ECM ENGINE CONTROL AND MONITORING

EGR / O_2 Analyzer 4830

(Model EGR 4830)

Instruction Manual

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Introduction

The EGR 4830

The EGR 4830 is a revolutionary instrument for the development, calibration, and testing of engines. Using non-sampling, non-intrusive means, the analyzer measures the following engine parameters:

- EGR (exhaust gas recirculation percent, gravimetric-based), (0 to 100%)
- EGR (exhaust gas recirculation percent, volumetric-based), (0 to 100%)
- Intake O_2 (0 to 25%)
- Exhaust O_2 (0 to 25%)
- λ (lambda) (0.58 to 25)
- AFR (air-fuel ratio) (8.5 to 364)
- Intake Pressure (0 to 75 Psia, 0 to 518 kPa)
- Exhaust Pressure (0 to 75 Psia, 0 to 518 kPa)

The EGR 4830's features include:

- Two programmable displays
- Four programmable 0 to 5 VDC analog outputs
- Improved $\%O_2$, λ, and AFR accuracy due to pressure compensation
- Simple calibration using ambient air
- Diagnostic displays
- Programmable for fuel H:C, O:C, and N:C composition

Theory of Operation

There are two commonly-use definitions of EGR: gravimetric (mass) and volumetric (molar).

$$\%EGR_g = 100 \cdot m_e / (m_a + m_e) \qquad \text{[See Figure 1]}$$

$$\%EGR_v = 100 \cdot v_e / (v_a + v_e)$$

where:

$\%EGR_g$ = gravimetric (mass) exhaust gas recirculation, percent
$\%EGR_v$ = volumetric (molar) exhaust gas recirculation, percent
m_e = mass of exhaust gas inducted into the engine
m_a = mass of air from the atmosphere inducted into the engine
v_e = volume of exhaust gas inducted into the engine
v_a = volume of air from the atmosphere inducted into the engine

Historically, these EGRs have been determined by CO_2 concentration measurements in the intake and exhaust of the engine. In a similar manner, O_2 concentrations in the intake and the exhaust of the engine can be used to calculate EGR.

One issue that must be dealt with when using ceramic oxygen sensors to measure O_2 concentration is the sensitivity of the sensor to pressure. Information from the EGR 4830's pressure sensors is used to correct the O_2, λ, and AFR measurements.

EGR 4830 Components List

The following items are included with the EGR 4830 analyzer kit:

Item No.	Description	Part Number
1.	EGR 4830	4830-1
2.	Oxygen (O_2) Sensor (2 required)	4830-2
3.	Pressure Sensor (2 required)	07-03 (US) or 07-04 (metric)
4.	Oxygen Sensor Cable, 10 m. (2 required)	2400E-32
5.	Oxygen Sensor Adapter Cable, 0.2 m. (2 required)	2400E-32b
6.	Pressure Sensor Cable, 10 m. (2 required)	4830-3d
7.	Pressure Sensor Tubing, Two-Piece, Total length 0.5 m. (2 required)	12-08(US) or 12-11 (metric)
8.	Oxygen Sensor Boss and Plug (18 mm. x 1.5 mm.) for exhaust of engine (steel boss)	1000A-5
9.	Oxygen Sensor Boss, Plug (18 mm. x 1.5 mm.), and copper gasket for intake of engine (tall aluminum boss)	4830-5
10.	Pressure Sensor Boss (1/4" NPT) and plug for exhaust of engine (steel boss)	4830-6
11.	Pressure Sensor Boss (1/4" NPT) and plug for intake of engine (aluminum boss)	4830-7
12.	AC Power Cord (* = country)	2400G-38(*)
13.	Spare AC Power Fuses, 2 A (b: 1 A), Slow Blow, for 120 VAC (b: for 230 VAC) (2 required)	4800R-18(b)
14.	DB15M Outputs Connector	2400E-9
15.	EGR 4830 Instruction Manual	4830-8

Important Operation Notes

Read the **Calibration (AIR-CAL)** section.

When replacing an O_2 or pressure sensor, read the **Setup - Consts - Intake (Exhaust) O_2 (P)** section. The calibration data must match the sensor and installation location.

Do not use the O_2 sensors in a heavily-sooting or crankcase-oil-burning engine because these conditions can shorten the life of the sensors.

Do not operate an engine for more than three minutes with an O_2 sensor installed in the intake or exhaust if the EGR 4830 is off.

Do not mount an O_2 sensor where liquid fuel or condensed water will collect on the sensor's tip.

Do not mount a pressure sensor or its tubing so that liquid fuel or condensed water will collect in the tubing or sensor.

Do not modify the length or internal diameter of the pressure sensor tubing without contacting ECM. Altering the tubing will affect the accuracy of the dynamic pressure compensation used to make the $\%O_2$, λ, AFR, and hence EGR measurements. Bending the tubing is okay. Refer to the **Setup - Consts - Filters** section for more information.

Do not modify the length or gauge of the cables without contacting ECM. Altering the cables may affect the operation of the O_2 or pressure sensors.

Do not use the O_2 sensors or pressure sensors where gas temperatures or pressures exceed their specified ranges. Refer to the **Sensor Limits and Information** section.

Do not allow the O_2 sensor's sealing rubber (where the wires come out of the sensor) to exceed 200 deg. C.

Do not drop an O_2 sensor onto a hard surface.

The O_2 sensor is self-heated. Do not touch or expose it to flammable substances when the EGR 4830 is on.

Before installing an O_2 sensor or pressure sensor, apply a small amount of non-lead containing antiseize compound to the threads that will engage with the engine.

Route and cable-tie the O_2 sensor cables, pressure sensor cables, and pressure sensor tubing away from hot, moving, or electrically noisy objects.

Installation

Mounting and Powering the EGR 4830

The EGR 4830 fits into a standard 19" rack. For cooling, there should be at least 20 mm open space above the analyzer. The standard cables supplied with the analyzer are 10 m long. If 10 m will not reach from the analyzer to the engine, longer cables (up to 30 m) can be supplied. These cables will be larger gauge to minimize power losses.

For power, there are two AC line voltage selections: 100-120 VAC and 220-240 VAC. To program the module for a different AC line input voltage or to change the AC line fuses (2), open the module by putting a screwdriver in the slot on the top of the module and carefully pull the module door open. After the module's door is open, pull out the red fuse holder. The AC line voltage is programmed by putting the red fuse holder in the module so that either "115V" (for 100-120 VAC) or "230V" (for 220-240 VAC) on the fuse holder is seen from the back of the analyzer when the AC line input module's door is closed. 2 A Slow Blow fuses are required for 100-120 VAC power and 1 A Slow Blow fuses are required for 220-240 VAC power. All fuses must be rated for 250 VAC.

Installing the O_2 and Pressure Sensor Bosses

In the engine's intake, one O_2 sensor and one pressure sensor boss must be installed, and in the engine's exhaust, one O_2 sensor and one pressure sensor boss must be installed (i.e. four bosses total). The O_2 sensor and pressure sensor boss pairs (i.e. one O_2 sensor and one pressure sensor is a pair) should be as close as possible to each-other so that the pressure measured is representative of what the O_2 sensor is experiencing. See Figure 1.

The tall aluminum O_2 sensor boss and the aluminum pressure sensor boss are to be installed in the intake manifold. The aluminum O_2 sensor boss will position the tip of the O_2 sensor at the plane of the inside surface of the intake manifold. Mount the bosses so as to avoid any liquids from entering the O_2 sensor or pressure tubing. Keep in mind that the EGR 4830 measures the %EGR at the intake O_2 sensor location. Thus, the distribution of EGR in the engine can be mapped with several intake O_2 sensor positions. If the intake manifold is aluminum, the bosses can be welded to the manifold. Run taps into the bosses after welding to straighten their threads. If the intake manifold is plastic, the aluminum O_2 sensor boss will have to be epoxied to the manifold and should be additionally physically attached to the intake manifold to keep it from being broken loose when the O_2 sensor is installed/removed or due to vibration. This additional attachment method will be application-specific and the installer will have to improvise. A few small pieces of aluminum angle and some screws may be all that is required. For engines with a plastic intake manifold, the manifold probably can be directly tapped for the pressure sensor tubing fitting (¼" NPT (US), ¼" ISO tapered (metric)) so the aluminum pressure boss will not be used.

The short steel O_2 sensor boss and the steel pressure sensor boss are to be installed in the exhaust manifold. It is preferred that they are installed downstream of the turbocharger (to

minimize the degree of pressure compensation applied to the O_2 measurement) although it is not necessary because exhaust pressure is being measured. Mount the bosses so as to avoid condensed water in the exhaust from entering the O_2 sensor or pressure tubing. Run taps into the bosses after welding to straighten their threads.

After the pressure sensor bosses have been mounted in the intake and exhaust, the stainless steel tube end of the pressure sensor tubing can be screwed into them. Use some antiseize if screwing into metal, or pipe sealer if screwing into a plastic manifold. The teflon tube end of the pressure sensor tubing will attach to the pressure sensors. Orientate the run of the tubing so that they will drain any condensed fluid into the manifolds.

The length and internal diameter of the pressure sensor tubing should not be altered without contacting ECM. Altering the tubing will affect the accuracy of the dynamic pressure compensation used to make the $\%O_2$, λ, AFR, and hence EGR measurements. Bending the tubing is okay. See the **Setup - Consts - Filters** section for more information.

Do not install the O_2 or pressure sensors yet. The system has to be calibrated first.

Installing the O_2 and Pressure Sensors, and Cables

Run four cables from the back of the EGR 4830 to their respective sensors. Make sure the sensors match their entered calibration data and assigned locations.

Next, the EGR 4830 must be calibrated via the Air-Cal procedure. Refer to the **Calibration** section. After calibration, the sensors can be installed.

When an O_2 sensor is installed, it should be tightened to approximately 10 ft-lbf except if it is going into a boss that has been epoxied to a plastic manifold. In that case, hold onto the intake O_2 sensor boss when tightening and be careful not to shear the boss off. The tightening torque should be the minimum required to seal. Sometimes replacing the intake O_2 sensor's tin gasket with the copper one will enable sealing at low torques. Use either the tin gasket supplied with the intake O_2 sensor or the copper gasket, not both at the same time.

Analog Outputs, Grounds, and Shields

The EGR 4830 has four programmable analog outputs. These outputs are available from the female DB15 connector on the back of the analyzer. Refer to the back panel or the **General Information** section for the DB15 connector pin assignments.

On the back of the analyzer are connections to the case ground and O_2 sensor cable shields. The case ground is normally connected to the cable shields. To reduce the effects of electrical noise, it may be necessary to disconnect the case ground from the cable shields and make individual connections from these terminals to alternate dynamometer grounding points. Inside the EGR 4830, there is a 2.2K resistor connecting the case ground and the power ground.

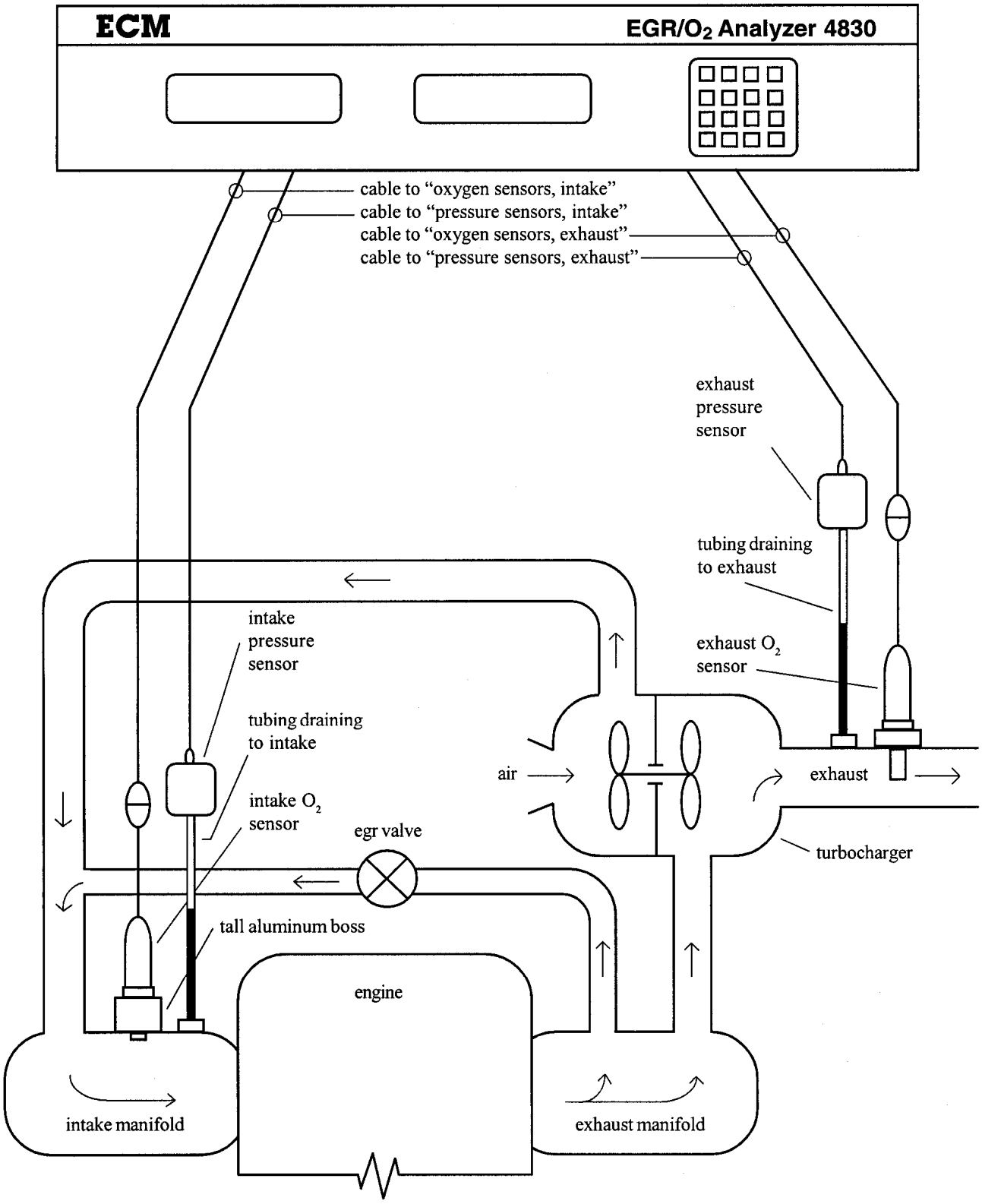

Figure 1: EGR 4830 Installed on an Engine

Operation

The RUN and SYS Keys

There are two modes of operation of the EGR 4830: RUN and SYS (system). Either mode can be entered at any time by pressing the RUN or SYS key. In RUN mode, the analyzer is measuring and outputting its parameters. In SYS mode, analyzer setup, calibration, and diagnostics can be performed.

RUN Mode

In RUN mode, measurements from the O_2 and pressure sensors are used to determine the following parameters:

1. EGR (gravimetric): designated "%EGR (MASS)" on the display
2. EGR (volumetric): designated "%EGR (VOL)" on the display
3. Intake O_2 (compensated for pressure): designated "INTAKE %O2" on the display, or
   Lambda (compensated for pressure): designated "INTAKE λ" on the display, or
   Air-Fuel Ratio (compensated for pressure): designated "INTAKE AFR" on the display
4. Exhaust O_2 (compensated for pressure): designated "EXHAUST %O2" on the display, or
   Lambda (compensated for pressure): designated "EXHAUST λ" on the display, or
   Air-Fuel Ratio (compensated for pressure): designated "EXHAUST AFR" on the display
5. Intake Pressure: designated as "INT PSIA" (if displayed in absolute PSI units) or
   "INT kPa" (if displayed in absolute kPa units) on the display.
6. Exhaust Pressure: designated as "EXH PSIA" (if displayed in absolute PSI units) or
   "EXH kPa" (if displayed in absolute kPa units) on the display.
7. Intake O_2 (not compensated for pressure): designated "INT %O2 RAW" on the display
8. Exhaust O_2 (not compensated for pressure): designated "EXH %O2 RAW" on the display

All eight of these parameters can be displayed at the same time. Any two of them can be selected to be displayed in large fonts at the same time. Any four of these parameters can be selected to be output on the four analog output channels.

SYS (System) Mode

In SYS mode, the analyzer can be set-up (SETUP), calibrated (AIR-CAL), and diagnosed (DIAG). Figure 2 shows the menu tree of SYS mode. Default values are given in square parentheses and can restored via the "DEFAULTS" command.

Normally, the user will only need to set the analog outputs ("ANALOG") and calibrate ("AIR-CAL") the analyzer. In SYS mode, the default or current selection is displayed following the ">" symbol. Any improper or out-of-range entries are rejected by the analyzer and the "-" key

is used as a backspace to erase an entry. The entry of any selection must be completed by the pressing of the "ENT" key.

Main Menu	Level 1	Level 2	Function
1 RUN			Measure & display
2 SETUP	1 DISPLAY	1 SIZE LEFT	Small or large display [Small]
		2 SIZE RIGHT	Small or large display [Small]
		3 UNITS	PSIA, kPaA [PSIA] %O2(IN), λ, AFR [%O2] %O2(EX), λ, AFR [%O2]
		4 RATE	Display and analog output update rate [F]
	2 OUTPUTS	1 ANALOG	Program analog outputs [EGR(M), 0, 100, %O2(IN), 0, 25, %O2(EX), 0, 25, P(IN), 0, 60 PSIA]
		2 AVERAGING	Display and analog outputs [0.5,0.5,1,1,1,1,1,1,1,1,1,1]
		3 CAL D/A	Calibrate analog outputs
	3 CONSTS	1 FUEL	H:C, O:C, N:C [1.85, 0, 0]
		2 INTAKE O2	Pressure compensation data
		3 EXHAUST O2	Pressure compensation data
		4 INTAKE P	Pressure sensor calibration data
		5 EXHAUST P	Pressure sensor calibration data
		6 FILTERS	Alpha constants for O_2 and P [0.05, 0.05, 0.01, 0.999] and EGR curve fitting [1, 0, 1, 0]
	4 DEFAULTS		Restore default programming
3 AIR-CAL		1 PERFORM AIR CAL	Calibrate O_2 measurement function in air [20.7]
		2 SET INTAKE %O2	Set $\%O_2$ in intake for 0% EGR [20.7]
4 DIAG	1 CODES AND BITS		O_2 codes and A/D bits data
	2 RAW VOLTAGES		A/D voltages
	3 AIR-CAL VOLTAGES		Recorded Air-Cal voltages

Figure 2: Menu Tree for the EGR 4830
[Default values given within square parentheses]

Set-up (SETUP)

All menu selections in SETUP are self-explanatory except for: “AVERAGING”, "INTAKE O2 (P) EXHAUST O2 (P)", and "FILTERS" which will be explained below.

◆ Setup - Outputs - Averaging

“Averaging” allows the user to set the averaging on the parameters (see the list of eight parameters in the RUN Mode section) before those parameters are used for the display routine or output as analog outputs. The averaging for the eight parameters is set via eight "α" filter constants each of which can be programmed from 0.001 to 1. The averaging is performed using the following recursive formula every 10 ms. 10 ms is also the sample rate of the raw O_2 and pressure measurements.

$$Average_{n+1} = \alpha \cdot Value_{n+1} + (1 - \alpha) \cdot Average_n$$

where:

$Average_{n+1}$ = the current average to be used for the display routine and analog outputs
$Value_{n+1}$ = the most recent value of that parameter
$Average_n$ = the previous average (10 ms ago)
α = filter constant (alpha). ex. If α = 1, no averaging is performed

The "n+1"th average value ($Average_{n+1}$) is immediately used to drive the analog outputs. However for the display, this value is further averaged (via the RATE command), before it is displayed.

The default averaging values were selected to give good EGR accuracy during rapid intake and exhaust pressure changes. For better steady-state EGR accuracy, the α for EGR averaging can be increased with a subsequent loss of transient EGR accuracy during rapid intake and exhaust pressure changes.

◆ Setup - Consts – Intake (Exhaust) O_2 (P)

Whenever an O_2 or pressure sensor is replaced, this menu selection must be visited to enter the sensor's pressure data. Be careful not to switch the assigned intake and exhaust O_2 (or P) sensors. The data must match the sensor and location.

◆ Setup - Consts - Filters

There are two parts of the "FILTER" menu option.

In the first part, coefficients of filtering applied to the raw measured parameters (the two O_2s and two pressures) is set. There is one filter for each parameter and hence four coefficients that can be set. These coefficients are each called α (alpha) and have a range of 0.001 to 0.999. The purpose of these filters is to align the dynamics of the oxygen and pressure measurements so that the O_2 sensor pressure compensation is accurate during engine intake

and exhaust pressure transients. The filtering is dependent on the dynamics of the O_2 sensors, the dynamics of the pressure sensors, the relative location of the O_2 and pressure sensor pairs, and the length and diameter of the pressure tubing. If the pressure tubing length or diameter is modified what is provided with the EGR 4830, the filter coefficients must be changed. How to properly set the filter coefficients for modified pressure tubing is beyond the scope of this manual. Contact ECM if this is necessary. So in summary, do not change these four coefficients unless the pressure tubing is modified and only with the assistance of ECM.

In the second part of the FILTER menu option, the calculated %EGRs (both gravimetric and volumetric) can be fit to match an %EGR determined from a different method. This "fit" value is what will be displayed and output on the analog outputs.

$$\%EGR_{fit} = m \cdot \%EGR_{calculated} + b$$

where:

m = programmable gain
b = programmable offset

Normally, m=1 and b=0 (i.e. no modification).

Calibration (AIR-CAL)

Calibration is performed by exposing the two O_2 sensors and two pressure sensors to ambient air (i.e. not in intake or exhaust manifold) for 30 minutes (or after 3 minutes with a minor reduction in accuracy), selecting “AIR-CAL”, “PERFORM AIR-CAL” from the menu, and then following the displayed instructions. If an O_2 sensor fails an Air-Cal: replace it, enter the new sensor’s pressure compensation data (see "INTAKE O2" or "EXHAUST O2" in menu), and perform an Air-Cal again.

Note that after an Air-Cal (or when the sensors are exposed to atmospheric air), both EGRs will have “-----“ displayed on the screen and their voltage outputs set to 0. This is normal and occurs when the intake and exhaust-measured $\%O_2$s are within 1% of the “%O2 IN AIR”. No engine runs under this condition and thus displaying a value for EGR would not make sense.

For calibration, the "%O2 IN AIR" must be entered. The $\%O_2$ in air for the case of zero humidity is 20.945% and decreases with increasing humidity. The $\%O_2$ in air can be calculated from the barometric pressure (Pb), the relative humidity (Rh), and the saturated water vapor pressure (Pws) by using the following formula:

$$\%O_2 = 20.945\% \cdot (Pb - (Pws \cdot (Rh/100))) / Pb$$

The saturated water vapor pressure (Pws) is a function of the ambient temperature (Ta) and is given in the following table. The table is a little tricky to read but here’s an example: at 32 ºC, the water vapor pressure is 35.663 mmHg. 1 mmHg is 0.01934 lbf/in^2. A typical $\%O_2$ in air is 20.7.

If an Air-Cal is accidentally performed with one or more of the sensors in the engine, all sensors must be removed and the Air-Cal performed again.

Calibrate the EGR 4830 when first installing it on an engine, before a sensor is first used, and periodically when using the analyzer. The frequency of calibration depends on the application and can only be determined by experience. One way to get this experience is to expose the sensors to ambient air after four hours of use in the engine and see if the $\%O_2$s displayed are accurate. If after four hours of use the values displayed are accurate, then repeat after another four hours.

The second option under "AIR-CAL" is "SET %O2 AT 0% EGR". This is the $\%O_2$ of air flowing in the intake manifold under 0% EGR conditions. If the engine is drawing air from the same atmosphere the sensors were calibrated in, this number will be the same as the "%O2 IN AIR" entered during the "AIR-CAL". Normally this is the case, and after each Air-Cal the value entered for the "%O2 IN AIR" is automatically assigned to the "%O2 AT 0% EGR".

However, there may be some cases where the "%O2 IN AIR" is not the "%O2 AT 0% EGR". An example of this would be where the sensors are calibrated in the dynamometer cell but the engine's air comes from outside the building. Outside air can have higher humidity and thus a lower $\%O_2$. Examples like this can lead to %EGR errors and a non-zero %EGR when the %EGR really is 0%. For such cases, put the intake O_2 and pressure sensors in the intake manifold after the Air-Cal and look at the %O2 number displayed. If it is not the "%O2 IN AIR" entered during the Air-Cal, select "%O2 AT 0% EGR" and enter the %O2 number displayed. You must be sure that no EGR really is in the intake during this test or the %EGR numbers calculated will be wrong.

Ta (°C)	0	1	2	3	4	5	6	7	8	9
	Pws (mm Hg)									
0	4.579	4.926	5.294	5.685	6.101	6.543	7.013	7.513	8.045	8.609
10	9.209	9.844	10.518	11.231	11.987	12.788	13.634	14.530	15.477	16.477
20	17.535	18.650	19.827	21.068	22.377	23.756	25.209	26.739	28.349	30.043
30	31.824	33.695	35.663	37.729	39.898	42.175	44.563	47.067	49.692	52.442
40	55.324	58.34	61.50	64.8	68.26	71.88	75.65	79.60	83.71	88.02
50	92.51	97.2	102.09	107.2	112.51	118.04	123.80	129.82	136.08	142.60
60	149.38	156.43	163.77	171.38	179.31	187.54	196.09	204.96	214.17	223.73
70	233.7	243.9	254.6	265.7	277.2	289.1	301.4	314.1	327.3	341.0
80	355.1	369.7	384.9	400.6	416.8	433.6	450.9	468.7	487.1	506.1
90	525.76	546.05	566.99	588.60	610.90	633.9	657.62	682.07	707.27	733.24

Diagnostics (DIAG)

With the exception of "CODES" from "CODE AND BITS", the diagnostics features are primarily used during communication between the analyzer's user and ECM when solving a problem.

"CODE(IN):" precedes the code from the intake $\%O_2$ sensor and "CODE(EX):" precedes the code from the exhaust $\%O_2$ sensor.

Code	Meaning	Recommendation
0	No codes	
1	O_2 sensor heater open	Inspect cable or replace sensor.
2	O_2 sensor heater shorted	Inspect cable or replace sensor.
3	O_2 sensor controller voltage too high or low	Electronics problem. Contact ECM.
4	Vs > 1.3 V	Replace sensor.
5	Vp < -2 V	Replace sensor.
6	Vp > 2 V	Replace sensor.
7	Rvs > 220 Ω	Sensor too cold. Relocate.
8	Rvs error > 5 Ω	Sensor too cold or hot. Relocate.

"-----" is displayed for both EGRs (and their analog output voltages set to 0) if the intake and exhaust-measured $\%O_2$s are within 1% of the "%O2 IN AIR". No engine runs under this condition and thus displaying a value for EGR would not make sense. Therefore, immediately after an Air-Cal, "-----" will be displayed for both EGRs. This is normal.

Maintenance and Troubleshooting

Maintenance consists of:

1. Air-Caling the system
2. Inspecting the cables for damage
3. Draining any liquids from the intake or exhaust pressure sensors and tubing
4. Keeping the holes in the O_2 sensors open. If they get plugged with soot, poke them open with a paperclip but do not stick the paperclip in more than 2 mm. Do not attempt to clean the O_2 sensors with any solvent.
5. Making sure the analyzer has not been wrongly programmed. Figure 2 contains default program values.

It has been found that the response time of the O_2 sensors can degrade when in diesel engines. Air-Caling will compensate for accuracy degradation but not response time degradation. Therefore, for applications where a response time is important (transient testing), replace the O_2 sensors after 500 hrs or earlier if a reduction in response time is suspected.

If the EGR 4830 gives values that do not make sense, here are some simple tests that may point to a problem:

1. Make sure the analyzer has not been wrongly programmed. Figure 2 contains default program values.
2. Air-Cal the system
3. See if there are any O_2 sensor codes.
4. Take the O_2 sensors out and blow on them. Does the $\%O_2$ go down?
5. Suck a little on the pressure sensors. Does the pressure go down?
6. Replace the O_2 sensors. Don't forget to enter their pressure compensation data and Air-Cal the system.

#1 or #6 (above) most commonly points to the problem. If the cables have been damaged, the O_2 sensor electronics may have been damaged. This requires the return of the instrument to ECM.

Specifications and Limits

Measurements and Accuracies

Parameter	Range	Response Time[1]	Accuracy
%EGR	0 to 100%	< 1 sec [2]	±1% (absolute)
$\%O_2$	0 to 25%	< 150 ms [3]	±0.2% (absolute)
Lambda (λ)	0.58 to 25	< 150 ms [3]	< 1.5%
AFR	8.5 to 364	< 150 ms [3]	< 1.5%
Pressure	0 to 75 Psia, 0 to 518 kPa	< 50ms [2]	±0.75 Psi (absolute) ±5.2 kPa (absolute)

[1] The response times are affected by FILTERS and AVERAGING programming.
[2] This response time for %EGR and Pressure is with the default FILTERS and AVERAGING programming (see Figure 2).
[3] This response time for $\%O_2$ (or Lambda or AFR) is with $\alpha = 0.999$ for %O2 under FILTERS (not 0.05, the default setting) and $\alpha = 1$ for %O2 (or Lambda or AFR) under AVERAGING (the default). Therefore, the response time with the default FILTERS setting will be slower than shown. Default settings give best pressure compensation. $\alpha = 1$ settings give fastest response.

Sensor Limits and Information

◆ **O_2 Sensors**

Exhaust Gas Temperature Range: 0 - 850 deg. C, 32 - 1562 deg. F.

Maximum Exhaust Temperature: 950 deg. C, 1742 deg. F.

Maximum Rate of Temperature Change: 50 deg. C/sec, 122 deg. F/sec.

Fuel Composition:

H:C ratio range: 1.00 - 10.00
O:C ratio range: 0.00 - 10.00
N:C ratio range: 0.00 - 1.00

Maximum allowable levels of fuel "Impurities":

Lead: 0.012 gm/gal., 0.003 gm/ltr.
Phosphorous: 0.0008 gm/gal., 0.00027 gm/ltr.
Sulfur: 0.035 % by weight

Do not use the O_2 sensors in a heavily-sooting or crankcase-oil-burning engine because these conditions will shorten the life of the sensor.

Thread Size: M18X1.5 mm. Lightly coat with non-lead containing antiseize compound.

Hex Size: 22 mm.

Cable Length: 10 m.

◆ **Pressure Sensors**

Note: Must attach to engine via pressure sensor tubing only!

Maximum Pressure: 200 PSI (absolute), 1379 kPa (absolute)

Cable Length: 10 m.

Thread on Pressure Sensor: ¼" NPT

Fitting on Pressure Sensor: Swagelok SS-400-7-4 to mate with ¼" tube (US) or
Swagelok SS-6MO-7-4 to mate with 6 mm tube (metric)

◆ **Pressure Sensor Tubing**

Mating Thread with Engine: ¼" NPT (US) or ¼" ISO Tapered (metric)

Tubing Diameter: ¼" (US) or 6mm (metric)

Tubing Assembled Length: 0.5 m. (0.23 m. stainless steel, 0.23 m. teflon, 0.04 m. fittings)

Nut, Front Ferrule, Back Ferrule at Pressure Sensor end of Tubing:
Swagelok SS-402-1, SS-403-1, SS-404-1 (US) or
Swagelok SS-6M3-1, SS-6M4-1, SS-6M2-1 (metric)

Union between Stainless Steel and Teflon Tubing: Swagelok SS-400-6 (US) or
Swagelok SS-6MO-6 (metric)

Fitting on Engine End of Tubing: Swagelok SS-400-1-4, ¼" tube to ¼" NPT (US) or
Swagelok SS-6MO-1-4RT, 6 mm tube to ¼" ISO tapered (metric)

General Information

◆ Analog Outputs

Connector: Female DB15.

Terminal 1: Analog Channel 1	Terminal 9: Analog Channel 3
Terminal 2: Analog Channel 2	Terminal 10: Analog Channel 4
Terminals 3, 5: Gnd	Terminals 12, 13: Gnd

Output Range (linearized in displayed units): 0 - 5 VDC, 20 mA max.

Bits Resolution: 12 bits

◆ Power

100-120 VAC, 0.35 A (continuous)

Fuses (2): 2.0 A, Slow Blow, 250 VAC, Type 3AG.

220-240 VAC, 0.17 A (continuous)

Fuses (2): 1.0 A, Slow Blow, 250 VAC, Type 3AG.

Case Ground

On the back of the analyzer are connections to the case ground and O_2 sensor cable shields. The case ground is normally connected to the cable shields. To reduce the effects of electrical noise, it may be necessary to disconnect the case ground from the cable shields and make individual connections from these terminals to alternate dynamometer grounding points. Inside the EGR 4830, there is a 2.2K resistor connecting the case ground and the power ground.

◆ Dimensions and Weight

19" x 3.5" x 14", 483 mm. x 89 mm. x 356 mm. (W x H x D)

15 lbs., 6.8 kg.

Safety Warnings

In installation and use of this product, comply with the National Electrical Code and any other applicable Federal, State, or local safety codes.

Always wear eye protection when working near engines, vehicles, or machinery.

During installation, turn off the power and take all other necessary precautions to prevent injury, property loss, and equipment damage. Do not apply power until all wiring is completed.

Never work on a running engine.

When installing the EGR 4830's sensors and cables on a stopped engine it is best to think-out your moves before you make them.

Route and cable-tie all cables and tubing away from hot, moving, sharp, high energy (spark), and caustic objects.

Take into consideration the movement of the engine, chassis, and wind buffeting when instrumenting the engine.

The O_2 sensors get hot enough to burn you when they are on (even with the engine off).

The part of the O_2 sensors that stick into the intake or exhaust is heated and may ignite a combustable mixture inside the intake or exhaust.

Clear tools away from the engine before starting.

Operate the engine only in a well ventilated area and never when you or one of your coworkers is tired.

When operating the EGR 4830 in a moving vehicle, the operator should keep his or her eyes on the road.

One measure of professionalism is how much you and your coworkers can accomplish without an injury. Always be at your professional best. Think and act with safety in mind.

Warranty and Disclaimers

WARRANTY

The products described in this manual, with the exception of the O_2 and pressure sensors, are warranted to be free from defects in material and workmanship for a period of 365 days from the date of shipment to the buyer. Within the 365 day warranty period, we shall at our option replace such items or reimburse the customer the original price of such items which are returned to us with shipping charges prepaid and which are determined by us to be defective. This warranty does not apply to any item which has been subjected to misuse, negligence or accident; or misapplied; or modified; or improperly installed.

This warranty comprises the sole and entire warranty pertaining to the items provided hereunder. Seller makes no other warranty, guarantee, or representation of any kind whatsoever. All other warranties, including but not limited to merchantability and fitness for purpose, whether express, implied, or arising by operation of law, trade usage, or course of dealing are hereby disclaimed.

LIMITATION OF REMEDY

Seller's liability arising from or in any way connected with the items sold and/or services provided shall be limited exclusively to repair or replacement of the items sold or refund of the purchase price paid by buyer, at seller's sole option. In no event shall seller be liable for any incidental, consequential or special damages of any kind or nature whatsoever, including but not limited to lost profits arising from or in any way connected with items sold and/or services provided to buyer, whether alleged to arise from breach of contract, express or implied warranty, or in tort, including without limitation, negligence, failure to warn or strict liability. In no event shall the company's liability to buyer arising out of or relating to the sale of any product or service exceed the purchase price paid by buyer to the company for such product or service.

PRODUCT CHANGES

We reserve the right to discontinue a particular product or to make technical design changes at any time without notice.

ECM ENGINE CONTROL AND MONITORING

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EC DECLARATION OF CONFORMITY

We declare under our sole responsibility that the products:

AFM1540 Lambda module
AFM1600 Lambda and O_2 meter
DIS1000 Display head
Lambda 5220 Lambda meter
NOx 5210 NOx meter
EGR 5230 EGR meter
LambdaCAN Lambda module
NOxCAN NOx module
NOx1000 NOx module
EGR 4830 Analyzer

To which this declaration relates are in conformity with the essential requirements of the following standards:
EN61326: 1997/A2: 2001 (Class A & Annex A)
EN61010-1: 2001 (Electrical Safety)

And therefore conform to the requirements of the following directives:
89/336/EEC Electromagnetic Compatibility (EMC)
72/23/EEC Low Voltage Directive (LVD)

Ronald S. Patrick
Vice President Sales
February 22, 2006

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