WELDING Journal

Improving Welders' Safety and Productivity in Industrial Shipbuilding

BY JOE SABOL, DRU BRANCHE, CASSIE JACOBSON, AND MICHAEL HALLOCK

Pictured are keel blocks positioned in Dry Dock 12, Newport News, Va., in preparation for John F. Kennedy's (CVN 79) move west. Huntington Ingalls Industries christened the vessel during a ceremony celebrating the U.S. Navy's newest nuclear-powered aircraft carrier on December 7, 2019, at the company's Newport News Shipbuilding division. (Photo by Matt Hildreth. Courtesy of Huntington Ingalls Industries.)

Industrial shipbuilding requires large numbers of welders. Historically, Huntington Ingalls Industries, Newport News, Va., America's largest military shipbuilding company, has utilized a number of individual pieces of personal protective equipment (PPE) to help protect its welders. These include passive welding helmets, grinding shields, reusable half-facepiece respirators, protective eyewear, and hearing protection.

Recently, the shipbuilder decided to evaluate a PPE solution that may help improve welder productivity, worker safety, and comfort, while continuing to meet all applicable Occupational Safety and Health Administration (OSHA) workplace safety requirements. The company's objective was to compare welder productivity between two differing PPE configurations: the traditional, stand-alone welding shield with multiple pieces of additional PPE, and a new integrated welding system that combines these individual PPE components into a unified solution.

Productivity was measured using cumulative daily wire consumption, per hours worked, per welder. Additionally, weld quality, visibility, ease of use, and comfort were measured using a survey and an interview tool for par-

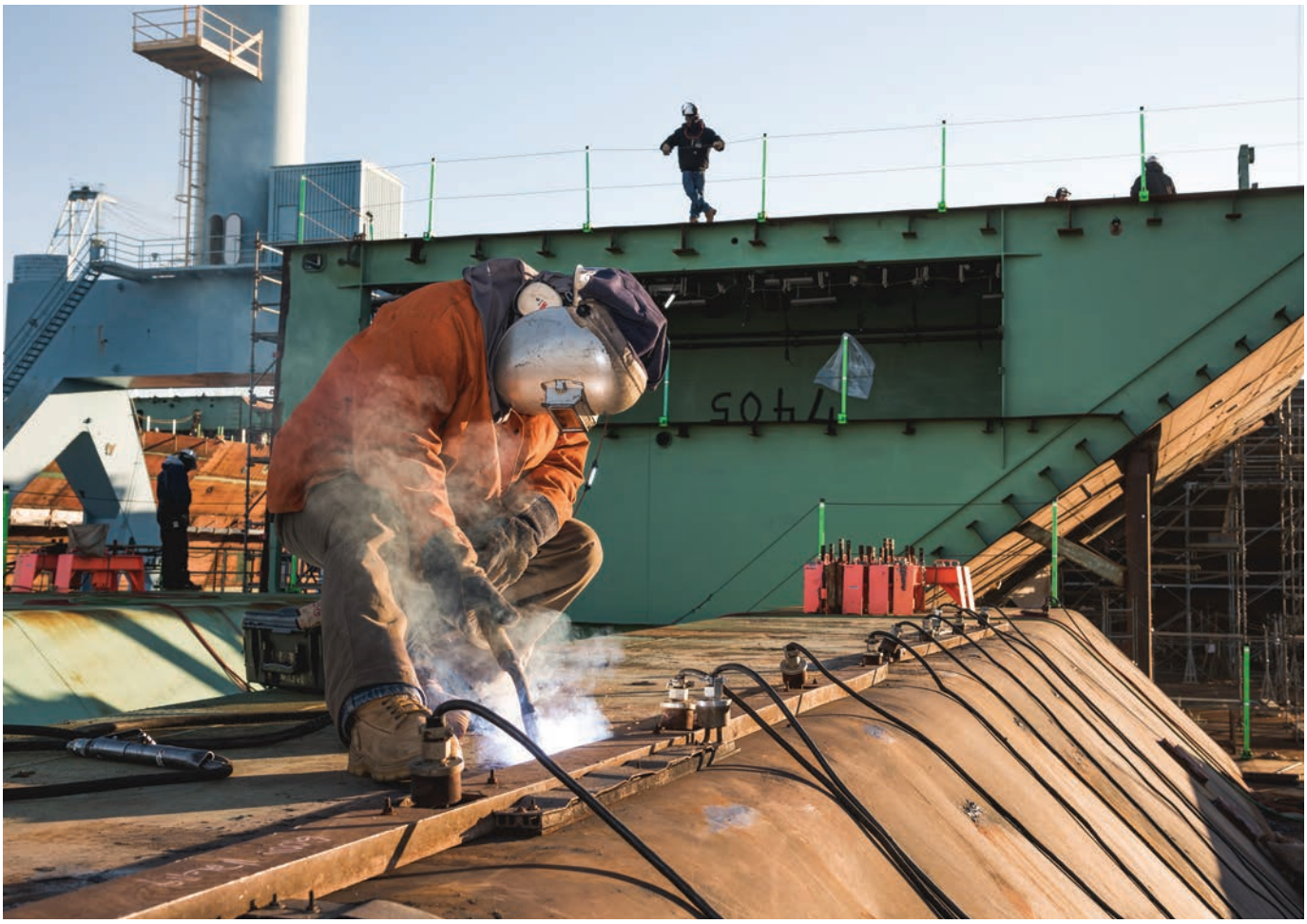

Fig. 1 — Douglas Rainey welds pieces of steel wearing the legacy welding PPE. (Photo by Matt Hildreth. Courtesy of Huntington Ingalls Industries.)

ticipating welders. The results of the case study are detailed in this column.

Methods Managed and Sample Size Specifics

There were two welding PPE configurations tested during this study, as outlined below:

• The legacy welding PPE. This traditional collection of PPE includes a hard hat with passive welding shield, worn with a reusable half-facepiece respirator (where required), separate grinding shield, and safety glasses — Fig. 1.

• The 3M™ Adflo™ powered air-purifying respirator (PAPR) with 3M™ Speedglas™ 9100MP integrated welding helmet. The new integrated welding and respiratory protection system includes a welding helmet with hard-hat protection, an autodarkening filter (ADF), and an integrated grinding shield, as well as connection via a breathing tube to a continuous flow of filtered air delivered by the PAPR system motor/blower — Fig. 2. In addition to this integrated welding system, the welders wore safety glasses, as required by OSHA.

Thirty welders with varying levels of experience, from different shifts and four different welding areas within the shipyard, participated in this study to ensure a reasonable sampling across the welder population. It was determined a sample size minimum of 20 welders would provide statistical power of greater than 90% to detect a 10% difference in productivity, and enrolling 30 welders to participate would account for a potential loss of welders during the study (i.e., those who did not participate in sufficient data collection).

Each welder was asked to participate in data collection for a total of 20 working days, and those 20 days were broken into two, ten-day phases, allowing the two different above-mentioned welding systems to be tested in a randomized fashion to help minimize bias.

Training on the integrated welding system was conducted twice throughout the study, prior to each of these two phases. Welders were also given a minimum of at least one week to acclimate to the new system prior to the start of data collection. However, welders did not receive additional training on their legacy welding PPE because it is currently in use at the shipbuilding facility.

Each welder completed a data collection form at the end of each day/shift to record the total hours spent welding, the weight of wire pre- and post-shift, and other key aspects about their welding process and output.

They were also asked to complete a survey at the end of the first phase of testing, and again at the end of the second testing period, to obtain data for all remaining secondary endpoints.

A final interview with the welders

Fig. 2 — Bailey Riddle welds on a unit in the foundry wearing the Speedglas integrated welding helmet. (Photo by Ashley Cowan. Courtesy of Huntington Ingalls Industries.)

Table 1 — Welder Demographics

Main Work Location Areas	Shipboard A: N = 4 Steel Production Facility: N = 7 Shipboard B: N = 3 Shipboard C: N = 2 Unspecified: N = 4
Years of Welding Experience	0–5 years, N = 11 5–10 years, N = 6 > 10 years, N = 3
Years of Experience in Current Shipyard	0–5 years, N = 12 5–10 years, N = 7 > 10 years, N = 1
Gender	Male, N = 19 Female, N = 1
Welder Weight	100–150 lb, N = 2 150–200 lb, N = 9 200–250 lb, N = 6 250+ lb, N = 3
Welder Height	Less than 5 ft, 6 in., N = 1 5 ft, 6 in. to 6 ft, N = 16 6 ft to 6 ft, 3 in., N = 2 Greater than 6 ft, 3 in., N = 1

Note: N stands for number.

was also conducted at the end of the study to capture the welders' qualitative feedback on product performance, usability, and comfort level for both the PPE configurations.

Data Analysis

Welder productivity = (Preshift wire weight – Postshift wire weight)/(Hours worked – Work stoppages)

Although the goal was to have each welder complete ten days on each system, due to time off or changes in schedules, the final data analysis included any welder using both the legacy and integrated welding systems for at least seven days. There were a total of 20 welders who met these criteria.

The Results

The study was conducted from July to September 2018. Table 1 is a summary of the demographic information for the 20 welders included in the data analysis. The study included welders from four different areas of the shipyard with a broad range of experience.

The primary endpoint of the study was welder productivity. An analysis of variance test confirmed the statistical significance (p-value 0.04 = i.e., 96% confidence) of the increase in welder productivity, when using the new integrated welding system, when accounting for the differences among welders (experience level, type of welding, welding area, and so forth).

Table 2 summarizes the overall average productivity increase when the new system was used by welders in this shipbuilding study.

On average, welders applied 0.79 lb of weld wire/h while using their legacy welding PPE vs. 0.90 lb of weld wire/h while using the integrated welding system, which is an increase of 14%.

Additionally, welders were asked to provide qualitative feedback related to weld quality, visibility, ease of use, and comfort. A total of 25 of the 30

Table 2 — Average Productivity by PPE Type

Average Productivity Measured by Amount of Welding Wire Applied (Weight Difference in lb/h Worked)	
3M Adflo Integrated PAPR System	Legacy System
0.90	0.79

Table 3 — Summary of Key Study Endpoints

	Quality of Weld	Overall Welder Satisfaction	Productivity Gains
Study Outcomes	68% of welders reported improvement in their weld quality.	Welders rated the 3M Adflo PAPR integrated welding system an 8.3 (on a 10-point scale with 10 being the best). 92% of the welders interviewed said they would recommend the 3M Adflo PAPR integrated welding sytems to their supervisor.	On average, welders applied the following: • 0.79 lb of weld wire per h with their legacy system • 0.90 lb of weld wire per h with 3M Adflo PAPR integrated welding system. This equates to an increase of 14%.

welders completed a survey and an interview at the end of the study. They provided positive feedback about the autodarkening welding lens and how it allowed them to lift their welding shield less frequently, which they associated with improved weld quality and productivity. Improved welding quality was also associated with better visibility due to the larger viewing lens and ADF. The welders felt the ADF capability allowed for fewer starts and stops, less stray arcs, an easier time positioning their welding electrodes, and enhanced visibility of weld defects, such as porosity, in real time.

Moreover, the integrated welding system provided an added safety feature in the form of less frequent lifting of the welding shield, which resulted in fewer opportunities for eye injuries while the welding shield is up. The welders indicated using this new system also reduced fogging of their safety glasses as well as provided a continuous flow of filtered air to breathe.

The welders did have concerns about how this system would operate in cases where there was a need to work next to heater bars or in extremely tight spaces. Although not addressed in the study, there are solutions to cool incoming breathing air when using supplied air respiratory protection systems; the manufacturer suggested that, for tight spaces, it is possible to reposition the PAPR blower belt, part of the system, to allow for greater flexibility in appropriate situations. There was one incident reported of eye irritation due to the absence of side shield covers when working next to another welder. Additional training was provided to the welders to ensure they knew to apply side shield covers as needed.

In addition, the participants provided feedback on their legacy welding PPE. Two welders reported liking the legacy PPE components simply because they were familiar with it and have used it for a long time. But these welders also indicated it is heavy and hot, and safety glasses frequently fog up. This group of welders also noted spending significant time flipping the welding shield up and down on the legacy PPE to start and stop, which can impact weld quality and stray arcs.

When the welders were asked if the integrated welding system provided enhanced weld quality, 68% said yes, 32% were neutral, and none of the welders answered no. When asked to rate the system on a scale of 1 to 10 (with 10 being the best rating), the welders surveyed rated it as an 8.3. When asked if they would recommend it to their supervisor, 92% of welders interviewed answered yes.

Discussion and Conclusion

Table 3 is a summary of the key study endpoints. The study demonstrated a statistically significant increase in welder productivity (as measured by the weld wire applied), as well as positive welder assessments of comfort and improved weld quality, plus an opportunity to reduce the potential for eye injuries, when comparing the new system vs. using traditional, separate welding PPE components together.

This shipbuilder has concluded that implementation of the new integrated system will have a net positive impact on an annual basis from both the anticipated productivity gains, as well as savings from the elimination of consumables associated with the reusable respirators no longer needed by welders using the new system. There is also the positive impact on the welders' reported increased comfort, which may translate to worker retention due to higher worker satisfaction and comfort.

Currently, this shipbuilding facility has started a phased approach to implementation of the integrated welding systems. Initial estimates for the study facility indicate positive savings annually that are expected to offset the investment in these systems, while showing potential to increase if implementation expands to additional systems. WJ

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JOE SABOL is director of welding, shipfitting, and metrology, and DRU BRANCHE is director of environmental, health, safety, and security, at Huntington Ingalls Industries, Newport News, Va. CASSIE JACOBSON (cjacobson@mmm.com) is application engineering manager, and MICHAEL HALLOCK is application engineering specialist, at 3M Co., St. Paul, Minn.