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Mail-Out #95-20

May 22, 1995

TO: ALL PASSENGER CAR MANUFACTURERS
ALL LIGHT-DUTY/MEDIUM-DUTY VEHICLE MANUFACTURERS
ALL OTHER INTERESTED PARTIES

RE: Guidelines for Compliance with On-Board Diagnostics II (OBD II) Requirements

BACKGROUND

The California Air Resources Board (ARB) adopted the OBD II regulation in 1989 (Section 1968.1, Title 13, California Code of Regulations). The OBD II regulation requires manufacturers to implement on-board monitoring strategies for virtually all emission-related components and systems. Upon detecting a malfunction, the OBD II systems will alert the vehicle operator of a problem by illuminating the Malfunction Indicator Light (MIL) on the instrument panel. Further, diagnostic information will be stored to assist in the diagnosis and repair of the detected malfunction.

Implementation of the OBD II regulation began with the 1994 model year. The regulation permits manufacturers to phase-in OBD II systems consistent with planned changes to the on-board computer provided all vehicles subject to the requirements comply by the 1996 model year. To date, the ARB has certified more than 50 OBD II-equipped engine families.

Upon review of these initial applications, staff has found in a number of instances that certain aspects of the OBD II requirements have been misunderstood. In other instances, monitoring strategies have been implemented which the staff has found to be unreasonably conservative, such that the intent of the monitoring requirements will likely not be fulfilled on in-use vehicles. This guidance sets forth necessary clarification of the regulation and the staff's interpretation regarding the minimum acceptable performance of certain monitoring strategies. The staff has previously apprised manufacturers of its concerns regarding some or all of these issues, and have requested that manufacturers consider changes to their monitoring strategies to address these concerns. In general, the staff requests manufacturers to fully address these concerns by the 1997 model year.

<u>Misfire Detection</u>
Several issues concerning misfire detection have surfaced during discussions with manufacturers. Section (b)(3.3.1) allows manufacturers to request Executive Officer approval of disablement of the misfire monitoring system during certain operating conditions where misfire detection cannot be reliably detected. In this regard, many manufacturers have requested approval to disable misfire detection for a set amount of time from engine start-up (end of crank). The ARB staff is concerned that misfire could occur at engine start-up (e.g., during cold start when engines can run

rough), and then cease once warming of the engine has occurred. Such misfire problems are likely to have a significant impact on emissions since the catalyst will not have reached light-off temperature. In order to ensure that such malfunctions are detected, misfire detection delays after engine starting should be minimized or deleted. For the 1997 model year, the ARB will only approve a brief (i.e., no more than five seconds) disablement of misfire detection systems after start-up. After model year 1997, any delay after start-up will not be approved unless a manufacturer can demonstrate that the disablement is necessary.

A second area of concern is multiple cylinder misfire detection as required by Section (b)(3.1). Staff is using the following guidelines in determining compliance with the regulation: (1) For all multiple cylinder misfire situations which result in a misfire rate less than (but not including) 50 percent, the monitoring system should detect misfire with respect to <u>all possible cylinder combinations</u>; and (2) For all multiple cylinder misfire situations which result in a misfire rate greater than or equal to 50 percent, systems should be capable of detecting cylinder combinations which can be caused by a single component failure. For example, on a four cylinder engine with shared ignition coils (one coil for two cylinders), multiple continuous misfire in the pair of cylinders which share a coil should be detected whereas multiple continuous misfire in two of the cylinders which do not share a coil is not required to be detected.

<u>Oxygen Sensor</u>
Some manufacturers continue to misunderstand the definition of oxygen sensor response rate as used in the regulation. Section (b)(8.1.1) defines response rate as "the time required for the oxygen sensor to switch from lean-to-rich once it is exposed to a richer than stoichiometric exhaust gas or vice versa." Some manufacturers have implemented monitoring strategies that measure the slope of the signal (e.g., the time required to pass between 300 and 600 millivolts) once switching has begun. However, this strategy is not capable of detecting deterioration that causes a delay in the initial response of the sensor. Section (b)(8.1.2) of the regulation contains a suggested response rate check strategy. Alternatively, with Executive Officer approval, manufacturers may utilize other strategies. In this regard, manufacturers have provided data showing that monitoring of the frequency of the sensor signal provides an adequate indication of response rate. In order to accept oxygen sensor response rate monitoring strategies that measure only the slope of the signal, the ARB will require data which adequately demonstrate that deteriorated sensors will be detected before emissions exceed 1.5 times the standard, as required by the regulation.

<u>Rationality Checks</u>
Section (b)(10.1.1)(A) requires manufacturers to conduct rationality checks, where feasible, for input components. In general, several manufacturers have had trouble distinguishing rationality checks from out-of-range checks. The range checks are designed to identify components that are operating outside of their normal range (e.g., a 0 - 5.0 Volt sensor reading less than 0 V or greater than 5.0 V). Rationality checks are intended to identify components which are still operating within their normal range but are no longer accurate due to sensor drift or deterioration. In addition to having an emission impact, inaccurate sensors could disable other monitors if they are used as inputs or disable criteria. Where sensor readings are used as a disable criteria for diagnostics, inaccurate sensors could also cause false

MIL illumination by allowing the diagnostics to run during inappropriate conditions.

Rationality checks are to be "two-sided" to the extent feasible to maximize the probability of identifying sensors with inappropriately high or low values. Presently, staff believes that it is necessary and technologically feasible to conduct two-sided checks for manifold absolute pressure, mass air flow, and throttle position sensors at a minimum. For other sensors such as fuel level, coolant temperature, and intake air temperature, two-sided rationality checks that would be reliable in-use do not currently appear feasible and thus, are not required.

Rationality checks must also have reasonable fault thresholds and not look for extreme operating conditions before a fault is identified. For example, the fault thresholds for a mass air flow sensor should not be chosen such that the diagnostic looks for a signal indicating extremely high engine load (i.e., a near out-of-range value) while the engine is operating at or near idle. A more reasonable diagnostic would look for a signal indicating moderate or moderate-to-high engine load while the engine is operating at or near idle.

<u>Engine Coolant Temperature Sensor</u>
Section (b)(10.1.1)(C) of the regulation requires the engine coolant temperature sensor to "be monitored for achieving a stabilized minimum temperature level which is needed to achieve closed-loop operation ... within a manufacturer-specified time interval after starting the engine." As a general guideline in certifying OBD II systems, staff will allow the specified time interval to be a function of engine start temperature (and other inputs if necessary) but the time interval should be a maximum of five minutes for engine start temperatures above 20 deg F and a maximum of two minutes for engine start temperatures above 50 deg F. Longer time intervals will be permitted only if the manufacturer adequately demonstrates that its vehicles take longer to warm up under normal conditions. Other inputs and/or engine operation conditions can be used to identify extreme conditions and modify the fault threshold if appropriate. For example, the time interval can be extended if the vehicle remains at idle for a prolonged portion of the engine warm-up and the manufacturer demonstrates that the situation could cause false illumination of the MIL.

<u>Idle Speed Controller</u>
Functional checks, when feasible, are required for all output components under Section (b)(10.1.2) of the regulation. To functionally check the idle speed controller, most manufacturers specify a revolutions per minute (rpm) tolerance to which the idle speed is controlled. If the target speed cannot be maintained within that tolerance, a fault is indicated. The size of that tolerance varies from engine to engine, but the staff believes that idle speed controller malfunctions will not be reliably detected if the tolerances are larger than +200 rpm or -100 rpm (i.e., if the engine speed is more than 200 rpm above the target speed or more than 100 rpm lower than the target speed, a fault should be indicated). Therefore, monitoring strategies with greater tolerances are generally not considered to be acceptable to the staff. For many engines, much smaller limits are possible and should be used whenever feasible. The ARB may insist on more stringent malfunction thresholds on future model year engine families if ARB's validation testing indicates that it is necessary.

Camshaft/Crankshaft Position Sensors
Rationality checks are required, where feasible, for all input components under Section (b)(10.1.1)(A). For vehicles that require precise alignment between the camshaft and the crankshaft (e.g., vehicles with variable valve timing, etc.), the OBD II system should check (to the extent feasible) for proper alignment between the camshaft and the crankshaft in addition to both of these sensors being monitored for circuit continuity and rationality. Many manufacturers already check this by comparing the position and reference signals of the two sensors. This check helps to identify a malfunction where a timing belt or chain has either slipped or been installed incorrectly. Further, many diagnostic systems use the camshaft sensor for misfiring cylinder identification and therefore, proper relative alignment between the camshaft and the crankshaft may be important to prevent misdiagnosis.

Battery Voltage
Section (b)(10.1) requires the diagnostic system to monitor any component which "...is used as part of the diagnostic strategy for any other monitored system or component". Because most manufacturers disable certain diagnostics if battery voltage is below a specified minimum voltage, the staff has requested that the battery voltage be monitored to avoid prolonged monitoring system disablement should battery voltage remain below the threshold voltage. Realizing that most vehicles will not run for a prolonged period with battery voltage below 11.0 Volts (i.e., the alternator is not charging properly and the battery will eventually lose its charge), the ARB will not require battery voltage monitoring if the enable criteria for the diagnostic is less than 11.0 Volts. However, if the enable criteria requires battery voltage greater than 11.0 Volts, battery voltage should be monitored by the OBD II system. The ARB will consider manufacturers' requests to disable monitoring above 11.0 Volts only if the manufacturer can demonstrate that vehicles are not likely to operate for extended periods of time with the battery voltage below the disablement criteria. Manufacturers also should be aware that if they monitor battery voltage and illuminate the MIL when a fault occurs, they will be subject to replacing the battery under the emission warranty if it is still in effect.

Overdrive On/Off Selector Switch
Many vehicles currently allow a driver to manually enable or disable the overdrive gear on automatic transmissions. The staff has concerns that in-use emissions could increase should the manual switch malfunction such that overdrive is permanently disabled. Under Section (b)(10.1), any input component which "...can affect emissions during any reasonable in-use driving condition..." must be monitored for malfunction. However, the staff recognizes the difficulty in designing a diagnostic that can distinguish between a malfunctioning switch and the situation where a driver always selects the overdrive gear to be "off." The staff also understands that in most cases, an indicator light is illuminated when overdrive is enabled and/or disabled. This indicator should be helpful in alerting the vehicle operator to any problems with the switch. Therefore, the staff will not require monitoring of the switch. Nonetheless, the staff prefers to see switches which are automatically reset to overdrive "on" at every key-off so that a driver must actively select overdrive "off" each time the car is started.

Fuel Level Sensor

Manufacturers are increasingly finding it beneficial to disable certain diagnostic strategies at very low fuel levels in order to prevent misdiagnosis should the vehicle run out of fuel. Further, some manufacturers are using fuel level as an input for evaporative system leak detection strategies (see Sections (a)(2.1) and (b)(4.1.3)). Besides monitoring of circuit continuity for the fuel level sensor, the staff requires rationality monitoring of the sensor under the requirements for electronic input components (Section (b)(10) of the regulation). The ARB's primary concern is that a stuck fuel level sensor could result in false MIL illumination or permanent disablement of monitoring systems. The most common method to verify that the sensor is not stuck is to look for a reduction in fuel level after an extended period of driving. To facilitate the development of fuel level sensor rationality checks, the ARB is willing to consider monitoring strategies that require a longer monitoring period than available during a Federal Test Procedure (FTP) test provided the diagnostic uses a cumulative time/fuel level comparison and does not reset the diagnostic at every key on/off.

<u>Automatic Transmission (A/T) Inhibitor ("PRNDL") Switch</u>
After numerous discussions with industry regarding the feasibility of transmission inhibitor switch monitoring, staff has determined that the following checks are necessary to satisfy the regulation (Section (b)(10.1.1)) for most vehicle designs. At a minimum, the diagnostic is required to identify the following two faults: (1) no signal; and (2) more than one signal at the same time. Nonetheless, the ARB staff is willing to consider equivalent alternate monitoring strategies.

<u>A/T Shift Solenoids</u>
Because the shift solenoids are output components, each one must be monitored for functionality as well as circuit continuity under the requirements of Section (b)(10.1.2). To verify that the solenoid is functioning properly, manufacturers must verify that a shift has occurred, or at a minimum that the solenoid plunger moves when commanded to do so. Most diagnostics look at input and/or output speeds and gear ratio to verify that the shift has occurred. Additionally, the staff suggests that separate fault codes for each shift solenoid be used to aid in the diagnosis and repair of malfunctions. As an exception, a single fault code is acceptable if the solenoids are packaged together and sold/repaired only as a single unit (single part number).

<u>Torque Converter Clutch (Lock-up) Solenoid</u>
Similar to shift solenoids, the lock-up solenoid must also have a functional check to verify that lock-up has occurred. Most manufacturers presently utilize a strategy similar to that used to monitor the shift solenoids. With this strategy, the system monitors torque converter slip to determine if lock-up has occurred. A separate fault code should be stored for this fault unless the torque converter clutch solenoid is packaged with the shift solenoids and sold under a single part number.

A/T Control Module (TCM)
As is required of the Engine Control Module (ECM), the TCM must have self diagnostics such as check sums and a watchdog timer. The MIL should be illuminated and an appropriate fault code stored if a TCM fault affecting OBD II performance occurs. At a minimum, if the TCM fails the MIL must be illuminated and a fault code indicating TCM failure must be stored.

Default Modes
Section (c) 1.0 of the regulation requires MIL illumination "whenever the powertrain enters a default or 'limp home' mode of operation." The staff has learned that several manufacturers employ over-temperature management strategies that enrich fuel delivery and/or modify engine timing to help cool the engine. Many of these strategies are executed at coolant temperatures significantly below that at which the temperature is considered critical (i.e., the temperature at which the hot light is illuminated or the temperature gauge reaches the red zone). The ARB considers these strategies to be default modes and are thus subject to the MIL illumination requirements listed above. Staff is concerned that a partially plugged radiator or malfunctioning fans could result in higher than normal engine temperature conditions which could cause these protection strategies to occur even during normal driving (including stop-and-go traffic) without any indication to the driver that there is a problem. During such occurrences, vehicle emissions would likely increase substantially due to the nature of the engine control changes (i.e., enrichment of the fuel system). In model year 1996 and earlier vehicles, the staff will not consider lack of MIL illumination for this situation a deficiency, provided the electronic coolant fans are monitored for proper circuit contimuity at a minimum. The ARB requests manufacturers to implement a strategy by the 1997 model year to illuminate the MIL when the default mode is entered.

However, manufacturers do have two options other than MIL illumination that will be considered acceptable to the ARB. If a manufacturer does not initiate the strategy until either the engine temperature gauge enters the red zone or the engine temperature ("hot") light is illuminated, MIL illumination is not required. The second option would require the manufacturer to verify that the strategy was only initiated because of the occurrence of severe operating conditions. For example, verifying that the vehicle is operating in extremely high ambient temperature and/or that the vehicle is under a severe load for a prolonged time (e.g., pulling a trailer up an extended grade) would be grounds for determining that the MIL should not be illuminated.

Vehicle Readiness Code
Section (e) of the regulation requires a readiness code to be stored once a full set of diagnostics has been performed. The code should be set to "not ready" only if the computer memory is cleared (either through the use of a scan tool or possibly disconnection of the battery). The code should not be set to "not ready" at each vehicle power down (key-off).

Certification Application Format
In addition to the information required for submittal in Section (h) of the regulation, staff has developed a summary table format that has helped to expedite and simplify the approval process for certification. A sample summary table is included as Attachment A. As staff gains more experience with the systems, it is the ARB's goal to reduce the amount of documentation

needed to approve an OBD II system. The use of the summary table format is the first step towards that goal.

Fault Codes
Whenever possible, manufacturers are required by Section (k)(3.0) to utilize generic (P0xxx) fault codes (identified in Society of Automotive Engineering document J2012). Manufacturer specific (P1xxx) fault codes are allowed, but should be used only when the generic codes are not adequate to describe the fault. Also, when manufacturer specific codes are used, manufacturers are requested to be as consistent as possible across their product line when assigning the fault codes.

Fault Threshold Criteria
Several fault thresholds are set at the point where emissions "exceed 1.5 times the standard." The standard used in that equation is dependent on the number of miles on the vehicle. If the vehicle has less than 50,000 miles, the 50,000 mile standard is applicable or if the vehicle has more than 50,000 miles but less than 100,000 (120,000 for medium-duty vehicles), the 100,000/120,000 mile standard is applicable. The ARB recently amended section (n) (1.0) to clarify this requirement.

SUMMARY
Staff has drafted this notice in an attempt to maintain consistency from manufacturer to manufacturer in both interpretation of the regulation and in implementation of any necessary changes. As more experience is gained from OBD II-equipped vehicles in the field and from the ARB validation testing, additional implementation issues may need to be addressed. As has been done in the past, staff will continue to work with the industry to reach reasonable solutions.

Additionally, there will always be manufacturer-specific questions that will still arise and these will continue to be addressed in the existing manner of meetings and/or discussions with staff during the application process. The staff appreciates the generally positive attitudes of manufacturers' representatives during discussions of these matters, especially during this initial implementation period of OBD II systems. Should you have any questions or require clarification regarding this notice, please contact Mr. Allen Lyons, Manager, Advanced Engineering Section, at (818) 575-6833.

Sincerely,

K. D. Drachand, Chief
Mobile Source Division

Attachment

Engine Family		Certification Standard	Enhanced Evap					
xxxxx.xxxxxxx		(Tier 1, TLEV, etc..)	(yes/no)					
Component/	**Fault**	**Monitor Strategy**	**Malfunction**	**Threshold**	**Secondary**	**Enable**	**Time**	**MIL**
System	**Code**	**Description**	**Criteria**	**Value**	**Parameters**	**Conditions**	**Required**	**Illum.**
Catalyst	P042x	oxygen storage	rear oxygen sensor	> xxx	Engine speed	xxxx - xxxx rpm	xxx secs	two trips
			vs front oxygen sensor		Injector pulse width	xxx - xxx ms	once per trip	
		Malfunction criteria:			vehicle speed	xxxx - xxxx mph		
		(1.5 x standard, 50% efficiency,						
		2 x standard + 4k, etc...)						
Misfire	P0301	Crankshaft speed	FTP Emissions Threshold	> xxx %	Engine speed	xxxx - xxxx rpm	1000 revs	two trips
	to	fluctuation	I/M Emissions Threshold	> xxx %			continuous	
	P030x			Disable conditions:	Load change	< xxx ms/s		
	P0300	Multiple misfire			Speed change	< xxx mph/s		
					Time from engine			
					start-up	< 5 sec		
					rough road	< xxx		
			Catalyst Damage	see load/rpm map			200 revs	immediately
Evaporative	P0440	functional check	Lambda shift	> xxx	Coolant temperature	> xxx deg C	xxx secs	two trips
Purge System					Fuel system status	closed loop		
					normal purge	on		
Evap Purge	P0443	circuit continuity-ground	voltage min/max	< > xxx - xxx V			continuous	two trips
Valves		circuit continuity-open	voltage min/max	< > xxx - xxx V			continuous	two trips
Secondary Air	Pxxxx	functional check	oxygen sensor signal		secondary air	on/off	xxx secs	two trips
System	Pxxxx				(normally on when		once per trip	
					starting coolant temp)	< xxx deg C		
					oxygen sensor	xxx - xxx V		
					altitude	< xxxx ft		
					evap purge valve	on/off		
				During diagnostic:	fuel trim			
					closed loop fuel control			
Secondary Air	Pxxxx	circuit continuity	voltage	<> xxx V			continuous	two trips
System Relay								
Fuel System	P0170	fuel trim limits exceeded	Short term	> +/- xxx %	Fuel system status	open/closed loop	xxx secs	two trips
			Long term	> +/- xxx %				

Oxygen sensor	P0133	Response rate:	sensor signal period	> xxx sec	Engine speed	xxxx - xxxx rpm	xxx secs	two trips
(front)			(average over 10 periods)		Inj. pulse width	xxx - xxx ms		
					Catalyst temp (model)	> xxx deg C		
	P0130	circuit continuity	oxygen sensor voltage				continuous	two trips
	P0132	range check-high	Maximum voltage	> xxx V			continuous	two trips
	P0131	range check-low	Minimum voltage	< xxx V			continuous	two trips
Oxygen sensor	P0136	range check-high	maximum voltage	> xxx V			continuous	two trips
(rear)		range check-low	minimum voltage	< xxx V				
		circuit continuity	oxygen sensor voltage				continuous	two trips
Oxygen sensor	P0135	Heater current	calculated resistance	< xxx or > xxx			continuous	two trips
heater (front)								
		circuit continuity	voltage				continuous	two trips
Oxygen sensor	P0141	Heater current	calculated resistance				continuous	two trips
heater (rear)								
		circuit continuity	voltage				continuous	two trips
Throttle	Pxxxx	Range check-min	TPS voltage	< xxx V (xxx deg)			continuous	two trips
Position								
Sensor	Pxxxx	Range check-max	TPS voltage	> xxx V (xxx deg)			continuous	two trips
	Pxxxx	rationality-low	TPS voltage	< xxx deg	engine speed	> xxxx rpm		
	Pxxxx	rationality-high	TPS voltage	> xxx deg	engine speed	< xxxx rpm	continuous	two trips
Camshaft	P0340	rationality	no signal		engine speed	xxxx - xxxx rpm	continuous	two trips
Position			alignment to crankshaft	> xxx teeth				
Sensor								
Mass Air	P0100	range check - low	voltage	< xxx V			xxx secs	two trips
Flow Sensor		range check - high		> xxx V			xxx secs	two trips
		rationality - high	voltage	> xxxx	engine speed	< xxxx rpm	xxx secs	two trips
		rationality - low	voltage	< xxxx	engine speed	> xxxx rpm		

Coolant	P0116	rationality	time to reach closed loop	> xxx secs	temperature at start	> xxx deg C		
Temp Sensor			enable temperature		vehicle speed	> xxx mph for xxx% of time		
		range check-min	resistance	< xxx Ohms (xxx deg C)			continuous	two trips
		range check-max	resistance	> xxx Ohms (xxx deg C)			continuous	two trips
		circuit continuity	voltage				continuous	two trips
Vehicle	P0500	circuit continuity	no signal		engine speed	xxxx - xxxx rpm	xxx secs	two trips
Speed Sensor					injection pulse width	xxx - xxx ms		
		rationality-low/high	calculated speed	> +/- xxx	vehicle speed	xxx - xxxx mph	xxx secs	two trips
			vs measured speed					
		range check-high	indicated speed	> xxx mph			xxx secs	two trips
Intake Air	P0111	range check-min	resistance	< xxx Ohms (xxx deg C)			continuous	two trips
Temp sensor		range check-max	resistance	> xxx Ohms (xxx deg C)			continuous	two trips
Crankshaft	Pxxxx	rationality	counted teeth- actual	> xxx teeth			continuous	two trips
Position sensor			number of teeth					
		circuit continuity	sensor signal	no signal				
Injection Valve	P0201	circuit continuity	voltage				continuous	two trips
	to							
	P020x	range check- max	voltage	> xxx V			continuous	two trips
		range check- min	voltage	< xxx V			continuous	two trips
ECM	P0600	functional check	auto watchdog timer		at power up		xxx secs	two trips
			check-sum		at power up		xxx secs	two trips
Idle Control	P0xxx	functional check	actual - desired	> xxx rpm	battery voltage	> xxx V	xxx secs	two trips
Module (EML)			air mass					
		functional check	actual-desired rpm	< xxx rpm			xxx secs	two trips
A/T range	P0705	rationality	range switch	multiple signals			xxx secs	two trips
switch								
		circuit continuity	range switch	no signal detected	engine speed	xxxx - xxxx rpm	xxx secs	two trips

A/T Input	P0715	range check-min	input speed	< xxx rpm	Gear			
speed					engine speed	xxxx - xxxx rpm		
					output speed	xxxx - xxxx rpm		
		range check-max	input speed	> xxx rpm				
		circuit continuity	voltage					
A/T Output	.P0720	range check-min	output speed	< xxx rpm	Gear selected			
speed					input speed	xxxx - xxxx rpm		
		range check-max	output speed	> xxx rpm				
		circuit continuity	voltage					
A/T Gear Ratio	P0730	rationality	input-output x gear ratio	> +/- xxx rpm	Gear		xxx secs	two trips
					input speed	xxxx - xxxx rpm		
					output speed	xxxx - xxxx rpm		
Torque	P0743	circuit continuity	voltage				continuous	two trips
Converter								
Clutch		functionality	calculated slip	> xxx %				
Pressure	P0748	circuit continuity	voltage				continuous	two trips
Control								
Solenoid								
Shift	P0753	circuit continuity	voltage				continuous	two trips
Solenoid A								
Shift	P0758	circuit continuity	voltage				continuous	two trips
Solenoid B								
Transmission	Pxxxx	TCM	bus-check		at power up		xxx secs	one trip
Control Module								
	Pxxxx	TCM	check-sum (EPROM)		at power up		xxx secs	one trip
Battery	P0601	range check	voltage	< xxx V or > xxx V			xxx secs	two trips
Voltage								