

UNDERWATER WET WELDING

PSS
PROFESSIONAL
SUBSEA SERVICE



ISO 9001:2015
BUREAU VERITAS
Certification



DNV GL 10001
BUREAU VERITAS
Certification



ISO 14001
BUREAU VERITAS
Certification



About us

Group of companies PSS operates in the market of professional diving services over 20 years. We perform surface air supply diving operations and specializes in conducting various underwater and technical works at oil extracting platforms, pipeline transport, in energy and heavy industry.

The main objective is to fulfill and provide the highest levels of quality in the field of subsea services, encouraging and maintaining the highest level of quality, safety, protection of the environment, professionalism and integrity in relations with our Customers, Suppliers, Subcontractors, Professional Partners and other interested parties.

Such factors as supporting of long-term relations with our Customer and stably growing volumes of works allow to take group of companies PSS for a leader of Ukrainian market of diving services. During the years, we also performed diving works in such countries as Turkmenistan, Vietnam, Yemen, Iraq and Russian Federation.

For 25 years of activity, we proved to be reliable partner who gives professional solution for our Customer. For the years of our activity we received the recognitions of Lloyd's Register Recognition, American Bureau of Shipping Approval, American Welding Society, Bureau Veritas, Det Norske Veritas and has Quality management system Certificate in compliance with ISO 9001-2015 standards and a diversity of national confirmative and permissive documents indicate a high professional level of our services.



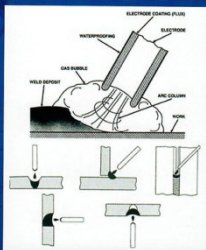
Wet welding

Underwater welding can be separate into two types: dry (hyperbaric) welding and wet welding. Underwater wet welding directly exposes the diver and electrode to the water and surrounding elements.

The electric arc heats the workpiece and the welding rod, and the molten metal is transferred through the gas bubble around the arc. The electro current flow induces transfer of metal droplets from the electrode to the workpiece and enables positional welding by a qualified operator.

The presence of a gas bubble, which is formed around the arc, is a necessary condition for the existing of discharge welding. It occurs at the initial moment of welding when the electrode contacted with the surface by heating the contact place with the electro current. An arc is appear when the electrode had been separated from the bubble and this causes the further development of the process.

The arc burns in the closed volume of the gas bubble, which have formed due to the products of water dissociation, as well as the combustion and evaporation of the metal of the fuse electrode and the product. The volume of bubble is constantly changing due to the continuous process and gas formation.



In the table below we compare underwater wet welding with dry (hyperbaric) welding.

Wet welding	Dry (Hyperbaric) welding
Advantages	Advantages
Cheapest and fastest method	Surface quality welds
Increased tensile strength	Surface monitoring
Ease of access the welding point	Advanced NDT
No chamber, no construction, no waste of time	Disadvantages
Disadvantages	Extremely high cost of process
Decreased ductility and impact strength	Large quantity of costly and complex equipment
Limited NDT (VT, ACFM and MPI only)	More deep – more energy requirements
Poor visibility in water	Weld spot position limitation

Staff

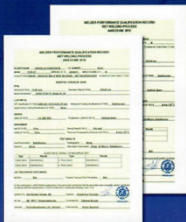
Qualified staff is one of the most important components for quality wet welding. Our company pays special attention to the training of divers for maintaining high qualifications.

In accordance with our training method, the diver with at least 500 hours of practical diving operations is admitted to mastering the technology of wet welding. First, the candidates study the principles of topside welding, safety procedures and start practical training on mastering of topside welding. Over the years of our practice, we came to the conclusion that not all people are able to master this technology. According to the results of practical training, we select the most capable candidates, and they proceed to studying the principles of wet welding. After mastering of the definite position of the weld, the diver performs welding of test samples, which are further provided to the laboratory for testing and are subjected to tensile tests and bending tests; besides, macrostructural analysis of the welds is carried out. If the submitted samples pass the tests, the diver is admitted to mastering of the next position. It is rather long and energy-intensive process. Further, the diver may confirm his skill by producing the control samples in the presence of the surveyor or one of the world classification societies and gain the recognition from that society. However, it is only a part of the way. In order for your specialist not to lose his skills, he needs constant training or practice. Our diver welders take training courses at least two times during a calendar year and before performance of each contract. During the training period, the diver should confirm all specified positions of the weld. Our underwater welders carry out daily training at our base.

When divers are employed under the contract, the situation is more complicated; the only way is making control samples by the diver before the contract, but it will not give you confidence that the diver performs welding stably. In specialized centers of some countries, for example, the USA and Great Britain, the divers have an opportunity to restore their skills and to provide the relevant confirmation to the employer, but it involves additional costs and may increase the period of mobilization of these specialists to the work site. At present time, many divers and diving companies state underwater welding, as one of the types of work performed by them, but quality of their services does not always comply with the accepted international standards. The reason is misunderstanding or unwillingness to understand the essence of the technological process of underwater welding and all its constituent parts. Today it is not enough to employ a diver with the relevant certificate; it is necessary to have the appropriate equipment and know the characteristics of different welding materials.

As a result of our staff policy, our company has 6G and 3G divers-welders certified according to the international welding standard AWS D3.6M-2017. Our team has both qualified divers-welders and NDT specialists/engineers for development of WPS and welding quality control.

Our welders were certified by the classification community BUERAU VERITAS and DET NORSKE VERITAS for the most difficult welding position - 6G.



Equipment

Over the past few years, our representatives visited many countries, exhibitions, diving schools and training centers. Since we are interested in the subject of underwater welding, we always asked questions about the equipment which is used for teaching underwater welding. As a rule, conclusions drawn by divers when they undergo training at various centers are not quite right.

For underwater welding, direct current of straight polarity, increased by 15-20% compared to welding in the air, is used. At the direct current, the welding arc burns more steadily than with the use of alternating current. This is due to the fact that direct current decomposes water even before the arc is ignited, while alternating current decomposes water and forms a gas bubble at the moment of short circuit under action of high temperature. With increase in depth, the arc burns steadily but the current and voltage will grow. For underwater welding, it is necessary to use power supply sources featuring high no-load voltage and at the same time ensuring the welder's safety. The higher no-load current of the power source, the more stable is the welding arc burning.

We use in our underwater welding practice the generators of direct current with the limits of current strength regulation of 100-500 A, and no load voltage of 70-110 V. To improve the reliability of welding arc ignition and compensation of voltage losses in the power cable, we choose the operating voltage of 24-40 V. In addition to the distance of the power source from the welding location, the current strength limits are also connected with different positions of the weld, namely, "Horizontal welding" (lower position), "Vertical welding", "Overhead welding". These positions have various parameters of current strength (A). Besides, diameter of the electrode also has its effect on increase in the current strength. In the world market there are electrodes of 2 - 5 mm in diameter; accordingly, current strength will increase. Correct choice of the power source is an important part of welding technology, but still not everything.



WELDING POSITIONS TUBE WELD JOINTS

GROOVE



FILLET



WELDING POSITIONS PLATE WELD JOINTS

GROOVE

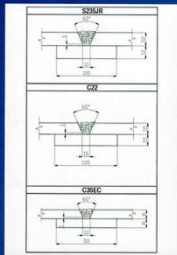


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Welding materials

WELD JOINT SCHEME



TENSILE STRENGTH TEST RESULT



Electrodes used:

No	Wet welding electrodes brands	Diameter, mm
1	Broco SoftTouch Wet Welding Electrodes (AWS E7014) UW-CS-2	4.0
2	Oxilance SURWELD #1	3.25
3	Oxilance SURWELD #2	4.0
4	Oxilance SURWELDNI	2.35
5	Paton EPS-K1	4.0
6	Barracuda Speciality Welds	3.2
7	Hammerhead Speciality Welds	3.2
8	Ceweld Aquaforce LC	4.0

In the course of our communication with the colleagues all over the world, we made for ourselves a disappointing conclusion that only few people devote their time and allocate funds for conducting practical tests of any particular materials. There is a certain hierarchy of leaders on the world market, and the most of consumer companies take it as a reality and indisputable fact. It should be recognized that for some time we followed that way too. At a certain stage, we ran into the problem of poor-quality weld. The power source is chosen correctly, diver welder qualification is unquestionable; however, the weld does not meet the specified requirements.

We decided to produce a number of welding samples under the same conditions, using materials of various world-leading companies that are most demanded in this market. As a test procedure for comparing materials, in order to minimize the effect of human factor, we chose the simplest process weld, i.e. 1G position. I think that our colleagues will agree that this is one of the most elementary welds, which the overwhelming majority of underwater welders may cope with. As a method, we chose the static tensile test. We think, this technique allows obtaining the objective figures to make the subsequent strength calculations of the structures.

Diver welders of our company welded 120 samples to perform the tests. Preparation of welding samples and welding operations were carried out in accordance with AWS D3.6:2017, manual arc welding, welding position 1G, weld class "B". The welding process was recorded on video with the use of ROV.

Steel grades and sample thicknesses:

S235JR – 12 mm; C22 – 10 mm; C35EC – 8 mm;

Welding works were conducted in the freshwater lake in Ukraine.

After completion of welding operations, in accordance with the internal standard of Ukraine, samples for mechanical testing were prepared. Mechanical tests were carried out by the Z.I.Nekrasov Iron and Steel Institute of the National Academy of Sciences of Ukraine. The result of tests is summary table of static tensile tests of samples (Table 3).

Our experience

Lam-22 offshore platform
reconstruction, anodes welding

Caspian sea,
Turkmenistan

1999-2014

Welding positions: 2F, 3F, 3G
About 600 meters of weld joint



TP-1 offshore platform. Installation of new
nodes by underwater welding
Installation of electrochemical protection
system by underwater welding

Black sea,
Ukraine

2001,
2003

Welding positions: 1G, 2G
About 200 meters of weld joint



Podolsky bridge building.
Underwater welding of metal
structures

Dnipro river,
Ukraine

2005-2009

Welding positions: 2F, 3G, 4F
More than 1300 meters
of weld joint



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Russia, Moscow
Reconstruction of gas
pipeline

Ukraine, Black sea
gas pipeline Shtormovoe-
Archangelskoe

Ukraine, Feodosia
Construction of
petroleum terminal

Iraq, Arabian Gulf
Inspection of the sunk ships

Ukraine, Crimea
Offshore platform
Vostochno-Kazantipskoe field

Turkmenistan
Reconstruction of offshore
platform "LAM"
and "ZHD" fields

Vietnam
Inspection of offshore
platforms "White tiger" field

Yemen
SBM

Geography of works

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