討會報告之開發過程與性能，此氣櫃打破傳統之設計概念，使用較少能源而且可獲得更好之功能，因此所展出之此氣櫃實體與模型，一直獲得各界之詢問，甚至包括AIHA工業通風委員會主任委員也特別前來參觀，也有工業通風研究

者，帶領研究生在氣櫃前後研究二、三十分鐘，似乎要將本所設計完全吸收。

另外在展出期間，大會主席經過本所攤位時，特別到本所致意，表達對台灣支持AIHce之活動，且此次能夠盛大的參與展出，讓參觀者印象深刻。化學氣櫃實體與模型解說情形如圖9，吹吸型氣罩模型解說如圖10，氣簾輔助系統模型解說如圖11，多組解說及各項展示品解說情形如圖12，可看出參觀者對本所展出內容之興趣。

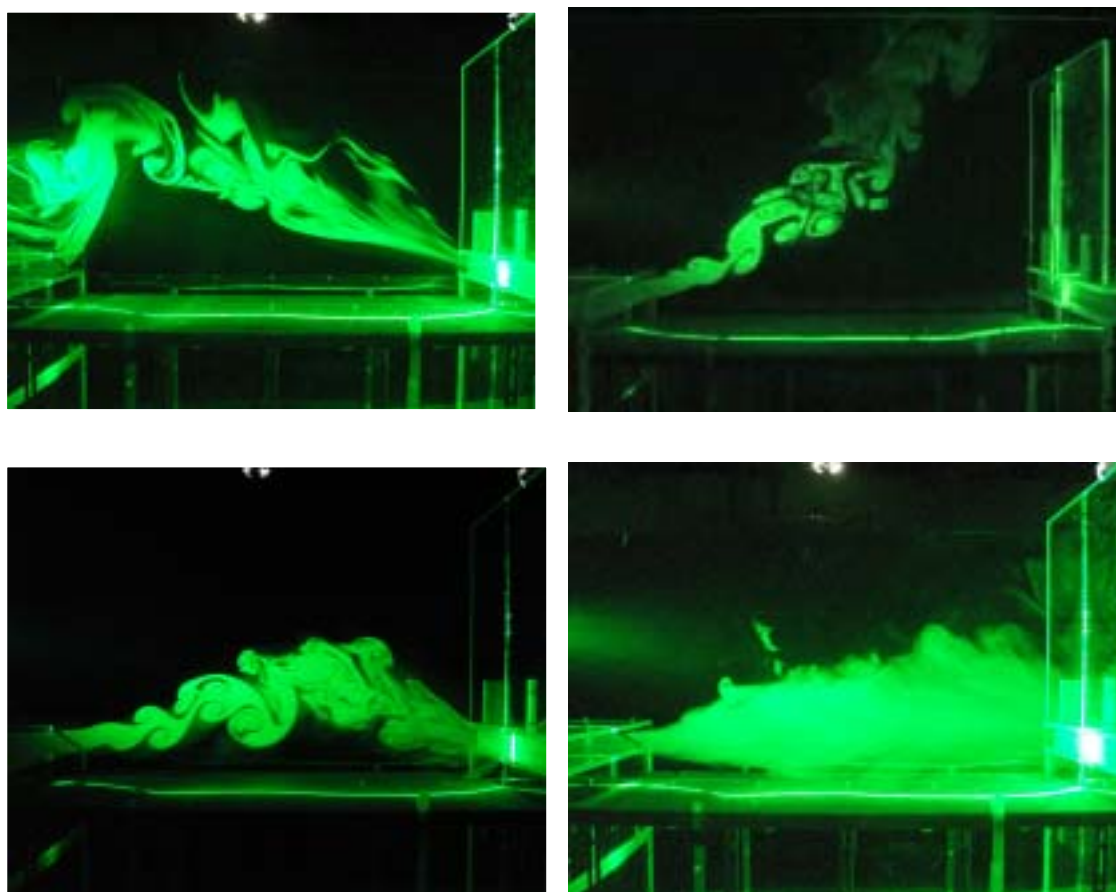


圖8 吹吸式氣罩流場可視化展示圖

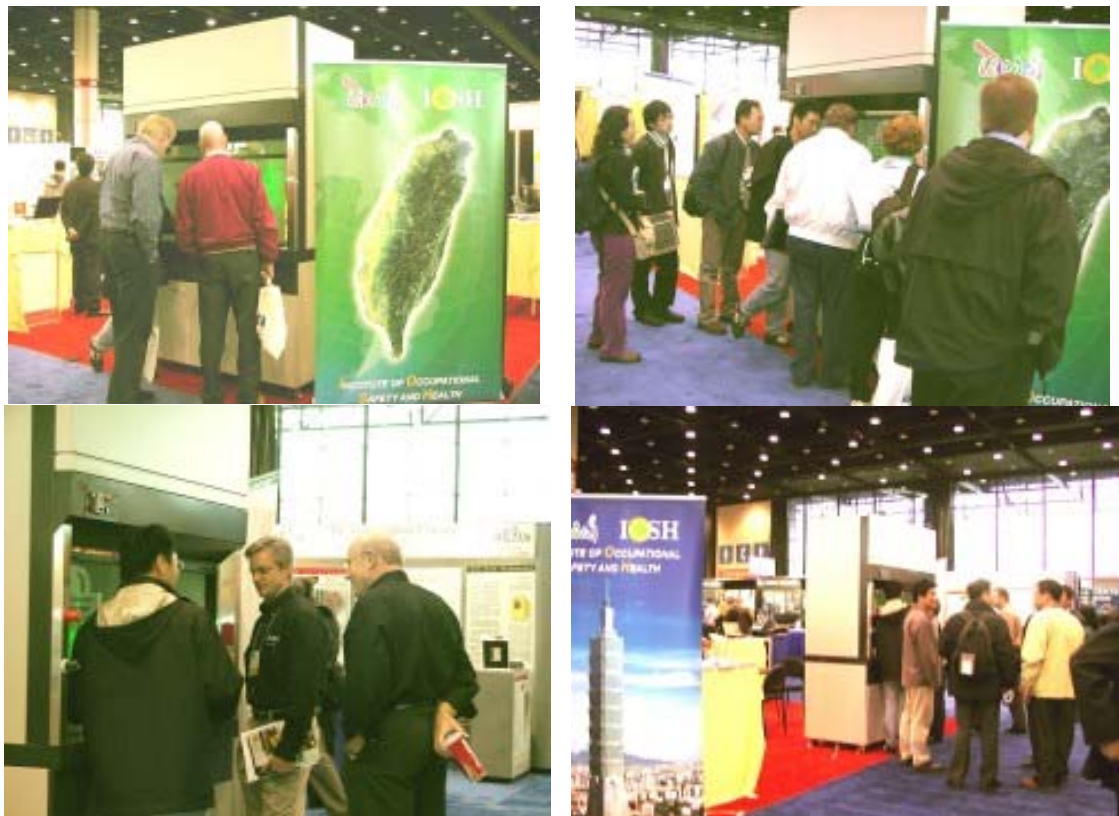


圖9 化學氣櫃實體與模型展示解說情形圖



圖10 吹吸式氣罩展示解說情形圖





圖11 氣簾輔助系統展示解說情形圖



圖12 多組解說及各項展示品解說情形圖

#### 四、論文發表

此次參加AIHce 2006，2位參加人員也都有發表論文，採用海報方式，分別如下，

Penetration of 4.5 nm to 10um aerosol Particles through Fibrous Filters. C.Chen; S.Huang; C.Chang(陳春萬，黃盛修，張振平)

Improving Efficacy of a Wall-Mounted Receiving Hood by Three-Piece Air Curtains S.Wang ; C. Chen ; S. Wu ; D. Lin ; C. Chang (王順志，陳志傑，林東青，張振平)

所發表論文現場如圖13，關於奈米之研究「Penetration of 4.5 nm to 10um aerosol Particles through Fibrous Filters」詳細內容如附錄二，係與最熱門之奈米科技有關。經查此次大會會議議程，奈米科技安全衛生論壇中所發表2篇與本所這次發表類似，都是談奈米微粒過濾問題，該2篇文章為避免實驗誤差，都採用單一粒徑方式，慢慢的測定濾材對奈米微粒捕集效率，本所之研究應用對於SMPS(掃描式微粒靜電移動度分析儀)之熟悉，將完整之微粒粒徑完全掌握，並且實際對一般防塵口罩濾材進行測試，再加上結合理論，讓整篇防塵口罩對防護奈米微粒之研究，完整呈現，因此吸引很多參觀者，超過30位相關研究人員，表示希望能獲得更詳細資料，其中包括美國呼吸防護具研究主管機關NIOSH、美國呼吸防護具最大廠商3M、美國微粒儀器大廠TSI、及學校教授與業衛生技師。在展出期間，美國NIOSH奈米微粒研究經理，特別前往本所攤位，希望本所能參加今年10月在美國辛辛那提舉辦之奈米科技職業與環境安全衛生國際研討會，顯示研究成果獲得肯定。

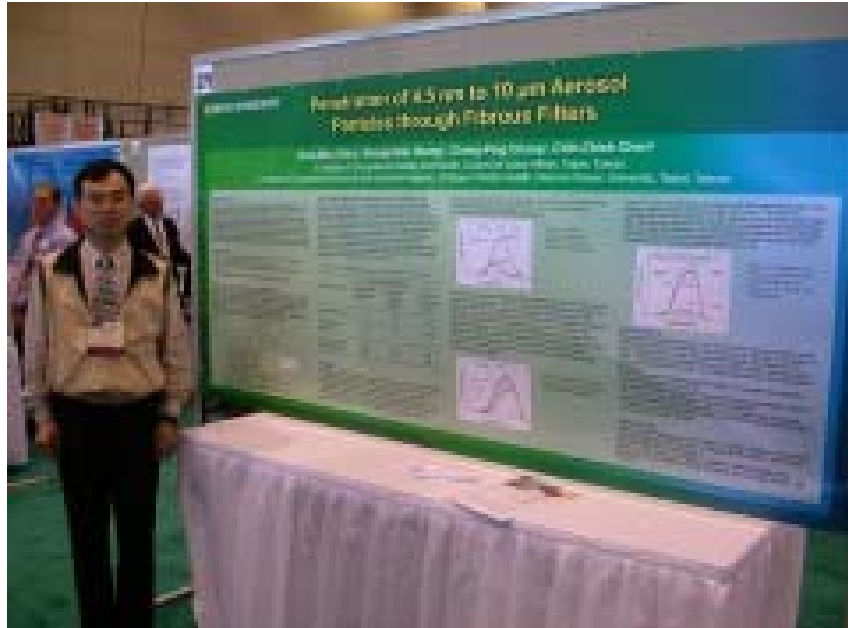


圖13 發表海報論文情形圖

而「Improving Efficacy of a Wall-Mounted Receiving Hood by Three-Piece Air Curtains」與這一次之展出內容有關。除了這二篇文章外，在AIHce 2006研討會發表之文章與本所有關之論文還包括下列5篇，前二篇與此次展出有關，當第一篇論文報告後，許多參與者都前往本所攤位來看實際氣櫃與模型。

此次之經驗發現，若能夠結合發表之論文與展出內容，將可使得展出更為成功，也可產生一項展出之議題，值得未來展出參考，不過因考慮配合問題，規劃時間及內容應更早確定。

1. Development of an Aircurtain, Isolated Chemical Fume Hood with Considerations of Aerodynamics. R.Huang; C.Chen ; C.chang, ; T.Shih(黃榮芳, 陳春萬, 張振平, 石東生)
2. Contributions of Aerodynamics to Laboratory Fume Hood Performance. L.Tseng; R.Huang ; C.Chen ; H.Chen ; C.Chang(張振平)
3. Occupational Exposure of Dioxins in Taiwan. U.Shi-Nian(汪禱年)
4. Survival of bacteria under different storage conditions and nutrients on respirator filter; C. Lai, C. Chiang, T. Yu, Y. Ho, C. Chang(賴全裕, 于台珊, 何雨芳, 張振平)
5. Monitoring Evaluation of Volatile Gas from Pickle Tank ; C. Lai, T.Wu, F. Tang ; Y. Yan; S.Tsai ; D.Tang(湯大同)

## 參、心得

這一次我們參與AIHce 2006算是一項成功經驗，利用AIHce 2006+VENT 2006之機會，對於本所豐碩之工業通風研究成果進行一次有效之展出，將台灣及台灣安全衛生研究機構[Taiwan IOSH]推向國際，讓國際了解台灣對工業衛生之研究努力。透過研發成果的品質與成效，告訴國際友人，我們在台灣如何在職業安全衛生領域，保護我們的勞工朋友，也建立國際我們樂於分享及交流台灣經驗的印象(image)。

經過這次展示，我們的研究成果並不輸工業先進國家的產品，我們應該掌握更多機會與國外廠商接觸，從而建立國際行銷商機或合作機會。因此，應及早重視國際行銷、代理及建立通路，除了透過商業合作模式外，未來也可以與國外安全衛生研發機構合作，建立完整及系統化的銷售及服務網絡。

這一次的參加展出，參考本所過去參加國外研討會展覽之經驗，因此準備上充實許多，例如過去曾建議1.結合發表論文、專業課程開課(workshop)，利用機會廣加宣傳。2.預定最醒目之展示位置，選擇主打議題，集中火力介紹新設備與技術。都已於應用於這一次之展出中，雖然仍有改善空間，但過去經驗讓這次展出更為成功。

不過對於過去聘用[協助攤位解說員]之建議，今年展示並未落實，如何應用可能仍需要建立模式。一般台灣前往參加如AIHCe 國際學術研討會之教授學生不多，而會參加研討會之教授，一般都有發表論文，也都會希望能吸收更多學術研究經驗，因此並不方便請教授協助。而會從台灣前往國外參加如AIHCe 國際學術研討會之學

生並不多，一般都會與教授一起活動，再加上學生專業有限，對展出內容可能無法有效說明，因此過去經驗--[培訓國內參與 AIHce 研討會之學生為解說員]今年並未實際落實，未來除非檢討模式，如所提供經費能夠支付部份旅費，較可能應用。而對於--[聘請國外顧問與華人解說義工]建議，則須看研討會舉辦地點與國外留學生聯繫情形，因此必須建立平時與國際學者聯繫管道，才有機會應用此項建議。

這一次之展出，台灣前往參加AIHce 國際學術研討會之教授(4位)與學生(4位)，雖然沒有正式邀請協助佈置攤位與協助解說，不過由於事先有聯繫與溝通，因此都能鼎力協助佈置攤位，在展出期間也常常出現於攤位協助解說，提供本次展出很大之協助。如此協助方式並非強制合作模式，有時比較不容易安排，應該研擬適當模式(包括經費與資格要求)，能讓台灣參加國際研討會之教授學生，更有制度協助展出之解說。

另外對於此次展出，因展品很多很大，因此展品運送及攤位佈置等有許多程序要處理，雖然主辦單位都會提供合作廠商，不過一般費用都不便宜，而且不一定適用本所展出需求，因此若要繼續參加過內外之展出活動，對於展品運送及攤位佈置應該早期規劃，如此才能在適當經費下，獲得最大之效果，若是能確定適當攤位標題(印象，image)及攤位大小，利用摺疊式之展示架(此次已採用二支捲軸式展示海報架及二支捲軸式播放螢幕，但都不適合整體佈置)來佈置，將可簡化攤位佈置。而對於展品之運送，應該在規劃展品時，就應將包裝一併考慮。

## 肆、建議事項

行政院勞工委員會勞工安全衛生研究所研究同仁已有很多研究經驗，若能參加類似AIHce 國際學術研討會及展出，將可適當宣導研究成果，讓國際上安全衛生工作人員能對台灣更清楚認識--台灣對於這方面之研究經驗，也可推廣研究成果，擴大應用及合作層面。這次的出國展示，算是一項成功經驗，就參展經驗，提出下列建議，可供未來參考。

1. 此次展出的研究成果並不輸工業先進國家的產品，值得繼續推廣本所成果，與國外研究機構與廠商接觸，擴大成果應用與授權。
2. 過去展出經驗之建議「結合發表論文、專業課程開課(workshop)，利用機會廣加宣傳。」、「預定最醒目之展示位置，選擇主打議題，集中火力介紹新設備與技術」，此次都已有應用經驗，可繼續應用此建議讓展出更為成功。
3. 由於國外展出，需要更多專業人手協助，若不容易招聘適當[解說員]，可能需要考慮適當展出規模，主要展出特定議題，顯示Taiwan IOSH之研究成果。
4. 一般展示攤位之佈置費用不低，特別是需要現場裝潢之佈置，參考其他攤位作法，很多採取組合式作法，因此建議應該固定本所固定形象(image)，製作摺疊式展示架，未來可彈性來佈置展示攤位。
5. 對於所展示內容，為擴大展出效果，建議將相關展式內容能夠放在本所英文網站，可透過電子郵件方式，將本所研究成果讓國外相關學者，了解本所研究成果。

# 附錄一 展覽品之說明海報

## 1. 化學氣櫃實體

### The Taiwan IOSH-NTUST HOOD (Air-Curtain Hood)

**Source**


A hood design of hood design, simply but efficient. The Taiwan IOSH-NTUST Hood was designed by the research group of Institute of Occupational Safety and Health (IOSH) and National Taiwan University of Science and Technology (NTUST), Taipei, Taiwan.

**Specifications**

The Taiwan IOSH-NTUST Hood like an curtain hood, incorporates a hood through design for the hood, it particularly discards the design principle of the conventional hood. It features an wind-tunnelly method for air flow check in all directions the ventilation of the hood. This is particularly designed for the peak position in downward flow hood, incorporates an air curtain principle in regard. These standard hood gas concentration measurements method (the ACGIH MSAF 10-199 method, Reynolds LTI protocol and the recent UK method) with analytical sampling level of the environmental badge levels of the system measurement of contaminants. Unlike the other hood, it features working flexibility with various good hood performance shown in Table 1. 1. Contaminant leakage rate almost less than 0.01% (1 ppm for both the inlet and exhaust flow). The hood performance did not deteriorate with an increase in task width. The exhaust rate 1.2 m<sup>3</sup>/min (400 L/min) average saving up to 30% can be obtained while the hood performance remains much better than that of a conventional hood. In addition, the inlet air flow is, the down-draft velocity can be adjusted, energy saving up to 30% possible for a hood with 1 m<sup>2</sup> catch area.

**Photo**

Taiwan Patent 102117146, 13 Patent applications submitted.



Air-Curtain Hood

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### The Taiwan IOSH-NTUST HOOD (Air-Curtain Hood)

**Table 1** Results of hourly gas concentration measurements following the peak test method of the ACGIH MSAF 10-199 hooded chemistry breathing zone sampling method.

| Item          | IOSH-NTUST Hood         | Conventional Hood       |
|---------------|-------------------------|-------------------------|
| Leakage rate  | 0.01%                   | 0.1%                    |
| Exhaust rate  | 1.2 m <sup>3</sup> /min | 1.5 m <sup>3</sup> /min |
| Energy saving | 30%                     | 0%                      |

**Table 2** Results of hourly gas concentration measurements following the peak test method of the ACGIH MSAF 10-199 hooded chemistry breathing zone sampling method.

| Item          | IOSH-NTUST Hood         | Conventional Hood       |
|---------------|-------------------------|-------------------------|
| Leakage rate  | 0.01%                   | 0.1%                    |
| Exhaust rate  | 1.2 m <sup>3</sup> /min | 1.5 m <sup>3</sup> /min |
| Energy saving | 30%                     | 0%                      |

**Table 3** Results of hourly gas concentration measurements following the peak test method of the ACGIH MSAF 10-199 hooded chemistry breathing zone sampling method.

| Item          | IOSH-NTUST Hood         | Conventional Hood       |
|---------------|-------------------------|-------------------------|
| Leakage rate  | 0.01%                   | 0.1%                    |
| Exhaust rate  | 1.2 m <sup>3</sup> /min | 1.5 m <sup>3</sup> /min |
| Energy saving | 30%                     | 0%                      |

**Figure 1** Air-Curtain Hood (Medium Section)

**Figure 2** Air-Curtain Hood (High Section)

**Figure 3** Conventional Hood (High Section)

Results of hourly gas concentration measurements following the peak test method of the ACGIH MSAF 10-199 hooded chemistry breathing zone sampling method. IOSH-NTUST Hood:  $C_{in} = 1000$  ppm,  $C_{out} = 10$  ppm.

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## 2. 吹吸型氣罩模型

### Aerodynamic Characteristics and Design Guidelines of Push-Pull Ventilation Systems

**Characteristics**

Aerodynamic characteristics such as air flow patterns, velocity field, turbulence evolution, characteristics, flow losses, and characteristics, flow regimes of the push-pull ventilation system are investigated by using the flow field simulation flow visualization method and laser Doppler velocimetry. Four characteristic flow regimes, which are demand air dispersion, recirculation, recirculation, and strong air flow, are identified in the domain of the push-in and pull flow velocities or various gap surface task widths and flow gas velocities. It is argued phenomenologically from the aerodynamic point of view that operating the system in the strong recirculation regime would be a better strategy to lower air capture efficiency, thus operating in other characteristics together for the combination of optimal efficiency.



(a) Demand Air Dispersion (b) Recirculation

(c) Recirculation (d) Strong Air Flow

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### Aerodynamic Characteristics and Design Guidelines of Push-Pull Ventilation Systems

**Design**

Design guidelines are developed and verified and according to the results obtained in this work. The objective for under the conditions the control volume of the push-in and pull flow velocities are provided for every scenario. The effect of the flow field on the gas velocity distribution is performed to measure capture efficiency. The results of hourly gas concentration measurements indicate that there are critical flow velocity fields, recirculation and recirculation. The operating criteria obtained by applying the ACGIH design criteria are compared with the present results to help manufacturers and capture efficiency. Methods for improving capture efficiency and energy consumption are suggested.

**Photo**

IOSH 201204

**Reference**

Thang, W.-C., Liu, Y.-Y., Jen, Y.-Y., Chen, Y.-L., Chen, C.-P., Yen, W.-C., Chang, C.-P., Hsu, T.-C. and Chen, C.-C., "Aerodynamic characteristics and design guidelines of push-pull ventilation systems," Ann. Occupational Hygiene, Vol. 46, No. 1, 2002, pp. 4-12.




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### 3. 氣簾輔助系統

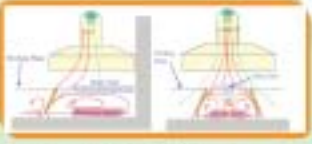
#### Embracing Air Curtain Device (EACD)

- Features**
  - 1. A new method and practice to improve efficacy of an exterior door with portable fixed opening. Both water-tight and airtight arrangements can be well achieved to control space pollution by multiple air curtains.
- Specifications**
  - 1) 11 types, 12 sizes and 4 types of EACD with different usage levels are specially available. 1 person needs 1 set of EACD for other situations.
  - 2) The arrangement of air curtains is convenient to adjust. The distance can be reduced 10% or increased while the 1 space efficiency of the device can be maintained. 2. A 100% water-tight or airtight EACD is designed.
  - 3) Water-tight operation in controlled space can be well achieved, reducing the spreading rate of air-polluting agents.
- Point**
  - 1. Recently applicable technology for both Taiwan and the U.S.

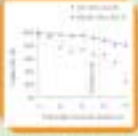


Interior view of a door with EACD. Light and air rights in 4-panel EACD is shown as.

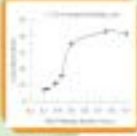
#### Embracing Air Curtain Device (EACD)




Air flow characteristics of 4-panel EACD and 4-panel EACD-2




4-panel EACD showing air flow characteristics in a controlled space. The air flow rate is significantly reduced compared to a standard door.



Another 4-panel EACD showing that the surrounding air is pushed away from the door, reducing the air flow rate in a controlled space. The air flow rate is significantly reduced compared to a standard door.



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### 4. 摺疊式負壓隔離艙

#### Inflatable Negative Pressure Isolation Chamber

- What is INPC designed for?**
  - 1. Inflatable negative pressure chamber for biohazardous laboratory and EICU for high-risk operations and hospital emergency treatment rooms.
  - 2. The spread of infectious diseases by direct contact for the purpose of emergency operations in the EICU, all to control other health facilities and reduce the risk of infection and the workers negative health reduction in handling and transporting patients and sample collection devices. To increase the level of clinical performance and further protect them, the all operators involved in transporting patients with infectious agents, we have designed this space-removable, inflatable negative pressure isolation chamber (INPC).
- Why is INPC necessary in every Biohazardous Cases?**
  - 1. The INPC is a robust, inflatable plastic chamber equipped by a specially designed frame protected by an airtight air or nitrogen INPC. There are installed on both ends of the chamber to lift the air flowing in and out, a circulation fan is connected to the INPC filter on one end of the chamber to provide a largely protected space inside the chamber and to filter a stable level of air exchange. The filter can be easily changed a number of a filter until the filter saturated on the bottom.

#### Inflatable Negative Pressure Isolation Chamber

- Advantages of INPC**
  - 1. Compared the INPC is an excellent choice because it is not big.
  - 2. Easy to use. Its operation is like an inflatable bag, making operation easily set up as a INPC when needed.
  - 3. Airtight. The INPC can be used in emergency of moving operations including emergency care and delivery.
  - 4. Portable. For common designed INPC, users can attach various medical equipment, such as ventilated devices and operations are at through the chamber.
  - 5. Sustainable. The INPC is a high-quality plastic material can be removed after use, and can be reused for next time.
- Point**
  - 1. INPC: weight 1.2 tonnet, 1.5 square meter.



Component: 100% air conditioner



INPC provides emergency protection protection



Finally, 1 person necessary medical equipment attached







Advantage: 1. Use in various different operations.



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## 5. 新型分徑採樣器

### Virtual Cyclone Sampler

a small, rugged, short sampler

- Features**
  - Operates on 120V standard power, 1500 rpm variable speed motor
  - Operates easily with the MDS9000/2000 sampler system
  - Available in 100, 200, 400, 800, 1600, and 3200 rpm
  - Large motor for space saving and low noise levels at long term sampling
- Specifications**
  - Motor size will vary by necessary flow rate (0.5 to 100 L/min)
  - Motor size: 1/2 to 1/2 hp
  - Motor speed: 1500 rpm
  - Available for use with 10, 20, 40, 80, 160, and 320 L/min
- Photo**
- References**
  - Chen, F.C., and Wang, J.L. (1999), "A Study of Aerosol Penetration to Respiratory Tract by Virtual Cyclone Sampler", *Annals of Occupational Hygiene*, 43(4): 411-417.
  - Chen, F.C., Wang, J.L., Lin, W.C., and Hsu, T.S. (1999), "The Virtual Cyclone Sampler: A Novel Aerosol Sampler", *Annals of Occupational Hygiene*, 43(4): 411-417.




### IOSH NEW CYCLONE

a rugged, short sampler with a large motor space

- Features**
  - Based on ISO 21501 Method 2000, 2000 rpm, for rugged, portable sampling
  - Operates on 120V standard power, 1500 rpm variable speed motor
  - Large motor allows steady particle flow up to the wall near the inlet
  - Long-term plastic construction eliminates electrolysis effect
  - Compact design for easy storage and transport
- Specifications**
  - Motor size: 1/2 to 1/2 hp
  - Motor speed: 1500 rpm
  - Available for use with 10, 20, 40, 80, 160, and 320 L/min
- References**
  - Chen, F.C., Wang, J.L., and Hsu, T.S. (1999), "Field Study of the Accuracy of the Respirable Sampling in Indoor Air", *Annals of Occupational Hygiene*, 43(4): 411-417.
  - Chen, F.C., Wang, J.L., Lin, W.C., and Hsu, T.S. (1999), "Effect of Impaction Losses on the Accuracy of Aerosol Sampling by the Virtual Cyclone Sampler", *Annals of Occupational Hygiene*, 43(4): 411-417.






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## 附錄二 研討會發表有關奈米微粒論文

### **Penetration of 4.5 nm to 10 $\mu$ m Aerosol Particles through Fibrous Filters**

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#### **Introduction**

Particulate respirators are widely used in workplaces to protect against hazardous airborne particles. Filtering facepieces are the most popular form of respirator among workers because of their lightness, better vision, and low maintenance compared with elastomeric respirators. The performance of filter media has been extensively tested using non-biological particles and biological particles. However, most of these studies focused on particle sizes above 100 nm. Because of increasing concern regarding the health effects associated with the production of nanomaterials and other nanoparticle related issues, an urgent need exists for performance assessment for filter media in the nano-sized range.

#### **Objectives**

Penetrations of particles in the size range of 4.5 nm to 10  $\mu$ m through fibrous filters were carried out with the purposes of:

1. exploring the filtration characteristics of particles less than 10 nm in diameter and;
2. checking the pervious experimental data (Balazy et al., 2004).

## Experimental materials and methods

Figure 1 schematically represents the test system for measuring the particle penetration through filter media. Three particle size spectrometers: the TSI 3080 electrostatic classifier equipped with nano or long differential mobility analyzer, and the TSI 3321 aerodynamic particle sizer, were used to measure nanometer, submicron, and micron sized particles. NaCl aerosol particles were generated by using spray-drying methods.

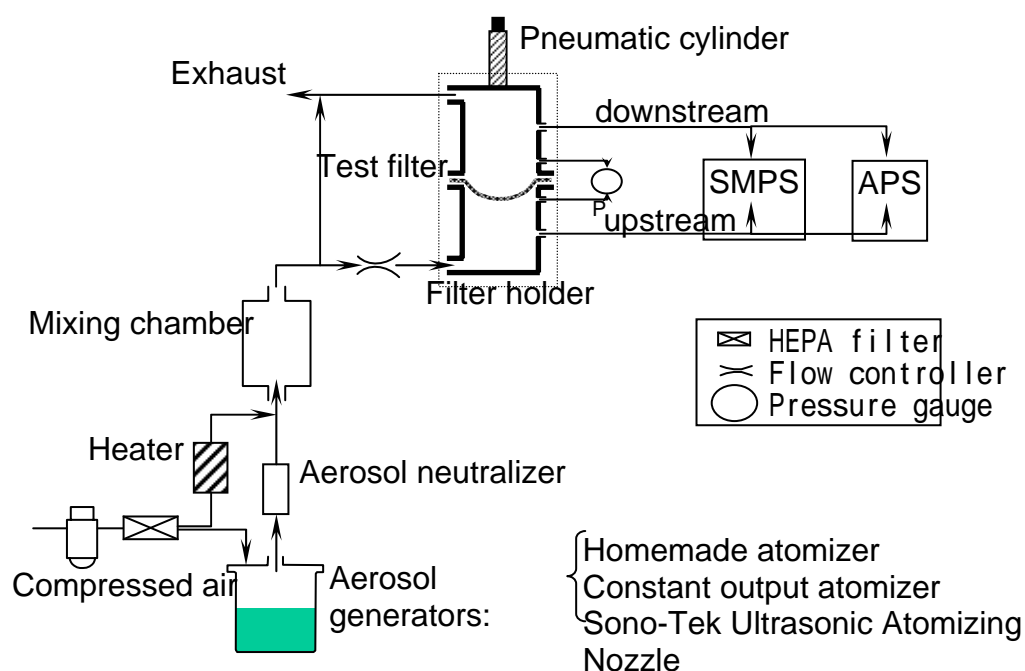


Figure 1. Schematic diagram of the experimental set-up.

Table 1 listed the size distribution characteristics of challenge aerosol particles used in this work. The generated particles were then passed through an aerosol neutralizer to neutralize the aerosol particles to the Boltzmann charge equilibrium. Next, the neutralized aerosols were mixed with dried and filtered air to obtain the desired flow rates, and it was ensured that the aerosol particles were completely dry before entering the filter test system. In this study, the air flow rate was 85 L/min, unless otherwise specified. To eliminate electrostatic charges,

filters were dipped in isopropanol for five minutes and allowed to dry. These dipped filters, along with controls of each filter type, were then tested to determine the aerosol penetrations in the size range of 4.5 nm to 10  $\mu$ m.

*Table 1. The size distribution characteristics of challenge aerosol particles.*

| Aerosol generator                    | Particle size distribution |                     |                              |   |
|--------------------------------------|----------------------------|---------------------|------------------------------|---|
|                                      | Count                      | median diameter, nm | Geometric standard deviation | Number concentration, #/cm <sup>3</sup> |
| Homemade atomizer                    | 9                          |                     | 1.50                         | $1.3 \times 10^4$                       |
| Constant output atomizer             | 78                         |                     | 1.86                         | $1.0 \times 10^6$                       |
| Sono-Tek Ultrasonic Atomizing Nozzle | 1300                       |                     | 1.30                         | 478                                     |
|                                      | 2730                       |                     | 1.47                         | 268                                     |

## Results

The filters with the electrostatic charge removed show a clear and significant increase in aerosol penetration, particularly for particles in the 0.1  $\mu$ m to 1  $\mu$ m size range, indicating that electrostatic attraction is an important mechanism for filters when collecting submicrometer-sized particles. The maximum penetrations increase from approximately 5.8 % to around 18.9 %. However, for particles with sizes of below 10 nm and above 5  $\mu$ m, the penetrations were close to zero regardless of whether or not the filters had charges, implying that electrostatic force is not a dominant filtration mechanism for the above particle size ranges.

The experiments with less efficient filter at different testing flow rates did not reveal any new features. Figure shows the performances of respirator B, which was treated with isopropanol at different testing flow

rates. The penetrations of submicrometer-sized particles clearly increased with testing flow rate, indicating that this respirator removed submicrometer-sized particles via diffusion. Conversely, the penetrations of micrometer-sized particles through the treated filter decrease with increasing testing flow rate, indicating that this respirator removed micrometer-sized particles by impaction. This unique pattern was also observed in the previous study (Chen and Huang, 1998).

Figure compares theoretical calculations with the experimental data of the treated respirator B at a testing flow rate of 85 L/min. The solid line indicates the total filter efficiency and the efficiency due to each of the single fiber mechanisms; moreover, the open symbol represents the experimental data. As expected, diffusion is the only important mechanism for collecting particles below 300 nm, and impaction and interception are the dominant mechanisms for collecting particles larger than 1  $\mu\text{m}$ .

## **Conclusions**

Penetrations of particles sized 4.5 nm to 10  $\mu\text{m}$  through fibrous filters were performed to explore the filtration characteristics of particles sized below 10 nm in diameter and to check previous experimental data (Balazy et al., 2004). Particle size was measured using a SMPS system equipped with a nano- or long-DMA and an APS. The results obtained can be summarized as follows:

The phenomenon of thermal rebound effect on nanoparticles collection does not observed in this study.

As the electrostatic charge was reduced, the aerosol penetration values in the 10 nm to 5  $\mu\text{m}$  size range increased considerably.

Almost all particles with size less than 10 nm or larger than 5  $\mu\text{m}$

were collected in the respirator filters, and the penetration values wouldn't be affected by the amount of filter charge.

## **References**

- Balazy, A. and Podgorsky, A. and Gradon, L. (2004). Filtration of Nanosized Aerosol Particles in Fibrous Filters I — Experimental results. *J. Aerosol Sci.* pp. S967-S968. EAC Proceedings II.
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