

AAN 006-06 INTRINSIC SAFETY INFORMATION FOR APPROVALS**Introduction**

Alphasense Oxygen sensors are electrochemical cells that produce small currents at low voltages. The purpose of this application note is to both detail the output at 20% and 100% oxygen and to examine the effects of possible fault conditions on oxygen sensors. Three conditions are reviewed:

- 1 Maximum output current during normal (“steady state”) use.
- 2 Maximum open circuit voltage that would occur if there was a fault in the instrument or when changing sensors.
- 3 Pulse behaviour of the sensor when going from open circuit to short circuit conditions.

It is useful to compare these worst case numbers with the definition of a simple apparatus as defined in BSEN 50014, Section 1 Clause 1.3. This section titled “General Requirements” states that:

“Devices in which, according to the manufacturer’s specifications, none of the values 1.2V, 0.1A, 20 μ J or 25mW is exceeded, need not be certified or marked.”

Steady State (Normal) Operation

Oxygen sensors were tested from 10-100% oxygen at 20°C. The output at 100% oxygen is typically 15 times the output at 20% oxygen. This type of oxygen sensor is non-linear, especially above 80% oxygen- see Application Note AAN 003.

Taking into account the output current increase with temperature (5% increase at 50°C), and including the 95% confidence interval, a maximum output current of 0.8mA at 20% oxygen and 15mA at 100% oxygen is reasonable. Although the 20% oxygen output current is independent of the load resistor, the output current at 100% oxygen is dependent on the load resistor. The worst case output current of 15mA is the extrapolated output current if the load resistor were less than 1 ohm which is a simulation of a PCB short circuit (typical applications use a load resistor between 10 and 100 Ω).

Maximum Open Circuit Voltage

The open circuit voltage was tested for eight sensors. The voltage of the sensor was measured with various load resistors from 1M Ω to 1G Ω . The sensors showed no apparent dependency on the load resistor and hence extrapolation to infinite resistance (open circuit) results in the open circuit voltage (OCV) listed in table 1. The open circuit voltage is independent of the oxygen concentration.

	Typical OCV	95% Confidence Max OCV
O2-A1/2/3, G1/2	0.7V	0.8V

Table 1. Open circuit voltage for Alphasense oxygen sensors.

Short Circuit Transient Behaviour

Sensors were tested for their transient performance when going from open circuit to short circuit at 20% and 100% oxygen. Sensors were tested with load resistors from 2.2 to 100Ω.

The peak voltage was monitored with an oscilloscope and the peak current and power subsequently calculated. The peak current was the same at both 20% and 100% oxygen, but with the important difference that at 20% oxygen the peak decayed rapidly within a few seconds to the steady state value. This decay time depended on the load resistor. However, at 100% oxygen, the peak value was found to be the same as the steady state value. This showed that the peak current represents a saturated state that is also achieved by supplying 100% oxygen to the sensor. Extrapolating from tests with load resistors between 2.2 and 100Ω to short circuit (0Ω load resistor) resulted in the output currents and power shown in table 2.

	Typical Short Circuit Current	95% Confidence Short Circuit Current	Max Power
O2-A1/2/3, G1/2	12mA	15mA	12mW

Table 2. Short circuit current and power for Alphasense oxygen sensors.

Summary

Table 3 below summarises these results and compares with BS5501 specifications. Alphasense oxygen sensors do not exceed the general requirement for a low power device that may not need to be certified or marked, depending on the application.

O2-A1, O2-A2, O2-A3, O2-G1, O2-G2

Measurement	Units	BS 5501	20.9% O ₂	100% O ₂
Maximum Current (steady state)	mA	-	1.4	15
Maximum Open Circuit Voltage	V	1.2	0.8	0.8
Maximum Current (short circuit peak)	mA	100	15	15
Maximum Power (short circuit peak)	mW	25	12	12

Table 3. Comparison of Alphasense oxygen sensor intrinsic safety performance with BS 5501.

NOTE: Alphasense O2-A2/3, O2-G1/2 oxygen sensors have lower output currents than the one year sensors and thus fall well within the requirements of BS 5501.