Pr14143 Essential requirements applicable to Oxygen sensors

1 Scope This European Standard specifies minimum requirements for self-contained re-breathing diving apparatus to ensure a minimum level of safe operation of the apparatus. It applies to the following: a maximum depth of 6 m for apparatus using pure oxygen; - a maximum depth of 40 m for apparatus using oxygen in nitrogen gas mixtures; - a maximum depth of 100 m for apparatus using oxygen and helium or oxygen, nitrogen and helium gas mixtures; water temperatures from 4°C to 34°C.	
Resistance to temperature.65 Testing at-20°C and +50°C 65 Testing after storage at - 30 °C and + 70 °C	[1]
5.6.7 Inhalation temperature The maximum inspired gas temperature shall be less than 45°C . Testing shall be done in accordance with 6.3.4.	
6.3.4 Inspired gas temperature Stabilise the temperature of the water in the test chamber at (34 ± 2)°C. Completely immerse the apparatus in water at a depth sufficiently deep to preclude surface effects, but not more than 6 m. This test shall be conducted at a ventilation rate of 40 I min-' and an associated carbon dioxide injection rate as per Table 4. Measure the temperature at the mouth with a temperature probe having a response time of less than 150 ms to 95 % of the step change. The temperature monitoring shall be continued until steady-state inhaled temperature is achieved.	
5.7 Gas control or supply system **5.7.1** Inspired partial pressure of oxygen The apparatus shall under all conditions of use specified by the manufacturer maintain an inspired partial pressure of oxygen greater than 0,20 bar. The inspired partial pressure of oxygen shall remain within the limits specified by the manufacturer. The inspired partial pressure of oxygen shall also be maintained at a partial pressure of less than or equal to 1,6 bar; except during the descent phase(s) and initial bottom time of a dive for a period not greater than 1 min where it may increase to a maximum of 2,0 bar.	

1 This is outside the normal and historic specification of oxygen sensors.

Pr14143 Essential requirements applicable to Oxygen sensors

In the event of a failure of an automatic system provision may be made for the addition of respirable gas by the diver. If fitted this shall also be able to satisfy the inspired partial pressure of oxygen requirements of this clause. Where the inspired partial pressure of oxygen is not maintained automatically, the following additional requirements shall be fulfilled: The system shall have a minimum continuous flow of oxygen into the breathing circuit of 0,6 I min-' STPD; The system shall have at least one inspired partial pressure of oxygen monitor with an alphanumeric display; The system shall have at least one active warning device for minimum and maximum permitted oxygen partial pressures. The minimum warning level shall be 0,4 bar or greater. The maximum warning level shall be less than or equal to 1,5 bar; Provision shall be made for the addition of gas by the diver at all times during the dive to both increase and decrease the partial pressure of oxygen in the apparatus. Testing shall be done in accordance with 6.2, 6.7 and 6.15.	
6.2 Visual Inspection	
6.7 Inspired oxygen level Prior to testing the test house shall decide with the manufacturer the relevant point(s) on either the facepiece or the inhalation hose from which the sample(s) shall be taken. Using the conditions identified in 6.6.1 and 6.6.3 record the inspired partial pressure of oxygen at the agreed sample points. When testing inspired oxygen levels, the dive profile shall be conducted with a descent rate of 30 m min-' and an ascent rate of 20 m min-	
6.15 Practical performance 6.15.1 General For reasons of safety, practical performance tests shall be carried out only after all laboratory tests have been satisfactorily completed.	
5.7.2 Oxygen partial pressure setpoint maintenance in apparatus with a fixed oxygen partial pressure setpoint the inspired partial pressure of oxygen shall be maintained within ± 0,10 bar during constant depth phases of the dive. This at a ventilation of 40 I min-' and associated oxygen consumption of 1,78 I min-' Standard Temperature and Pressure, Dry (STPD).	[2]

2 The overall accuracy of the sensor to F.S,D is +/-1 % @ constant temperature and Pressure. The accuracy of the temperature compensation is nominally +/-5% of the reading
This can increase to +/- 7.5% in the first hour after the temperature has changed. The error is not constant during a temperature change,
At a setpoint of 1.3B 0.1b variation is 7.7% at 1.6B it is 6.26%.

Pr14143 Essential requirements applicable to Oxygen sensors

During the ascent phase the inspired partial pressure of oxygen may reduce to a minimum of 0,5 bar below the set point but shall regain steady state set point within 1 min of halting an ascent. When gas is injected into the breathing circuit the volume of oxygen added in 1 min shall be at least 6 I (STPD). 5.7.2 Testing shall be done in accordance with 6.7.	
6.7 Inspired oxygen level Prior to testing the test house shall decide with the manufacturer the relevant point(s) on either the facepiece or the inhalation hose from which the sample(s) shall be taken. Using the conditions identified in 6.6.1 and 6.6.3 record the inspired partial pressure of oxygen at the agreed sample points. When testing inspired oxygen levels, the dive profile shall be conducted with a descent rate of 30 m min-' and an ascent rate of 20 m min-	
6.6.3 Gas endurance Test the apparatus with the breathing simulator ventilating at 40 I min-' and oxygen being removed from the exhaled gas from the breathing simulator at a rate of 1,78 I min-'. Determine the time taken for any gas supply gas cylinder pressure to reach 50 bar, either by testing or a combination of testing and calculation.	
6.6.1 General Conduct all appropriate tests three times at the following depth conditions: a) with oxygen or oxygen and nitrogen gas mixtures at a pressure of 1,6 bar; b) with oxygen and nitrogen gas mixtures at the maximum dive profile (pressure and bottom time) specified by the manufacturer, if not specified at a constant pressure of 5 bar c) if required, with oxygen and helium or oxygen, nitrogen and helium gas mixtures at the maximum dive profile (pressure and bottom time) specified by the manufacturer.	
5.7.3.Alphanumeric display for inspired partial pressure of oxygen (if fitted)- The limit deviation of the oxygen partial pressure display shall be as defined in Table 0.1 to 0,4 | +/- 0.03 >0.4 to 2,0 | ± 0.6 Testing shall be done in accordance with 6.2 6.10.2 and 6.15.	[3]

3 See foot notes 1 & 2 on temperature changes

Pr14143 Essential requirements applicable to Oxygen sensors

6.2 Visual Inspection	
6.10.2 Monitor for inspired partial pressure of oxygen The partial pressure of oxygen in the inhalation hose shall be measured and compared with the indicated value. Test the oxygen partial pressure monitor by exposure to partial pressures of oxygen in the range 0,1 bar to 2,0 bar in increments of 0,2 bar. The monitor shall read within the limits given in Table 2. The oxygen partial pressure monitor shall be pressurised to 1,1 times the maximum stated depth with suitable gases to maintain constant partial pressure of oxygen of 0,2 bar and 2 bar respectively. The rate of pressurisation shall be 30 m min-'. The partial pressure of oxygen monitor reading shall be recorded at 10 m intervals. The partial pressure of oxygen monitor shall be held at 1,1 times of the maximum stated depth for a period of 1,5 times the maximum bottom time specified by the manufacturer. The oxygen partial pressure of monitor shall be decompressed using the stop depth specified by the manufacturer. The rate of ascent shall be 20 m min-' and the partial pressure of oxygen monitor held at each stop for a period of 2 mm. After a period of 1 min the indicated value shall be compared with the partial pressure of oxygen in the inhalation hose.	
5.9.3 Monitors for inspired gases 5.9.3.1 Monitor for inspired partial pressure of oxygen The apparatus may be fitted with a device that is independent of any oxygen control system to measure and provide warning to the user for high and low partial pressure oxygen levels. The partial pressure of oxygen displayed shall be to an accuracy as specified in Table 2. It shall have a maximum response time of 15 s to 90 % of a step change of oxygen partial pressure. The manufacturer shall demonstrate the independence of the device by the provision of a failure mode effect and criticality analysis (FMECA). Testing shall be done in accordance with 6.2, 6.7, 6.1 0.2 and 6.15. 5.9.3.2 Monitor for inspired carbon dioxide (if fitted) An inspired carbon dioxide monitor shall have a limit deviation under all conditions within ± 3 mbar. Testing shall be done in accordance with 6.2, 6.10.3 and 6.15.	
5.14 Resistance to temperature 5.14.1 Leakage The apparatus shall not leak or release gas when tested at temperatures of - 20 00 and + 50 00. Testing shall be done in accordance with 6.13.1. 5.14.2 Storage	

Pr14143 Essential requirements applicable to Oxygen sensors

Trouble free operation shall be ensured after storage at temperatures ranging from - 30 00 to + 70 00. Testing shall be done in accordance with 6.13.2. 5.15	
6.1.2 Nominal values and tolerances Unless otherwise specified, the values shall be subjected to a limit deviation of ± 5 %. Unless otherwise specified, the room temperature for testing shall be (22 ± 5) 00 and at a relative humidity of at least 50 %. The temperature limits shall be subject to a limit deviation of ± 1 00.	
6.15 Practical performance 6.15.1 General For reasons of safety, practical performance tests shall be carried out only after all laboratory tests have been satisfactorily completed.	
6.10.4.1 Inspired partial pressure of oxygen Test the active warning device by exposure to partial pressure of oxygen in the breathing circuit and check that the device activates within ± 0,05 bar of the warning levels.	
6.13 Resistance to temperature 6.13.1 Testing at -20 °C and + 50 °C Before performing the following test the apparatus shall, where required, be calibrated and shall be breathed from for a period of 5 minutes. Place the fully assembled apparatus, with cylinder valves closed and gas cylinders charged to 50 % of the rated working pressure and the electronic control, if fitted, switched off, in an environmental chamber and cool to - 20 °C for a period not less than 3 h. Open the cylinder valves, ensuring the apparatus is still at - 20 °C. Repeat the same test at + 50 °C.	
6.13.2 Testing after storage at - 30 °C and + 70 °C Before performing the following test the apparatus shall, where required, be calibrated and shall be breathed from for a period of 5 minutes. On completion of the above procedure (both - 30 °C and + 70 °C) for a period not less than 3 h allow the temperature of the apparatus to return to standard laboratory conditions. Switch on the apparatus and calibrate, if required. Test at a pressure of 1,0 bar and a ventilation rate of 40 I min-' with an oxygen consumption of 1,78 I min-' for the duration of the apparatus as specified in the manufacturers information, during which time the performance shall remain within the limits specified.	
Each of the test dives shall be conducted for at least 15 min or the maximum endurance of the apparatus as stated by the manufacturer.	