

## Sizing System Development and Testing for a Protective Coverall Design

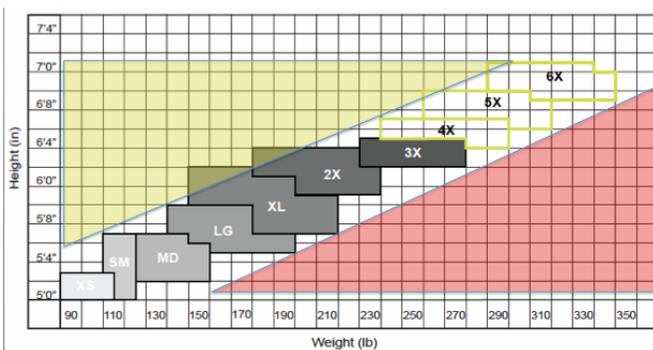
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### Background

Body size and shape varies greatly between individuals and within populations. The sizing system currently used by protective coverall manufacturers does not sufficiently fit the population of coverall wearers. Figure 1 is the American National Standards Institute (ANSI) sizing system chart (ANSI/ISEA 101-1996 (R2008)) used by many protective coverall manufacturers (2008). The shaded areas indicate portions of the population that are not covered. A new sizing system is needed to fit both height and circumference variances.

The ANSI sizing system is based on the assumption that there is a correlation between height and weight, stature and circumference. In order to determine if this relationship is true, correlation statistics were



examined using the U.S. Army Anthropometric Survey (ANSUR), a 1988 anthropometric survey of military personnel, and the Civilian American and European Surface Anthropometry Resource (CAESAR, 2002). Height and weight correlations and some circumference correlations related to stature were reviewed. The correlation between stature and circumference was minimal. In contrast, stature and length correlated, indicating the relationship could be used to develop a new sizing system.

Our goal in developing the sizing system was to eliminate the current coverall fit issues by encompassing a larger, more diverse population.

Figure 1. ANSI sizing system and population not covered by the system indicated in shaded areas.

### Sizing System Development

The impetus for developing the sizing system occurred when we designed a new protective coverall, “the Hybrid,” for a Fortune 500 company. The initial sizing system development began by examining the new coverall design features, the pitfalls of the current ANSI system, and data on human size/shape variance. A Hybrid design feature, anatomically placed elastic, accommodates up to 9” in height variance and up to 10-12” in circumference variance. This feature allowed the researchers to estimate reduction of the number of sizes from 10 to 4 or 5 SKUs. Because height and circumference do not correlate strongly, the researchers studied body types the Hybrid needed to accommodate, and the examined ways to separate stature from circumference. The size divisions based on knowledge of body variance were: 1) short and lean, 2) short and husky, 3) tall and lean, and 4) tall and husky.

Based on the data from ANSUR and CAESAR, and the projected good fit of the Hybrid design, the researchers determined basic specifications for a 4-SKU sizing system to fit a broad range of body shapes and sizes. Table 1 shows the proposed Hybrid size, justification for the size divisions, and the basic specifications for each Hybrid coverall size. Ease for each size was determined based on literature and knowledge of body dimension changes during movement.

The Hybrid combined with the new sizing system fits a larger percentage of the population while reducing the number of sizes from 10 to 4. The Hybrid sizing system was developed for an American and European market, but can be adapted for other international markets using market-specific anthropometric data.

Size Category Name	Stature	Reasoning	Circumference and Length Division Reasoning	Hip (Total Circumference)	Inseam	Sleeve	Vertical Trunk Circumference: ratio of front to back measurements
Yellow	5'1"-5'10"	Min - Average male/female height	Min/Q1 to Median of Male/Female short categories	127cm, 50"	78cm, 31"	86.82cm, 34"	Front: 83cm Back: 101.5cm
Green	5'1"-5'10"	Min - Average male/female height	Median to Q3/max of male/female short categories	153cm, 60"	78cm, 31"	86.82cm, 34"	Front: 85.6cm Back: 104cm
Blue	5'10.5"-6'7"	+Average male height to under male tall max	Q1 to Q3/max	147cm, 58"	91.44cm, 36"	92.71cm, 36.5"	Front: 93.22cm Back: 113.6cm
Purple	5'7"-6'3"	Under median height for male short to Over median for male tall	Q3-Max (or just under max)	180cm, 71"	83.82cm, 33"	90.17cm, 35.5"	Front: 89 Back: 108

Table 1. Reasoning and Specifications for the Hybrid Sizing System

**Hybrid Sizing System Testing**

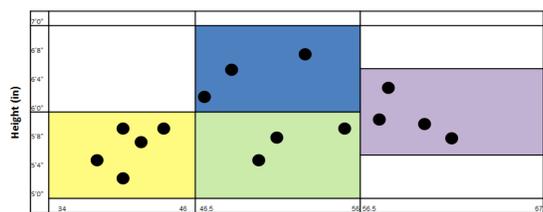


Figure 2. Recruitment for the Hybrid Size System.

The Hybrid sizing system was tested using the coverall evaluation protocol outlined by Griffin, Lastovich, Bye, and LaBat (2014). Researchers recruited participants for each size category. Hybrid sizes were divided into quadrants and participants were recruited for each quadrant (figure 2). Initial testing of the sizing system revealed that each size fit a wide range of body types. Figure 3 shows participants wearing each coverall size within the Hybrid sizing system.

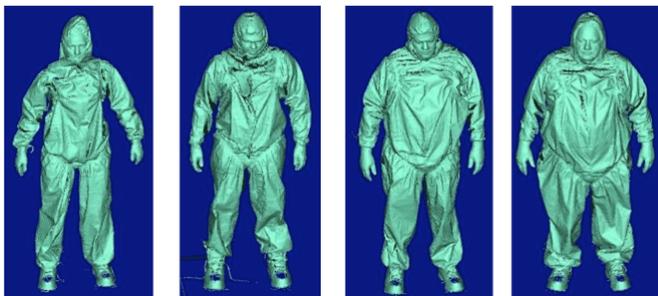


Figure 3. The Hybrid Coverall Sizing System: yellow, green, blue, and purple shown.

Next, the researchers tested the coverall fit for the Hybrid sizing system against the company sizing system. Every participant in the study was scanned wearing a company coverall and the Hybrid coverall, consulting the size chart of each for size selection. Five of the 15 participants for this study could not be fitted to the current company coverall.

Initial testing indicated the Hybrid design and new sizing system provided better fit compared to the current company coverall.

**References**

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