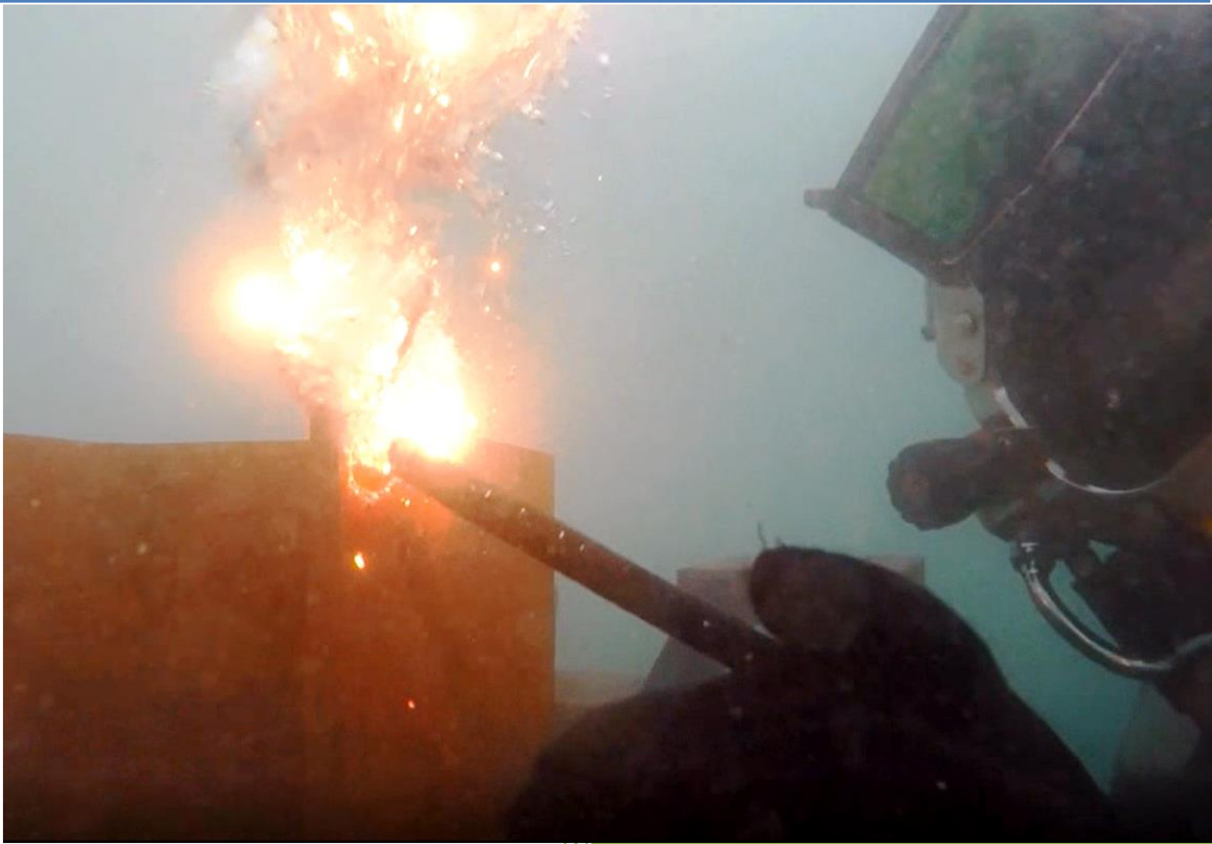
2019

INFLUENCE OF OXYGEN PURITY IN UNDERWATER CUTTING



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My thanks to OCTO Diving for the technical assistance and the provision of the material necessary for the realization of these tests as well as to Emmanuel Brisack and his diving team for their quick reactions regarding the parameters of oxygen consumption rates

Abstract
Whether on the surface or underwater, to burn and turn into iron oxide, a metal (iron) needs some supply of pure oxygen.
In order to obtain a maximum efficiency, most manufacturers of cutting material as well as some cutting manual's advice to use an oxygen purity of at least 99, 5 %, and predict that it is impossible to cut as soon as the purity of oxygen becomes equal to or less than 95%.

Is it a myth or a reality?

Introduction
Cutting with thermal electrodes (also called ultra or exothermic) is currently the method most used by commercial divers.
As a reminder, it is done by using a small hollow electrode into which passes a jet of oxygen under pressure.
These electrodes are generally composed of a thin outer steel or copper envelope into which is crimped a series of metal wires, Among these, one is composed of a special alloy which allows an exothermic combustion to reach a temperature close to 5500 ° C (10000 ° F).
In order to function properly, some manufacturers [1, 2] of cutting equipment and electrodes as well as various cutting manuals [3.4] stipulate that oxygen must be used with a degree of purity of at least 99.5%. Below this value, efficiency as well as cutting speed would decrease by about 25% per percent impurities and therefore they predict that cutting becomes impossible with oxygen equal to or less than 95% purity.
At first glance, this may seem logical because to burn, 5 grams of steel needs about 10 litres of oxygen molecules and therefore if we decrease the quantity of molecules available in the flow under pressure, we will automatically change the combustion parameters.
But are the mentioned values accurate?
One may ask the question and this especially since in 2018 when an American colleague told us that for some of his cuts he diluted oxygen with compressed air and then cut with a mixture O_2 / N_2 close to 60/40.
Being somewhat sceptical, we therefore proceeded in May of that same year for a first cutting test above water with a mixture containing only 70% of oxygen[5] and to the general surprise, the results were convincing, since this low percentage of oxygen still allowed cutting.
Of course, the cutting performance was well below that obtained with pure oxygen, but one could therefore ask the question of what this degree of purity would give under water.
This year, thanks to the technical assistance of the Belgian company OCTO Diving, various cutting tests were carried out with the aim of verifying if under water a mixture of depleted oxygen could still cut steel.
The answer is in the following pages.

Date of the tests

- April 20, 2019

Place

- Water tank of OCTO Diving

Depth

- 3 m

Visibility

- Good

Thickness metal piece

- 10 mm

Current intensity

- 150 & 0 Amps (Hot & Cold)

Oxygen pressure

- 7, 3 bars

Type of rods

- Broco (rod A) and two European rods (rods B & C).

Length used by each electrode

- 37 cm

Cutting mixtures

- Pure O_2, 95/5 & 75/25

Cutting technique

- Pushing the rod with the helmet away of the cut.

Diver's experience with cutting

- Very good but had no longer dived since 2013 and cut since 2005 and so it can be estimated that with a little more practice the performance shown on the graphs could be higher.

RESULTS

With pure oxygen

- The author burned a first electrode in order to get his hands back before recording the results of the second electrode.

With the 95% oxygen purity

- The diver has hardly felt a difference in combustion of the electrode or in the steel compared to pure oxygen.

With the 75% oxygen purity

- Impossible to cut without current (cold).
- Cutting virtually impossible with both European electrodes.
- Difficult cutting and frequent extinction of the flame with the Broco electrode.
- Appearance of the cut rather erratic.
- Production on the surface of a very white and very toxic smoke in place of the classic brown fumes.

With the 70% oxygen purity

- Not made given the poor results obtained with the previous mixture.

Chart n° 1: Electrode cutting length (the green bar represents the 2018 test)

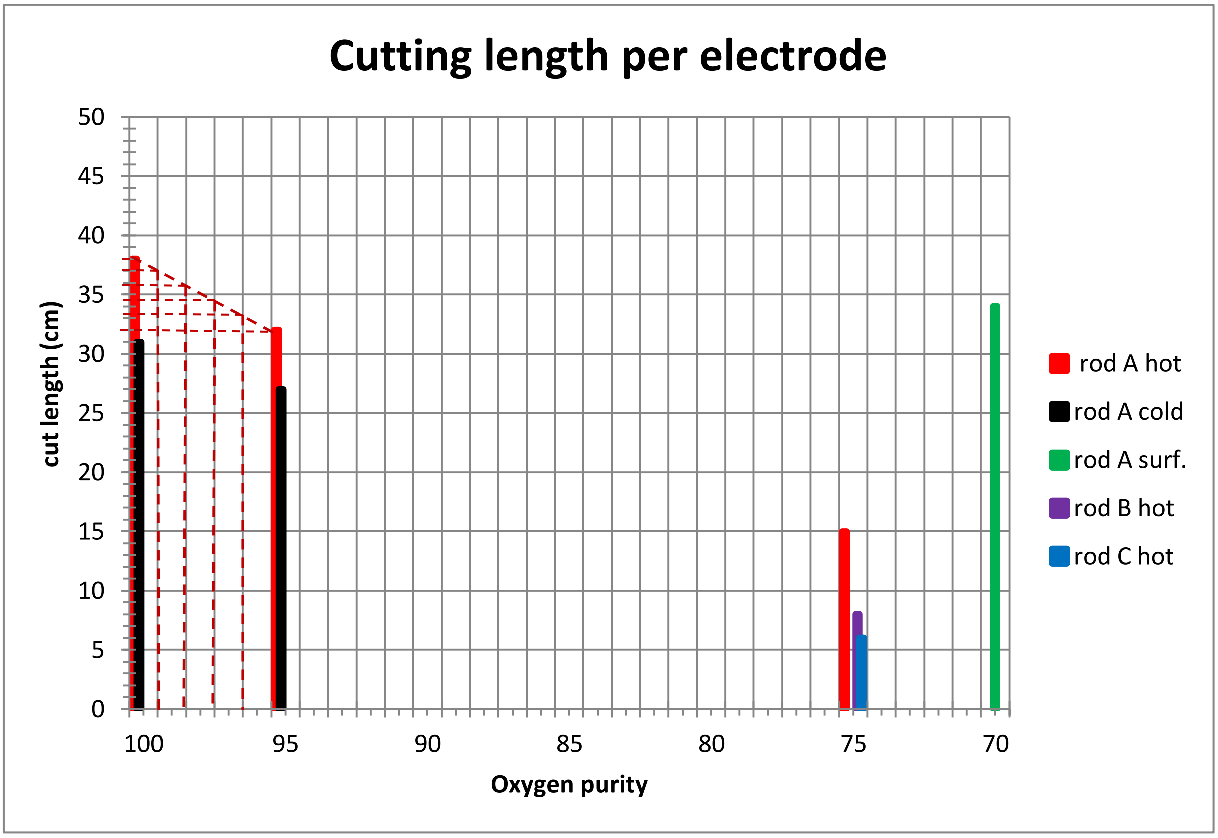
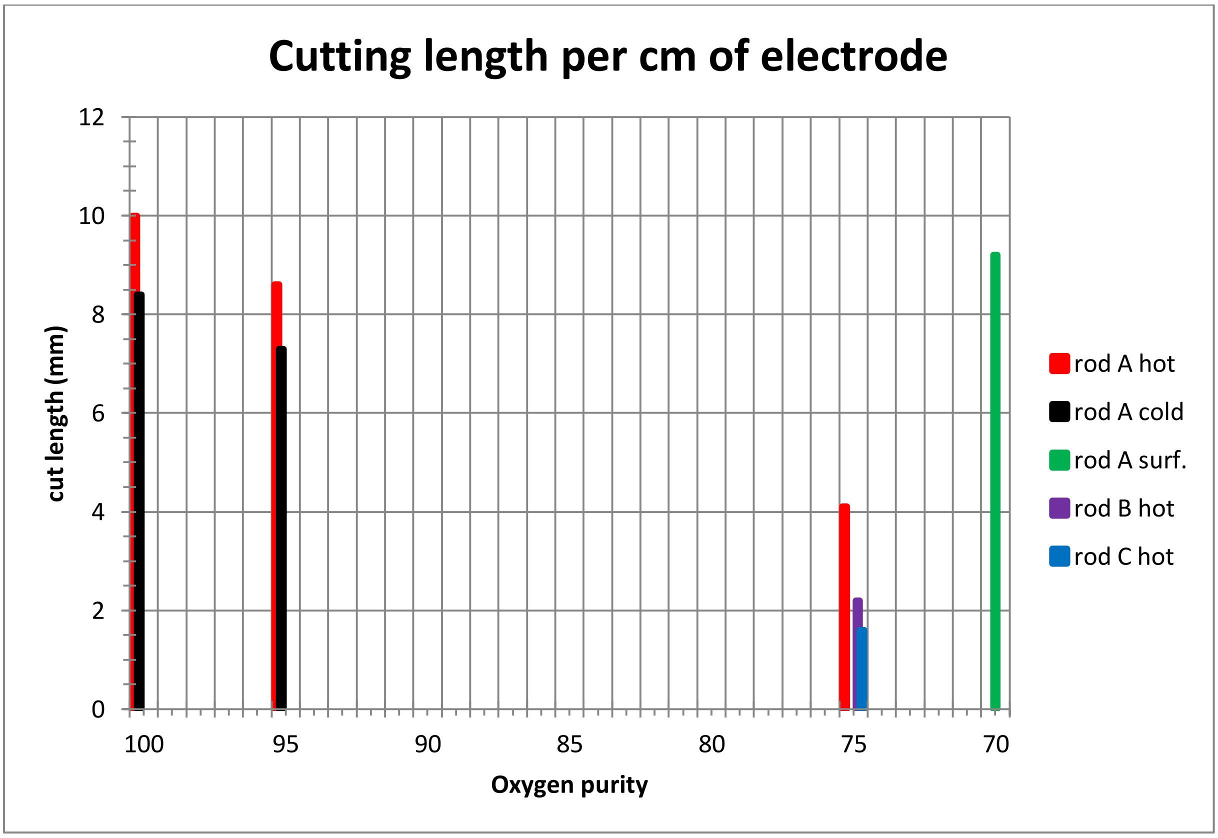
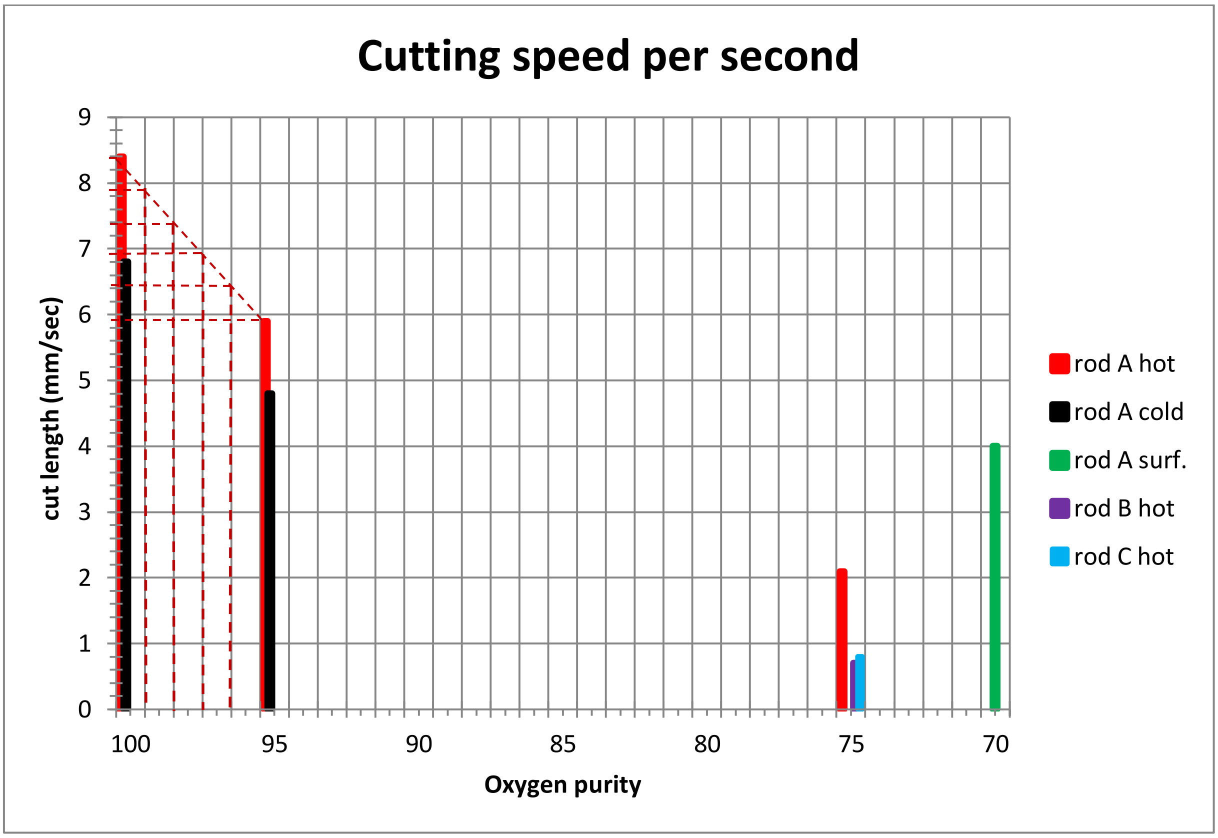


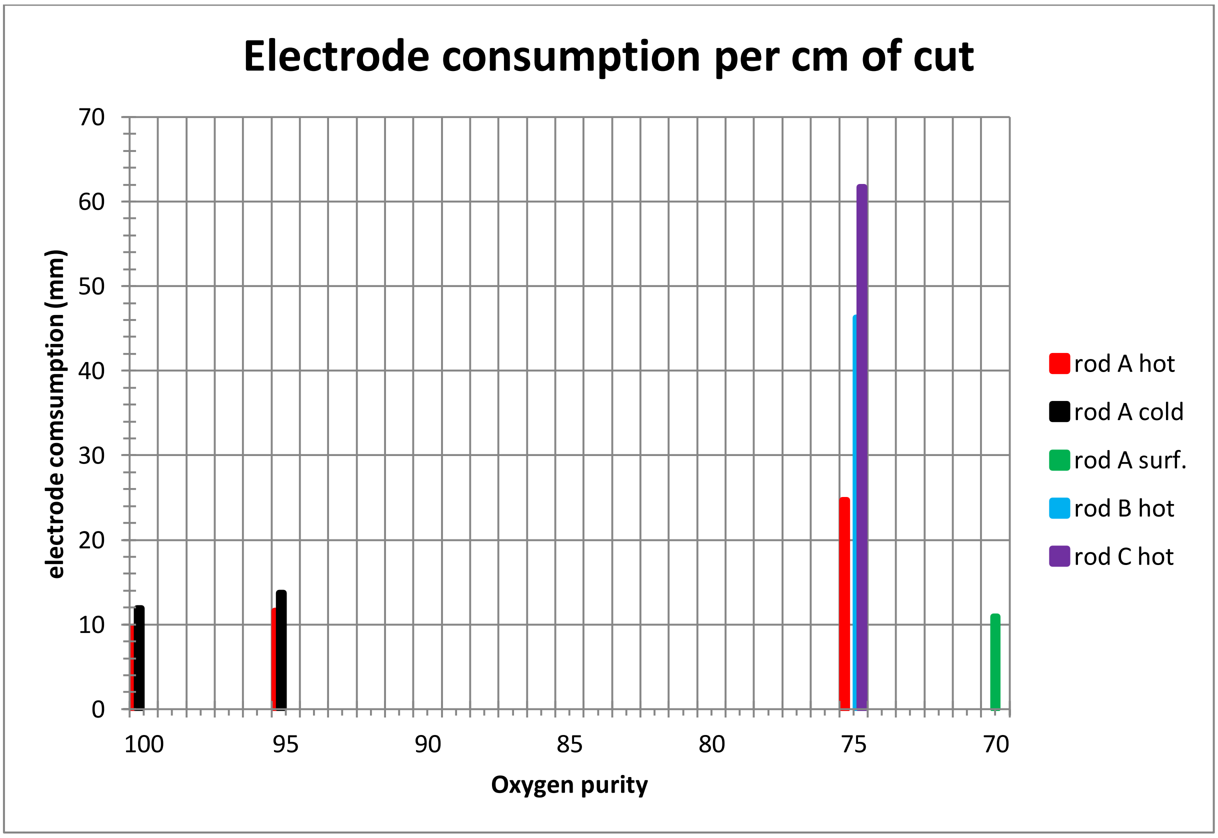
Chart n° 2: Cutting length per cm of electrode (the green bar represents the 2018 test)



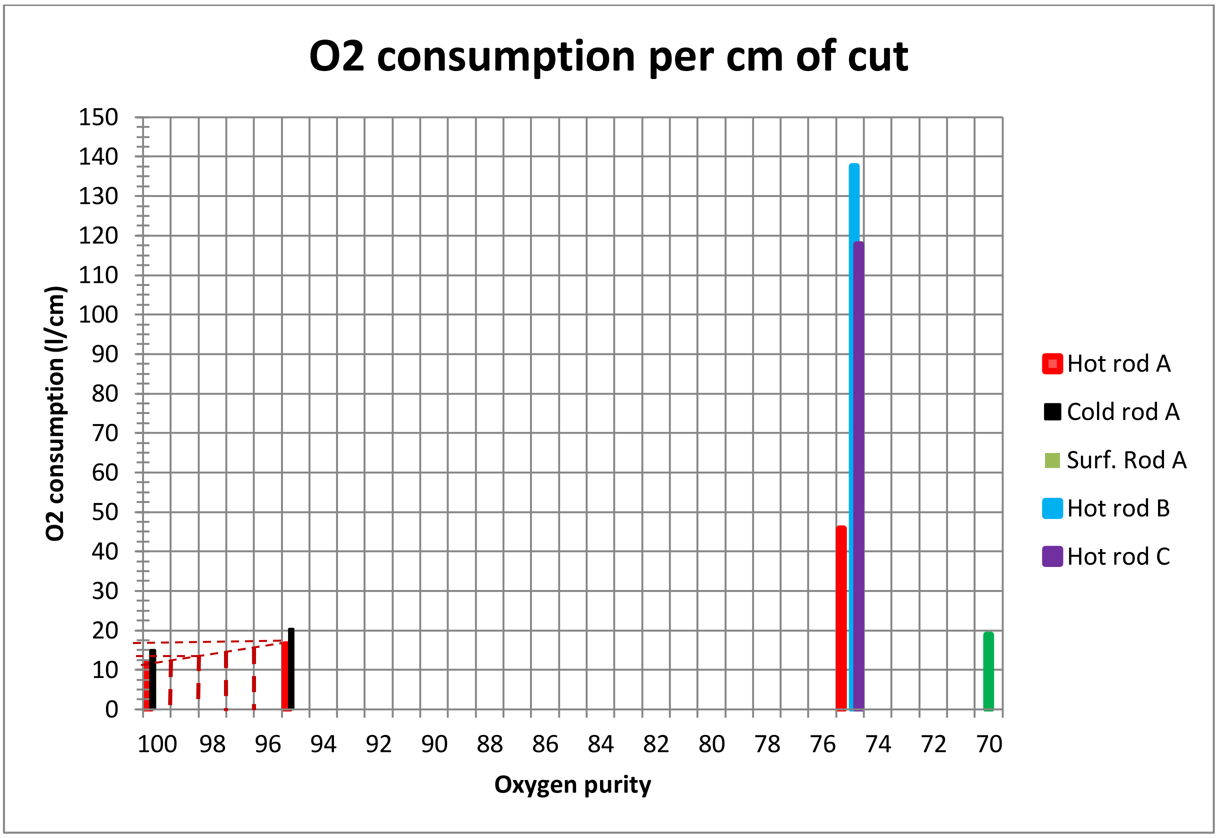
Graph n° 3: Cutting speed per second (the green bar represents the 2018 test)



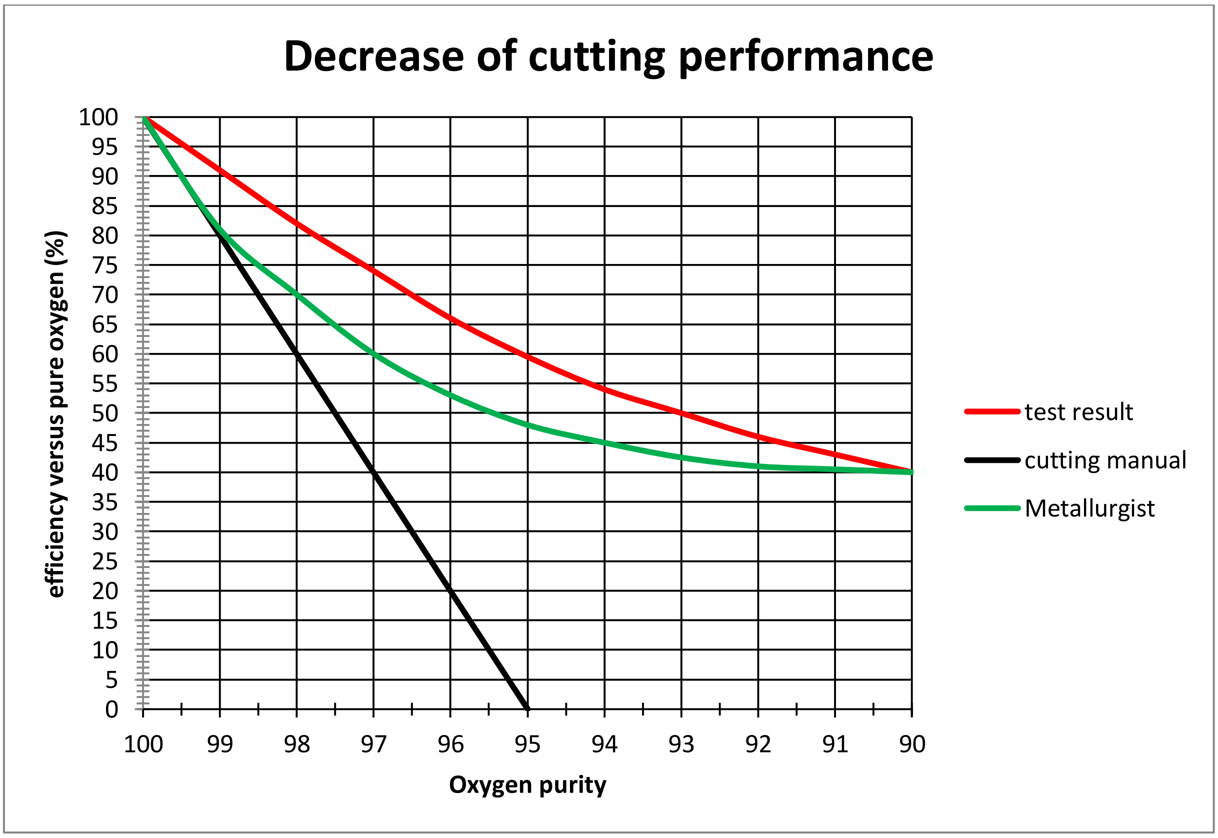
Graph n° 4: Electrode consumption per cutting cm (the green bar represents the 2018 test)



Graph n° 5: O2 consumption per cm of cut (the green bar represents the 2018 test)



Graph n°9: Decrease cutting performance



By using the graphs, depending on the degree of purity, we can extrapolate the parameters and estimate the consumables and the time required to make a cut (see example table n ° 1).

Table n ° 1: Prevision of consumables on a cutting length of 10 m

Purity (%)	Nb electrodes (u)	% +	Cutting time (min)	% +	O2 consumption (l/cm)	% +
99,9	26,3		19:50		11,6	
99	27	2,66	21:05	7,94	12,6	8,6
98	28,6	8,74	22:31	14,41	13,6	17,2
97	29	10,26	24:09	23,53	14,6	25,9
96	30	14	26	33,33	15,6	35,5
95	32	21,67	28:14	44,3	16,6	42,2

Conclusions

As can be seen by reading the various graphs and table, it is always better to use high purity oxygen in order to obtain a maximum yield, but the presence of a few tenths of a percent of impurity in oxygen is not likely to strongly modify the cut.
For example, if we compare 99.9% and 98% on a 10 meter section, the loss of efficiency is not very important.
It is also noted that the regression curve announced by the electrode manufacturers as well as in the manuals does not correspond to the reality that appears in the various graphs and in the table.
In addition, tests done with 95% demonstrated that there was no difficulty in cutting with this oxygen content.
By way of comparison, the regression curve established by metallurgists[7] after some gas torch cutting testing has been added to graph n° 6.
It is observed that it decreases more rapidly than the curve calculated from the tests.
This reduction is mainly due to the difference in the flame temperature of the cutting tool used, which as it should be recalled, is linked to the combustible gas and does not generally exceed 3500 ° C (6332 ° F).
With regard to cutting under water, it is safe to say that a variation in the percentage of purity will be more quickly felt when using an underwater gas burning torch than with thermal electrodes.
Finally, these tests allowed noting that contrary to what some thought, the depth of water and therefore the increase of the partial pressure of the oxygen in a depleted mixture did not improve the cutting performance in comparison with this same mixture on the surface. Quite the contrary since in the present case we saw that underwater the limit of the percentage of oxygen still allowing cutting was 75%, while that on the surface the 70% could still cut (relatively) well.
The idea of using a mixture of depleted oxygen at great depth is therefore not exploitable

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