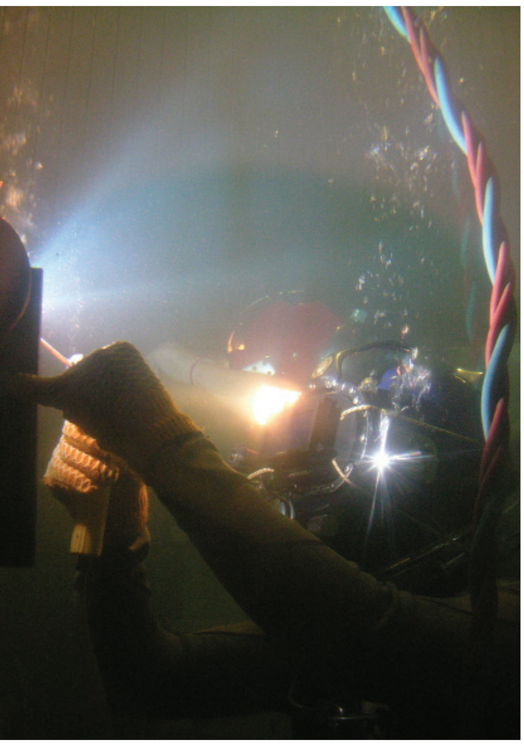
Underwater (Wet) Welder Training from an Engineer's Prospective

This first-hand account of an intensive ten-day program details the skills learned ranging from theoretical preparation to testing of welds made underwater

BY UWE ASCHEMEIER



A diver makes a fillet weld with the shielded metal arc process.

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My adventures in underwater wet welding began with a phone call. I had been asked to find a speaker to talk about underwater welding for a German Welding Society (DVS) seminar, so I called Kevin Peters, president of Miami Diver, Inc., Miami, Fla.

While discussing the possibilities of a joint talk with him, he asked, "Why don't you come down here to Miami and participate in our Hydroweld wet welding training program?" I agreed right away.

As a welding engineer trained in Germany, I went through an apprenticeship program and I learned how to weld. So, I believed, it shouldn't be too difficult for me to weld underwater. On top of this, working also as a commercial diver I thought it should really be a walk in the park. Having dived in all kinds of environments, from potable water to sewage, I viewed this opportunity as just taking my welding skills to a familiar underwater environment.

What Miami Diver Dedicates Itself To

A member of the Subsea Solutions Alliance, Miami Diver specializes in underwater ship services offering repair and maintenance solutions worldwide. Trained service personnel with specialized equipment perform maintenance and highly specialized repairs underwater on predominantly floating structures anywhere in the world. These structures include merchant, naval, and passenger vessels, semisubmersibles, Floating Production, Storage and Offloading (FPSO)/Floating Storage and Offloading unit (FSO), and barges.

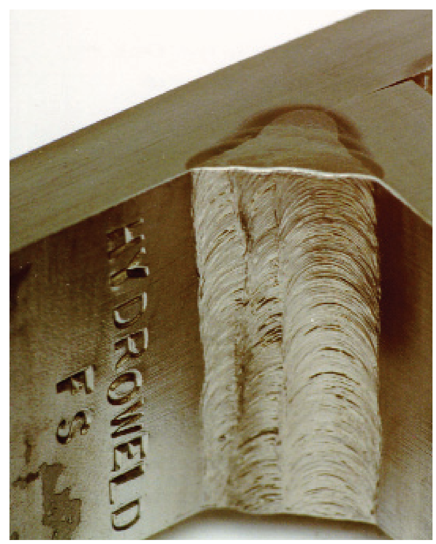

Fig. 1 — Macro of a multipass wet welded fillet weld.

In order to retain their position as a world leader in the field of underwater ship services, the company recognizes the need to maintain a highly skilled, competent workforce. It has a policy to ensure its personnel are provided with the latest, state-of-the-art training opportunities, including specialist training in underwater shaft seal replacement, propeller straightening, and underwater welding.

The Basics of Educating Welder Divers

The modular courses offered by Hydroweld last for ten days and are intended to train commercial divers to the standard required to pass a Welder Performance Qualification (WPQ) to AWS D3.6M:1999, *Specification for Underwater Welding,* to Class 'B' welds and, where applicable, to Miami Diver Class 'A' procedures. The WPQ is witnessed by Lloyds Register (LR), which also issues the certification. Lloyds Register is a major classification society, and certification issued by them is generally accepted by other classification societies worldwide.

The course objective is to train welder divers who are serious about pursuing a career in wet welding or who wish to improve on their current wet welding capabilities and gain a recognized wet welding qualification.

Established in 1987, in West Midlands, Great Britain, Hydroweld develops wet welding consumables, processes, and techniques, and training programs as well as consultancy, personnel, and services with the aim of significantly improving the quality and reputation of wet welding. The modular nature of the courses is in recognition of the time required to develop the wet welding skills in each position and/or joint configuration. With wet welding predominantly completed in the vertical or overhead position, modules one and two concentrate on these positions and lead on to more difficult positions such as 5F pipe to plate and further to butt joint/groove welds.

The courses systematically guide students through various tasks designed to improve their wet welding skills and provide a sound foundation for subsequent tasks. With the philosophy that 'practice makes perfect' and with some guidance, the courses have a realistic time frame in order for even some of the less naturally capable students to succeed. However, it is not an attendance course and students are subject to failure should they not meet the standard. Student numbers are limited to ensure maximum water time is achieved.

While no previous underwater welding experience is necessary, an understanding of topside welding, both theoretical and practical, is a significant advantage to any student wishing to enroll. This knowledge helps the student progress more rapidly though the courses and increases the likelihood of satisfactorily completing the welder performance coupons to the standard required by AWS D3.6M:1999.

The courses are open to both individual commercial divers and diving contractors. Commercial diving contractors who wish to sponsor a number of welder divers on a project-specific wet welding course are welcome to discuss their individual requirements. These requirements may also include the development and qualification of welding procedures in addition to the qualification of wet welders to the specific welding procedures.

Identifying Four Weld Classes

The AWS D3.6, *Specification for Underwater Welding*, was first published in 1983 to establish a standard reflecting state-of-the-art technology relative to underwater welding and to provide those with a requirement for underwater welding a choice of weld quality, on a fitness-for-purpose basis. As with all AWS/ANSI documents, the specification is revised on a regular basis (approximately every five years) to keep up with modern technology. The AWS D3.6 specification sets out four classes of welds identified as A, B, C, or O. These classes are broadly defined as follows:

- **Class 'A' welds**, which are intended to be comparable with above-water welds by virtue of specifying comparable properties and testing requirements.
- **Class 'B' welds**, which are intended for less critical applications where lower ductility, greater porosity, and larger discontinuities can be tolerated.
- **Class 'C' welds**, which are intended for applications where load bearing is not a primary consideration and that satisfy lesser requirements than Class A, B, and O.
- **Class 'O' welds**, which must also meet the requirements of another code or specification.

The AWS D3.6 specification details a list of essential variables, which are addressed and recorded during the development of the welding procedures. These variables take into consideration the joint configuration, base metal, filler metal, position, weldment temperature, electrical characteristics, technique, and environment — Fig. 1. The specification also details the nondestructive and destructive

Fig. 2 — Hydroweld's 35,000-gal training tank.

Fig. 3 — Arrangement of the communication station.

Fig. 4 — Michael A. Pett watching the author through the observation window.

Fig. 5 — Underwater welding station setup.

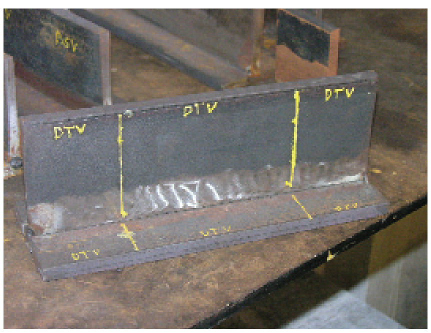

Fig. 6 — Location of test specimen on $\frac{1}{2}$-in.-thick fillet weld test plate.

testing criterion for each class of weld. While Class 'B' and 'C' welds are easily achieved with the wet welding process, the production of Class 'A' welds has not, until recently, been an option because of the difficulties in meeting all of the mechanical and visual property requirements detailed in the specification.

Essential to the production of these Class 'A' surface quality welds is the welding consumable. Many diving contractors carry out wet welding using off-the-shelf welding electrodes originally designed for surface welding. These electrodes are either taped up or dipped in paint, varnish, or other such coatings in an attempt to insulate and waterproof them. However, while these electrodes may perform well on the surface, when used underwater the environmental conditions can significantly alter the welding characteristics and the mechanical properties of the completed weld.

Wet welding is often seen as a poor relation of conventional dry welding with some justification. Although wet welding can produce results to Class 'A' surface quality welds, the process is discredited by diving contractors unfamiliar with the technology taking on projects, including ship repairs, that frequently result in unacceptable weld defects and, in some cases, weld failure. This failure or unacceptability is then seen by clients who then are subsequently reluctant to accept wet welding for anything other than noncritical, temporary repairs.

Advantages of Underwater Wet Welding

It is with the above in mind that we can turn to the importance of wet welder training and certification. In today's world with an ever-increasing requirement for traceability, quality assurance, and quality control, it should be possible to virtually eliminate or at least minimize the risk of unacceptable wet welding. In the offshore oil and gas industry, generally there is always a requirement for proof of competency, training, and qualification, yet in the shipping industry it is often a case of whoever is available at the time the work needs to be performed.

Underwater wet welding for repairing large structures submerged in the sea is often much more economical than the alternative of building a hyperbaric containment structure around the weld locations in order to perform welding in a dry environment.

The wet welding process is the most versatile, cost effective, and widely used method of repairing and modifying steel structures underwater. The process is used extensively in the offshore oil and gas industry, for applications such as replacement and modifications to structural members, strengthening project and new installations. Most of this wet welding is subject to class approval and generally requires the qualification of wet welding procedures and welder qualifications. In civil engineering, permanent repairs and strengthening of structural piles on bridges and jetties as well as dock walls are also completed using the wet welding process.

Day-by-Day Details of the Program

The class took place in Miami in February at the corporate office of Miami Diver. Hydroweld shares part of the facilities: a classroom, shop area to prepare test specimens, and the heart of the training facility, a 35,000-gal training tank — Fig. 2. The 20-ft-diameter tank provides three workstations, allowing three divers to weld at one time. The instructor can watch and critique each welder through an observation window of about 1 ft in diameter at each welding station. He can communicate with each welder through a head set and microphone.

Students learn to master coupon preparation and wet welding in the 3F (vertical fillet weld) position in the controlled environment.

The program is scheduled for 10 days. I thought, "Ten days … who needs ten days to learn how to weld two pieces of steel together with a fillet weld in the vertical position?" After the program was over, I completely understood the need for ten days. There were nine wet welders-to-be in the class from such places as the United States, Canada, and the Caribbean.

The first day we got familiar with the facility and equipment, and received extensive theoretical training in underwater wet welding. The instructor, Michael Pett, taught us the theory of welding underwater, including introductions to the equipment, safety aspects, and underwater welding techniques.

The second day the nine welders rotated in groups of three: One group welded underwater, one group operated the communications stations, and one group prepared the weld specimens — Fig. 3. Every two and a half to three hours the rotation was switched, which is one reason for the ten days, since each welder only practices underwater up to three hours per day. Any longer, student concentration drops off and, in some cases, cold sets in.

The first task was to weld beads on plate — first just stringer beads, then a pad across the plate. This relatively simple task enabled students to familiarize themselves with the setup underwater, to deposit a considerable number of welding electrodes, and provide the instructor with a guide to the general capability of each student.

On the third day, the task was to weld fillet welds 12 in. long on a $\frac{1}{4}$-in.-thick cruciform specimen (see lead photo). During my 30 years in the welding field, I have firmly held to the rule that vertical welding on structural steel is performed in an upward progression. With some exception, such as the root on pipes, sheet metal, or to repair undercut on welds on structural steel, you never weld downward. I had to learn that it is opposite underwater and that travel speed is different. When welding downhill topside (as in nonstructural applications), you generally have to weld quickly to be ahead of the weld pool; underwater, travel speed is much slower due to the rapid cooling of the slag and weld metal. Just about everything is more critical and precise underwater — the heat generated by the arc is more constricted and every movement of the electrode, such as a wobble, will be seen in the finished weld. Travel speed is critical as is electrode angle and bead positioning.

First we learned how to weld the root pass on the cruciform, which was a big challenge for me. It seemed for the first few days in the tank I was unable to accomplish the given task; mastering control over the tip of the electrode was difficult resulting in incomplete side wall fusion, cavities in the weld, and burning more holes than depositing weld metal into the joint. Initially the amperage for a ⅛-in.-diameter shielded metal arc welding (SMAW) rod was 150 A.

I continued to practice welding the root pass with a ⅛-in.-diameter rod into ¼-in. material. While the other welders were making progress, I was not.

On the fourth day, those who mastered the amperage of 150 A and were producing constant acceptable welds had their amperage increased to 160 A. I was still producing holes in my welds though.

On the fifth day, for those who mastered the increased root amperage, they started to weld a second and third pass. I still stuck with my root pass.

Pett was very patient with me. He put on his headset with his microphone, watching me the entire time through the observation window, and never gave up on me.

The sixth day was basically the same as the other days, increasing the amps on root and cover passes for those who mastered the previous parameters and were producing constant acceptable welds. But not me. Pett even had a stool in front of my observation window at this point — Fig. 4.

The seventh day, Pett took me into the welding booth where we produced the samples, and I demonstrated to him that I can produce a sound specimen in the dry — Fig. 5. We discovered that the problem was my vision. Since there is limited room in the diving hat for glasses, we usually don't dive with glasses, but use cheater lenses on the outside of the hat attached to the weld lens holder. We decided to jerry-rig my glasses and wear them in the diving hat. Problem solved. When the rotation reached me for welding underwater, I was able to control the pool and to produce satisfactory root and cover passes. I felt much better than I had the days before.

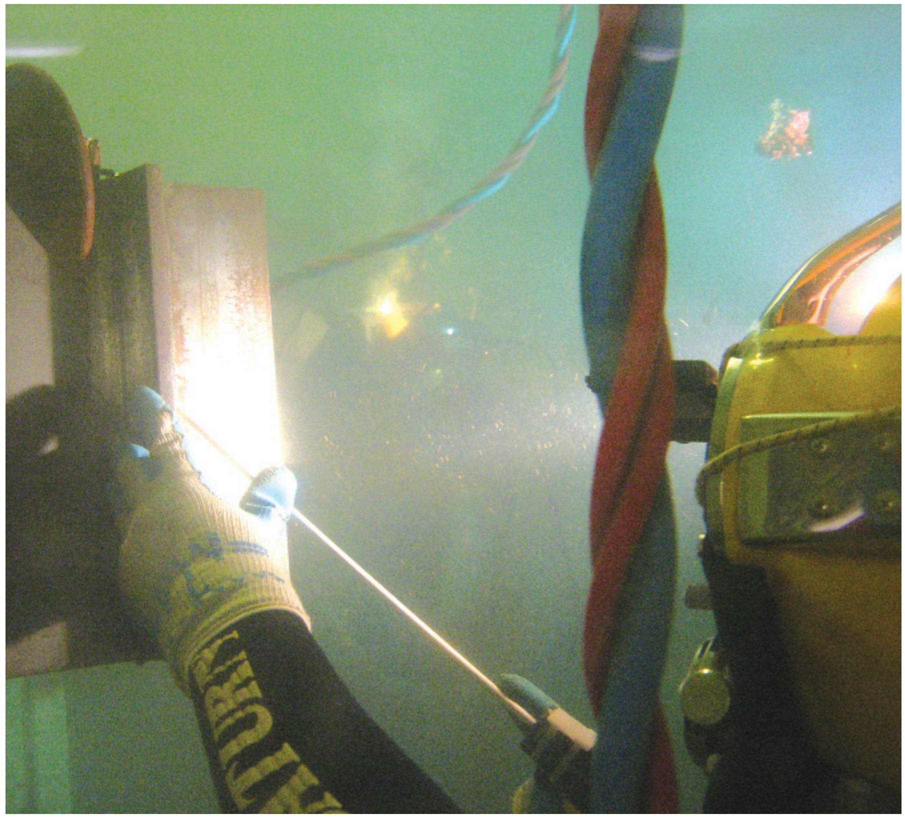

Fig. 7 — Diver welding a fillet weld with the shielded metal arc welding process on a ½-in.-thick plate.

The eighth day I caught up with the divers using ½-in. cruciform plates and increased the amperage for the root pass to 175 A and for the cover passes 150 A.

The ninth day we increased the amperage again, this time to 180 A, and left the capping runs the same at 150 A.

The tenth day was test day — Figs. 6, 7. We had about one hour of practice time in the tank to weld the test specimen according to AWS D3.6, Fig. 5.8 (½-in. fillet weld, ½-in.-thick material, 12 in. long). The test was witnessed by Lloyds Register. After welding the specimen, I came out of the water and presented it to Pett and the inspector from Lloyds. They didn't seem too impressed with my welding skills. After discussions, they agreed to accept it visually, but the break test results caused me to fail due to incomplete root penetration. I had to go back in the water. The second run proved to be much more successful. I remembered the tips Pett had given me the previous days, and I applied them during the test. This time the results were satisfactory for the visual and break test. The macros showed very deep penetration with no defects.

Concluding Thoughts

Now I understand why the training is scheduled for ten days. To produce AWS D3.6 Class 'B' welds underwater is not as easy as it seems. It requires the welder to adopt new welding techniques and to be very patient. The ten days of the course also makes sense, since each welder has only 2.5 to 3 hours of practice time each day in the tank.◆

Acknowledgment

As a welding engineer and a commercial diver, this was a very challenging and educational experience. I am very grateful for all the help Michael Pett provided me and the invitation from Kevin Peters to be a part of this wonderful opportunity. I hope I will get the call one day to put my newly acquired skills to work.