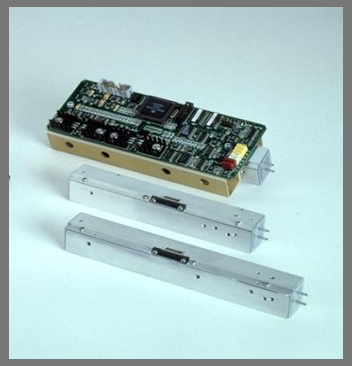
Fast Responding Oxygen Sensor

Aircrew hypoxia warning times can be reduced by perfecting laser diode absorption spectroscopy oxygen sensors for OBOGS monitoring.



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Pilot Hypoxia

- **Pilot hypoxia** can result in impaired judgment, loss of aircraft, and loss of aircrew.
- 22 aircrew hypoxia reports investigated by NAWCAD over 2 years.
- F/A 18C Class A mishap, May 2001, loss of pilot/aircraft, $30M cost of aircraft and site cleanup.

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Time Response Issues

- Time from loss of oxygen to pilot unconsciousness: 12 to 15 seconds.
- Zirconia oxygen sensor response: 30 sec. Long tail for large changes.
- Laser diode oxygen sensor response: 1 sec.

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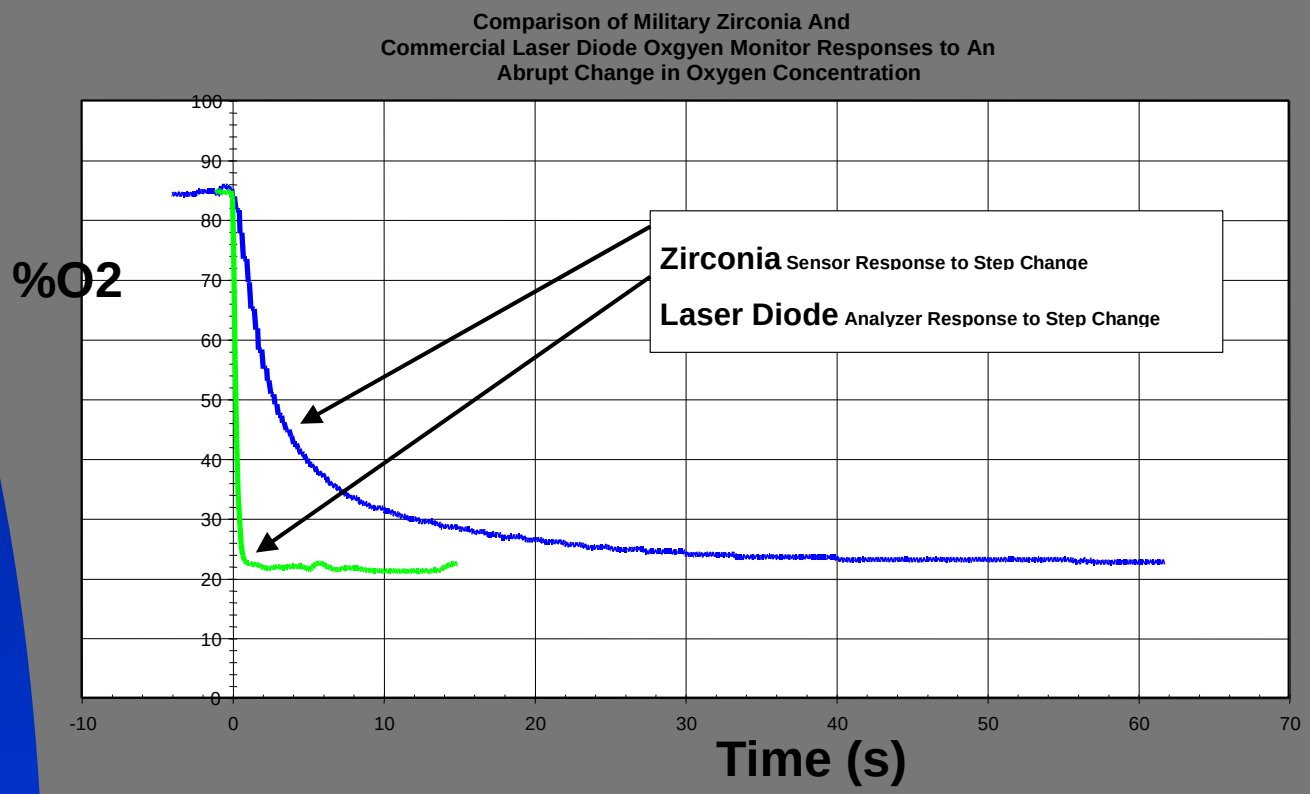
Zirconia vs Laser Diode Oxygen Sensor Time Response



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Pilot/Oxygen Time Response

- Gas sampling time OBOGS to sensor: 1 s
- Gas sensor: 1 s or 30 s?
- Signal data computers: 8 s
- Pilot issue acquisition time: ?
- Pilot reaction time: ?
- Automated backup oxygen turn on time: ?

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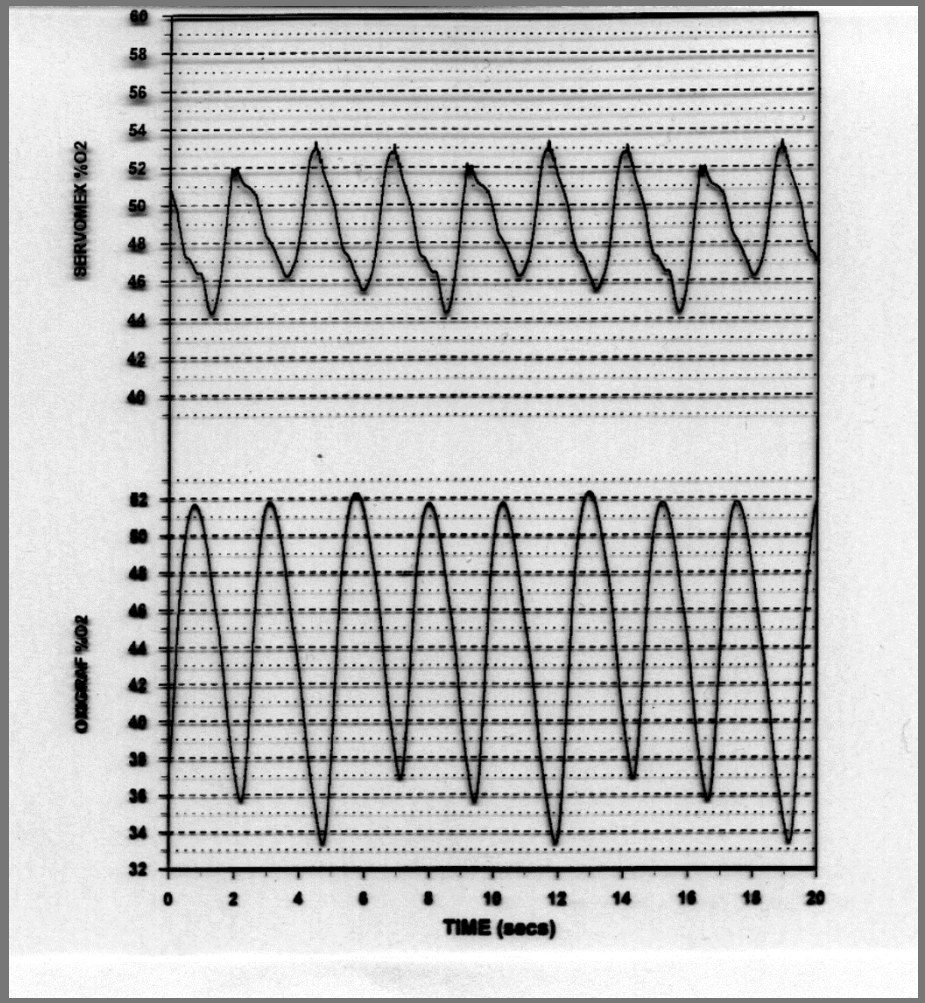
(OBOGS Cycle Time Resolution: LD vs Paramagnetic Analyzer)



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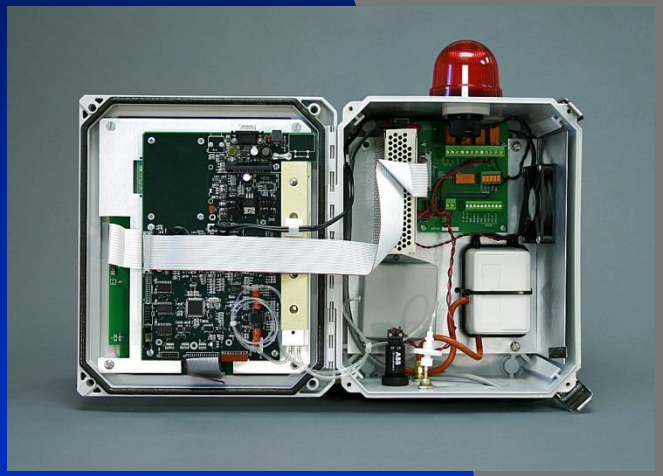
Lab Analyzer for OBOGS Systems

Industrial Oxygen Analyzer



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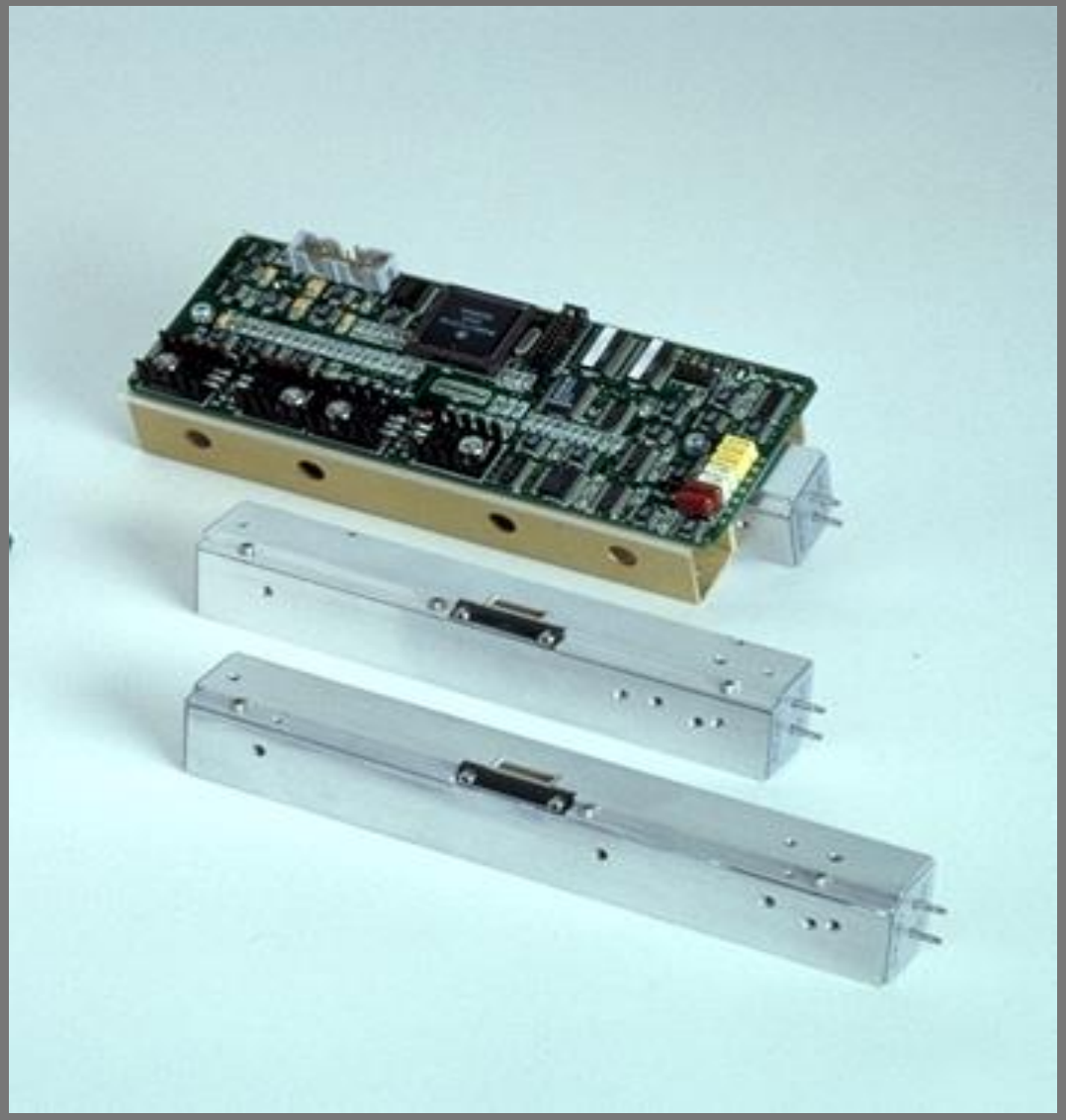
Laser Diode Oxygen Sensors



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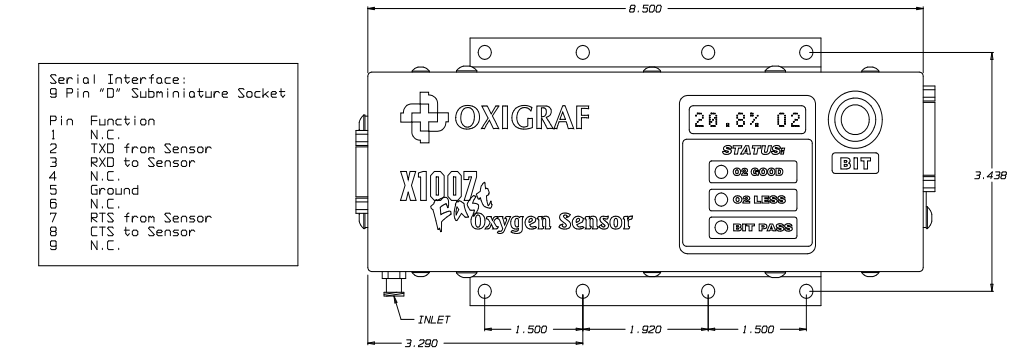
Aircraft Package 1st Gen.

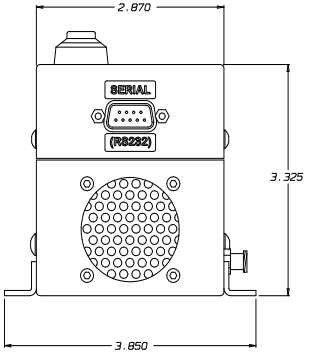


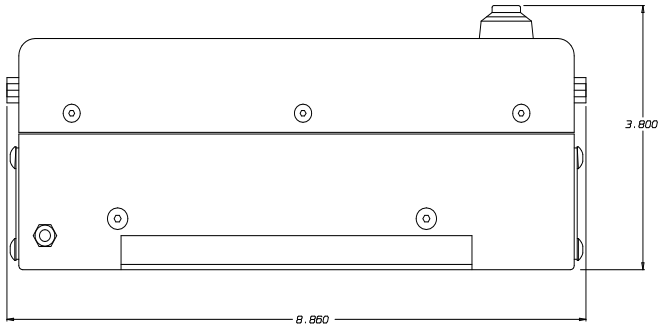
Serial Interface:
9 Pin "D" Subminiature Socket

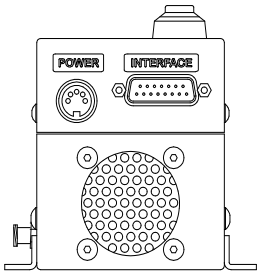
Pin	Function
1	N.C.
2	TXD from Sensor
3	RXD to Sensor
4	N.C.
5	Ground
6	N.C.
7	RTS from Sensor
8	CTS to Sensor
9	N.C.

Parallel Interface:
15 Pin "D"Subminiature Plug

Pin	Function
1	+BIT Output
2	+Less Output
3	+More Output
4	+BIT Switch Input
5	Analog Output
6	+10 to 36 VDC
7	Input Power Return
8	Case Ground
9	-BIT Output
10	-BIT Output
11	-More Output
12	-BIT Switch Input
13	Analog Output Gnd
14	+10 to 36 VDC
15	Input Power Return







Aux Power:
5 Pin Circular DIN Socket

1	Input Power Return
2	Input Power Return
3	N.C.
4	N.C.
5	+10 to 36 VDC

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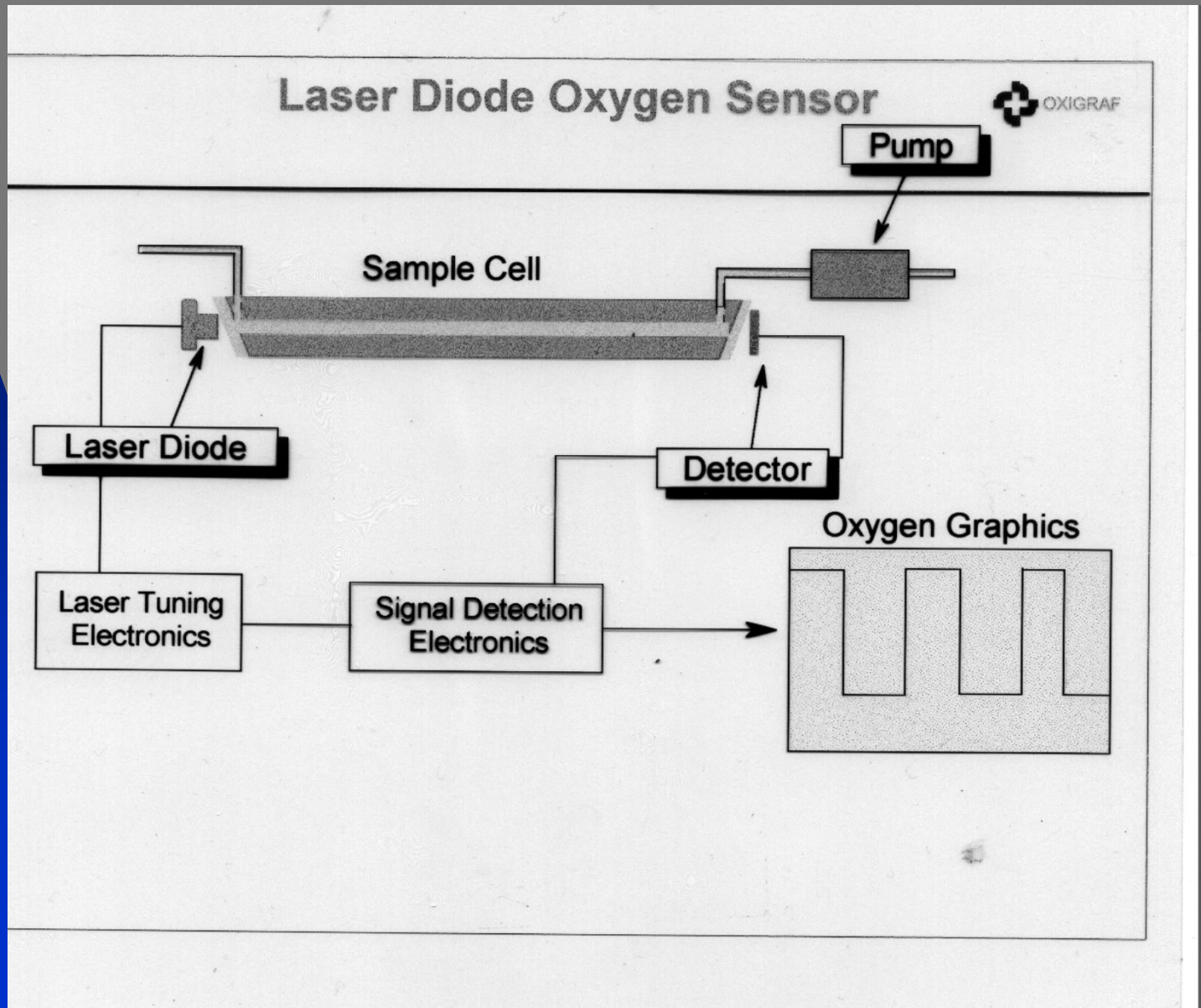
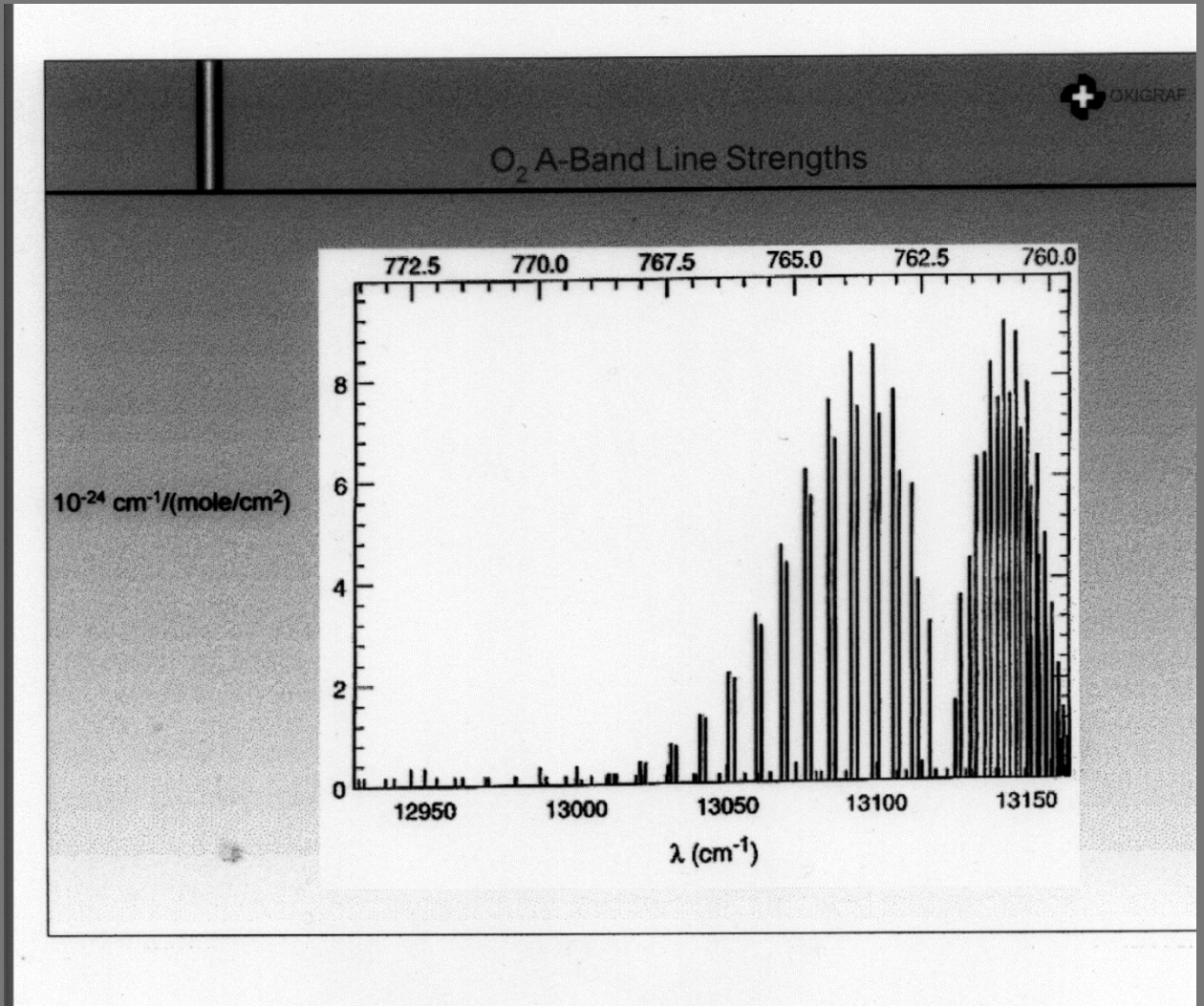
Sensor Schematic



Oxygen Absorption in the Visible Spectrum



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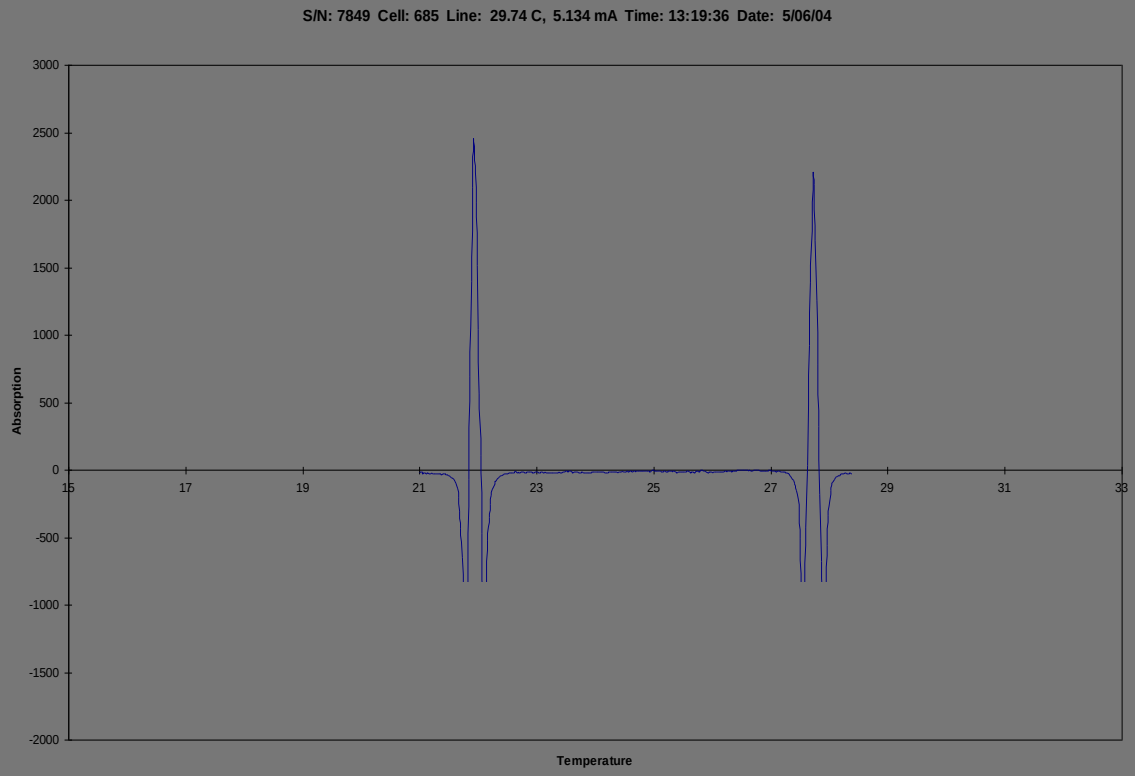
Scanning the Oxygen Absorption Lines



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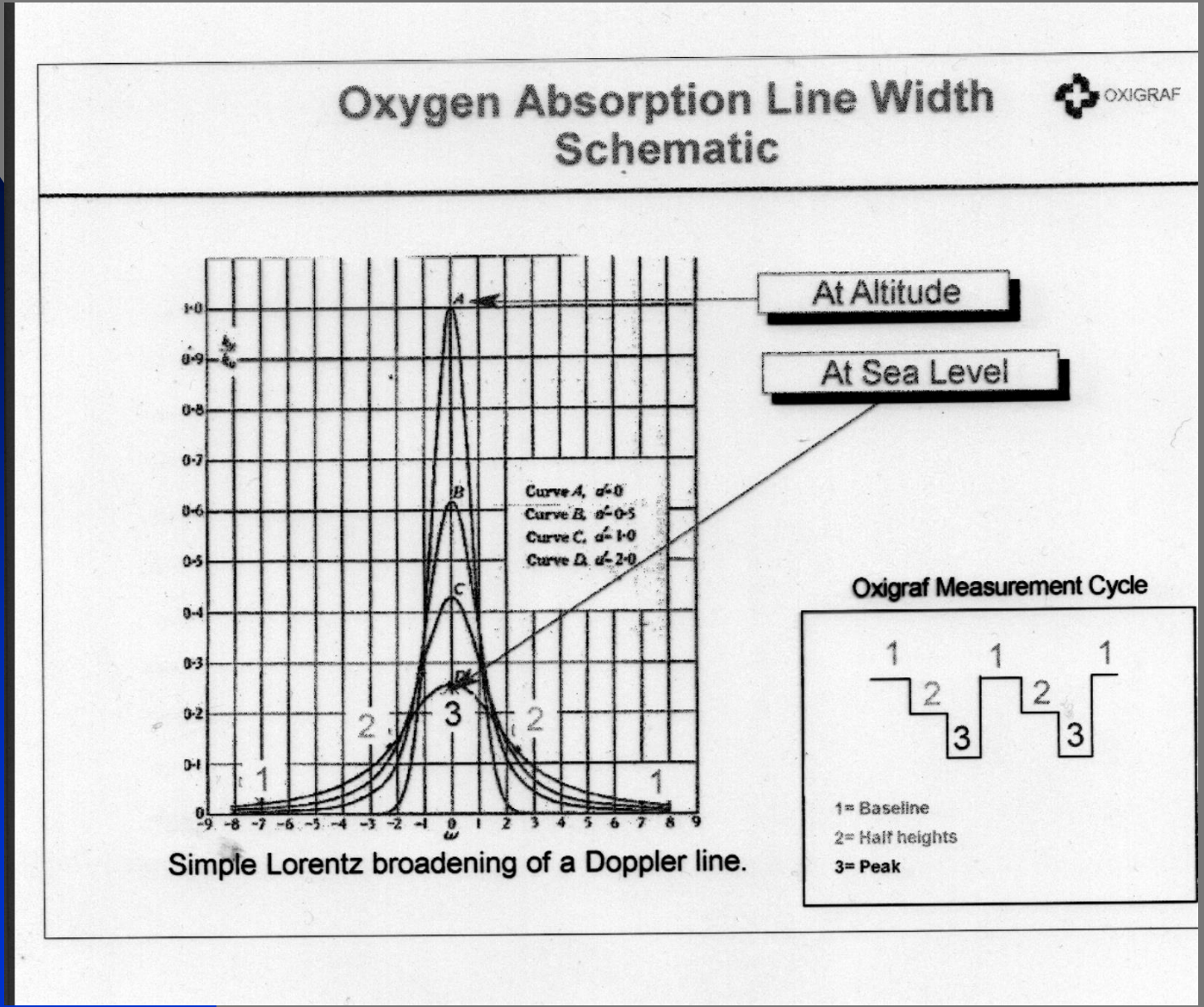
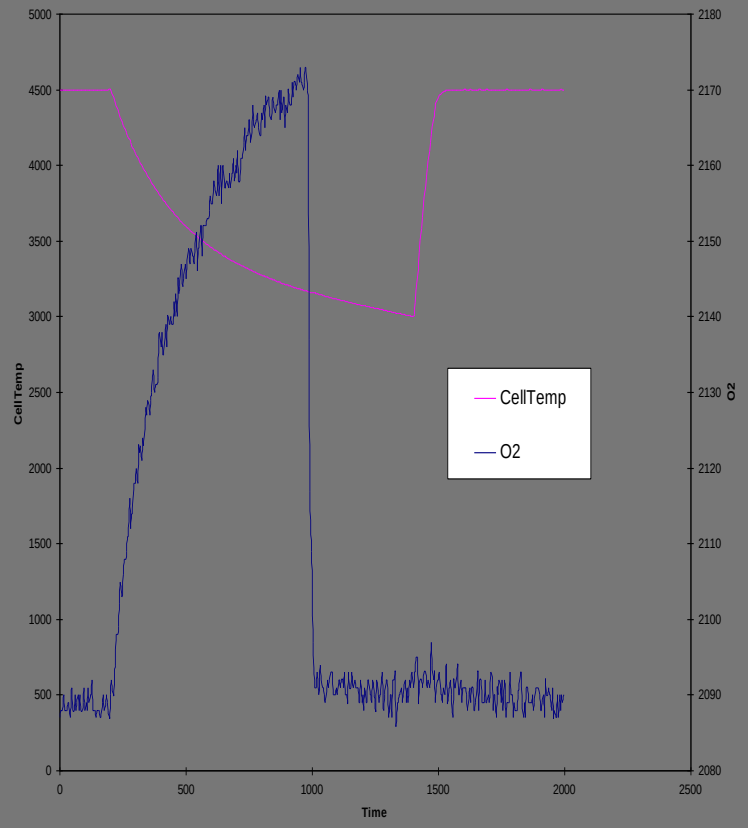
O2 Line Width



Temperature Correction



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Pressure Correction

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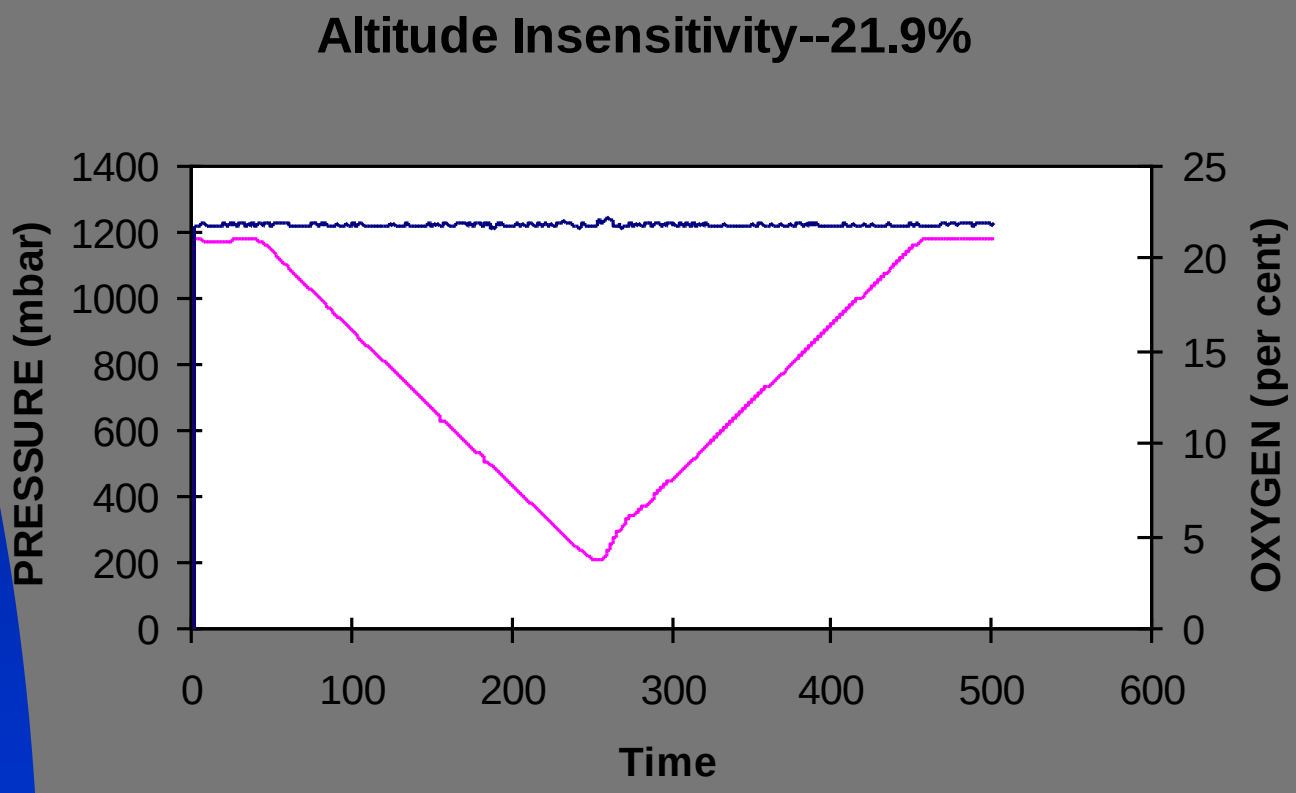
Altitude Performance



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Vibration

- Oxigraf
  - Medical Analyzers: 10 cm drop, 90 degree tilts
  - Sensors: MilSpec 883 vibration testing: 2.5 g sinusoidal
  - Sensors: Damec ESA/NASA Space Qual
  - Redesign and test for Mil Flight Qual needed: 9.5 g RMS

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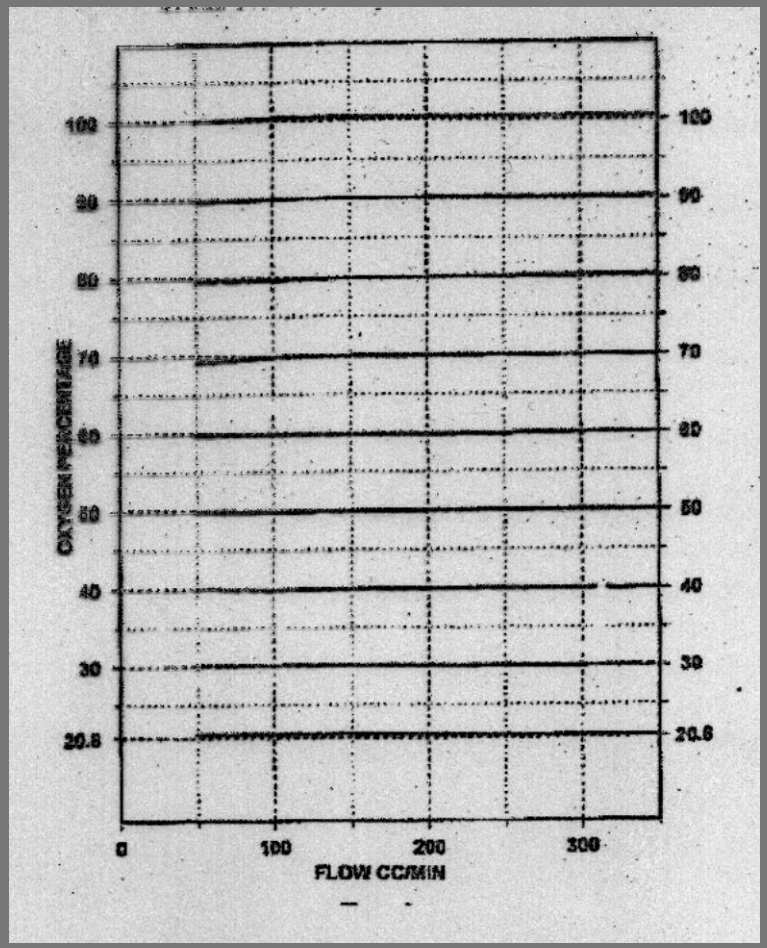
Thermal Range

- Oxigraf
  - Medical Analyzers: 10 to 40 C
  - Industrial Analyzers: -20 to 50 C
  - Sensors: -54 to 60 C
  - Redesign and test for 70, 90 or 100 C as required.

Nine O2 mixtures at –54C and flow rates from 50 to 350 ml/min: Oxigraf X1007 tested by NGL.



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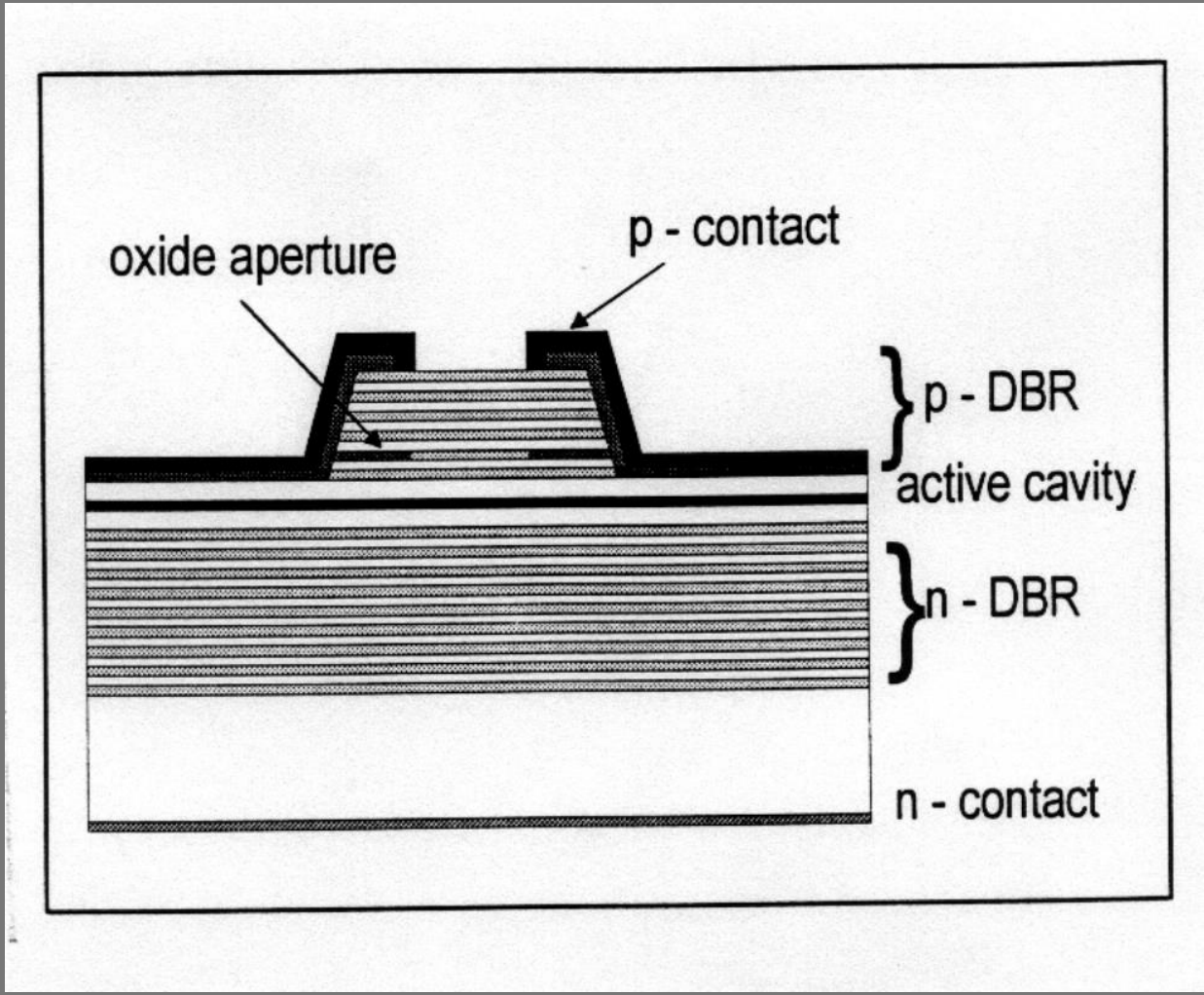
VCSEL: Vertical Cavity Surface Emitting Laser



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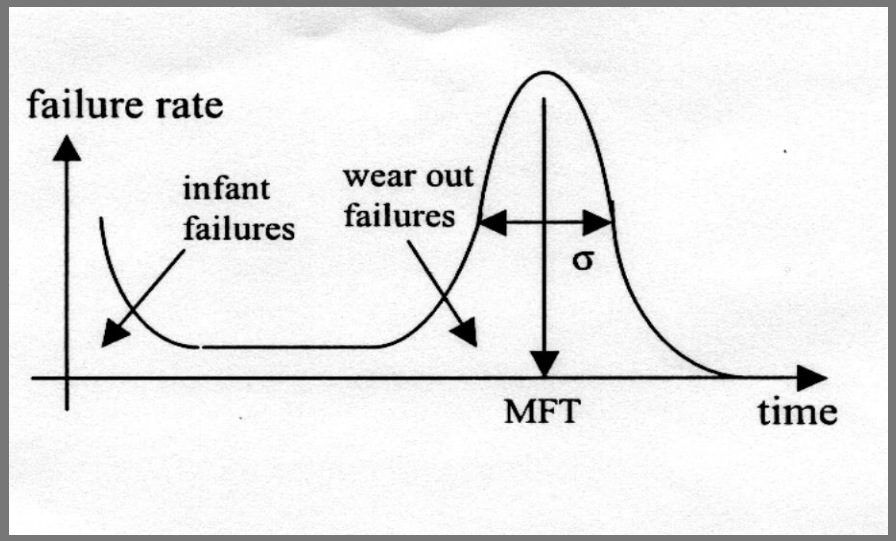
Laser Diode Reliability



Method: Stress groups of LDs at

- 75, 100, 125 C and
- 8, 12, and 16 mA.

Acceleration Model MFT~ I^{-n} exp(E/kT)

(Operate LDs at 30 C and 4 mA.)

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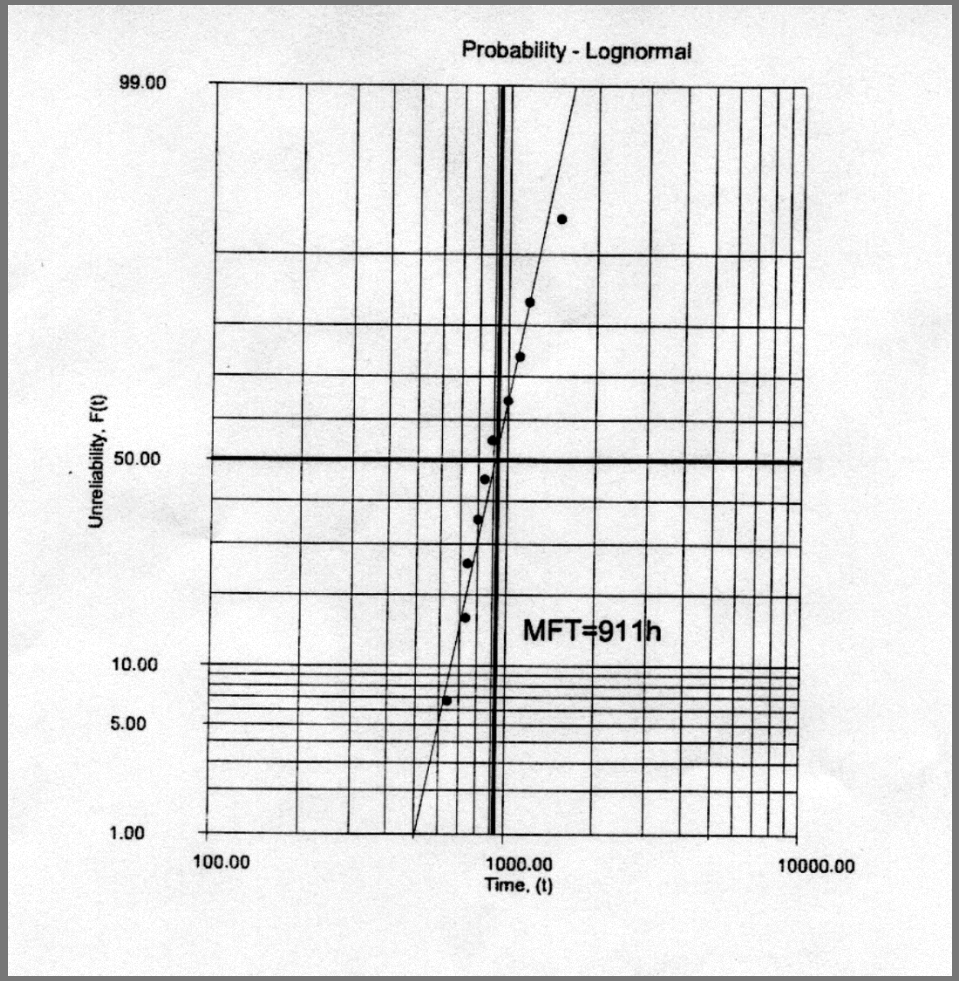
Laser Diode Reliability at 125 C and 8 mA



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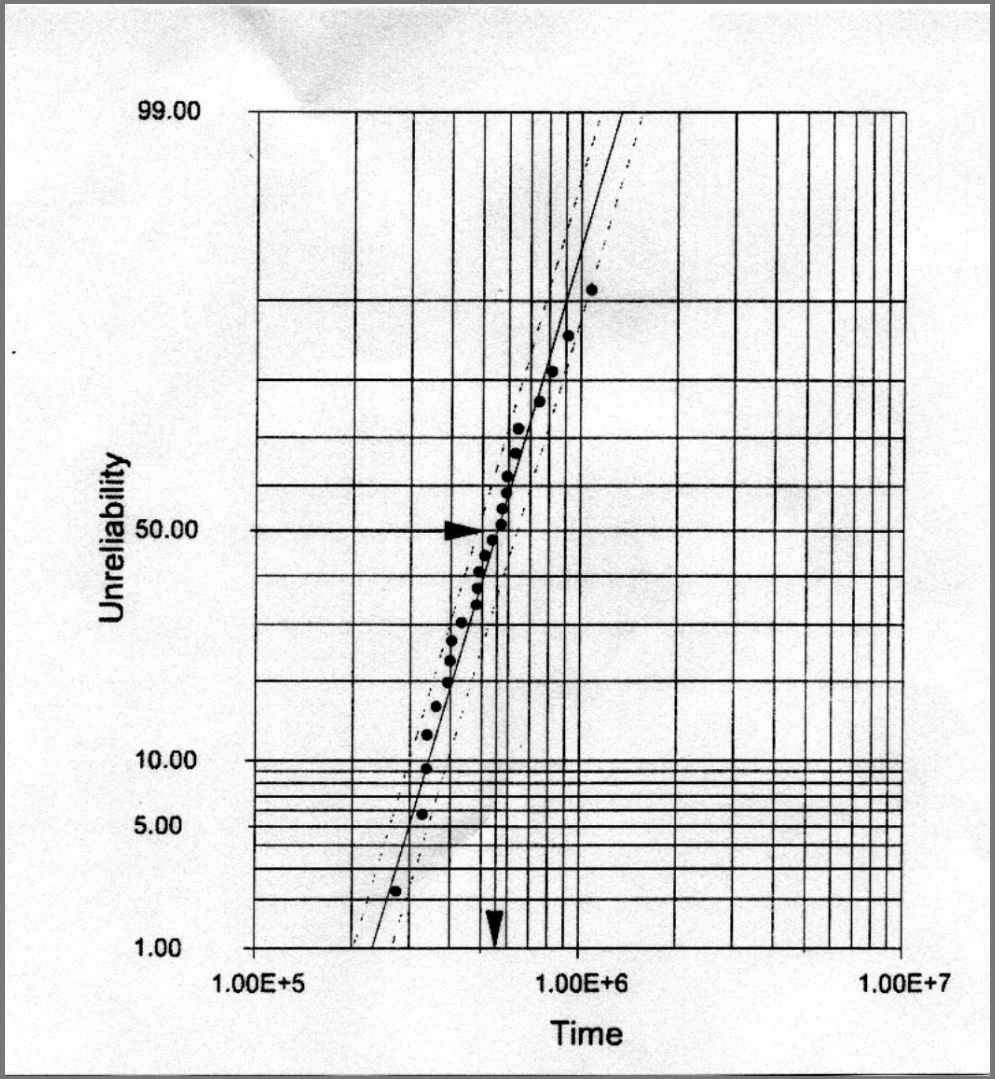
Laser Diode Reliability at 50 C and 4 mA: 550,000 hours



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Other oxygen system warning indicators?

- OBOGS low flow
- OBOGS low pressure
- Cabin altitude
- Chemical/biological detection

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Summary

- Reliable VCSELs now make laser diode oxygen sensors viable for air crew OBOGS monitors.
- Effort can be combined with OBOGS flow/pressure monitor for integrated pilot “dry mask” warning or backup system.
- LD Sensor fast enough to monitor gas composition blender systems.

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