

Underwater Cutting Products Operating Instructions

▲ WARNING! Underwater cutting and welding equipment is potentially dangerous and can result in serious injury or death. This equipment must be used in strict accordance with the instructions provided. Users must read and understand these operating instructions thoroughly and follow all procedures when using the Broco® Underwater Ultrathermic cutting system.

▲ Underwater cutting and welding should be performed by trained commercial divers only and according to industry accepted safe diving practices. Always adhere to ANSI Z49.1:2012 "Safety in Welding and Cutting" standards or similar locally prevailing standards when using this equipment and follow industry accepted safe diving practices as found in the Association of Diving Contractors International "Consensus Standards for Commercial Diving."

▲ All personnel and supervisors engaged in underwater cutting operations must be familiar with these instructions, the correct use of underwater cutting equipment, and accepted safe commercial diving practices. Employers must provide operator training before allowing their personnel to begin using the Broco Underwater Ultrathermic cutting system. Supervisors must ensure that all personnel become thoroughly familiar with all safety precautions prior to cutting.

▲ If you have any questions regarding the safe operation of BROCO Underwater Ultrathermic cutting systems **STOP! DO NOT ATTEMPT TO CUT UNDERWATER!** Contact Broco, Inc. at (800) 845-7259 or (909) 483-3222, and fax (909) 483-3233 for technical information.

See American National Standard Z49.1:2012 "Safety in Welding and Cutting" published by the American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166, (305) 443-9353; "Consensus Standards for Commercial Diving" published by the Association of Diving Contractors International, 5206 FM, 1960 West, Suite 202, Houston, TX 77069, (281) 893-8388; OSHA Safety and Health Standards "29 CFR 1910" available from the U.S. Department of Labor, Washington, D.C. 20210, (202) 693-1999.

CUTTING EQUIPMENT

WARNING! To avoid serious injury or death, follow the safety information in this section and in all other warning sections.

▲ **DO NOT** modify this equipment or use it in any way not specified in these instructions. Modification of this equipment can cause oxygen leaks that can lead to an explosion.

▲ To prevent burns to your hands and body 1) Use only Broco replacement parts; 2) Always release the oxygen lever to extinguish the torch while there is at least 2" of rod remaining; 3) **DO NOT** use a damaged Ultrathermic cutting rod; 4) Always insert the correct end (recessed, untapped) of the rod into the torch; and 5) Always wear insulated suit and gloves.

▲ Using compressed air, oils, solvents or other material to clean the oxygen system can contaminate the oxygen system, cause internal burning in the torch or hose, or can cause an explosion. Always keep oil and grease away from oxygen cylinders, valves, regulators, hoses and fittings. A qualified and knowledgeable technician must perform all service on oxygen delivery parts.

▲ Using a torch without a flash arrestor and screen (BR-22) or sintered flash arrestor (BR-22 PLUS) can cause flashback in the torch and an explosion. **DO NOT** operate the torch without the flash arrestor and screen in place.

▲ Using a torch or cutting rods designed for surface use (not insulated) for underwater cutting can shock the diver. Always use a Broco Underwater cutting torch and Broco Underwater cutting rods.

▲ To prevent electrical shock to the diver and electrical damage to the diver's life support equipment, always ensure that the safety knife switch is open before changing cutting rods.

▲ **DO NOT** use a "burning bar" for underwater cutting operations. It can cause excessive gas buildup and an oxygen explosion. A "burning bar" is considered to be any underwater cutting rod operating with oxygen as a fuel source whose diameter is greater than 3/8" and/or length is longer than 36".

▲ The use of underwater cutting rods from other manufacturers can cause flashbacks or internal burning and injury to the diver. Always use Broco Underwater Ultrathermic cutting rods with the Broco BR-22 and BR-22 PLUS underwater cutting torch.

Equipment Required

1. Broco BR-22 or BR-22 PLUS cutting torch, preferred because it is designed for diver comfort, maximum oxygen flow, and ease of operation and maintenance.
2. Broco Underwater Ultrathermic cutting rods.
3. Broco HVR-4401 high volume two-stage oxygen regulator.
4. Single pole single throw, or double pole single throw safety knife switch (rated 400 amps DC unfused).
5. C-type grounding clamp (appropriate for underwater use).
6. 150-200 amp 100% duty cycle DC welding power source, or 12v or 24v battery.
7. Size 1/0 (minimum) welding cables for torch power and ground leads.
8. Oxygen supply (gas only, 99.5% purity minimum).
9. 3/8" inside diameter oxygen supply hose (regulator to torch; taped to torch power cable at 2' intervals).

TOPSIDE (AT SURFACE)

WARNING! To avoid serious injury or death, follow the safety information in this section regarding topside safety and in all other warning sections.

▲ The use of damaged or worn components can cause equipment failure and result in injury. Before entering water, check equipment for leaks and replace damaged or worn components.

▲ To reduce the risk of injury in the unlikely event of regulator failure, **DO NOT** stand directly in front of or directly behind the oxygen regulator while opening the oxygen cylinder valve.

▲ Using the vessel's primary battery as a power source for rod ignition can damage or cause wear to the battery and could render the vessel inoperable. Always use a separate battery for cutting.

▲ Using alternating current (AC) for underwater cutting can electrocute the diver. **DO NOT** use AC power for underwater cutting operations. Use only direct current (DC) from a known power source.

▲ To avoid electrocution **DO NOT** touch live electrical parts.

1. Before beginning, inspect components to insure that:

- A. Hose and cables are in good condition with no visible cuts, cracking or splitting. Cable lug connectors should be securely attached and without visible excessive corrosion.
- B. All electrical connections are made watertight by carefully taping with UL approved electrical insulating tape. Tape should extend at least 4" up the cable on both sides of the connection.

C. Cutting torch is in good condition with no visible gaps in the seam between the handle halves. Torch should be inspected to make sure flash arrestor, neoprene compression washer, collet washer and appropriate size collet are in good condition and in place. To replace the collet:

- Remove the collet nut and collet from the torch.
- Make sure the neoprene collet washer is in place.
- Insert the desired collet and replace the collet nut.

D. Welding power source is DC output.

E. Diver is equipped with proper diving dress and life support equipment in good condition. Rubber “linesman” gloves must be worn in addition to other gloves the diver may have.

F. Appropriate eye protection is attached to the diver’s faceplate. Use an approved welding lens. A minimum #4 shade is usually suggested for muddy water, #6 shade for average conditions, and #8 shade or above for clear water, however, the diver must use his best judgment as experience and conditions dictate.

Note: Set the welding power source to 150 amps delivered to the torch, and the oxygen regulator delivery pressure to 90 psig over ambient pressure at depth.

2. Make sure the supply valve, regulator, hose, and torch are clean and free of any grease, oil or particles. Purge the oxygen cylinder valve by opening it then closing it. Attach the oxygen regulator to the oxygen supply and purge with oxygen by opening and closing the oxygen supply valve. Attach the oxygen supply hose to the regulator outlet. Purge the regulator and hose with oxygen to clear any obstructions.
3. Attach the torch to the oxygen supply hose.
4. Set the regulator delivery pressure to 90 psig over the ambient bottom pressure or other pressure which may be required due to depth or nature of operation. Add 1 psi for every 10’ of oxygen supply hose to compensate for hose friction loss. Regulator delivery pressure must be increased with increased working depth. (See Table #1 – “Setting Oxygen Delivery Pressure for Depth”)
5. Purge the torch. Check fittings, connections, and the torch for leaks using soap suds.
6. With the safety knife switch in the open position, attach the safety knife switch to the torch power lead. Attach the other end of the torch power lead to the torch cable. Attach a cable from the welding power source negative terminal to the safety knife switch. Ensure the safety knife switch is positioned within reach of the tender. The safety knife switch is activated only upon command from the diver.
7. Wrap all cable-to-cable connections with rubber strips and electrical tape.
8. Attach the ground cable to the welding power source positive terminal. Attach the other end of the ground cable to the ground clamp.
9. With the safety knife switch in the open position, start the welding power source and set output for 150 amps maximum at the rod tip. (See Table #2 – “Setting Amperage for Cable Length and Size”)
10. Check polarity by immersing the rod tip and ground clamp in a bucket of salt water approximately 2” apart. Energize the rod by closing the safety knife switch. A stream of bubbles should rise from the rod tip. If not, reverse the polarity and retest.
11. Check amperage using a clamp-on or inline gauge. Do not rely on dial indicators on the welding power source.

UNDERWATER GAS/EXPLOSION DANGERS

WARNING! To avoid serious injury or death, follow the safety information in this section regarding gas/explosion dangers and in all other warning sections.

▲ Underwater cutting can lead to a buildup of potentially explosive gas mixtures that may be ignited by a spark from a cutting rod. Always flood area with an inert gas (such as argon or nitrogen) before cutting and/or vent the area by drilling large holes behind and above the cut to allow the escape of gases generated during cutting.

▲ To avoid explosions caused by cutting into chambers or other areas filled with gas, check what is behind the material being cut. If there is a possibility that there is gas, flood area with an inert gas or vent the area by drilling holes to provide for the escape of the gases.

▲ When melting concrete, ensure entry hole is large enough to allow venting of all gases in and above work area.

▲ Cutting where there is a pressure differential – either blowing out or sucking in – can cause an explosion and injuries to extremities due to partial pressure. Drill a hole and wait for pressure to equalize.

▲ Oxygen and hydrogen trapped in mud can cause an explosion. Before cutting below the mud line, jet and airlift or pump the mud from behind the cut.

WARNING! Explosive gases can accumulate within an energized underwater cutting rod. **DO NOT** energize a cutting rod until ready to initiate underwater cutting. Purge the cutting rod with oxygen by squeezing and holding the oxygen lever for at least four seconds with the rod in cutting position prior to energizing the cutting rod and initiating the arc.

UNDERWATER OPERATIONS

WARNING! To avoid serious injury or death, follow the safety information in this section regarding diver safety in underwater operations and in all other warning sections.

▲ For the diver’s safety, never conduct underwater cutting or welding operations without a topside tender to monitor the diving operation and a standby diver for emergency response.

▲ To avoid burns, diver’s hands should not be closer than 4” from the electrode tip.

▲ Using SCUBA breathing apparatus while performing underwater cutting or welding can result in electric shock and does not allow for communications with the topside tender. Always use surface-supplied breathing air and hard-wire communications. **DO NOT** use life support equipment that has been modified from the manufacturer’s original specifications.

▲ Failure to wear protective clothing while cutting can result in electrical shock. Divers must wear full wet or dry suits and rubber electrical insulating gloves (in good condition) to insulate their bodies and hands.

▲ A diver is at risk of severe electrical shock when cutting while only partially immersed in water. This splash zone is the most hazardous location where divers work. Always wear full wet or dry suits, rubber insulating gloves, appropriate eye protection, and dive helmet when working in the splash zone.

▲ To prevent damage to the diver’s life support equipment, serious injury or death, **DO NOT** touch the cutting rod to any metal on the diver’s helmet, dress, or equipment including any part of the diver’s body, hoses, cables, and compressed gas cylinders.

▲ Wearing improper eyewear during underwater cutting can result in vision damage. **DO NOT** use cutting equipment without using an approved welding lens with a shade appropriate for the conditions of the water.

▲ Material may fall and injure the diver. Always be aware of the environment around you and position yourself and your life support equipment away from falling debris.

▲ If a diver’s body comes between the cutting rod and the ground, the diver may become part of the electrical circuit and risk electrocution. Always face your ground and **DO NOT** turn your back to the ground connection.

▲ Oxygen pops (flashbacks) can disintegrate the flash arrestor and screen and cause serious injury to the torch user. If the diver feels oxygen pop strong enough to move his hands or arms back, stop work immediately and bring the torch topside to have the flash arrestor and screen checked.

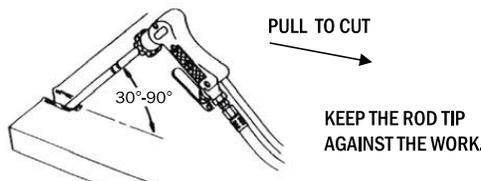
▲ Failure to securely tighten the collet nut may cause arcing and possible flashback and result in serious injury or death. Tighten the collet nut securely. If there is a loose connection between the rod and the collet, oxygen bubbles may escape from the collet nut area when operating the torch. If bubbles escape, remove and reinsert the rod against the collet washer. If bubbles continue to escape, stop using the torch immediately and have it repaired. Check to ensure the collet washer is present and in good condition.

Note: Broco Underwater Ultrathermic cutting rods will continue to burn as long as the oxygen flow is maintained, even with the power off. The oxygen lever must be released to extinguish the cutting rod.

1. Ensure the safety knife switch is in the open position and the welding machine is turned off prior to securing the ground clamp to the work piece as close to the area to be cut as possible. Ensure the ground clamp is away from the diver as he proceeds to cut. The diver should always be facing the ground clamp.
2. Check that the oxygen delivery pressure is correctly set by squeezing the torch lever to release a stream of oxygen. A 6" jet of oxygen should issue from the cutting rod tip.
3. Loosen the torch collet nut 1/2 turn.
4. Insert the end of the Broco Underwater Ultrathermic cutting rod that has the recessed internal wires into the collet opening until it bottoms on the collet washer.
5. Tighten the collet nut to lock the rod in place.
6. Check for oxygen leaks at the collet nut and around the collet by squeezing the oxygen lever. If a leak exists: make sure the rod is firmly seated on the collet washer; inspect the rod for damage; inspect the collet washer for damage and replace if necessary.
7. Place the tip of the rod against the work at the point where the cut is to be initiated and squeeze the oxygen lever for four seconds to purge the rod and torch.
8. With the oxygen still flowing call for the current to be turned on. The tender will close the safety knife switch.
9. Draw the tip of the cutting rod across the work to strike the arc.
10. Once the arc is struck and rod ignited, pull (drag) the cutting rod along the line to be cut. The angle of the rod to the work should be between 30 and 90 degrees, depending on the metal thickness.
11. Maintain pressure to keep the rod against the work. Keep the tip of the rod in the puddle at all times. Move slowly at first, making sure full penetration is achieved. As cutting speed is increased, back spray and cutting noise will indicate insufficient penetration.

Note: Do not try to hold an "arc". Keep the tip of the burning rod in direct contact with the target material at all times. Hold the rod "like a pool cue" with your free hand approximately 4" or more from the rod tip for a more stable cut. Keep moving the hand back as the rod consumes.

12. When the rod has burned to within approximately 3" of the torch collet nut, call for the current to be switched off.
13. Lift the rod from the work and release the oxygen lever to extinguish the cutting rod.
14. After the tender has confirmed the current is off, loosen the collet nut 1/2 turn and remove the rod stub from the torch.
15. Insert a new cutting rod and repeat the process until the cut is complete.



Note: When cutting or melting non-conductive materials such as concrete, rock, coral, mastic, rope, or marine growth, a striker plate (consisting of a steel or copper plate connected to the ground cable) is necessary to initiate the arc and light the rod. Once the rod is ignited, maintain the oxygen flow and bring the rod into contact with the target material.

Table #1

Setting Oxygen Delivery Pressure for Depth

DEPTH		PRESSURE GAUGE SETTING	
FT	M	PSIG	BAR
33	10	108	7.4
40	12	112	7.6
60	18	123	8.4
80	24	134	9.1
100	30	145	9.9
120	37	155	10.5
140	43	166	11.3
160	49	177	12.0
180	55	188	12.8
200	61	199	13.5
220	67	210	14.3
240	73	221	15.0
260	79	232	15.8
280	85	243	16.5

Calculate regulator gauge pressure setting as follows:

For every 10' of hose required, add 1 psig to the 90 psig necessary at the tip. This compensates for frictional line losses. Additionally, add 0.445 psig for every foot of working depth.

Table #2

Setting Amperage for Cable Length and Size*

LENGTH OF POWER CABLE (supply to work distance)		AMPERAGE SETTING FOR Cable Size		
FT	M	#1/0	#2/0	#3/0
150	46	155	152	150
200	61	157	154	152
250	76	159	156	154
300	91	161	158	156
350	107	163	160	158
400	122	165	162	160
450	137	167	164	162
500	152	169	166	164

* The increases in amperage compensate for resistance losses. For greater lead lengths, add 2 amperes per fifty feet to settings.

TROUBLESHOOTING

Broco Underwater Ultrathermic cutting rods are different from steel tubular cutting rods in that Broco Underwater Ultrathermic cutting rods require higher oxygen flow and lower amperage. Additionally, Broco Underwater Ultrathermic cutting rods require direct contact with the work, not maintenance with the arc. Most operational problems stem from operators using steel tubular cutting rods' setup and cutting techniques.

Oxygen Supply Problems:

1. Efficient cutting with Broco Underwater Ultrathermic cutting rods relies on high volume, unobstructed oxygen flow. With inadequate oxygen flow, the rod can burn without significantly affecting the work.

Symptoms include: the rod burning longer than 60 seconds of continuous use; cuts of less than 12" in 1/2" thick steel plate; and an oxygen jet of less than 6" length underwater.

Solutions:

- A. Ensure that a high volume two-stage oxygen regulator and 3/8" oxygen hose are being used.
- B. Ensure that the hose is not kinked, pinched or obstructed.
- C. Ensure that the oxygen cylinder valve (if using a manifold system) is fully opened.
- 2. The Broco Underwater Ultrathermic cutting rod requires oxygen of at least 99.5% purity to sustain ignition without power. Cutting with continuous power, a reduction in the purity of the oxygen by 1% can decrease cutting efficiency by 25%.

If the rods continuously extinguish underwater or burn erratically, the problem is probably poor quality oxygen.

Solution:

- A. Obtain a source of oxygen from a different, unrelated supplier.

Note: Since a gas supplier will usually have all his oxygen coming from one manufacturer, changing cylinders for one filled at the same place or time will not solve oxygen purity problems. Using oxygen from another manufacturer will either solve or rule out an oxygen purity problem.

Power Source Problems:

- 1. If the rods consume too quickly, it is likely the welding power source is delivering greater than 150 amps.

Solution:

- A. Use an inline or clamp like ammeter to verify current output. Adjust as necessary.

SURFACE PRACTICE FOR NEW USERS

WARNING! If you are a new cutting torch user, to avoid serious injury or death, follow the safety information in this section regarding surface practice for new users and in all other warning sections.

▲ Fumes from burning tape can cause respiratory injury. Always remove the tape insulation from underwater cutting rods before burning at the surface and keep your head away from the fume plume.

▲ Cutting torches can cause burn injuries. Always wear adequate protective clothing, welder's gloves, and face and eye protection specifically designed for burning (use a #6 welding lens if using a battery and a #10 lens with a welding machine).

- 1. Cutting with Broco Underwater Ultrathermic cutting rods requires practice. A diver with surface arc welding or cutting qualifications will get excellent results underwater in a short time.
- 2. Burning at least three or four rods on the surface before attempting to cut underwater is essential to gaining maximum proficiency with the Broco Underwater Ultrathermic cutting system.
- 3. Do not try to "maintain an arc". Instead, practice metal to metal contact, keeping the rod tip in the molten puddle, while adjusting travel speed to ensure complete penetration.

TECHNIQUES

Note: Continuous power is recommended for cutting with the 1/4" diameter Broco Underwater Ultrathermic cutting rod, otherwise it is difficult to maintain ignition.

Cutting Steel

The 1/4" diameter Broco Underwater Ultrathermic cutting rod may be used for cutting steel up to 1/2" in thickness for maximum cutting econo-

my. The 1/4" rod leaves a narrow kerf and is preferable for fine cutting.

In bad visibility or for thicker steels, the 3/8" diameter cutting rod will give better production. For materials 1/2" thick or thicker, the 3/8" rod is preferable. For metal several inches thick, employ saw and wedge cutting (analogous to chopping wood) to achieve full penetration.

"Rule of Thumb" Estimates

ROD DIA.	PLATE THICKNESS	RANGE OF CUT PER ROD
1/4"	1/4"	20" – 25"
1/4"	1/2"	10" – 15"
3/8"	1/2"	12" – 20"
3/8"	1"	9" – 14"
3/8"	1 1/2"	8" – 12"

Note: The U.S. Navy Underwater Cutting and Welding Manual, NAVSEA 0929-LP-000-8010, gives estimates for the 3/8" Broco Ultrathermic cutting rod at the high end of these ranges.

Cutting Cast Iron, Stainless Steel, and Non-Ferrous Metals

The Broco Underwater Ultrathermic cutting rod will melt all of these materials. Make sure that the tip is firmly buried in the work. Saw and wedge cutting may be necessary. Maximum cutting efficiency may be achieved by burning a series of holes through the piece prior to cutting across it.

Cutting Thick Non-Ferrous Metals

Note: Increase oxygen delivery pressure to 110 psig over ambient pressure for metal over 3" in thickness.

Create a puddle and dip the rod tip slightly below the surface of the molten metal. From time to time push the cutting rod deeper into the metal to wash it out and blow the slag away.

Cutting (Melting) Concrete and Rock

Note: Always use the 3/8" Broco Underwater Ultrathermic cutting rod when cutting concrete or rock.

Light the rod by striking the tip against a copper or steel plate attached to the ground cable. Keep the oxygen lever depressed and raise the rod from the plate to the work piece. Call for the current to be switched off. Press the rod tip into the material to create a molten pool. While melting through the material, periodically move the rod in and out and around to enlarge the hole to vent gases and to blow the molten material away.

Cutting Rope and Wood

Light the rod by striking the tip against a copper or steel plate attached to the ground cable. Keep the oxygen lever depressed and raise the rod from the plate to the work piece. Call for the current to be switched off. Apply firm pressure to the tip to keep the maximum heat in direct contact with the material to be cut. In ship work, the rod may be angled or bent up to 90 degrees to prevent damage to the hull, shaft or stern tube. On wire rope the 1/4" diameter rod may be used for finer cut control. When using the 1/4" rod, continuous metal to metal contact is necessary to maintain rod ignition.

Using 3/8" Broco Underwater Ultrathermic Cutting Rods with a Battery

Note: Use of a battery power source is not recommended for cutting at depths below 60 fsw.

A vehicle or boat battery (12v or 24v DC) may replace a welding machine as the ignition power source. The use of a safety knife switch is recommended, although jumper cables may be used as the make/break connection. To preserve battery life, the tender must disconnect the battery immediately on the diver's command once the rod is ignited.

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