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-
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 hardhat 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...
was also conducted at the end of the
study to capture the welders’ qualita-
tive feedback on product performance,
usability, and comfort level for both
the PPE configurations.

Data Analysis

Welder productivity = \( \frac{\text{Preshift wire weight} - \text{Postshift wire weight}}{\text{Hours worked} - \text{Work stoppages}} \)

Although the goal was to have each
welder complete ten days on each sys-
tem, due to time off or changes in
schedules, the final data analysis in-
cluded any welder using both the lega-
cy 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 sum-
mary of the demographic information
for the 20 welders included in the data
analysis. The study included welders
from four different areas of the ship-
yard 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 inte-
grated welding system, when account-
ing for the differences among welders
(experience level, type of welding,
welding area, and so forth).

Table 2 summarizes the overall av-
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 sys-
tem, 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

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**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.

**Table 2 — Average Productivity by PPE Type**

<table>
<thead>
<tr>
<th>Average Productivity Measured by Amount of Welding Wire Applied (Weight Difference in lb/h Worked)</th>
<th>3M Adflo Integrated PAPR System</th>
<th>Legacy System</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.90</td>
<td>0.79</td>
<td></td>
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</tbody>
</table>
Table 3 — Summary of Key Study Endpoints

<table>
<thead>
<tr>
<th>Study Outcomes</th>
<th>Quality of Weld</th>
<th>Overall Welder Satisfaction</th>
<th>Productivity Gains</th>
</tr>
</thead>
</table>
| 68% of welders reported improvement in their weld quality. | Welders rated the 3M Adflo PAPR integrated welding system on 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 systems 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%. |

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.

Acknowledgments

Huntington Ingalls Industries purchased the 30 Adflo PAPRs and filters, manufactured by 3M, used in this study. 3M provided, free of charge, several backpack accessories for use in the study.