



Protective Coverall Design Development and Testing

Linsey Griffin, Theresa Lastovich, Elizabeth Bye, and Karen LaBat

Keywords: Design development, functional apparel, protective apparel

The purpose of this study was to improve the design and function of a disposable, level-one protective coverall for a Fortune 500 company. Level-one coveralls are worn for protection in industries ranging from pharmaceutical to paint application to construction to asbestos cleanup. This research used the design process in conjunction with product benchmarking, on-site observational studies, user feedback, 3D body scan technology, fit tests, and expert evaluation to develop a coverall that is superior to the company's current offering.

User Research

A comprehensive investigation of user-needs through industry site visits were conducted to gain knowledge about how the protective coveralls are worn, coverall performance, and current on-site size availability. The goals of the site visits were: to understand user needs, work environment, and tasks performed. These site visits included fit, wear, and performance observation of the coverall, base layer interaction, and don and doff protocol. Interviews revealed the strengths and weakness of the current coverall design. The observation discoveries included a vast difference in men and women body types and a lack of sizes available for the workers. The workers were observed making modifications to the coveralls to compensate for fit difficulties. Literature supported the need to address the sizing and fit of protective coveralls. The wearability and fit of coveralls not only affects compliance to safety standards (Asdown & Watkins, 1992; Huck, Manganga, & Kim, 1997), but poor fit can also hinder job performance, decrease durability, and expose the wearer to work hazards (Huck et al., 1997). After synthesizing user-need data, the design process was used to improve coverall design elements with an emphasis on enhancing user comfort, movement, and fit.

Design Development and Prototypes

The ideation process was guided by the user research and the following research questions: which coverall design features will reduce the need for wearer modification; how can the coverall design reduce the size range while maintaining fit and safety for a diverse population; and how can the coverall pattern be developed to better fit and accommodate the users' full range of motion?

The Hybrid design (Figure 1) features a modified harness elastic design to accommodate height and circumference variations, elastic at the side waist to accommodate waist and chest circumference variations, and a lumbar patch to help control crotch and rise. The Hybrid design was determined by design experts and company representatives to have the most potential to improve functional movement and fit for the medium to 2XL size range. Because of concerns about manufacturability, four variations of the Hybrid design were developed to test the design with minimized elastic: a variation with no side panels or lumbar patch, a variation with side panels and no lumbar patch, a variation with the lumbar patch and no side panels, and a coverall variation with the maximum elastic of the Hybrid design.

Functional Design Evaluation

Fit tests were conducted with eight participants (4 women, 4 men) who met the ANSI and ISEA size specifications for sizes medium to 2XL. A protocol for coverall fit and evaluation was used to test four coverall variations of the Hybrid design in three movement postures plus the control (standing) posture (Griffin, Lastovich, Bye, & LaBat 2014). Two fit analysis experts observed the scanned images and evaluated the extent of wrinkles at 13 fit points. Still photos were taken as additional documentation

of coverall fit and compared to the scanned images if needed. After detailed fit analysis, the coverall that eliminated the side panels was selected for design refinement.

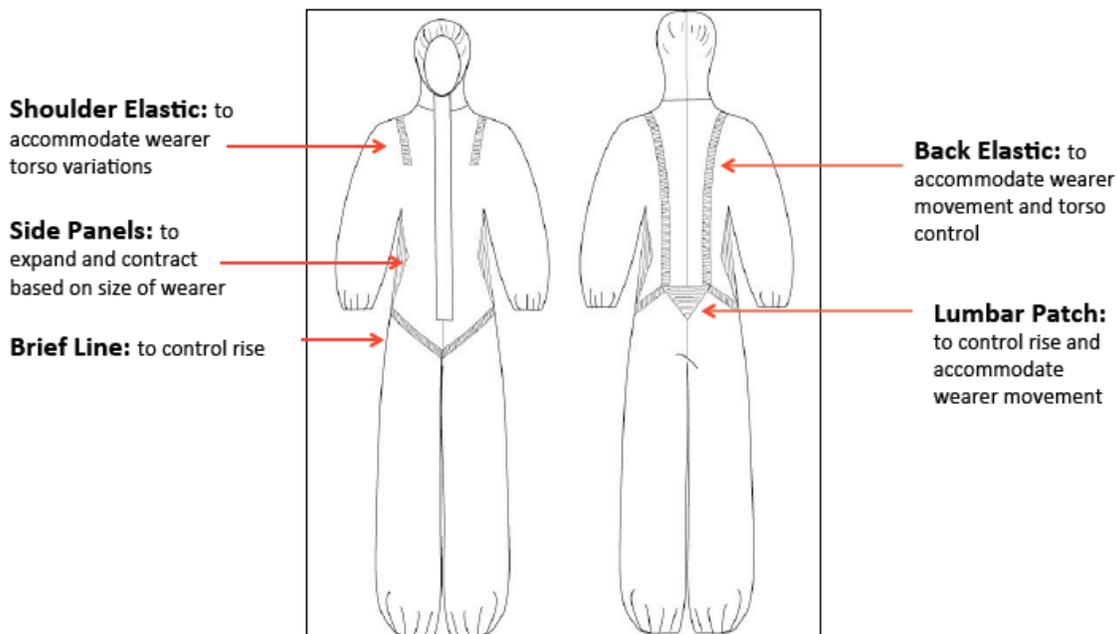


Figure 1: Hybrid Coverall Design

Design Refinement

The next phase of the coverall development involved design refinement, resulting in the Hybrid V2 design. The Hybrid V2 was tested against the current company coverall purchased from an online source. Fit tests were conducted with ten participants (4 women, 6 men) who met the ANSI and ISEA size specifications for sizes medium to 2XL. The protocol described above was used to test the Hybrid V2 (one size) against the company's current coverall in all size offerings.

Results and Conclusions

Overall, the one-sized Hybrid design provided better fit, comfort, and function than the company coverall across the size range, particularly across the L, XL, and 2XL size categories. This testing demonstrated that the Hybrid design fit a broad range of individuals in one-size and provided superior fit, function, and performance compared to the company's coverall. Next steps include developing a sizing system for the Hybrid design that reduces the company's current size range from ten to four SKUs. A patent application has been filed for the Hybrid design.

- Ashdown, S.P. & Watkins, S.M. (1992). Movement analysis as the basis for the development and evaluation of a protective coverall design for asbestos abatement. In J.P. McBriarty & N.W. (Eds.), *Performance of protective clothing: ASTM STP 1133* (pp660-674). Philadelphia, PA: ASTM.
- Huck, J., Maganga, O., and Kim, Y. (1997). Protective overalls: Evaluation of garment design and fit. *Int. J. Clothing Sci. Technol.*, 9(1), 45–61.
- Griffin, L., Lastovich, T., Bye, E., LaBat, K. (2014). A Protocol for the Evaluation of Coverall Fit. Proceedings of the annual meeting of International Textile and Apparel Association, Charlotte, NC.