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At the American Welding Society (AWS), we are actively following the Novel Coronavirus (COVID-19) outbreak. The welding and fabrication industries have been determined to be an essential business, especially as it relates to repair and maintenance of key infrastructure. The content of the September 2020 issue of the Welding Journal is intended to be accurate when published, but we recognize that we are in a rapidly changing situation. For AWS’s official statement on COVID-19, as well as the latest updates and frequently asked questions, please visit aws.org.
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Welding Journal (ISSN 0043-2296 Print) (ISSN 2689-0445 Online) is published monthly by the American Welding Society for $200.00 per year in the United States and possessions, $160 per year in foreign countries: $750 per single issue for domestic AWS members and $10.00 per single issue for non-members and $14.00 single issue for international. Not available for resale in either print or electronic form. American Welding Society is located at 8669 NW 36 St., # 130, Miami, FL 33666-6672; telephone (305) 443-9353. Periodicals postage paid in Miami, Fla, and additional mailing offices. POSTMAS- TER: Send address changes to Welding Journal, 8669 NW 36 St., #130, Miami, FL 33666-6672. Canada Post: Publications Mail Agreement #40626308 Canada Returns to be sent to Bleuchip International, PO Box 26842, London, ON N6C 8E2, Canada.

September 2020.qxp_Layout 1 8/7/20 7:38 PM Page 4
This year, the Gases and Welding Distributors Association (GAWDA) — a network of more than 500 suppliers and distributors with industrial and medical gas industry involvement in the United States — marks its 75th anniversary.

As I said in our commemorative reel at gawda.org /75video, once this gas and welding business is in your blood, you don’t leave the industry. Members echoed similar sentiments in the same video, telling stories from the past and reminiscing about memories from former conventions.

One of the things that makes GAWDA special is the heavy saturation of family-owned or closely held businesses. We also reflect changes in the industry from innovations to more participation from women.

The next 75 years look even brighter for this organization.

Historical Highlights

GAWDA, based in Hollywood, Fla., exists to promote the safe operation and economic vitality of the gases and welding industry. Founded in 1945 as the National Welding Supply Association, the association was formed to promote the value of distribution in the supply chain. Industry forefathers believed that distributors benefited the supply chain, both downstream to customers helping buyers buy and upstream to suppliers helping sellers sell.

Throughout the years, GAWDA has built upon this inaugural mission by creating a robust network of resources for independent distributors.

Additional Acknowledgments

In honor of its 75th birthday, here’s why the independent distributor needs GAWDA:

• 24 h a day/7 days a week/365 days a year access to consultants
• Annual convention gathers more than 800 industry leaders
• Educational programs through the Association Education Alliance
• American Welding Society (AWS)/WEM-CO relationship supports our manufacturers
• Access to Compressed Gas Association (CGA) training modules
• Build consumer safety awareness through provided posters and public service announcement videos
• COVID-19 Risk Mitigation Roundtables
• Cross-industry compensation report for benchmarking

• Department of Transportation record-keeping checklists to always be audit ready
• More than 90% of GAWDA distributors are family businesses and share succession planning opportunities and challenges
• Read and share news in the GAWDA Connection e-newsletters
• Geographic and revenue membership diversity across North and Central America
• The Government Affairs Committee advises on regulatory issues and directs advocacy efforts
• Hazardous materials training resources
• Industry Partnering Committee provides a forum for suppliers and distributors
• Industry personal protective equipment checklists
• Learn from more than 200 suppliers
• Member Services Committee educates, enhances, recruits, and retains membership
• New employee orientation checklists
• Planning Committees develop the programs/meetings for members by members
• Regional meetings for local networking
• The Safety Committee liaises with CGA and AWS and promotes safe practices
• Sales training workshops
• Sample safety policies for drivers
• Scholarships program
• The sliding scale for dues fairly welcomes all members
• Spirit of volunteerism
• Welding & Gases Today magazine
• The Women of Gases and Welding Committee builds the network of women in the industry
• GAWDA’s focus on young professionals provides young executives with educational programs and networking.

Closing the Curtain on 2020

It is my honor to wish GAWDA a happy 75th anniversary and to thank our members and sister associations for their continued collaboration.

The independent distributor needs GAWDA, because while we may not be able to fund or source these resources on our own, collectively we harvest and reap their benefits. Perhaps equally as important, GAWDA needs the independent distributor.

With independent distributors, multinational gas manufacturers, gas and welding equipment suppliers, and technology and service providers, GAWDA represents a symbiotic industry 75 years strong.
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A vast part of much marine and offshore construction, such as the supporting structures of platforms and wind towers as well as pipelines, manifolds, steel waterway and harbor construction, bulkhead panels, locks, ship hull repairs, and more, are to a great extent done under water. Hence, welding and cutting activities for maintenance and repair are bound to take place under water as well.

Shielded metal arc welding (SMAW) is a versatile, flexible, and practical welding process. For this reason, it is often used for underwater maintenance and repairs. For more than 80 years, this process has been applied for sealing leaking rivets in riveted ship hulls. A power source and a covered electrode as the consumable is almost all that is required for this type of SMAW operation. In this case, the power source has to be adapted and prepared for underwater welding to meet all safety requirements. The
Diving In

When a diver submerges, their body experiences the pressure of the surrounding water. With every 10 m comes an additional bar in pressure. One bar of pressure equals a mass of 1 kg on a 1-cm² surface area. As a result of this dive, the pressure on the diver’s body at 10 m is two bar, one from the ambient surface pressure plus one from the 10-m water column.

At 20 m, the pressure increases to three bar, and so on. For the chest and lungs not to be compressed or squeezed, the diver has to inhale breathing air that has the same pressure as the surrounding water pressure. The pressure inside the lungs has to be equal to the external water pressure on the body to prevent any damage.

The pressure of the breathing air is equalized by a regulator or demand valve with a mouthpiece, which the diver uses to breathe. The regulator connects with the first stage, which reduces the high initial pressure, to the air supply in the form of gas cylinders that contain compressed breathing air.

Working Under Pressure

Underwater wet welding takes place directly in the water with “wet” welder/divers, who dive with compressed air or an enriched air mixture, with restricted depth and residence time. The advantage of such wet welding operations is that they are very flexible and mobile, also ideal for short repairs and welding jobs in a larger area, in docks, waterways, floodgates, locks, anchor lines, etc. The setup is also relatively quick and practical, from either the shore or a boat. Obviously, the underwater work has to be properly scheduled and planned in detail.

Welding with coated electrodes is often applied for underwater welding but other welding processes, such as gas metal arc welding (GMAW), flux cored arc welding (FCAW), and gas tungsten arc welding (GTAW), can also be applied when using special welding guns with special nozzles. The weld quality with electrodes is acceptable and very suitable for maintenance and repair welding, and for multipass fillet welds. To optimize the diver’s comfort, drysuits with wool jumpsuits underneath are mostly used. Also, full-face masks or helmets with communication systems included are used — Fig. 1.

Another option is “dry” hyperbaric welding with an underwater habitat, referred to as a cofferdam, built around the parts of the structure that needs to be welded or welded upon. In this situation, the water is pressed out with air to create a relatively “dry” environment. This means the humidity in the habitat is relatively high but there is no surrounding water to come in contact with the workpiece or the welding consumables and the electrical arc.

Wet Welding with Covered Electrodes

Because of its versatility and flexibility in application, SMAW with covered electrodes is often used for underwater maintenance and repairs, and is suitable for welding in all positions. A covered electrode as the consumable and a direct current (DC) power source are all that is necessary to be operational, and this process is suitable for welding in all positions. However, the DC power source has to be adapted and prepared for underwater welding to safeguard a welding operation under such conditions.

The DC power source can be a DC generator, transformer, or inverter, as long as the device is manufactured and approved for use in underwater welding operations. The modern welding machines can have additional options, such as hot start, arc force, and remote control functions, to make the welding easier to execute, and to provide better penetration and protection of the welding arc during welding. Many specialist welding power source producers focus their marketing efforts on underwater welding, since their product responds to the special demands of underwater welding companies.

Setting Up

When the suitable welding source has been determined, the connections of the workpiece and the electrode holder cable are as follows. From the welding machine, one cable connects to the electrode holder and another cable to the workpiece connector, as shown in Fig. 2 (Ref. 2). The electrode cable connects to the negative termi-
nal (straight polarity). When connecting the electrode cable to the positive terminal, electrolysis can occur, which could potentially deteriorate the metallic parts in the electrode holder. Hence, the workpiece lead connects to the positive terminal. The electrodes can usually be welded with direct current electrode positive (DCEP) or direct current electrode negative (DCEN), and many procedures are welded DCEP as well, so when having a problem losing the electrode holder, DCEN could be a possible solution.

Precautions have to be taken to prevent mixing up the cables with positive and negative polarity when preparing the welding operation. A fully insulated electrode holder is used to prevent any current passing through the hand of the welder/diver, as current always follows the way of least resistance. To ensure the electrical safety of the operation, the welder has to be completely insulated from all electrical circuits; the welder should wear watertight rubber or rubberized canvas gloves, all the metallic parts inside the helmet shall be completely electrically insulated, and a dry suit should possibly be used to complete the overall electrical insulation. When lowering the electrode holder to the diver changing the electrodes, during any break and in any case of possible danger, the power shall be off with a zero open circuit voltage (OCV).

This safety switch is only to be operated to switch the welding current on or off, upon the specific and direct request from the welder/diver in the water below.

An overview of the basic setup for an underwater welding operation is illustrated in Fig. 3. The figure shows the support vessel with the required equipment; the DC welding power source, the workpiece leads, the bulk cylinder with compressed air or mixed gas for the welder to breathe, and the audio-video communication system to connect the welder with the dive master/operator on the vessel.

The video connections make it possible to follow the welding processes and work underwater, for guidance and/or for documentation of the actions. The knife switch connects the workpiece and lead with the welding machine above. Below the water surface, the welder wears a full drysuit and diving helmet, carries a safety cylinder with breathing air on his/her back, and has a fully insulated electrode holder in hand. The airhose, the communication and light cables, and the depth tube all have a different color and combine to form a so-called “umbilical” that connects the diver with the equipment on board the vessel.

Although the breathing air for the welder is supplied from the bulk unit or directly from the compressor on the vessel, referred to as surface supplied equipment (SSE), the diver also needs to carry a small bottle on their back as a safety precaution in case the supply from the SSE may encounter a problem and fail to supply breathing air. As previously mentioned, the support vessel can also carry a recompression tank for safety and for carrying out complex and deep diving operations. The full organization of such an operation can become complex, since everything has to come together in one smooth and safe combination of events and in a team of individuals with different responsibilities.

**Staying in Touch**

The communication between the welder/diver in the water and the dive master/welding operator on the surface has to be seamless since lives are at stake. A great deal of training, learning, experience, and trust has to be intrinsic for cooperation within the whole team. The welder/diver has to be a highly competent professional and commercial diver, as opposed to a sport diver, knowing all the ins and outs of safe diving and also be an expert welder to execute welds under extreme, often dark and cold, circumstances. When welding underwater with electrodes, due to the gas that develops in the arc and the heat that makes the water boil, the welder cannot really see the actual weld pool and slag as he would under dry circumstances. These conditions require the welder to have an elevated skill level and competence to produce a suitable and solid weld. The welding training therefore requires significant practice and qualification welding with subsequent maintenance of the qualifications by repeating the performance regularly.

Many national and international underwater welding and training facilities have been established to provide organized training and practice as well as for qualification of welder/divers and welding procedures under international standards. Some standards used for such qualifications include AWS D3.6M:2017, *Underwater Welding*. 

![Fig. 3 — Overview of an underwater welding operation setup with equipment and support vessel. (Courtesy of Fred Neessen.)](image-url)
Metallurgy and Electrode Coating Development

Being underwater, electrodes are exposed to both a wet or very high humidity environment, the water/seawater, and an increased pressure caused by the water pressure, whereas every 10 m of water depth equals one bar of pressure. This means that consumables need to be specially developed and designed to meet the necessary welding, chemical, and mechanical requirements under these extreme circumstances.

When developing electrodes for underwater welding (Ref. 3), three main phenomena have to be taken into account and play an eminent role in the chemical composition and the mechanical properties of the resulting weld:

1) The surrounding water dissociates in the electrical arc, hence, the hydrogen and oxygen content in the arc and weld metal increase to relatively high levels. The amount of dissociated water is proportional to the water depth, hence, also the amount of hydrogen and oxygen in the arc and subsequently in the weld metal.

2) The water pressure influences the metallurgical processes in the electrical arc and results in a change in chemical composition, caused and enhanced by the higher oxygen content.

3) The surrounding water increases the cooling rate, resulting in a threedimensional and shorter T8/5 time. While preheating is usually not easy or practical to carry out, the hardness of the weld metal and adjacent base material increases.

Waterproofing the Electrodes

When the coated electrode is ready, it subsequently has to be protected against the underwater environment, which is the water itself, and the water pressure from the depth. This means applying protective waterproofing that meets certain requirements such as being nonconducting, nonhygroscopic, impervious, not water solvable, clear, can melt or burn away gradually during welding, and seal-tight to the electrode coating to prevent water coming in between the sealing and the electrode coating. It should also not have a negative influence on the welding behavior and be strong enough and resistant to impact or damage by the water pressure. For example, a type of alkyd resin varnish is used to provide an extremely tight waterproof coating that meets these requirements.

After the protective coating is applied, the electrodes should be properly packed in hermetically sealed metal cans or vacuum packaging to guarantee the optimal condition after transport and storage, before the electrodes are used on the job — Fig. 4.

Underwater Applications

Applications for underwater wet welding and cutting are numerous considering how much steel is used in and around water. Just as naval or commercial ships and submarine hulls need welding patches or repairs, many other situations require welding: platforms or wind towers in the sea with corrosion-preventing anodes welded upon them; corrugated bulkhead pan-
els (sheet pile walls) in waterways sealed with welds to make them watertight; and steel harbor constructions such as water locks and sluice gates.

What all the welds in these applications have in common is that the majority are fillet welds and welded at water depths down to about 20 m. In the case of ships, it makes a huge difference when a welding repair is carried out while in the water as opposed to a very expensive dry dock solution. For all these applications, wet welding with electrodes is very suitable. Also, electrodes are much more economical than complicated underwater oxygen arc cutting for underwater cutting of small parts or forming a hole.
Since all these applications fall under certain regulations and approvals, such as those governed by the American Bureau of Shipping (ABS), DNV-GL, or Lloyd’s Register (LR), the welding procedure qualifications and the welder performance qualifications have to be carried out in accordance and under the supervision of these approval agencies per their regulations.

**Putting it to the Test**

The Dutch Navy qualified using UTP Nautica 20 electrodes under LR for welding patches or lap joints onto naval ship hulls, in case the material thickness has reduced due to corrosion or other damage (Ref. 4). To qualify the wet welding procedures and the welders, fillet welds were executed in plates of 10 mm thickness. This took place in an indoor diving tank filled with 3% saltwater to simulate marine seawater conditions, as shown in Fig. 5.

Part of the qualification welds were fillet welds that were produced in double lap joints, prepared on one side with full fillet welds made in the workshop. The other side was welded in the tank with a 3.2-mm electrode at about 150 A in the downhill position. The test weld was a smaller size in order to test if the specimen would break in the weld or in the base material that was to be tested.

Figure 6 shows the double lap joints with one side welded in the shop (left) and the other side welded under water (right) showing the specimen broke in the base material or on the side of the workshop welds. The result of the multipass fillet weld in downhill position is shown in Fig. 7. The bead appearance was very good, especially considering the lack of visibility of the welder. The cross section of this weld in Fig. 8 shows joint penetration, which is one of the qualification requirements, proven by a break test that shows the amount of penetration per length of weld.

**Practice Makes Perfect**

Open-water training sessions are organized for the entire underwater diving and welding team of the Dutch Navy. Figure 9 shows the welder/diver with insulating rubber gloves and getting ready to plunge, standing behind an underwater workbench with a clamping device on a platform that can be lowered into the water for practicing purposes. These welders have also performed underwater cutting with the same electrodes.

Using 240 A, a 10-mm plate could easily be cut into many parts. The cutting length is up to 200 mm with one electrode. The electrode is 3.2 mm in diameter and 450 mm long. The electrode length of 450 mm made it possible to distinguish them from the repair electrodes used, which were 350 mm. The welder can easily carry both types to be prepared for all applications under water.

**Acknowledgments**

The authors thank Gerrit Weerstand and his colleagues of the Royal Dutch Navy — Diving Group for their valuable contributions and practical insight on underwater welding as discussed in this paper. Thanks also go to Fred Neessen, an international welding engineering consultant, for the expressive graphics (Figs. 2 and 5).

**References**


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