GUIDEBOOK TO UNDERWATER CUTTING

USING

THE PETROGEN OXY-GASOLINE CUTTING SYSTEM

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Introduction. The Petrogen System has a natural ability to operate under water. The gasoline fuel is kept liquid all through the system, into the cutting tip - where it vaporizes. The fuel expansion creates an extraordinary ability to maintain the preheat flame. The Petrogen torch can be buried in water, sand, earth and even mud without losing its flame. It is completely impossible for the torch to backflash up the fuel line because liquid gasoline is completely inert. A fuel-line backflash arrester is not required; in fact, its use must be avoided because it interferes adversely with the gasoline flow. DO install your oxygen backflash arrester.

The surface Petrogen torch, when first lit, emits yellow flames of incomplete fuel combustion for about 4 seconds. It takes those few seconds for the cutting tip to become warm enough to completely vaporize all the gasoline passing through the tip. Then the flame turns blue. This initial heat is provided mostly by radiation back from the work piece, by convection through the ambient air, and by direct conduction from the flame into the copper shell of the tip.

When underwater, radiation and convection are absent and conduction through the tip shell is thwarted by ocean temperatures. The result is that fuel vaporization is not complete, and a great deal of potential heat does not get delivered to the steel. It is necessary to find a new way to keep the tip warm enough to vaporize all the gasoline and deliver all the latent heat.

Underwater Shroud (tip nut + locknut + heat sink). The problem is solved by enclosing the tip in a metal blanket - or heat sink. This close-fitting heat sink permits the tip to retain most of the heat being delivered by conduction from the flame area. That heat is sufficient for total fuel vaporization.

The heat sink also serves as an adjustable stand-off, held in the desired location by the locknut. The shroud is to be used only underwater; cutting on the surface with the shroud can destroy the heat sink if not careful.

Underwater Torch. Our standard underwater torch is similar to our surface torch with the following exceptions: Its length is only 14 inches (36 cm). This short length permits easy one-hand operation. If the nature of your work permits two hands on the torch, we recommend you use one of our longer models. Any of our torches will work well underwater. For controlling the cutting oxygen we use a short over-center lever, thumb operated. Push forward and it's on; pull back and it's off; press down and it functions in a spring-loaded manner. The handwheels for preheat oxygen and gasoline are extra large for easy operation.

Tank. The tank is an ASME coded tank, built to standards for unfired pressure vessels. It is tested at a working pressure of 100 psi (710 kpa), with a large safety factor. Wall thickness is .092" (2.5 mm).

Underwater Cutting Tips. We have 3 sizes of tips. The smallest (81) is for thin steel; (83) for medium steel; and (77) for thick steel. Standard tip size 7 can be used instead of no. 77. See the cutting chart for details.

Filler Cap and Pressure Relief Valve. The filler cap in the tank contains a pressure relief valve. For surface operation the relief valve is set at 35 psi (245 kpa). For underwater operation relief pressure is set at 100 psi (710 kpa).

Air Hose. This is for delivering air from your air compressor (or Air Carry Tank - part 2365) to the gasoline tank. We supply the same hose and fittings as our oxygen hose, part 3112. One end fits into your air source and the other end fits into the air regulator.

Oxygen Hose. We use 5/16", single braid, type "S", grade "T". This is the highest quality, resistant to oil, fire, and abrasion. The fittings are standard CGA size "B" oxygen nuts. This hose is rated at 200 psi (1410 kpa) and can be used to depths of 100 feet. For working at greater depths, use 3/8" hose rated at 400 psi (2820 kpa)

Gasoline Hose. We use Gates 19B, 2-braid, 1/4". The fittings are standard acetylene CGA size "B". Rated pressure is 315 psi (2220 kpa).

Oxygen Backflash Arrester. PURGING THE OXYGEN LINE BEFORE IGNITING SHOULD ELIMINATE OXYGEN BACKFLASHES. However, in order to increase the safety margin, we furnish the arrester as standard equipment.

Underwater Igniter. The Petrogen underwater torch can be ignited underwater with our specially designed electric sparker. This igniter will generate voltage while submerged but requires an open, dry space at the sparking area. This open space is provided by the oxygen bubble coming from the cutting tip. Hold the spark end completely inside the heat sink and open the oxygen preheat valve; the amount of opening is a matter of experience. Too much or too little preheat oxygen will make ignition difficult. Activate the igniter and gradually open the torch gasoline valve until the mixture ignites. Open the gasoline valve an additional 1/4 turn; at this position the preheat flame is close to optimum balance.

Oxygen Pressure Regulator - Surface Station. Part number 3130, single stage with secondary gage reading to 400 psi, will deliver to 250 psi. With 250 psi oxygen, cutting can continue down to 400 feet..

Stem Adapter, American Oxygen Regulator to British Oxygen Bottle. This permits our American regulator to fit a British oxygen bottle. We are not able to offer adapters for metric bottles because of the excessive number of metric specifications.

FAMILIARIZATION PROCEDURE

Some Suggested Steps to Help You Get Started:

1. Set oxygen pressure at 60 psi (420 kpa)
2. Set Gasoline pressure at 25 psi (180 kpa)
3. Screw in the heat sink until the distance from the end of the copper shell is about 1/16 inch (2 mm) below the flat surface of the heat sink. Secure this position with the locknut.
4. VERY IMPORTANT (FOR ALL TORCHES): BEFORE LIGHTING, DEPRESS CUTTING OXYGEN LEVER TO CLEAR OXYGEN LINE OF FUEL FUMES.
5. Ignite the torch above water. You can practice underwater ignition later, after you first master basic cutting.
6. Adjust the preheat flame so that the inner blue core is just barely firm (a little extra would make the flame shake). Your surface cutting experience will help you recognize when you have a good flame adjustment. The end of the blue core should extend about 1/16 inch (2 mm) past the flat surface of the heat sink.
7. Underwater, It is harder to ignite steel on an edge, so start practicing in the middle by punching a hole. To ignite the steel, press the heat sink to the steel and wait about 10 seconds. A sudden large increase in orange light will indicate ignition and you may then press the cutting oxygen lever.
8. Keep practicing ignition by making very small changes in fuel and oxygen valve adjustments, and in the angle of the heat sink to the steel.
9. Now practice cutting by getting ignition and moving the torch in a straight line. KEEP THE HEAT SINK PRESSED TO THE STEEL. - either flat or at an angle, as you develop technique.
10. As you cut the steel, move the tip back and forth in a short sawing motion to prevent the heat sink from sticking to the burning steel and to maintain ignition. As you improve, you will not have to use this sawing motion and you will cut faster.
11. The heat sink is slightly beveled to permit the torch to ride over surface irregularities. If necessary, you can grind a larger bevel on the heat sink.
12. When cutting thick steel and starting in the middle, remember to slightly lift the tip from the steel in order to permit erupting steel to clear the area until full penetration is achieved.
13. Try to increase your cutting speed. The faster you cut, the better will be the quality of the cut.
14. CAUTION - WHILE LEARNING IN THE TUB YOU WILL SURELY RELEASE SOME UNBURNED GASOLINE. FUMES WILL ACCUMULATE AT THE SURFACE OF THE WATER. YOU MUST FREQUENTLY SET FIRE TO THOSE FUMES IN ORDER TO AVOID A LARGE ACCUMULATION.. IF YOU FAIL TO DO THIS YOU MAY GET A FLASH THAT MIGHT BE HAZARDOUS. After adequate training, you should operate without fuel spillage.
15. Now you can experiment with your electric underwater igniter and develop your technique for underwater ignition.

The Proper Preheat Flame is Your Key to Good Cutting. You will have problems if the flame is too large or too small; or too rich or too lean. It must be the right size and the right balance. A proper flame will ignite steel in 7 seconds. If you do not get ignition in 10-12 seconds you must take one of the following 8 actions.

1. more gasoline
2. more oxygen
3. less gasoline
4. less oxygen
5. more gasoline and more oxygen
6. less gasoline and less oxygen
7. more gasoline and less oxygen
8. less gasoline and more oxygen

With all these variables, it is best to start out with one constant: that constant is the opening of the preheat oxygen valve. If the opening is right, achieving the proper flame will be easy. That first estimated opening of the preheat oxygen valve depends on several things: the depth of the tip inside the heat sink; the angle you hold on the torch head; oxygen pressure at the regulator; tip size.

When trying to ignite the steel, keep the heat sink almost flat, with a tilt upwards in the direction of travel. Do not press the cutting lever until you see a bright orange glow and you are sure you have ignition. If you press too soon, the oxygen cools the steel and you must start over again. If you do not get ignition in 10-12 seconds, you must change something about the preheat flame. You will know you are cutting steel when you see a bright orange fireball and hear loud crackling.

You are now cutting steel. You must continue to cut or you will lose ignition. If you go too fast or too slow you will lose ignition. If you find that other considerations require you to move ahead slowly, you can still maintain ignition by cutting in a sawtooth pattern, back and forth across your line of direction. This keeps the steel lit without moving ahead very fast. Getting ignition on the edge of a steel plate presents a problem: much of the heat spills off the edge and does not heat the steel, making ignition difficult. To cut the edge, punch a hole near the edge and then cut towards the edge; then resume the cut in the other direction.

C. Practice Underwater. At first, go down only a few feet so you can quickly surface in order to communicate with your surface tender. Fix a piece of steel on which to practice. Go through the same practice procedure that you followed in the tub of water. IMPORTANT: PURGE OXYGEN LINE BEFORE IGNITING, BY DEPRESSING CUTTING LEVER FOR 4 SECONDS. As you work deeper, observe the new requirements for oxygen and gasoline pressures, hose lengths, and oxygen hose diameters.

CAUTION: TOO RICH A FLAME MAY SEND GASOLINE TO THE SURFACE. LOCAL SURFACE ENVIRONMENT MAY CREATE A POTENTIAL FOR HAZARD.

Hydrogen Hazard Underwater. All underwater cutting, burning and welding

Hydrogen Hazard Underwater. All underwater cutting, burning and welding generates hydrogen. At a critical temperature of about 700 degrees F. water can dissociate and reform and produce hydrogen. The amount of hydrogen depends on the temperature, on whether the heat is supplied by electric arc or by hydrocarbon fuel, and if there is any catalytic action generated by the material being burned. Different methods generate different amounts. The chemical nature of hot steel (and many other metals) coming in contact with water will dissociate the water molecule and produce hydrogen. Additionally, there are two other underwater processes that generate hydrogen:

1. Electric arc will dissociate the water molecule through the process of electrolysis.
2. If burning rods are used as fuel, the heat and metal will also react with water and increase the amount of water dissociation.

Hydrogen accumulation is dangerous. Be sure to know and employ all the operating techniques necessary to vent off the gases and eliminate their accumulation.

OPERATING PRESSURES

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Weight of sea water: 63.93 pounds/cubic foot
Weight of fresh water: 62.40 pounds/cubic foot
Weight of gasoline: 46.37 pounds/cubic foot

Gasoline Pressure. Gasoline weight will counteract 72.5% of sea pressure (74.5% of fresh water). The surface gasoline tank needs only 27.5% of sea pressure to equalize. In order to operate, the torch needs gasoline delivered at 20 psi. Our charts are set to deliver gasoline pressure of 25 psi to the torch. Therefore, gasoline tank pressure must be 25 psi plus 27.5% of depth pressure.

Oxygen Pressure. The Oxygen regulator at the surface must be set at depth pressure plus the operating pressure required by each tip.

OPERATING TABLES - ENGLISH MEASURE

TABLE NUMBER 1: CUTTING CHART

steel (in.)	tip size	oxygen bottle p.s.i.	gasoline tank p.s.i.
0-1	81	depth + 60	27.5% depth + 25
1-3	83	depth + 80	27.5% depth + 25
3-up	77	depth + 100	27.5% depth + 25

TABLE NUMBER 2: SAMPLE PRESSURES

depth feet	depth press.	oxygen bottle (81)	(83)	(77)	gasoline tank p.s.i.
	p.s.i.	p.s.i.	p.s.i.	p.s.i.	
10	4	64	84	104	26
20	9	69	89	109	27
30	13	73	93	113	29
40	18	78	98	118	31
100	44	104	124	144	37
200	89	149	169	189	62
400	178	238	258	278	74
655	290	350	370	390	100 (max)

TABLE NO. 3: DEPTH LIMITS FOR EQUIPMENT COMPONENTS

depth limit (ft)	part	working psi of component
2435	3010	315 - gasoline hose
680	3115	400 - 3/8 oxygen hose
300	3112	200 - 5/16 oxygen hose
655	2001	100 - tank
655	2360	100 - air regulator
655	2211	100 - tank air pressure gage
655	2151	100 - filler cap relief
400	3130	250 - oxygen regulator

OPERATING TABLES - METRIC MEASURE

TABLE NO. 1: CUTTING CHART

steel (cm.)	tip size	oxygen bottle kpa	gasoline tank kpa
0 - 2.5	81	depth + 420	27.5% depth + 180
2.5-7.6	83	depth + 560	27.5% depth + 180
7.6 -up	77	depth + 710	27.5% depth + 180

TABLE NO. 2: SAMPLE PRESSURES

depth	depth press.	oxygen bottle			gasoline tank
		(81)	(83)	(77)	
meters	kpa	kpa	kpa	kpa	kpa
3	30	450	590	730	185
6	60	490	630	770	195
9	90	510	660	800	205
12	130	550	690	830	215
15	160	580	720	860	225
30	310	730	870	1020	265
60	630	1050	1190	1330	350
90	940	1360	1500	1640	440
120	1250	1680	1820	1960	520
200	2040	2470	2610	2750	710 (max)

TABLE NO. 3: DEPTH LIMITS FOR EQUIPMENT COMPONENTS

depth limit (meters)	part no.	working kpa of component
740	3010	2220 - gasoline hose
210	3115	2820 - 3/8 oxygen hose
90	3112	1410 - 5/16 oxygen hose
200	2001	710 - tank
200	2360	710 - air pressure regulator
200	2211	710 - tank air pressure gage
200	2151	710 - filler cap relief
200	3130	710 - oxygen regulator

CONTENTS OFC37 57S OF

CONTENTS OF

COMPLETE PARTS & TOOL KIT
PART NUMBER 5100

7	UW cutting tip - heavy steel to 5"
81	UW cutting tip - light steel to 1"
83	UW cutting tip - medium steel to 3"
1300	preheat oxygen valve
1350	high pressure oxygen valve
1356	external O-ring for high pressure oxygen valve (6)
1357	internal O-ring for high pressure oxygen valve (6)
1401	lever assembly with nut and screw
1650	oxygen hose connector
1651	gasoline hose connector
1800	mixer with wick and 0-rings
1802	wick (2)
1810	tip nut for surface cutting
2157	filler cap gasket
2300	complete hand pump assembly
2306	pump check valve seal
2327	leather pump cup
4011	packing nut wrench (2)
4012	tip reamer (2)
4013	tip brush (2)
4016	jackscrew (2)
4017	installation tool for 0-ring 1357
4018	tip cleaner set (tip drills)
4019	hex wrench for torch hose connectors
4020	spark striker (flint type)
4021	extra flint
5023	extra heat sink
5101	large plastic tool box
5102	1-1/2" wrench for shroud assembly (2)

TANK AIR PRESSURE REGULATOR (PART 2360)

INSTALLATION

1. Remove hand pump from tank:
   a. Release tank pressure by opening filler cap.
   b. Remove screw cap and pump shaft.
   c. Use a large wrench to remove pump cylinder from tank.

2. Using large wrench, install regulator adapter (part 2350). This part is recognizable by a steel ball check valve on the "inside", and a male 1 inch pipe thread on the outside.

3. Install the air pressure regulator into its adapter:
   The regulator has a fitting installed into the "out" port of the regulator. The fitting ends in a male 1/4" pipe thread.
   Insert this fitting into the adapter and turn snug.

4. The tank filler cap (part 2151) should have a "100" stamped on the handwheel. If the filler cap has no stamp, it is our standard 35 psi cap (part 2150) and must be replaced by part 2151.

OPERATION

1. With the air hose, connect the air regulator to your air compressor (or Air Carry Tank)). The regulator has a fitting in the "in" port that is our standard oxygen/air male fitting.

2. With the air line to the compressed air source open, adjust the tank pressure:
   a. Pull out the yellow knob.
   b. Turn clockwise to increase tank pressure.
   c. When desired pressure is reached and stabilized, push in the yellow knob to lock.
   d. To reduce tank pressure, pull out yellow knob and turn counter-clockwise, slowly. When desired pressure is reached, push in yellow knob to lock
   e. After tank pressure is stabilized, there may be some air escaping from the small weep hole in the regulator. This a regulator characteristic. If operating from an air compressor there is no problem but if operating from an air carry tank that leakage will soon empty the air reservoir. To operate from an air carry tank without losing air capacity, place a piece of duct tape over the weep hole. When increasing tank pressure there is no effect from the tape. When reducing tank pressure, remove tape so that pressure can exhaust. When pressure is stabilized replace the duct tape.

3. When reducing tank pressure, turn yellow knob very slowly . Reducing pressure too fast can set the check valve in the adapter and stop any further pressure:-.e.