

NIOSH Anthropometric Data and ISO Digital Headforms

In 2003, the National Institute for Occupational Safety and Health (NIOSH) conducted a nationwide anthropometric survey of 3,997 subjects. The resulting head and face measurements were used to develop an anthropometric database detailing the face size distributions of respirator users using both traditional measurement methods and three-dimensional (3D) scanning systems. This database was used to establish fit test panels to be incorporated into NIOSH respirator certification and international standards. One of the panels developed, called the principal component analysis (PCA) panel, uses the first two principal components obtained from a set of 10 facial dimensions (age and race adjusted) and divides user population into five face-size categories. These 10 dimensions are associated with respirator fit and leakage and can predict the remaining face dimensions as well. Respirators designed to fit these panels are expected to accommodate more than 95% of the current U.S. civilian workers.

From the 3,997 subject anthropometric survey, 1,013 subjects were also scanned using a Cyberware 3D Rapid Digitizer. Three-dimensional scans of five individuals, who most closely represented a given size category, were averaged to construct a representative headform for each category (small, medium, large, long/narrow and short/wide). The NIOSH digital headforms are symmetric and represent the facial size and shape distribution of current U.S. respirator users. In addition, ears have been placed on the headforms to match the average position for the chosen heads of a given size. These headforms have been incorporated into a technical specification standard for ISO TC94 Personal Protective Equipment, SC15 Respiratory Protective Devices, WG1 General, PG5 Human Factors. That standard is titled “ISO 16976-2 Respiratory Protective Devices — Human Factors — Part 2: Anthropometrics”.

In an assessment of the 2003 NIOSH anthropometric survey of U.S. respirator users, the Institute of Medicine affirmed that “Having effective respiratory protection can be, and often is, a matter of life and death. The scientific bases for developing and fitting effective respiratory protection remain more art than science.” Thus, NIOSH encourages application of the data and results to address occupational safety and health issues.

Download Data

The anthropometric survey data for this study is available in CSV and XLS file formats. The ISO digital headform models are available in STL and IGS file formats.

Data Collection Methods

For the anthropometric data, a stratified sampling plan was used with three age strata, two gender strata, and four race/ethnic group strata. The plan called for an equal sample size of 166 in each cell. Subjects were obtained at 41 sites from 8 states. In addition to height and weight, 18 facial dimensions and neck circumferences were measured using traditional anthropometric methods. A total of 3,997 subjects were measured using traditional methods, and 1,013 of them were also scanned using a 3-D head scanner. The resulting data were weighted to correspond to the U.S. population.

For the development of the ISO Digital Headforms, ten facial dimensions relevant to respirator fit were chosen for defining a principal component analysis model, which divides the user population into five face-size categories. Mean facial dimensions were then computed to target the ideal facial dimensions

for each size category. Five scans in each category were chosen and averaged to construct a representative headform for each size category (small, medium, large, long/narrow and short/wide). All dimensions are within 3 mm of the computed means for the sample population in each size category.

Citations

Zhuang, Z. and Bradtmiller, B. (2005). "Head-and-Face Anthropometric Survey of U.S. Respirator Users." *J Occup Environ Hyg* 2(11):567-576.

Zhuang, Z., Bradtmiller, B., and Shaffer, R.E. (2007). "New Respirator Fit Test Panels Representing the Current U.S. Civilian Work Force." *J Occup Environ Hyg* 4(9): 647-659.

Zhuang, Z., Benson, S., and Viscusi, D. (2010). "Digital 3-D headforms with facial features representative of the current US workforce." *Ergonomics* 53(5):661-671.

Zhuang, Z., Landsittel, D., Benson, S., Roberge, R., and Shaffer, R. (2010). "Facial Anthropometric Differences among Gender, Ethnicity, and Age Groups." *Ann Occup Hyg* 54(4): 391-402.

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Contact

For further information, contact:

NIOSH/NPPTL Research Branch

412-386-6111