Mixture Meter

For Experimental Aircraft

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July 26, 2011

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Mixture Meter Source

- Mark Langford pioneered the Mixture Meter application for KR aircraft. This is an adaptation of current automotive engine technology.
- Parts are readily available from automotive parts stores and mail order suppliers.
- Wide band O2 sensors were first available in 1993.

What It Does

- The mixture meter allows the pilot to accurately read the mixture directly on a dedicated display in near real time.
- The mixture can be accurately set quickly and easily with the carburetor or injector mixture control during all power settings and at all altitudes.
- Allows maximum engine power and efficiency during all engine operations.

How Does It Do That?

- The mixture meter monitors the combustion products in the exhaust pipe.
- Specifically, the oxygen ratio in the exhaust is compared to the outside air with an O2 sensor.
  - To much oxygen in the exhaust means mixture is lean.
  - To little oxygen in the exhaust means mixture is rich.
- The O2 sensor is calibrated at the factory to center its output for the 14.7:1 by mass ideal stochiometric air to gasoline ratio.

How Does It Actually Do That?

- The O2 sensor is usually calibrated to operate from 900 to 1400 ºF (800ºF minimum), all altitudes from sea level to 25K ft. and air to gasoline ratios from 10:1 to 20:1 (wide band).
- The voltage generated by the wide band O2 sensor will vary from 0.0 VDC to 5.0 VDC lean to rich for Nerst cell units and -2 mA DC to +2.5 mA DC for oxygen pump units.
- The mixture meter for Nerst cell sensors is a type of high impedance voltmeter calibrated in terms of linear O2 ratio.
- The display for oxygen pump sensors requires a digital controller.

Mixture Displays

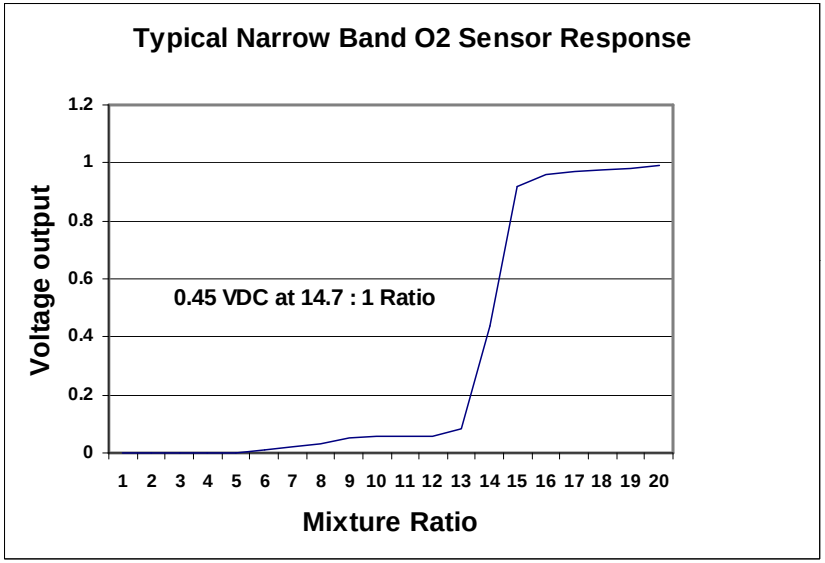
- There are dozens of displays:
  http://prosportgauges.com/wideband_AFR_Gauge.aspx
  http://www.14point7.com/
  http:/www.jegs.com/

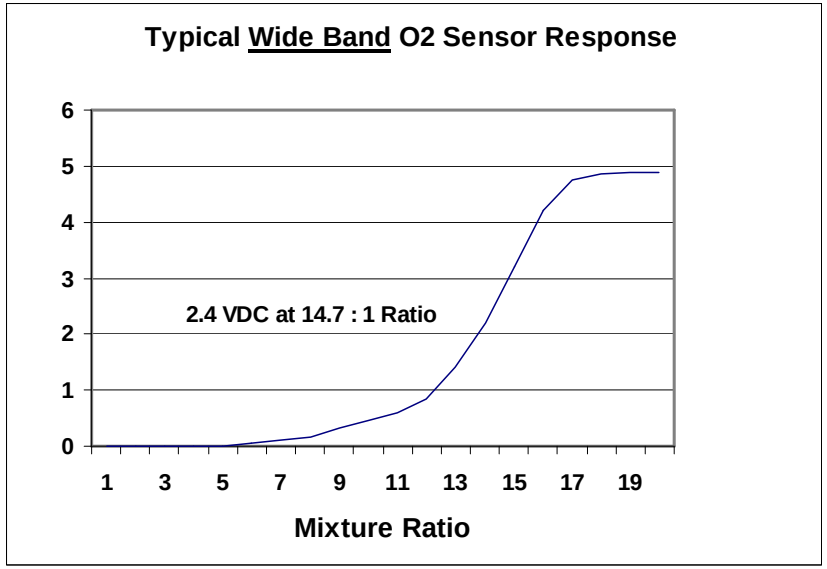
  - LED bar displays
  - LED with digital numerical readouts
  - Digital numerical readouts
  - Analog meter
- Displays are usually calibrated for wide band O2 sensors for after market applications.
- Narrow band O2 sensors are generally used with production computer controlled EFI systems for cars and trucks. These systems generally do not have displays.

Installations

- Most manual mixture meter installations use the LED bar display for easy readability, quick mixture adjustments and simplicity. Digital readouts provide better resolution.
- Un-heated O2 sensors are simple to install and use. Heated O2 sensors cost more and require about 10 watts electrical power for the heater, but provide better calibration.
- Oxygen Pump sensors require a controller and heater, and are more costly, but provide the best calibration.
- Mixture control is usually manually operated on most piston aircraft engines except for FADEC systems.

O2 Sensor Response

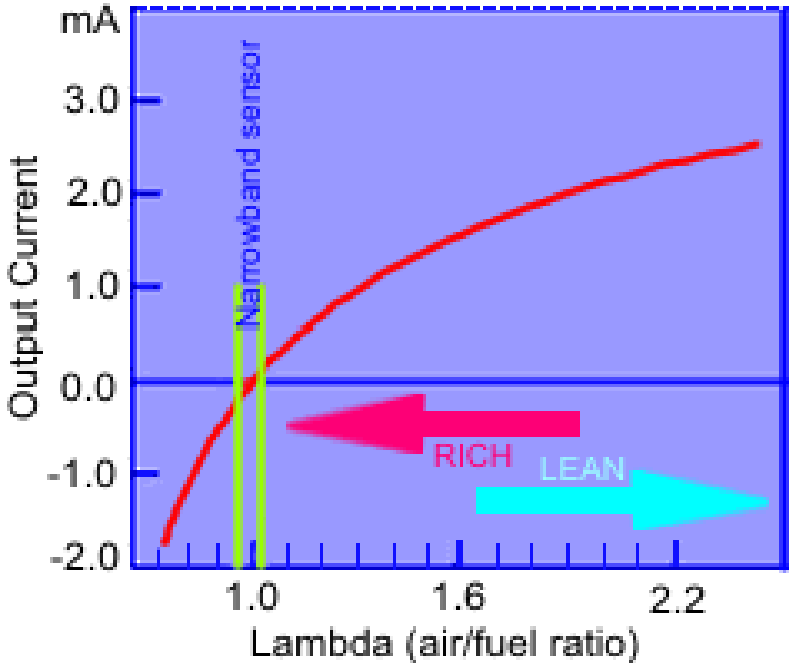




Narrow Band O2 Sensors response make it difficult for manual mixture control, but are idealized for computer operation.

Wide Band O2 Sensors response provide broader range and higher voltage output for smoother manual mixture control

Oxygen Pump Sensor Response



Oxygen Pump sensors have a +/-current response. The Controller changes the separate bias voltage to pump oxygen into or out of the cell to keep the current output at zero. The bias voltage is calibrated in terms of mixture values for display. The controller also monitors the temperature of the sensor to further refine the calibrated response output. O2 outside the cell is not used as a reference, but is needed for pump operation.

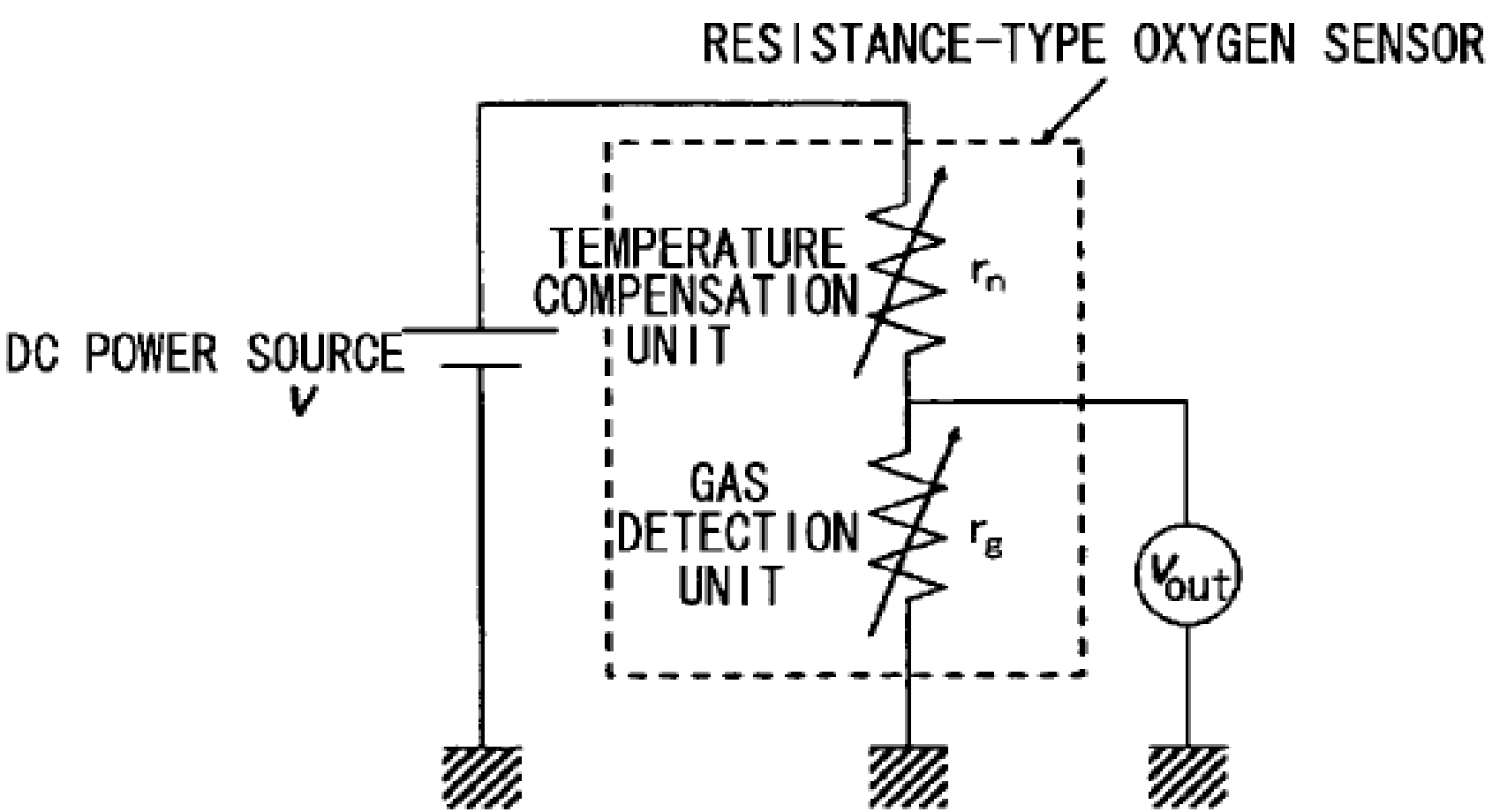
Ampertometric O2 Sensor Technology

- Senses O2 in exhaust without reference to outside O2.
- Produces current output response with a constant voltage input bias. Simplifies controller design.
- Less susceptible to clogging. (Tested with 100LL)
- Uses much less expensive materials.
- Patented 2003, Now ready but currently not in production. Looking for a manufacturer.
- *NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18592-1.*

Semiconductor O2 Sensor New Technology

- Senses O2 in exhaust without reference to outside O2 using a resistive absolute semiconductor sensor.
- Oxide comprising Cerium ions and a specific concentration of Hafnium ions
- Simplified control circuitry. Two-wire and ground simplifies controller design.
- Less susceptible to clogging due to simplified electrode design.
- Operates between 200°C and 1000°C
- Patented 2007, Currently in limited production, not yet available in USA.
- AIST (National Institute of Advanced Industrial Science and Technology) is Japan's extensive public research organization established in 2001.
- http://www.yet2.com/app/insight/techofweek/45832?sid=210

Semiconductor O2 Sensor New Technology



Mixture Displays

- There are dozens of displays: http://www.diyautotune.com/catalog/index.php
- $209 system price 7/20/11

Mixture Displays

- The 14point7 display system with Bosch 17014 O2 Sensor:
- http://www.14point7.com/
- Uses oxygen pump O2 sensor
- About $275 (as of 7/20/11)

Displays

- Cyberdyne 280-7009 O2 Gauge
  - Digital Air/Fuel Ratio Gauge Multicolor display, 2-1/16“ **$36.99** Jegs (7/20/11)
  - Use with **Cyberdyne #280-8941** Exhaust Gas Oxygen Sensor **$59.99** (7/20/11)
- http://www.jegs.com/i/Cyberdyne/280/7009/10002/-1?parentProductId=763711#accessories

Parts

- O2 Sensor Fitting, 1/pkg, 4130 Steel, 18 mm threads, JEGS #555-30740, $5.99
- http://www.jegs.com/p/JEGS/751058/10002/-1

Parts

- O2 Sensor Fitting, 1/pkg, Stainless Steel 18 mm threads, JEGS #555-30743, $7.99
- http://www.jegs.com/i/JEGS/555/30743/10002/-1

KR-2 Mixture Meter Users (1)

User	Engine	Status	Comments
Mark Langford	Corvair	Flying 3 years	http://home.hiwaay.net/~langford/corvair/o2meter/Part auto gas, part 100LL, Replaced sensor at every 100 hours
Mark Jones (N886MJ)	Corvair	Flying 80 hrs	www.flykr2s.com Exact set up as Mark Langford. very useful and accurate. run 100LL, no problems after 80 hours.
Joe Horton	Corvair	Flying 2 years	http://flykr2s.com/joehorton.html Pep Boys universal sensor lasted about 120 hours on pilots side exhaust, run 100LL. Local speed shop meter, $90 . Building a new stainless steel exhaust, a boss on both stacks and install O2 sensor in both with toggle switch. I use the exhaust temp to lean more than the O2 and could live without the O2 at all. It is useful in adjusting the carb for winter and summer flying to know when the weather has affected the overall settings. I do use it as a cross check.

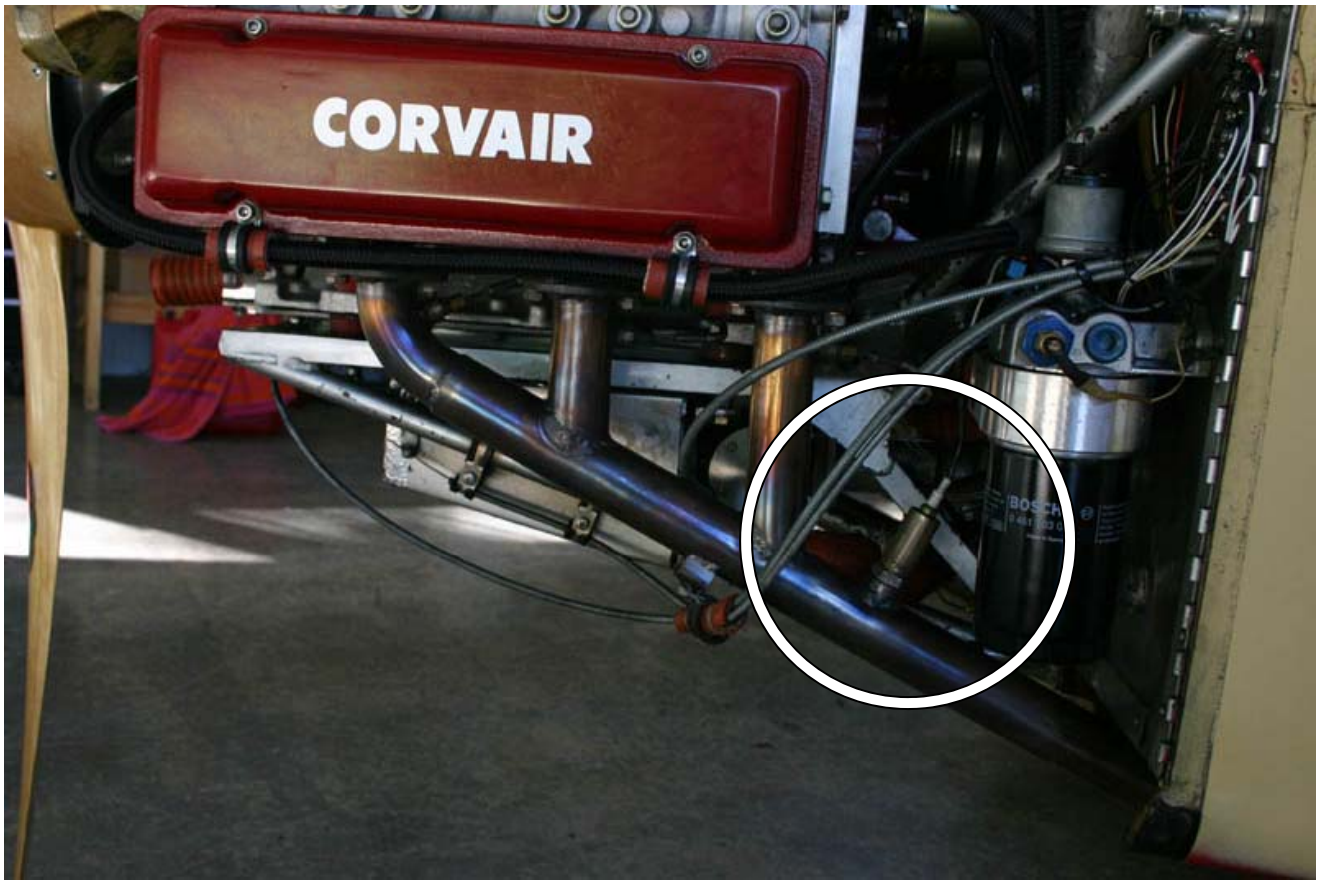
KR-2 Mixture Meter Users (2)

User	Engine	Status	Comments
John Gotschall	VW 2180, turbo	Installing	John Gotschall [johng143@comcast.net] Same as Mark Langford. Modifying meter for cockpit side wall installation. Bought two Bosch oxygen sensors for $15 on eBay.
Stephen Teate	Subaru, turbo, injected	Installing	STeate@compositecooling.com Using three Bosch #BS11027 O2 sensors: One at the turbo for the computer and one in each exhaust pipe so I can read each bank separately. Same instrument as Mark and a SPDP switch to select which bank. Photos not yet available.
Dave Goodman	Corvair	Installed, not flown	http://sites.google.com/a/wildblue.net/goodmans/Home/firewall-forward Same as Mark Langford.
Sid Wood	VW 2180	Installing	http://websites.expercraft.com/sidwood/index.php?q=log_entry&log_id=21302 Using 14Point7 DIY AFR with Bosch 17014 O2 Sensor. (as of 7/20/11)

KR-2 Mixture Meter Users (3)

User	Engine	Status	Comments
John Edwards	Hapi 1835 VW	KR-1 Flying 75 hours	cte82621@centurytel.net
Red Bull Race Teams	IO-540 25 ac	100LL fuel	Replace O2 sensor every 80 hrs at engine rebuild. All teams are using data loggers for all engine parameters.

Corvair Installation



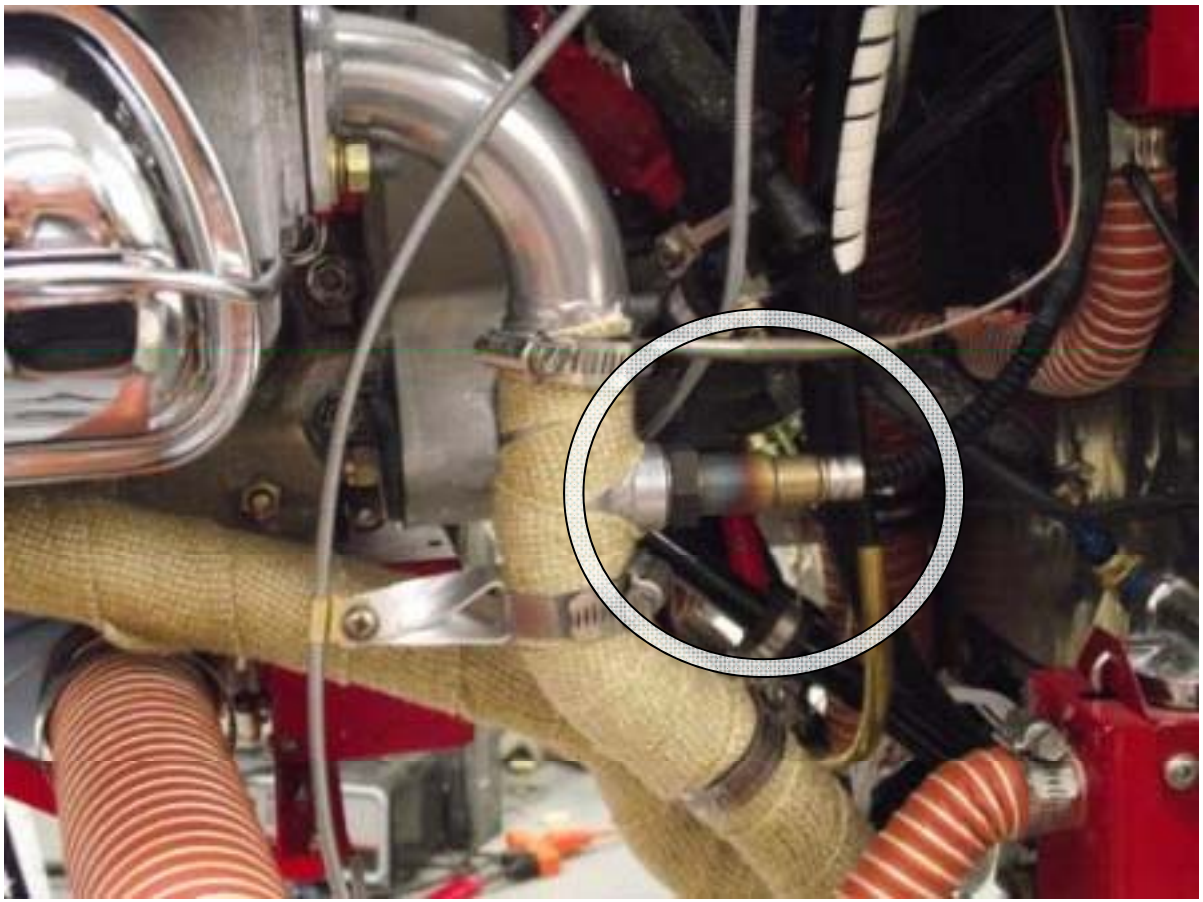
Mark Langford KR-2S O2 Sensor

http://home.hiwaay.net/~langford/corvair/o2meter/

Corvair Installation

Mark Langford KR-2S Mixture Meter

VW Installation



- N6242 KR-2 Bosch 17014 O2 Sensor

VW Installation

- N6242 KR-2 Mixture Display PCB

VW Installation

- N6242 KR-2 Bosch 17014 O2 Sensor

Mixture Meter Limitations

- Will not work for turbine and two-stroke engines - will always indicate mixture too rich.
- Diesel O2 sensors were introduced - 2006
- 100LL will foul the O2 sensor,
  - 82UL, 94UL, automotive gasoline ok.
- Must use wide band O2 sensor.
  - Scale factor calibration.
- Calibrated operation requires the engine and O2 sensor to be at operating temperature.

Mixture Meter Usage

- O2 Sensor Mixture Meters can be used with:
  - Any normal aspiration, turbo charging, or supercharger
  - Any carb or fuel injection with a manual mixture control,
  - Any compression ratio,
  - Any gasoline octane,
  - Any altitude, (up to 25K ft)
  - Any engine RPM
    - idle to wide open throttle.