RESPIRATOR FIT TEST PANELS

I. BACKGROUND

A. According to reference (1), United States (U.S.) military facial size measurements collected in the 1950s and 1960s were organized into respirator fit test panels, which were used by respirator manufacturers to design and size half mask and full facepieces. References (2) and (3) describe two respirator fit test panels developed in the 1970s by Los Alamos National Laboratory (LANL) that were developed from a late 1960s anthropometric survey of men and women in the U.S. Air Force. The LANL respirator panels were divided into 10 facial size categories based on the bivariate distribution of face length and face width for full face respirators and face length and lip length for half mask respirators. At that time, the LANL full face panel was thought to represent 91% of the U.S. population and the LANL half mask panel was thought to represent 95% of the U.S. population. However, as explained in reference (1), respirators designed and sized for a military population may not provide the same fitting characteristics for the civilian population because of military age/height/weight guidelines and strict military physical fitness requirements for troop retention.

B. The National Institute for Occupational Safety and Health (NIOSH) is responsible for establishing respirator certification criteria to ensure that workers wearing NIOSH approved respirators are protected against inhalation hazards. As discussed in reference (1), NIOSH recognized problems with respirators being designed and sized using old military data, so they initiated research aimed at developing an anthropometric database representing the heads and faces of the U.S. respirator user population. NIOSH created the largest anthropometric database in U.S. history and used this data to develop new respirator fit test panels that will both maximize respirator design and NIOSH certification testing for new respirators. According to reference (1), a total of 3997 respirator users were measured. NIOSH required that the database must represent the demographic variability in the United States and include respirator users from all sectors of the American workforce, including the health care and the emergency response sectors. Male and female health care workers made up the largest population of respirator users measured (37.1 %).

II. NIOSH FIT TEST PANEL RESEARCH

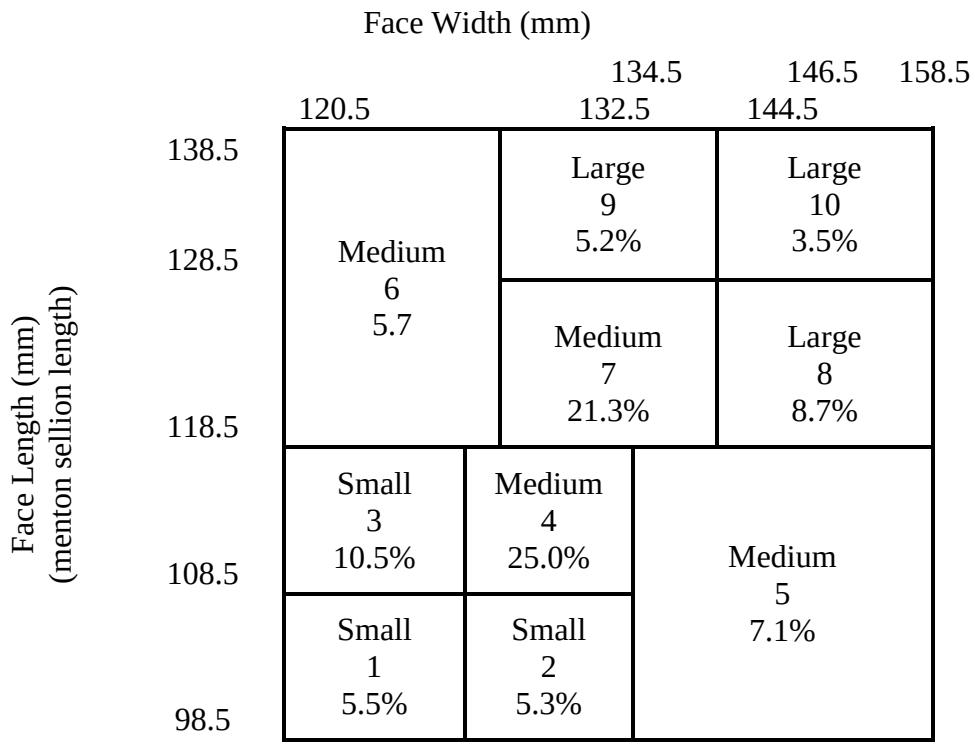
A. According to reference (4), NIOSH used their anthropometric database, representing U.S. respirator wearers, to develop two new fit test panels, which can be used for both half mask and full facepiece respirators. The NIOSH bivariate panel is based on face length and face width and the other fit test panel is based on principal component analysis (PCA) to best explain facial variations.

1. As explained in reference (4), NIOSH conducted an experiment to determine if respirator fit testing results for half mask respirators correlated with facial sizes in the bivariate fit test panel. The NIOSH bivariate fit test panel cells, illustrated in Figure 1, represent large, medium, and small faces and were shown to correlate highly with properly fitting large, medium, and small sized half mask respirators. This study included filtering facepiece respirators.

2. The PCA panel represents five size categories (small, medium, large, short/wide, and long/narrow faces) and is based on 10 facial dimensions transformed into two principal components. One component describes overall size of the face and the other component describes faces on an axis that ranges from long/narrow to short/wide. NIOSH stated in reference (4) that "*Facial sizes classified by the PCA panel were less consistent, as compared to the NIOSH bivariate panel classification, in the pattern with respirator fit.*" Therefore, the NIOSH bivariate fit test panel will be emphasized in this article.

B. Per reference (5), the bivariate fit test panel covers 96.7% male and 98.7% female U.S. respirator wearers. As shown in Figure 1, each of the 10 bivariate fit test panel cells represents the percentage of the population with a certain face size. Figure 1 was reproduced and annotated from the information in Figure 1 and Table 1 of reference (5).

Figure 1
NIOSH - NPPTL BIVARIATE TEST PANEL



A. Face sizes are classified into three categories (small, medium, and large faces). Small faces were defined as those falling in cells 1–3 of the panel, medium faces were those falling in cells 4–7, and large faces were those falling in cells 8–10. As shown in Table 1, face size categories of the bivariate panel matched the respirator sizing well in that the small, medium, and large face size categories achieved the highest number of passing fit tests with small, medium, and large respirator sizes, respectively. Also, the small, medium, and large panel categories achieved the highest fit factors when fit tested in small, medium, and large respirator sizes, respectively.

B. The largest passing fit test rate was 86% for subjects in the large face size category of the NIOSH bivariate panel. Although this is a good correlation for designing and planning purposes, there were still 14% of the test subjects who could not pass the fit test with a large size respirator. As explained by NIOSH (reference (4)), *"This finding further supports the need for individual fit testing as required in the OSHA 29 CFR 1910.134 standards."*

Table 1
Passing Fit Test Rate for the NIOSH Bivariate Face Size Panel by Respirator Size

Face Size Panel Category	Respirator Size with Highest Passing Fit Test Rate	Passing Fit Test Rate by Respirator Size and Geometric Mean Fit Factor(GSD)[1]		
		Small	**Medium**	**Large**
Small (NIOSH Cells 1–3)	Small	**81% Passed** 3464.7[A] GSD	67% Passed 245.5[B] GSD	26% Passed 18.1[C] GSD
Medium (NIOSH Cells 4–7)	Medium	67% Passed 390.5[B] GSD	**83% Passed** 1562.7[A] GSD	67% Passed 210.1[B] GSD
Large (NIOSH Cells 8–10)	Large	28% Passed 30.2[B] GSD	75% Passed 695.3[A] GSD	**86% Passed** 1744.1[A] GSD

[1] Superscript groupings apply across respirator sizes and within a given NIOSH face size category. Means with the same letter are not significantly different (alpha = 0.05).

III. CONCLUSIONS AND STOCKPILING RECOMMENDATIONS FOR PANDEMIC INFLUENZA

A. NIOSH research on the bivariate fit test panel shows that the highest numbers of passing fit tests were between the small, medium, and large bivariate face size panels and the corresponding respirator sizes. It also shows that the highest fit factors were achieved between respirators that were the same size as the face size cells of the bivariate fit test panel.

B. This NIOSH research has practical applications including, respirator design and sizing, and use in NIOSH respirator certification procedures (reference (6)). The NIOSH bivariate fit test panel can also be used as the basis for stockpiling respirators for protecting health care workers during pandemic influenza. As mentioned earlier, the majority of facial measurements in the NIOSH anthropometric database are from health care workers.

C. Using the information from the NIOSH bivariate fit test panel the following observations and recommendations can be made regarding stockpiling half mask respirators for pandemic influenza: Recommend stockpiling 17% large facepieces (total % of panels 8 – 10), 59% medium facepieces (total % of panels 4 – 7), and 21% small facepieces (total % of panels 1 – 3). Since these percentages add up to 97%, add one % to each respirator size to bring the total to 100%.

IV. REFERENCES

1 Zhuang, Ziqing and Bradtmiller, Bruce (2005) Head-and-Face Anthropometric Survey of U.S. Respirator Users, Journal of Occupational and Environmental Hygiene, 2: 11, 567 — 576, November 2005.

2 Los Alamos Scientific Laboratory of the University of California: Selection of Respirator Test Panels Representative of U.S. Adult Facial Sizes by A.L. Hack, E.C. Hyatt, B.J. Held, et al. (LA5488). Los Alamos, N.M.: Los Alamos Scientific Laboratory of the University of California, 1973.

3 Hack, A.L., and J.T. McConville: Respirator protection factors: Part I—Development of an anthropometric test panel. Am. Ind. Hyg. Assoc. J. 39:970–975 (1978).

4 Zhuang, Ziqing , Groce, Dennis , Ahlers, Heinz W. , Iskander, Wafik , Landsittel, Douglas , Guffey, Steve , Benson, Stacey , Viscusi, Dennis and Shaffer, Ronald E.(2008) Correlation Between Respirator Fit and Respirator Fit Test Panel Cells by Respirator Size, Journal of Occupational and Environmental Hygiene, 5: 10, 617 — 628, October 2008.

5 Zhuang, Ziqing, Bradtmiller, Bruce and Shaffer, Ronald E. (2007) New Respirator Fit Test Panels Representing the Current U.S. Civilian Work Force, Journal of Occupational and Environmental Hygiene, 4: 9, 647 — 659, September 2007.

6 NIOSH draft specific technical procedures to be applied for TIL testing - "Total Inward Leakage Test for Half-mask Air-purifying Particulate Respirators" Procedure No. RCT-APR-STP-0068, Revision-1; 12 Aug 09.