Andros Incorporated

Model 6900 Product Manual
Reorder Number 891166-001

Models 6900/6500/6510 Compact Automotive Gas Subsystem and Components

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Preface

About This Manual

***Important Note**: This manual contains preliminary technical information and all features, specifications, procedures, and descriptions are subject to change prior to final product release. If you have any questions, please contact your Andros sales or technical representative.*

Chapter 1 Introduction	Key features, applications, and configurations of the Model 6900 compact automotive emissions gas subsystem are described. Supported government mandated emissions programs are listed. Options and Accessories for the 6900 are listed.
Chapter 2 Specifications	Model 6900/6500/65106900 / 6500 / 6500 product performance specifications are defined.
Chapter 3 Operation	The Model 6900 subsystem and Model 6500/6510 analyzer's gas concentration measurement techniques are discussed. Functional descriptions are proved for the primary components and subassemblies. The start-up, warm-up, normal, standby and boot program operating modes are defined. The 6900 configuration mode control is reviewed.
Chapter 4 Calibration	Zero and span calibration is covered in detail.
Chapter 5 Hardware Interfaces	Model 6900/6500/6510 power, communications, and auxiliary I/O interfaces are described in detail.
Chapter 6 Sample Delivery	The 6900 pneumatic components and configurations are discussed. The 6900 leak test procedure is detailed.
Chapter 7 Host Communications	The Model 6900/6500/6510's communications protocol and command set are defined.
Chapter 8 Service Procedures	The 6900 maintenance and service guidelines, replacement procedures, and troubleshooting are covered in detail.
Chapter 9 Product Support	Depot service, technical support, and training programs are identified.
Appendices	Additional reference information for the 6900 is provided.

Andros Notation

The Model 6500/6510 always refers to the Andros bench analyzer. The Model 6500 contains all the associated driver circuitry and connections necessary to support the operation of a 12 VDC pump and solenoids, and is used in the Model 6900. The Model 6510 does not support the operation of a pump and solenoids. Users of the Model 6510 are required to supply all pump and solenoid controls separately.

The Model 6900 is the product number for a family of subsystems that are built around the Model 6500/6510 analyzer. When the term"6900" is used without reference to the term "Model" in this manual it may be referring to the bench analyzer, or one of the analyzer's functions, within a general subsystem context.

Hexadecimal numbers are preceded by a $ (dollar sign). The $F0 Reset command requires transmission of the hexadecimal command code $F0, which is equivalent to 240 decimal or 11110000 binary.

Analog-to-digital converters and their output values are abbreviated as both A–D and ADC.

Both NO and NOx are used to refer to nitric oxide (NO) and nitrogen dioxide (NO_2) collectively.

Individual bytes or bits in host system commands and ACK/NAK responses are specified in the following format:

Command_Code—Byte_Name—Bit_Number.

Bit numbers are not referred to when the entire byte is defined.

Example #1: $01–STAT1–5 refers to the $01 Data/Status command, STAT1 (System Status) byte, bit 5 (Zero Request).

Example #2: $03–TVM refers to the $03 Span Calibration command, TVM (Tag Value Mask) byte.

Example #3: $01-STAT2-7,6 = 11 refers to the $01 Data/Status command, STAT2 (Data Status 1) byte, CO2 Data status field (bits 7 and 6). In this example the CO2 Data status is reported as CO2 Zero Fail (11). Bits are always shown with the most significant bit listed first (on left).

Manual History

Revision	Date	Description
1	8/11/05	First preliminary release
2	16-MAY-06	Added new commands, updated drawings, added Model 6510 data
3	17-AUG-06	Various, changes reflect validation and B-Test issues, added new commands
4	19-OCT-06	Chapter 7: revised command descriptions; Chapter 5: revised connector locations and pinouts; Chapter 8: revised service procedures
5	15-MAR-07	Chapter 7: Added $18, SW Checksum command; revised Zero request conditions; Removed Flash Read/Write commands and support documentation; Chapter 5: Corrected connector tables J8 and J9; Chapter 3: revised Standby/Warm up specifications

Chapter 1 — Introduction

Key Features and Configurations

- Standard 6900 subsystems can be ordered as either 4-gas or 5-gas subsystems.
- Standard 6900 subsystems are shipped with a single-solenoid valve. The multi-solenoid valve version can be configured for BAR-97 gas delivery (e.g., zero calibration uses bottled zero gas). It requires an additional sample pump and solenoid valves which are to be supplied by customer.
- Custom 6900 subsystems can be designed for the high-volume OEM. Additional sample delivery options and accessories are available. Custom sheet metal to meet the OEMs system requirements can be provided.
- All Model 6900s include a Model 6500 Miniature Automotive Gas Analyzer.
- All 6900s exceed BAR-97 and OIML Class 0 gas measurement accuracy.
- All 6900s are ready for integration into OIML Class 0/1 systems.
- Single +12 VDC input power requirement (+9 to +16 VDC). Can be powered by +12 VDC power supply or automotive battery.
- Small-volume gas analysis subsystem package.
- Lightweight (2.0 to 2.4 kg, depending on configuration).
- Low power consumption: 13.5 watts nominal.
- Rugged design and construction.
- Fast warm-up time (within 35 seconds). Defined as the time from Power On Reset (POR) until Start-Up Status bit clears.
- Easy-to-use host system command set and RS-232C, USB 1, or TTL (3.3VDC) communications interface.
- End-user maintainable particulate filtration, O_2 sensor and NO_x sensor. These assemblies are mounted on the outside of the 6900 for easy end-user access. Optionally, the O_2 and NO_x sensors can be mounted behind a panel or cover when mandated by a government program.
- 10,000 hours MTBF (excluding O_2 sensor, NO_x sensor, pump and end-user replaceable filters).
- End-user or service-depot cleanable or replaceable sample cell and source.

Pneumatics Configurations

The 6900 subsystems are available in the following pneumatics configurations. Custom pneumatics configurations can be delivered.

Standard (Single-Solenoid Valve) 6900 Pneumatics Configuration:

Designed to support the lowest cost subsystem requirements, a Basic 6900 subsystem includes the following:

- High-capacity, fast-response sample delivery design.
- Wet- and dry-side pneumatic pump.
- Water trap/filter assembly: User-replaceable particulate filter. Automatic water bowl drain. Float check valve positively protects the Model 6500/6510 analyzer if the water trap bowl ever fills.
- Sample gas/room air solenoid valve.
- Calibration gas port.
- Designed to support diagnostic/repair applications and Inspection/Maintenance (I/M) programs (e.g., OIML Class 0 and Class 1).

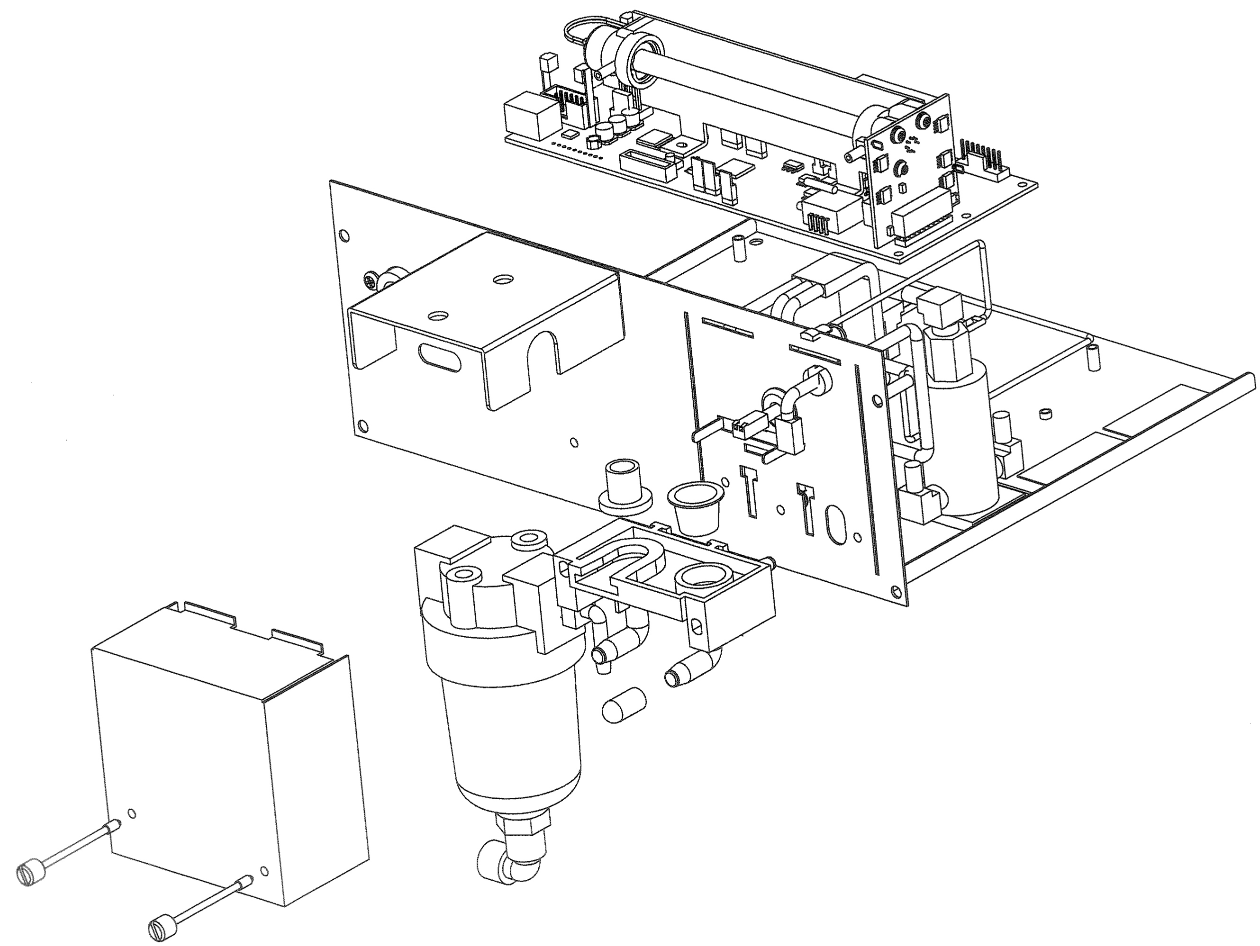
Gas Measurement Configurations

All 6900 subsystem configurations can be ordered with an Andros NOx sensor included (5-gas) or without (4-gas).

Note: All 4-gas 6900s can be field upgraded to a 5-gas operation by installing a NO_x sensor and performing a gas span calibration.

Caution: Any procedures involving bottled NO and/or NO_2 should be performed with adequate active venting to prevent lung damage due to exposure to toxic gases.

Model 6900 shown with Model 6500



6900 Subassembly (OIML configuration shown)

Government Programs Supported

The 6900 subsystem exceeds worldwide gas-measurement performance specifications for automotive emissions. The following governmental programs are supported:

Location	Agency
United States (EPA)	EPA ASM
United States (California)	ASM / BAR-97
Europe	ISO 3930/OIML R99, Class 0 and Class 1
Rest of World	Other agencies use variants of BAR or OIML

End-User Maintenance

The 6900 is designed to support end-user maintenance for the following components:

Component	Typical Life Cycle
Water Trap Filter Element	Every 80 vehicle tests, or once per week *
Room Air Filter	Once per month, or as required
O_2 Sensor	12 to 18 months
NO_X Sensor	12 to18 months
IR Source	36 to 42 months minimum
Sample cell	Cleanable or replaceable as an assembly

* Type, age and operating condition of vehicles may necessitate more frequent filter changes.

Options and Accessories

The following Andros accessories are available for integration with the 6900 subsystem:

- Hose and probe assembly
- Solenoid manifold
- 12 VDC sample pump

Chapter 2 — Specifications

Environmental Specifications

The 6900 subsystem will perform to specification when subjected to any combination of the environmental conditions listed below.

	Operating Range	Storage Range
Temperature	0 to 70ºC (32 to 158ºF) (reduced accuracy > 50ºC)	–25 to 70ºC (1) (–4 to 158ºF)
Humidity	5 to 95% (non-condensing) (2)	
Altitude	–300 to 3,000 m (–1,000 to 9,750 ft)	–300 to 3,000 m (–1,000 to 10,000 ft)
Vibration	1.0 g sinusoidal, 5 to 1,000 Hz	0.01 g^2/Hz(3)
Shock	7.6 cm (3.0 inch) drop on any corner (in final system enclosure)	
EMI/EMC	CFR Title 47, Part 15, Subpart J, Class A and B. CFR Title 47, Part 68.	

1. Storage temperature range for Andros supplied NO_X sensor is –20 to 50ºC; sensors may be stored outside this range for up to 10 days. The optimal storage temperature for the NO_X sensor is 5 to 20ºC.
2. NO_X sensor humidity range is 15 to 90% RH.
3. Installed configuration or packaged for shipment.

Mechanical Specifications

	Model 6900 Shelf Subsystem (excluding water trap/filter assembly)		Model 6500/6510 NDIR Bench
	Basic	**OIML**	**ALL**
Width	27.0 cm (10.6 in)	27.0 cm (10.6 in)	19.7 cm (7.7 in)
Depth	20.06 cm (7.3 in)	18.5 cm (7.9 in)	7.3 cm (2.87 in)
Height	10.16 cm (4.0 in)	10.0 cm (4.0 in)	5.0 cm (2.0 in)
Weight	2.1 kg (4.63 lb.)	2.1 kg (4.63 lb.)	0.3 Kg (0.8lb)

Power Specifications

The following input power specifications define the worst-case conditions for acceptable operating performance of the 6900 shelf subsystem:

Input Voltage	+12 VDC nominal (+9 to +16 VDC)	
	Model 6900	**Model 6500/6510**
Average Power Consumption (1)	13.5 W	1.8 W
Maximum Power Consumption	18.5 W	2.4 W

(1) 12 VDC input power @ 25°C

Gas Measurement Accuracy, Repeatability, Noise, and Resolution

Gas	Measurement Range	Accuracy	Repeatability	Noise (rms.)	Resolution
HC n-Hexane	0 to 2,000 ppm 2,001 to 7,000 ppm 7,001 to 15,000 ppm 15,001 to 30,000 ppm	±4 ppm abs. or ±3% rel. ±5% rel. ± 15% rel unspecified.	±3 ppm abs. or ±2% rel. ±3% rel. ±5% rel. unspecified	2 ppm abs. or 0.8% rel.	1 ppm
HC Propane	0 to 4,000 ppm 4,001 to 30,000 ppm 30,001 to 60,000 ppm	±8 ppm abs. or ±3% rel. ±15% rel. unspecified	±6 ppm abs. or ±2% rel. ±5% rel. unspecified	4 ppm abs. or 0.8% rel.	1 ppm
CO	0.00% to 10.00% 10.01% to 15.00%	±0.02% abs. or ±3% rel. ±5% rel.	±0.02 abs. or ±2% rel. ±3% rel.	0.01% abs. or 0.8% rel.	0.001vol. %
CO_2	0.00 to 16.00% 16.01 to 20.00%	±0.3% abs. or ±3% rel. ±5% rel.	±0.1% abs. or ±2% rel. ±3% rel.	0.1% abs. or 0.8% rel.	0.01vol. %
NO_X	0 to 4,000 ppm 4,001 to 5,000 ppm	±25 ppm abs. or ±4% rel. ±5% rel.	±20 ppm abs. or ±3% rel. ±4% rel.	10 ppm abs. or 1% rel.	1 ppm
O_2	0.00 to 25.00%	±0.1% abs. or ±3% rel.	±0.1% abs. or ±3% rel.	0.1% abs. or 1.5% rel.	0.01 vol. %

Notes:

1) The Models 6900 / 6500 / 6510 can report outside of its specified measurement ranges.
2) The Models 6900 / 6500 / 6510 can report gas concentrations at reduced accuracy when operated outside of specified conditions defined by ISO3930/OIML R 99 and BAR i.e., temperature > 50°C or < 0°C.
3) Negative gas concentrations can indicate either of the following:
    a) Negative measurement drift, or
    b) Incorrect HC, CO, CO_2 zero calibration (e.g., zero calibration when IR absorbing gas or moisture is present in the sample cell).
4) When both absolute and relative measurement tolerances are specified, the greater measurement tolerance of the two is used.
5) The accuracy table is based on California BAR-97 requirements between the temperatures between 35 to 110°F (1.7 - 43°C)
6) ISO 3930/OIML R 99, Class 0 allows for ±5% relative error for temperatures between 32 to 122°F (0 - 50°C)
7) Drift is measured with Nitrogen flowing through the sample cell at one to two liters per minute. All zero requests are honored when indicated. Maximum stability occurs per BAR 97 ASM 30 minutes after POR.

Measurement Range: The range that is applicable to the accuracy and noise measurements.

Accuracy: The 6900 gas concentration measurement tolerance.

Repeatability: An individual 6900s measurement tolerance when repeating the same measurement.

Resolution: The smallest increment reported.

Noise: Measurement transients produced by the analyzer.

Warm-Up

The bench/subsystem will transition from start-up to normal operating mode within 35 seconds after POR, after which it will request a zero. After the first zero, the analyzer is useable at reduced accuracy for the next three (3) minutes, after which it will request a second zero. The unit is at full accuracy after the second zero is performed. Zero drift as defined by the BAR 97 ASM specifications is measured after the unit has been allowed to stabilize for 30 minutes after POR.

Propane Equivalency Factor (PEF)

The 6900 subsystem Propane Equivalency Factor (PEF) value is nominally in the range of 0.470 to 0.560 for HC (n-Hexane) concentrations up to 2,000 ppm when the Models 6900 / 6500 / 6500 are operated at an ambient temperature environment of 25°C ±10°C. This applies to BAR-97 applications. For OIML and diagnostics applications the calculated variable PEF can be in the range of 0.470 to 0.585.

The 6900 variable PEF value (reported by $05–PEF1, PEF2) is calculated in real-time, and defines the n-hexane concentration as a fraction of the (optically) equivalent propane concentration that may be reported as the current HC concentration. The variable PEF range is 0.470 to 0.585.

Cross-Gas Interference

The presence of one gas can cause errors in the measurement of a second gas. Maximum 6900 cross-gas interference effects conform to ISO 3930/OIML R 99, Class 0/1 and BAR-97 specifications and are listed below:

Primary Gas	Maximum Cross-Gas Interference	Maximum Interfering Gas Concentrations
HC	±4 ppm	1) 16% carbon dioxide in nitrogen. 2) 1,600 ppm hexane in nitrogen. 3) 10% carbon monoxide in nitrogen. 4) 3,000 ppm nitric oxide in nitrogen. 5) 75 ppm hydrogen sulfide in nitrogen. 6) 75 ppm sulfur dioxide in nitrogen. 7) 18% carbon dioxide and 9% carbon monoxide in nitrogen. 8) h) Water-saturated hot air.
CO	±0.02%	
CO_2	±0.20%	
NO_X	±20 ppm	

System Transport Time

System transport times are specified for a 6900 with 8m-hose/probe and particle filter/water trap as follows:

	System Transport Time
HC	≤ 5 seconds.
Propane	≤ 5 seconds.
CO	≤ 5 seconds.
CO_2	≤ 5 seconds.
NO	≤ 7 seconds.
O_2	≤ 7 seconds.

Method: Create a rapid step change in gas concentration at the probe tip. System transport time is the time required to report the first analyzer gas concentration change.

System Response Time

System response times are specified for a 6900 with 8m-hose/probe and particle filter/water trap as follows:

	Rise Time	Fall Time
HC	T90 ≤ 8.0 seconds.	T10 ≤ 8.0 seconds.
Propane	T90 ≤ 8.0 seconds.	T10 ≤ 8.0 seconds.
CO	T90 ≤ 8.0 seconds.	T10 ≤ 8.0 seconds.
CO_2	T90 ≤ 8.0 seconds.	T10 ≤ 8.0 seconds.
NO	T90 ≤ 12.0 seconds.	T10 ≤ 12.0 seconds.
O_2	Response time from 20.9% to 0.10% O_2 ≤ 40 seconds, and T90 response time ≤ 15.0 seconds.	

Method: Create a rapid step change in gas concentration at the probe tip. System response times (at a flow rate into the water trap at 6 liters/minute) are the times required to report the specified analyzer gas concentration changes.

Model 6500/6510 Analyzer/Sensor Response Time

Analyzer /sensor response time is measured as follows:

	Rise Time	Fall Time
HC	T90 ≤ 3.0 seconds.	T10 ≤ 3.0 seconds.
Propane	T90 ≤3.0 seconds.	T10 ≤ 3.0 seconds.
CO	T90 ≤ 3.0 seconds.	T10 ≤ 3.0 seconds.
CO_2	T90 ≤ 3.0 seconds.	T10 ≤ 3.0 seconds.
NO	T90 ≤ 5.0 seconds.	T10 ≤ 6.0 seconds.
O_2	Response time from 20.9% to 0.10% O_2 ≤ 40 seconds. Rise time for 1.10% O_2 to 20.9% O_2 ≤ 20 seconds.	

Method: With a minimum gas flow of 1 liters/minute, create a rapid step change in gas concentration at the inlet port of the Model 6500/6510 analyzer. Analyzer/Sensor response times are the times required to report the specified analyzer gas concentration changes.

Host Communications Interface

The Models 6900 / 6500 / 6500 commands, status, and data-transfer are provided by the host communications interface. Refer to the Hardware Interfaces chapter for connector pin assignments.

Interface Type: RS-232C asynchronous or USB 1.1.

Baud Rate: 19,200 bps (default) or 9,600 bps (optional via Model 6500/6510 parameter change).

RS-232 Format: 1 start bit; 8 data bits; no parity bit; 1 stop bit.

Signals: Transmit data; receive data; signal ground. CTS and RTS handshaking signals are not used by current Model 6900 / 6500 / 6500 configurations.

Auxiliary I/O Interfaces

Auxiliary interfaces are provided for attachment of external devices to the 6900 subsystem. Refer to the Hardware Interfaces chapter for additional specifications and connector pin assignments.

TTL Outputs: AUXOUT 6 and AUXOUT 7 are user-defined TTL outputs host system controlled via the $08 Device Control command.

Tachometer Input: TACHIN is a TTL compatible pulse counter input dedicated to a tachometer function.

Analog Input: Model 6900/6500 Mode: ADC1 and ADC2 are user-defined analog inputs. Input range is 0.01 to 4.0 VDC. A companion reference signal (V Ref) and the Model 6900 / 6500 / 6500 analog ground is also provided.

User Notes Page

Chapter 3 — Operation

Gas Concentration Measurement

The Model 6900 /6500 / 6510 measures the following automotive exhaust sample gas concentrations: CO_2, CO, HC (either n-hexane or propane, host system selectable), O_2, and NO_X.

HC, CO, and CO_2 Measurement

The NDIR measurement method uses fixed, non-scanning infrared light frequencies to characterize HC, CO, and CO_2 gas concentrations. NDIR absorption profiles are the basis for measurement. The concentration of a gas volume is a function of the quantity of gas molecules in the sample. The absorption of infrared light increases with the number of gas molecules in the light path. As the concentration of infrared-absorbing gas increases, the transmission of infrared light decreases. A basic automotive NDIR measurement system includes the following elements:

Sample Delivery: The portion of the vehicle's exhaust gas is transported to the 6900 where liquid water and particulates are removed before the gas is introduced to the Model 6500/6510-analyzer module.

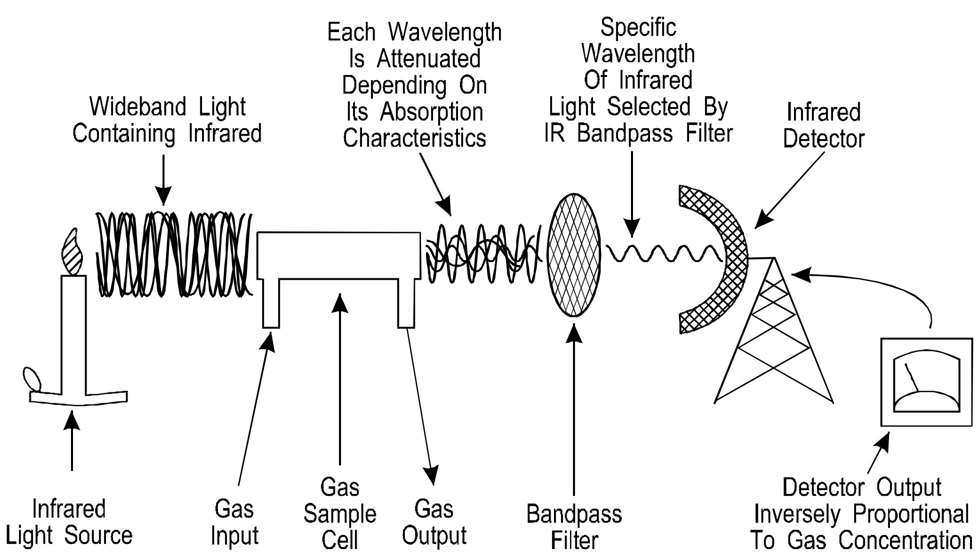
Infrared Source: An infrared light source produces a wide range of light at frequencies covering the infrared band and extending into the visible spectrum.

Sample Cell: The conditioned vehicle exhaust gas to be measured which is transported through a sample cell that allows infrared light to pass through the sample.

Infrared Filters: An optical band pass filter is used to select a specific band of infrared light. The filter wavelength is based on the gas to be measured. Separate infrared filters are used in the measurement of HC, CO, and CO_2 gas concentrations.

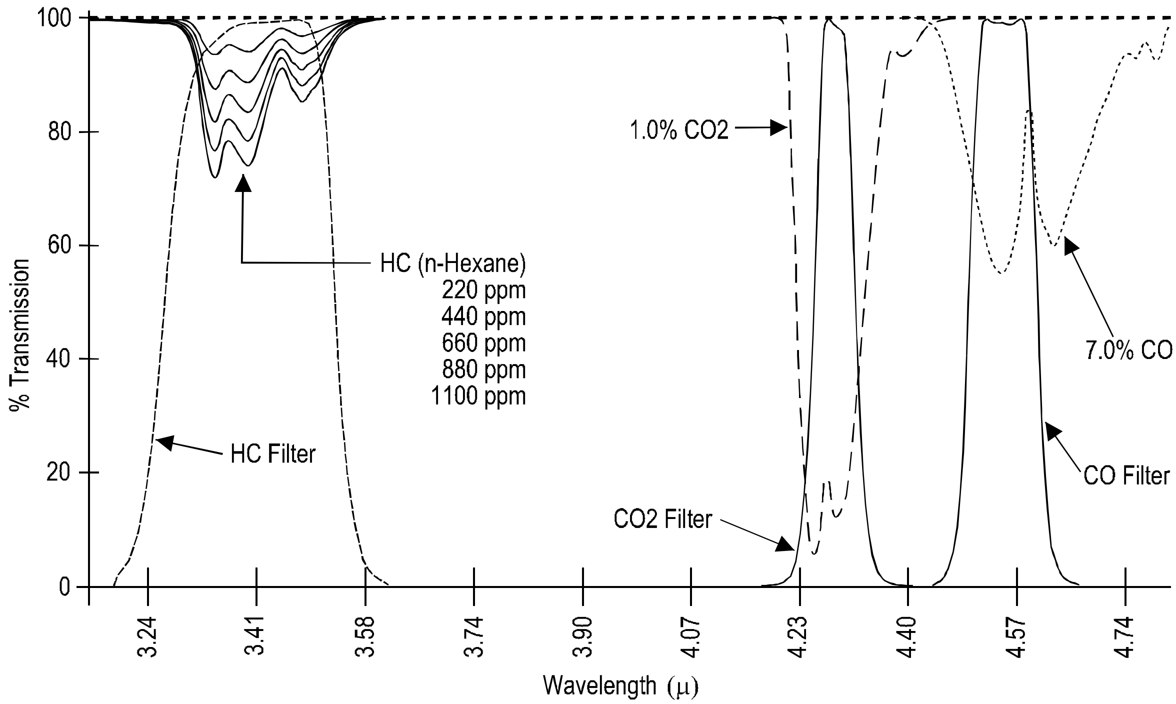
Infrared Detector: Infrared light not absorbed by the sample gas is transmitted to infrared detectors. The detectors produce an output voltage that is proportional to the measured light.

Simple NDIR Gas Analyzer Model



The Infrared Transmission Spectra

The concentration of a subject gas in the sample is computed as a function of the light intensity measured by the detector. The figure below characterizes the absorption and band pass filter curves for HC, CO, and CO_2 gases.

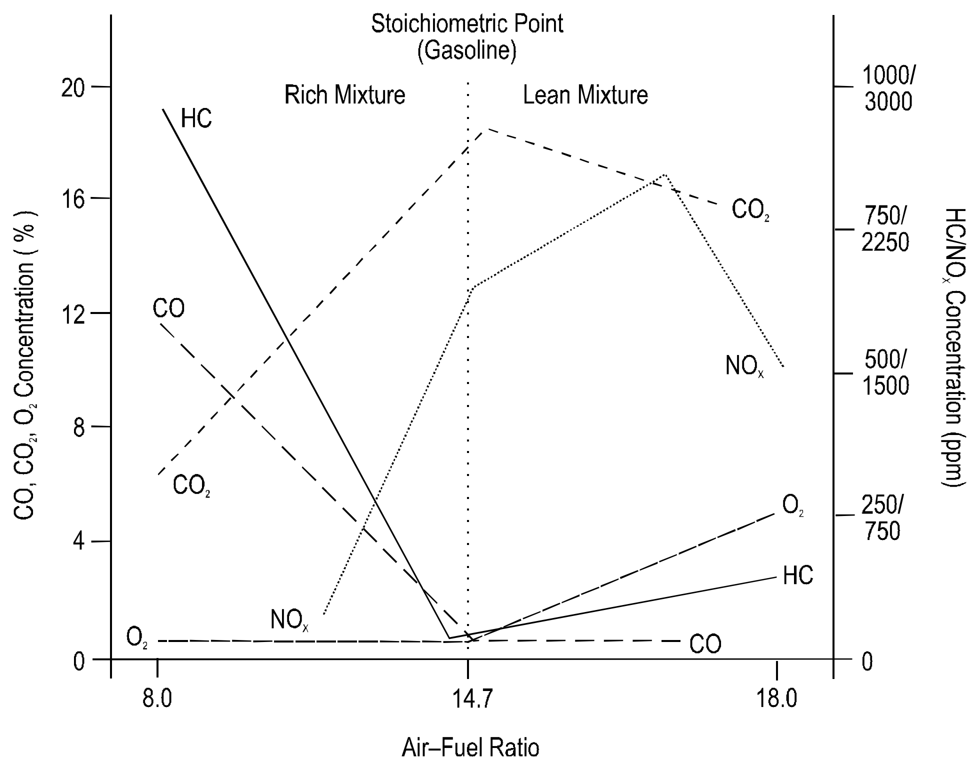


Air-Fuel Ratio and the Stoichiometric Point

For each fuel used in an internal combustion engine, there is an air-fuel ratio that optimizes the combustion process. For common gasoline, that ratio is 14.7 pounds of air to 1 pound of gasoline. This ratio varies with each type of fuel. The point of optimal combustion is called the Stoichiometric point. The combustion process burns fuel and oxygen. The following byproducts result from the combustion process:

- Mechanical force and heat.
- The pollutants HC (hydrocarbons), CO (carbon monoxide), NO_X (oxides of nitrogen), and $S0_2$ (sulfur dioxide).
- The favorable gases CO_2 (carbon dioxide), O_2 (oxygen), and H_2O (water vapor).

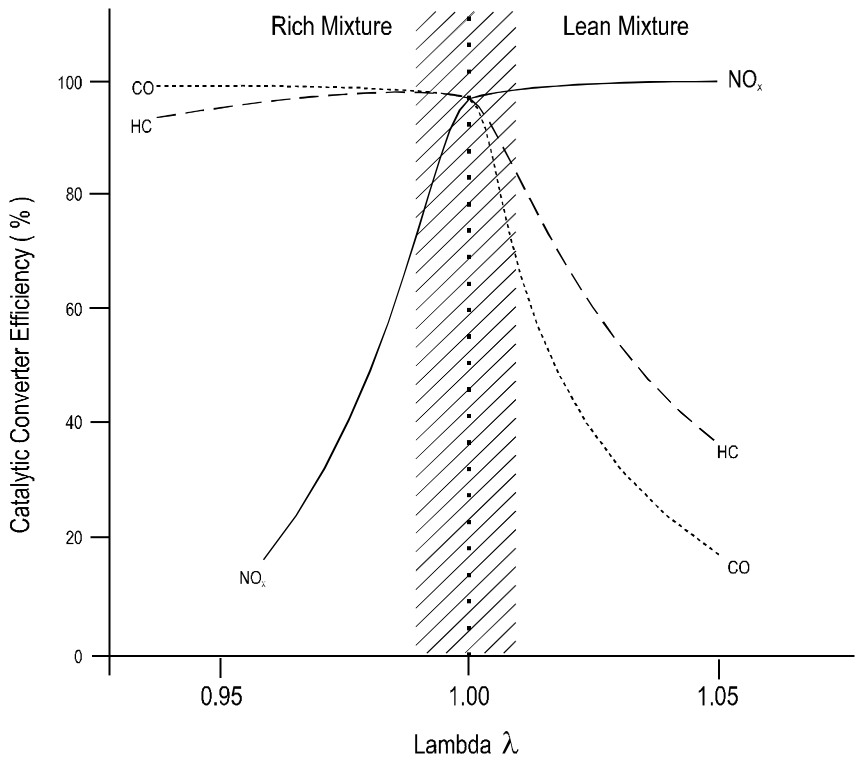
The figure below shows the relationship between the air-fuel ratio and certain unfiltered exhaust gases. Note that optimal combustion is identified by a low level of O_2, a high level of CO_2, and low levels of the pollutants HC and CO.



Lambda (λ) and Catalytic Converter Efficiency

Lambda is another characterization of the Stoichiometric point. The λ formula includes a factor for the specific fuel used. However, the Brettschneider Formula, used to calculate Lambda, is insensitive to fuel type. A value of 1.7261 is used for the H_{CV} factor in the Lambda calculation. Different fuels have different Stoichiometric air-fuel ratios, but optimal combustion is always achieved when Lambda = 1.00. Smaller λ numbers indicate a rich air-fuel ratio; larger λ numbers indicate a lean air-fuel ratio.

The figure below shows the relationship between certain pollutant exhaust gases and catalytic converter efficiency. Optimal combustion ($\lambda = 1$) is characterized by a highly efficient conversion of the pollutants HC, CO, and NO_X into CO_2, H_2O, and N_2.



O_2 and NO_X Measurement

O_2 and NO_X gas concentration are measured using electrochemical (fuel cell) sensors. A fuel cell sensor provides an electrical response that is proportional to the concentration of the sample gas.

Functional Description

Pneumatic System

Refer to the Sample Delivery chapter for the 6900 pneumatic flow diagrams.

Exhaust gas is delivered from the test vehicle to the 6900 water trap/filter via a probe and hose assembly.

The water trap/filter removes liquid water and particulates from the vehicle exhaust gas. The filter removes virtually all particulates ≥0.1μ. The 6900 water trap/filter assembly also includes a float valve that shuts off inlet flow if the water trap bowl ever fills up.

The 6900 pump provides a nominal dry side flow rate of 4 liters/minute, and a nominal wet side flow rate of 2 liters/minute.

The pump is turned ON (1) when the $01 Data/Status command is received, (2) by the $07 Pump On/Off command, or (3) when the 6900 enters its start-up mode, or (4) within 15 seconds of POR. The pump is turned OFF (1) when the $01 Data/Status data transmission is terminated, (2) by the $07 Pump On/Off command, or (3) when the 6900 goes into standby mode.

One or more solenoid valves, under the 6900 and host system control, determine the gas delivered to the Model 6500/6510 analyzer. In addition to the vehicle’s exhaust gas, one or more of the following gases can be introduced to the 6900:

- Room air,
- Calibration gas,
- Zero gas (20.95% O_2, balance N_2), or
- Calibration check gas.

The gas to be measured is delivered to the sample cell for HC, CO and CO_2 concentration measurement.

Its respective sensors measure the sample gas pressure and temperature, as well as IR detector temperature. These measurements are used for pressure and temperature by the algorithms used to calculate gas concentration.

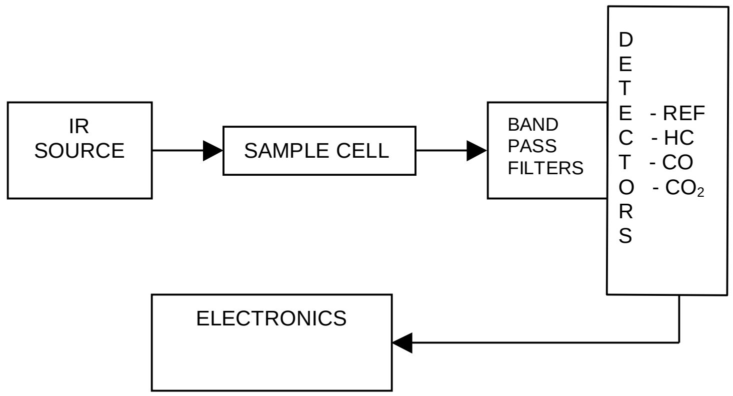
Fuel cell sensors are used to measure the NO_X and O_2 gas concentrations.

The sample gas is exhausted from the 6900.

Infrared Source

A current-regulated infrared (IR) source provides a photon stream in the range of 2 to 5 microns. Light is collimated and directed through the sample cell to the optical block. The source is modulated at 1 Hz, with a duty cycle of 50%.

Model 6500/6510 Optics



Sample Cell

The sample cell is a gold-coated glass chamber that provides a means for the infrared source to pass through the sample gas. Infrared-transparent sapphire windows are provided at each end of the cell. A microprocessor controlled transducer and thermistor provide measurement compensation for sample gas temperature and pressure variances. Sample gas exits the cell at the end opposite the IR source and is directed to a separate manifold for O_2 or O_2/NO_X measurement.

Optical Block

Infrared light not absorbed by the sample gas is transmitted to the optical assembly. The remaining light is directed to the band pass filters and on through to the quad detector.

System Board Assembly

The system board assembly is a surface-mount printed circuit board that includes the Model 6500/6510 digital and analog electronic components and the IR detector assembly. The IR detector assembly includes thermopile IR detectors for the HC, CO, CO_2, and reference channels. Light passed through the band pass filters is directed through the thermopile window to a detector substrate. The substrate has a light-sensitive coating, which produces a voltage that is proportional to light intensity. A reference voltage is produced by the reference detector, which provides an output that varies with light intensity and is not affected by the sample gas. The HC detector includes a thermistor. The detector block temperature measurement facilitates compensation for IR filter and IR detector temperature variances. The detector outputs are amplified and sent through a multiplexer to an ADC converter. The microprocessor samples the ADC converter output at 200 Hz and derives an uncompensated digital value representing each gas concentration. The data are subjected to a compensation routine that provides adjustment for temperature and pressure variances. The digital value representing each gas concentration is derived.

O_2 and NO_X Sensors

The Model 6500/6510 sample-cell exhaust is directed to a separate manifold for O_2 or O_2/NO_X measurement. Sample gas is delivered to the O_2 and NO_X sensors through this manifold. The O_2 sensor provides a linear output of approximately 9 to 13 millivolts that is proportional to the oxygen concentration in the sample. The NO_X sensor provides a linear output of approximately 50 nanoamperes per ppm of nitric oxide over the range of 0 to 5,000 ppm in the gas sample. A 3-volt lithium battery is included on the NO_X sensor to retain bias voltage when source power is not applied.

Both O_2 and NO_X sensor outputs are sent to an ADC converter that provides digital values representing gas concentration. Gas concentration is determined by comparing sensor output at calibration with the output of the sample measurement.

Configuration Modes

There are slight differences in operation depending on the application being addressed by a 6900 subsystem. The 6900 subsystems can be configured for any of the following modes of operation:

- Basic: international repair, diagnostic, and I/M applications.
- ISO 3930/OIML R 99, Class 0 and Class 1: European and derivative governmental I/M programs.
- BAR-97: California BAR-97 and derivative governmental I/M programs.

For additional details, refer to the $F1 Configuration Mode Control command description in the *Host Communications* chapter.

Model 6900 / 6500 / 6510 Operating Modes

Model 6900 / 6500 / 6500 operations comprise five modes of operation.

Start-up Operating Mode

After POR (power on / reset), the Model 6900 / 6500 / 6510 performs the following:

- Start-up and initialization.
- Self-test.
- Thermal warm-up. After a cold start or $F0 Reset command the warm-up time period is 35 seconds maximum. After leaving standby mode the typical warm-up time period is 20 seconds after completion of the first zero.

The following commands are not allowed during start-up mode:

- $02 Zero / O_2 Span calibration.
- $03 Span calibration.
- $11 Pressure Span

Normal Operating Mode

When the Start-up time has elapsed, the Model 6900 / 6500 / 6510 enters Normal Operating Mode

All commands are allowed except the three-boot/program mode commands $26, $27 and $28.

If continuous or single-packet $01 Data/Status has not been requested for >2 minutes, the Model 6900 / 6500 / 6500 leaves normal mode and enters standby mode.

Standby Operating Mode

The Model 6900 / 6500 / 65006900 / 6500 / 6500 Pump is turned OFF when the 6900 enters standby mode.

The 6900 enters standby mode as a result of any of the following:

- 2 minutes after any POR if neither single-packet nor continuous $01 Data/Status data has been requested.
- 2 minutes after continuous $01 Data/Status data is terminated and no single-packet $01 Data/Status data has been requested.

During standby mode, the Pump is turned OFF and the following commands are not allowed:

- $02 Zero / O_2 Span calibration.
- $03 Span calibration.

Normally, standby mode is terminated, and start-up mode is entered, when a $01 Data/Status command is received. If the standby mode was activated by a sample cell over-temperature condition, the only way to resume normal operation is via a software ($F0) or hardware reset.

Upon leaving standby mode, the Model 6900 / 6500 / 65006900 / 6500 / 6500 turns ON the pump, attains thermal stability during a 20-second start-up mode, and resumes normal mode operation.

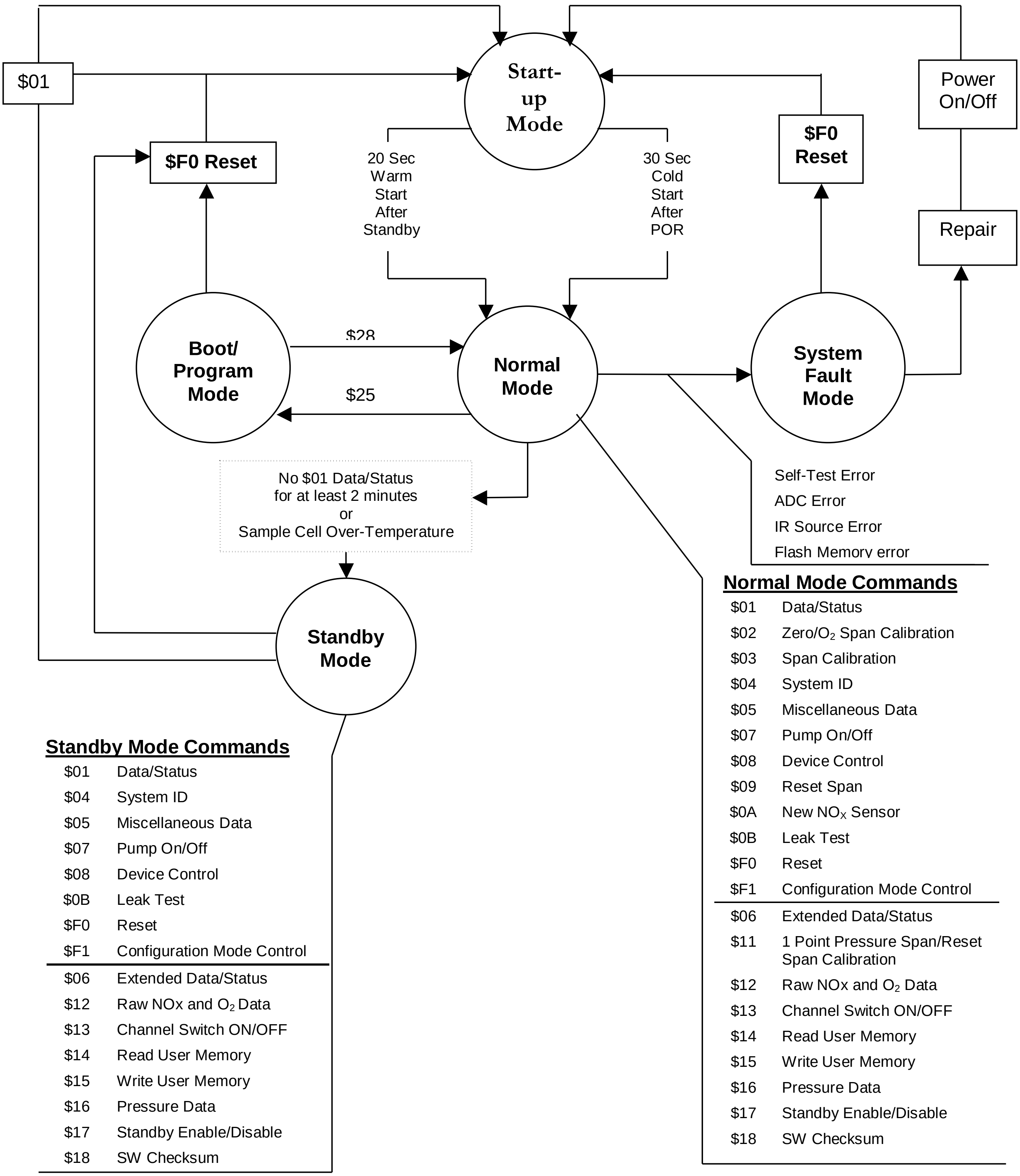
System Fault Operating Mode

System fault mode is entered if any of the following error conditions occur:

- Self-test error.
- ADC data acquisition error.
- IR source error.
- Flash memory error.

Recovery from system fault mode requires a power-down/power-on reset, and may call for product service.

6500 Process Flow



Model 6500 / 6510 Temperature Measurements

The analyzer incorporates several thermistors for the measurement of Model 6500 / 6510 temperatures.

IR Detector/Filter Temperature (HC Temp): A thermistor located in the optical assembly measures the IR detector and IR filter temperature. It is used as follows:

- "Gas law compensation" and detector response compensation during HC, CO and CO_2 gas concentration measurement.
- $03 Span calibration (via the use of temperature compensated HC, CO_2 and CO data).
- An "out of range" IR detector/filter temperature condition causes HC, CO_2 and CO data to be declared "data invalid."
- In the Model 6500 / 6510, the IR Detector/Filter Temperature is monitored to set the zero request bit as follows:

  Zero Request (STAT1–5) is set true if a ±5°C temperature change has occurred.
- Ambient Temperature Out Of Range status bit (STAT4–2) is set when the IR Detector/Filter Temperature is not within its allowed range.

Sample Cell Temperature: The Model 6500 / 6510 sample cell temperature is monitored by a thermistor in contact with the sample cell. This temperature measurement is used as follows:

- An "out of range" sample cell temperature condition causes HC, CO_2 and CO data to be declared "data invalid."
- Sample Cell Temperature Out Of Range status bit (STAT3–5) is set when the Sample Cell Temperature is not within its allowed range.

NO_X Sensor Temperature: A thermistor located in each NO_X sensor assembly monitors NO_X sensor temperature. It is used as follows:

- Sensor response during NO_X gas concentration measurement.
- An "out of range" NO_X sensor temperature condition causes NO_X data to be declared "data invalid."

Pressure Measurements

The Model 6500/6510 includes two pressure transducers for measurement of the Model 6500 / 6510 pressures. An absolute pressure transducer measures the pressure in the Model 6500 / 6510 sample cell. A differential pressure transducer on the power section of the Printed Circuit Board (PCB) measures the difference between ambient pressure and the sample gas pressure between the inlet port and the pump. These pressure measurements are used as follows:

Sample Cell Pressure (absolute). Sample cell pressure is used as follows:

- "Gas law compensation" during HC, CO and CO_2 gas concentration measurement.
- $02 Zero/$O_2$ Span and $03 Span calibration (via the use of temperature compensated HC, CO_2 and CO data).
- During $02 Zero/$O_2$ Span calibration, sample delivery pressure is compared to ambient pressure (see below). If the difference is too great, the Out Flow Fault status bit is set true (STAT4–3 = 1) and the pump is switched Off.

Sample System Pressure (differential): Ambient pressure is measured during Leak Test by turning the pump OFF and switching solenoid valve #1 to the room-air port, or whenever the Pump is switched ON. Ambient pressure is used as follows:

- The $0B Leak Test command tests the pneumatics path between the probe tip and the 6900 pump for leaks.
- Low Flow or In Flow Fault. In Flow Fault is set whenever a substantial reduction in inlet side pressure is detected.

Chapter 4 — Calibration

Factory Characterization

Normal Model 6500 / 6510 component tolerances result in small, but relevant differences in measurement of a given gas concentration. The IR source, pressure transducers, thermistors, band pass filters, and detectors are subject to these variances. During the Model 6500 / 6510 manufacturing process, each unit is individually characterized. Characterization results in a set of unique response characteristics for each IR gas channel. These individual response curves are stored in the Model 6500 / 6510 flash memory, and enable the Model 6500 / 6510 to measure gas concentration accurately.

Field Calibration

The Model 6500 / 6510 is designed to be zero and span stable in normal operation.

Zero calibration establishes the baseline for gas concentration measurement. These responses vary depending on existing temperature conditions (ambient, sample gas, and IR filters/detectors).

Span calibration compensates for the normal component drift that slowly occurs over the life of the instrument.

Zero Calibration

Andros recommends that zero calibration be performed as follows:

- Whenever Model 6500 / 6510 Zero Request status bit is true (STAT1–5 = 1).
- Immediately prior to each automotive exhaust gas emissions test.
- Immediately prior to taking any important set of gas concentration data.
- Immediately prior to any span calibration.
- Zero calibration is a recommended step in recovering from several types of malfunctions. Refer to the troubleshooting charts in the *Service Procedures* chapter.

The Model 6500 / 6510 Zero Request status bit is set true under the following conditions:

- At POR (power on / reset). When the Model 6900 / 6500 / 6510 is turned ON or reset, all gas channels will temporarily report 0 gas concentrations (volume % or ppm). Gas concentration data is first available after a successful zero calibration.
- After transitioning from standby to normal operating mode.
- Zero request interval timeout (90 seconds after POR, followed by a 3 minute then a 6 minute interval and 30 minutes thereafter).
- After a ±3°C change in detector temperature.
- When an ADC input range error occurs on one or more IR channel (CO_2, CO, HC, reference).

Zero calibration compensates for conditions that affect gas concentration measurement. Examples of these conditions are as follows:

- Changes in ambient temperature.
- Short-term sample cell contamination caused by inadequate particle filtering.
- Long-term sample cell contamination caused by deposits on the sample cell wall or windows.

Zero calibration execution time is typically 30 to 45 seconds, including a purge time that depends on the pneumatics configuration and a fixed calibration time of 20 seconds. The process will take longer under the following conditions:

- Purge time was extended by host system command ($02–PT byte value).

- The first Zero during a power cycle takes 5 seconds longer than a subsequent Zero with the same PT value.
- When the $02 Zero/$O_2$ Span Calibration command was transmitted, the NO_X concentration was above a set value. The purge time is extended in order to completely purge the NO_X sensor.

$02 Zero/$O_2$ Span Calibration Procedure

Zero calibration and O_2 sensor span calibration for the Model 6900 / 6500 / 6510is performed using the following procedure:

1) The host system transmits the $02 Zero/$O_2$ Span Calibration command to the Model 6900 / 6500 / 6510. The CO_2, CO, HC, and NO_X channels are zero calibrated and the O_2 channel is span calibrated. The host system can extend the purge time in 1-second increments using the $02–PT byte.
2) When the Model 6900 / 6500 / 6510 receives the $02 Zero command, it checks system status.
   a) The following conditions cause the Model 6500 / 6510 to refuse to execute the zero calibration command and to transmit a $02 Zero/$O_2$ Span NAK response to the host system:
      - System Fault (STAT1–7,6 = 11): NAK error code $00 (System Fault).
      - Model 6500/6510is in start-up mode (STAT1–7,6 = 01: NAK error code $02 (Not Allowed).
      - Model 6500/6510 is in standby mode (STAT1–7,6 = 10): NAK error code $02 (Not Allowed).
      - Model 6500/6510is in boot program mode: NAK error code $44 (Not Allowed).
      - Process In Progress (STAT1–4 = 1): NAK error code $02 (Not Allowed).
      - Incorrect $02 command structure: NAK error code $10 (Wrong Length).
      - In Flow Fault (STAT4 –7 = 1): NAK error code $03 (Sample Delivery Problem).
   b) If all conditions for zero calibration are met, the Model 6900 / 6500 / 6510 performs the following:
      - The Out Flow Fault status bit is cleared (STAT4–3 = 0). (Out Flow Fault may have been set true during a previous zero calibration failure.)
      - The Process In Progress status bit is set true (STAT1–4 = 1).
      - The $02 Zero/$O_2$ Span ACK response is transmitted to the host system.
3) The pump is turned OFF and all solenoid valves are deactivated.
4) After a settling delay, the ambient pressure (AtmPress) is measured and stored.
5) The pump is turned ON (if $F1 – CMT is $07, $05, or $01).
6) After a settling delay, the sample cell pressure (AbsPress) is measured and stored.
7) The absolute pressure limit is checked (AbsPress – AtmPress ≤ PressureLimit). If this test fails, the following error status bits are set and the zero calibration procedure is aborted:
   - STAT4–3 = 1 (Out Flow Fault).
   - STAT2–7,6 = 11 (CO_2 Zero Fail).
   - STAT2–5,4 = 11 (CO Zero Fail).
   - STAT2–3,2 = 11 (HC Zero Fail).
   - STAT3–7,6 = 11 (NO_X Zero Fail).
8) The correct pump and solenoid valve states (for both sample purge and zero data collection) are established before the Zero process (the Pump Control command $07 will NAK as "Not allowed" during this process):

a) Model 6500/6510 configuration ($F1–CMT = 1): Host software should use command $08 prior to the Zero command to execute the Zero with solenoid valve #1 activated. This state routes room air to the 6500/6510 analyzer.

b) Basic 6900 configuration ($F1–CMT = 3): Host software should use appropriate means to route room air or zero gas to the 6500/6510 analyzer.

c) OIML 6900 configuration ($F1–CMT =5): Pump ON and solenoid valve #1 activated; any other solenoid valves deactivated. Routes room air to the 6500/6510 analyzer.

d) BAR-97 6900 configuration ($F1–CMT =7): Pump OFF and solenoid valve #2 activated; all other solenoid valves deactivated. Normally, bottled zero gas containing O_2 (20.95%) would be routed to the 6500/6510 analyzer via solenoid valve #2.

9) The Model 6500/6510 is purged of sample gas by pumping room air (or flowing BAR-97 zero gas) through the entire 6900.

a) The default Model 6500/6510 zero calibration purge time is eight seconds in Model 6500/6510 and Basic 6900 Modes, 10 seconds in OIML 6900 Mode, or 18 seconds in BAR-97 6900 Mode.

b) The host system can specify a longer zero calibration purge time. The $02–PT byte specifies additional purge time in increments of one second. If $02–PT = $00, no additional purge is performed.

c) If the NO_X sensor is present, and the NO_X concentration is greater than a flash memory resident value, the Model 6500/6510 will be purged for an additional 60 seconds.

d) During zero calibration purge period, the O_2 sensor's electrical zero offset is calculated and stored.

10) The optimum gain is calculated for each IR channel.

a) If the CO_2, CO, or HC channel gain cannot be set (e.g., the IR signal is too strong), the appropriate error status bits are set:

- ♦ STAT2–7,6 = 11 (CO_2 Zero Fail).
- ♦ STAT2–5,4 = 11 (CO Zero Fail).
- ♦ STAT2–3,2 = 11 (HC Zero Fail).

b) If the reference channel gain cannot be set, the following error status bits are set:

- ♦ STAT2–7,6 = 11 (CO_2 Zero Fail)
- ♦ STAT2–5,4 = 11 (CO Zero Fail).
- ♦ STAT2–3,2 = 11 (HC Zero Fail).

c) If the peak-to-peak value for any IR channel is less than a flash-memory-resident minimum value, the following error status bits are set:

- ♦ STAT4–4 = 1 (IR Signal Lost).
- ♦ STAT2–7,6 = 01 (CO_2 Data Invalid).
- ♦ STAT2–5,4 = 01 (CO Data Invalid).
- ♦ STAT2–3,2 = 01 (HC Data Invalid).

11) The Model 6500/6510 collects and averages the following data:

a) CO_2, CO, HC, NO_X, and O_2 channel data.

b) IR detector temperature.

12) The following new calibration constants are calculated and stored in flash memory:

a) CO_2, CO, HC, and NO_X zero calibration constants.

b) O_2 span calibration constant.

13) If the O_2 sensor's output is lower than a flash-memory-resident minimum value, the New O_2 Sensor Required status bit is set true (STAT4–5 = 1).

14) If the zero calibration process is successful, the following actions are performed:

    a) The Zero Request status bit is cleared (STAT1–5 = 0).

    b) The 30-minute zero request interval timer is reset.

    c) The Process in Progress status bit is cleared (STAT1–4 = 0).

    d) After completion of a $02 Zero/$O_2$ Span Calibration procedure, the 6900 pump (if applicable) remains turned ON and all solenoid valves are deactivated. This is true even if the pump had been turned OFF via the $07 Pump On/Off command prior to zero calibration.

Additional ISO 3930/OIML R 99, and BAR-97 Zero Calibration Requirements

Complying with OIML and BAR-97 zero calibration requirements requires that the host system perform additional steps not described by the procedure above.

Span Calibration

The 6900/6500/6510 is designed to be span-stable. Frequent span calibration is not required to maintain accurate gas concentration measurement. The Model 6900/6500/6510 may need to be routinely span calibrated with suitable cocktail calibration gases. Most I/M programs specify the gas blends, tolerances, and concentrations to be used. These recommendations should be followed in order to properly span the analyzer system. Span calibration is recommended at the following intervals:

- As mandated by government programs.
- HC, CO, and CO_2 channels: Once every 12 months.
- NO_X channel: After replacement of a NO_X sensor, and once every month during normal operation. NO_X span calibration may need to be performed more frequently in some heavy-use applications.
- O_2 channel: O_2 span calibration is performed during every $02 Zero/$O_2$ Span Calibration execution. $03 Span Calibration of the O_2 channel is not required.
- When any span calibration has failed.

The Model 6900/6500/6510 supports the following span calibration gas ranges:

- 1.00% to 20.00% CO_2.
- 0.500% to 15.000% CO.
- 100 ppm to 60,000 ppm (propane.)
- 50 ppm to 30,000 ppm (n-hexane.)
- 100 ppm to 5,000 ppm NO_X.
- 1.00% to 25.00% O_2.

$03 Span Calibration Procedure

After POR (power on/reset), all span fail status bits are cleared and the last valid span calibration constants are loaded.

A span calibration is performed using the following procedure:

1) Verify that the hexane/propane selection in the $01 command is correct for the gas being used to span the HC channel.

2) Connect the 6900/6500/6510 to a host system that allows you to transmit commands to the unit and monitor its status.

3) Turn ON the 6900/6500/6510. You need to let the unit warm up for at least 5 minutes. For optimum span calibration accuracy, let the 6900/6500/6510 warm up for at least 30 minutes.

4) While the 6900/6500/6510 is warming up, perform the following steps:

   a) If the New NO_X Sensor Required status bit is set true ($01–STAT4–6 = 1), install a new NO_X sensor.

   b) If the New O_2 Sensor Required status bit is set true ($01–STAT4–5 = 1), install a new O_2 sensor.

5) Set up the span calibration gas bottle.

   a) Your span calibration setup needs to accomplish the following:

      i) 5 psig min – 25 psig max span calibration gas bottle pressure.

      ii) 1 liter/min. to 2 liter/min. span calibration gas flow rate through the Model 6900/6500/6510.

      iii) All exhausted span calibration gas must be scavenged outside or into a well-ventilated area.

   b) Open the span gas cylinder valve and adjust the regulator pressure to 5 to 25 psig. If the regulator is fitted with an integral flow-regulating valve, be sure that it is opened when adjusting the gas pressure.

   c) Close the span gas cylinder valve.

6) When the 6900/6500/6510 span calibration warm-up period is completed, perform a $02 Zero/$O_2$ Span Calibration procedure.

7) Verify that no 6900 errors are being reported (other than a possible span fail error).

8) Open the calibration gas cylinder valve. Adjust the pressure from 5 to 25 psig in order to achieve a flow rate to 1 liter/minute.

9) Connect the calibration gas bottle to the 6900 calibration gas port.

10) Transmit the $03 Span Calibration command to perform single-point span calibration of the HC, CO, CO_2, and NO_X channels. The O_2 channel is span calibrated with the $02 Zero/$O_2$ Span Calibration command. It is not necessary to perform O_2 span calibration with the $03 Span Calibration command.

    a) The host system uses the $03–TVM tag value mask byte to specify which channels are being span calibrated.

    b) The host system uses pairs of TV1, TV2 bytes to specify the calibration gas tag values.

    c) Refer to the $03 Span Calibration command description in the *Host Communications* chapter for detailed information concerning the TVM (tag value mask) and the TV1, TV2 (tag value) bytes.

11) When the 6900/6500/6510 receives the $03 Span command, it checks system status and the data fields included in the $03 Span command.

    a) The following conditions cause the 6900/6500/6510 to refuse to execute the span calibration command and to transmit a $03 NAK response to the host system:

       ♦ The System Fault status bit is set true (STAT1–7,6 = 11): NAK error code $00 (System Fault).
       ♦ The 6900/6500/6510 is in startup mode (STAT1–7,6 = 01): NAK error code $02 (Not Allowed).
       ♦ The 6900/6500/6510 is in standby mode (STAT1–7,6 = 10): NAK error code $02 (Not Allowed).
       ♦ The 6900/6500/6510 is in boot program mode: NAK error code $44 (Not Allowed).
       ♦ The Process In Progress bit is set true (STAT1–4 = 1): NAK error code $02 (Not Allowed).
       ♦ Incorrect $03 command structure: NAK error code $10 (Wrong Length).
       ♦ Incorrect TVM (tag value mask) data: NAK error code $01 (Illegal Data).
       ♦ Illegal TV1, TV2 (tag value) data: NAK error code $01 (Illegal Data).

12) If all conditions for span calibration are met, the 6900/6500/6510 performs the following:
   - Span fail status bits are cleared for the channels specified in the TVM byte.
   - The Process In Progress status bit is set true (STAT1–4 = 1).
   - The $03 Span ACK response is transmitted to the host system.
13) The 6900 pump is turned OFF and solenoid valve #3 is activated, routing calibration gas to the Model 6500/6510 analyzer's sample cell. The calibration gas is allowed to flow long enough to purge the entire sample system.
14) The Model 6500/6510 analyzer collects and averages gas concentration data over a period of time and new span calibration constants are calculated.
15) The validity of each new span calibration constant (CO_2, CO, HC) is checked. New span calibration constants for the HC, CO and CO_2 channels should not significantly differ from the factory span calibration constants. If a newly calculated span calibration constant does differ by greater than ±30% from the original factory value, the appropriate span fail status is set true:
   - STAT2–7,6 = 10, CO_2 Span Fail.
   - STAT2–5,4 = 10, CO Span Fail.
   - STAT2–3,2 = 10, HC Span Fail.
16) If the NO_X channel is being span calibrated, the current full-scale NO_X output is calculated and saved. If the current full-scale NO_X output is less than or equal to the flash memory resident Low NO_X Sensor Limit, the New NO_X Sensor Required status bit is set true (STAT4–6 = 1). The Low NO_X Sensor Limit is calculated and saved when the $0A New NO_X Sensor command is used. The $0A command should only be used after a new NO_X sensor has been installed. Do not transmit the $0A command after a NO_X span calibration unless a new NO_X sensor has been installed.
17) If no span calibration error occurred for a channel, the new span constant for that channel is stored in flash memory. If a flash memory write error occurs during the storage of a span calibration constant, the appropriate error status is reported:
   - STAT2–7,6 = 10, CO_2 Span Fail.
   - STAT2–5,4 = 10, CO Span Fail.
   - STAT2–3,2 = 10, HC Span Fail.
   - STAT1–7,6 = 11, System Fault (any channel).
18) The pump (if applicable) is turned ON and all solenoid valves are deactivated, routing hose and probe sample gas to the Model 6500/6510 analyzer.
19) The Process In Progress status bit is cleared (STAT1–4 = 0) and the span calibration procedure is complete.

Additional ISO 3930/OIML R 99, and BAR-97 Span Calibration Requirements

Complying with OIML and BAR-97 span calibration requirements requires that the host system perform additional steps not described by the procedure above.

$09 Reset Span

The host system can use the $09 Reset Span command to reset CO_2, CO or HC field span calibration constants to the original factory setting. Note that the O_2 and NO_X channel span calibration constants cannot be reset to the original factory settings. Both fuel cell sensors degrade with use, and a factory span constant would not be correct for any specific sensor. The O_2 channel is span calibrated every time the analyzer is zero calibrated. The NO_X channel must be periodically span calibrated (once per month in normal use) in order to maintain NO_X measurement accuracy

Chapter 5 — Hardware Interfaces

6900 / 6500 / 6500 Interfaces

J3 6500/6510 Power Input Interface			
	Signal Name	***Signal Source***	***Signal Description***
J3-1	+12V Power	Host	9 to 16 VDC input power from power supply or automotive battery.
J3-2	+12V Return	6900	Input power ground.
J3-3	Shield	Host	Chassis ground.
Connector Type: Straight square pin header; 0.45" square pins spaced 0.156". Molex 26-60-5030 or equivalent.			

J1 6500/6510 Host Communications Interface			
	Signal Name	***Signal Source***	***Signal Description***
J1-1	N/A	N/A	Not connected.
J1-2	N/A	N/A	Not connected.
J1-3	TXD	6900	RS232 serial data transmitted by the Model 6500/6510 analyzer to the host system.
J1-4	RTS	6900	6900 to host system handshaking. Passes directly through the 6900 power board. Not used by current 6900 subsystems.
J1-5	RXD	Host	RS232 serial data transmitted by the host system to the Model 6500/6510 analyzer.
J1-6	CTS	Host	Host system to 6900 handshaking. Passes directly through the 6900 power board. Not used by current 6900 subsystems.
J1-7	N/A	N/A	Not connected.
J1-8	N/A	N/A	Not connected.
J1-9	DGND	6900	Serial communications signal ground.
J1-10	N/A	N/A	Not connected.
Connector Type: Dual 2-row straight low profile shrouded header; 0.100" pin and row spacing. Molex 70247-1000.			

J1A 62XX Host Communications Interface			
	Signal Name	***Signal Source***	***Signal Description***
J1A-1	RXD	Host	RS232 serial data transmitted by the host system to the Model 6500/6510 analyzer.
J1A-2	TXD	6900	RS232 serial data transmitted by the Model 6500/6510 analyzer to the host system.
J1A-3	DGND	6900	Serial communications signal ground.
J1A-4	NC	NC	Reserved
Connector Type: Straight square pin friction lock header; 0.025" square pins spaced 0.100". Molex 22-05-3071 or equivalent.			

	J18 6500/6510 TTL Serial Interface		
	Signal Name	***Signal Source***	***Signal Description***
J18-1	TXTTL	Host	3.3 Volt TTL serial data transmitted by the host system to the Model 6500/6510 analyzer
J18-2	RXTTL	6500/6510	3.3 Volt TTL serial data transmitted by the Model 6500/6510 analyzer to the host system.
J18-3	TTL 232	6500/6510	High = Active enables serial TTL from the host. RS232 (J1) inactive when J18-3 is high. Can be jumpered high to activate using JMP5 on the Model 6500/6510.
J18-4	Shield	Host	Chassis ground.
Connector Type: Straight square pin friction lock header; 0.025" square pins spaced 0.100". Molex 22-05-3071 or equivalent.			

	J17 6500/6510 Host Auxiliary I/O Interface		
	Signal Name	***Signal Source***	***Signal Description***
J17-1	ADC1	Host	Optional analog input. Available for host system use. Input signal range is –0.6 to 4.0 VDC. Digitized value output via the $05 Miscellaneous Data command.
J17-2	ADC2	Host	Optional analog input. Available for host system use. Input signal range is –0.6 to 4.0 VDC. Digitized value output via the $05 Miscellaneous Data command.
J17-3	VREF	6900	+3.3 VDC reference voltage for ADC1 and ADC2.
J17-4	AGND	6900	Analog ground.
J17-5	AUXOUTB5	6900	Optional TTL output. Available for host system use.
J17-6	AUXOUTB6	6900	Optional TTL output. Available for host system use.
J17-7	DGND	6900	Digital ground return.
J17-8	TACHIN	Host	Tachometer input to Model 6900/6500. TTL compatible pulse stream; 1 microsecond minimum pulse width; jitter free. 120 to 60,000 RPM reported via the $05 Miscellaneous Data command. Connection from the tachometer pick up to the 6500/651 should be optically isolated to prevent damage to the 6500/6510.
Connector Type: Right angle square pin friction lock header; 0.025" square pins spaced 0.100". Molex 22-05-3071 or equivalent.			

J7 6900/6500/6510 Oxygen and NO Sensor Connector			
	Signal Name	***Signal Source***	***Signal Description***
J7-1	Vminus	O2 Sensor	O2 and NO sensor negative return
J7-2	O2 Sense	O2 Sensor	+ O2 mVDC input from externally mounted O2 sensor
J7-3	Vminus	O2 Sensor	O2 and NO sensor negative return
J7-4	NOX Temp	NO Sensor	NO sensor thermistor input from Andros PN 450300-000 or 560005-001
J7-5	+ 6 V	All Models	NO sensor voltage supply
J7-6	NOX-S-	NO Sensor	NOx sensor signal return
J7-7	NOX-S+	No Sensor	NOx sensor + input
J7-8	Vminus	All Models	O2 and NO sensor negative return
J7-9	NC	All Models	Reserved
J7-10	NC	All Models	Reserved
Connector Type: Right angle square pin friction lock header; 0.025” square pins spaced 0.100”. Molex 22-05-3071 or equivalent.			

J8 Optional 6900/6500/6510 Oxygen Connector			
	Signal Name	***Signal Source***	***Signal Description***
J8-1	Vminus	O2 Sensor	O2 and NO sensor negative return
J8-2	O2 Sense	O2 Sensor	+ O2 mVDC input from externally mounted O2 sensor
Connector Type: AMP series M TE 0-0103670-1 / 0 -0104257-1			

J9 Optional 6900/6500/6510 NO Sensor Connector			
	Signal Name	***Signal Source***	***Signal Description***
J9-1	VplusVminus	All Models	NO sensor voltage supply
J9-2	Common	All Models	NOx sensor signal return
J9-3	Vminus	NOSensor	NO sensor power negative return
J9-4	Vout	NO Sensor	NOx sensor + input
Connector Type: AMP series M TE 0-0103670-3 / 0 -0104257-3			

J10 IR Lamp Drive Connector			
	Signal Name	***Signal Source***	***Signal Description***
J10-1	Lamp Voltage	All Models	IR lamp driver
J10-2	+12VREG	All Models	+ 12 VDC IR lamp supply
Connector Type: AMP series M TE 0-0103670-1 / 0 -0104257-1			

J15 6500 only Pump and Solenoid Valve Interface			
	Signal Name	***Signal Source***	***Signal Description***
J15-1	SOL#1(+)	6900	Solenoid valve #1 drive signal. Controls a 3-way solenoid valve switching between the hose/probe port and the room air port in all configurations.
J15-2	SOL#1(-)	6900	Solenoid valve #1 ground return
J15-3	SOL#2(+)	6900	Solenoid valve #2 drive signal. Controls the zero gas port in BAR-97 configurations.
J15-4	SOL#2(–)	6900	Solenoid valve #2 ground return
J15-5	SOL#3(+)	6900	Solenoid valve #3 drive signal. Controls the calibration gas port in BAR-97 configurations.
J15-6	SOL#3(–)	6900	Solenoid valve #3 ground return
J15-7	SOL#4(+)	6900	Solenoid valve #4 drive signal. Controls the calibration check port in BAR-97 configurations
J15-8	SOL#4(–)	6900	Solenoid valve #4 ground return
J15-9	PUMP (+)	6900	+12 VHP pump drive signal.
J15-10	PUMP (–)	6900	Pump ground return.
Connector Type: Straight square pin locking header; 0.45” square pins spaced 0.156”. Molex 26-60-4100 or equivalent.			

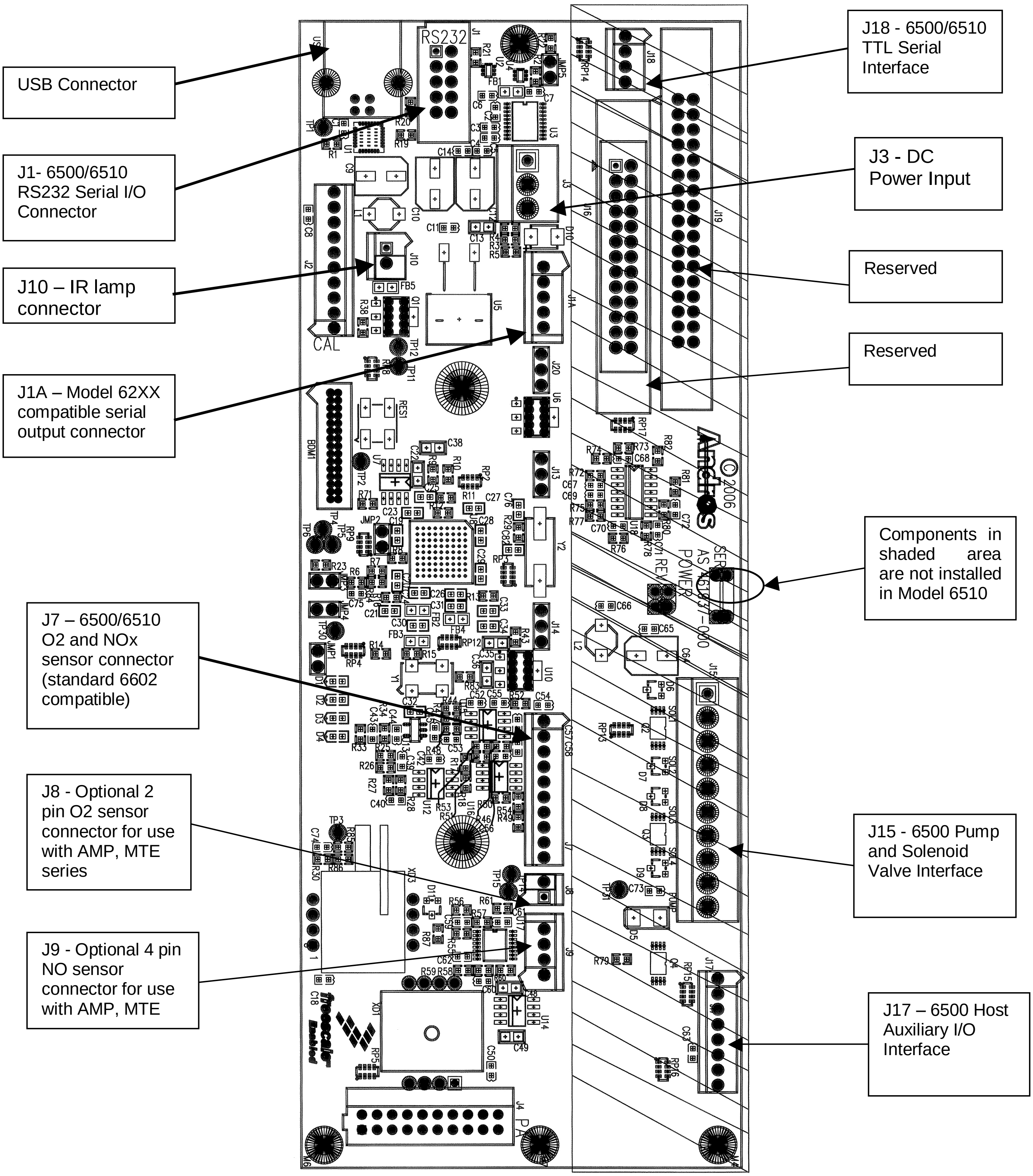
Configuration Jumpers

Jumper and configuration option for the Model 6500/6510 system board are identified below:

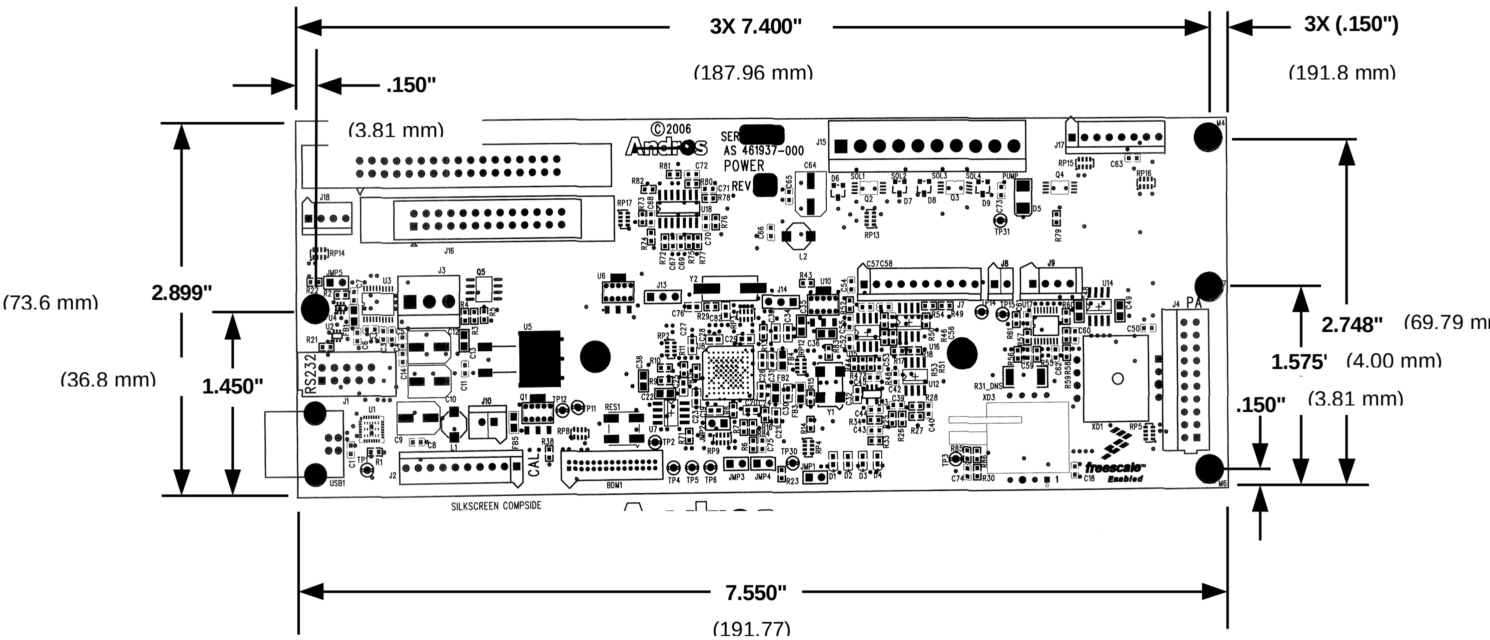
Jumper	Configuration Function
J13	Reserved – Factory set
J14	Reserved – Factory set
J20	NO sensor supply voltage 6VDC or 12 VDC - Factory set with pins 1 and 2 connected for 6 VDC
JMP1	Reserved – Factory set
JMP2	Reserved – Factory set
JMP3	Reserved – Factory set
JMP4	Reserved – Factory set
JMP5	Closed enables 3.3 Volt TTL Serial communications and disables RS232 Output- factory set to open

Power and Interface

Model 6500/6510 Circuit Board Connector Locations

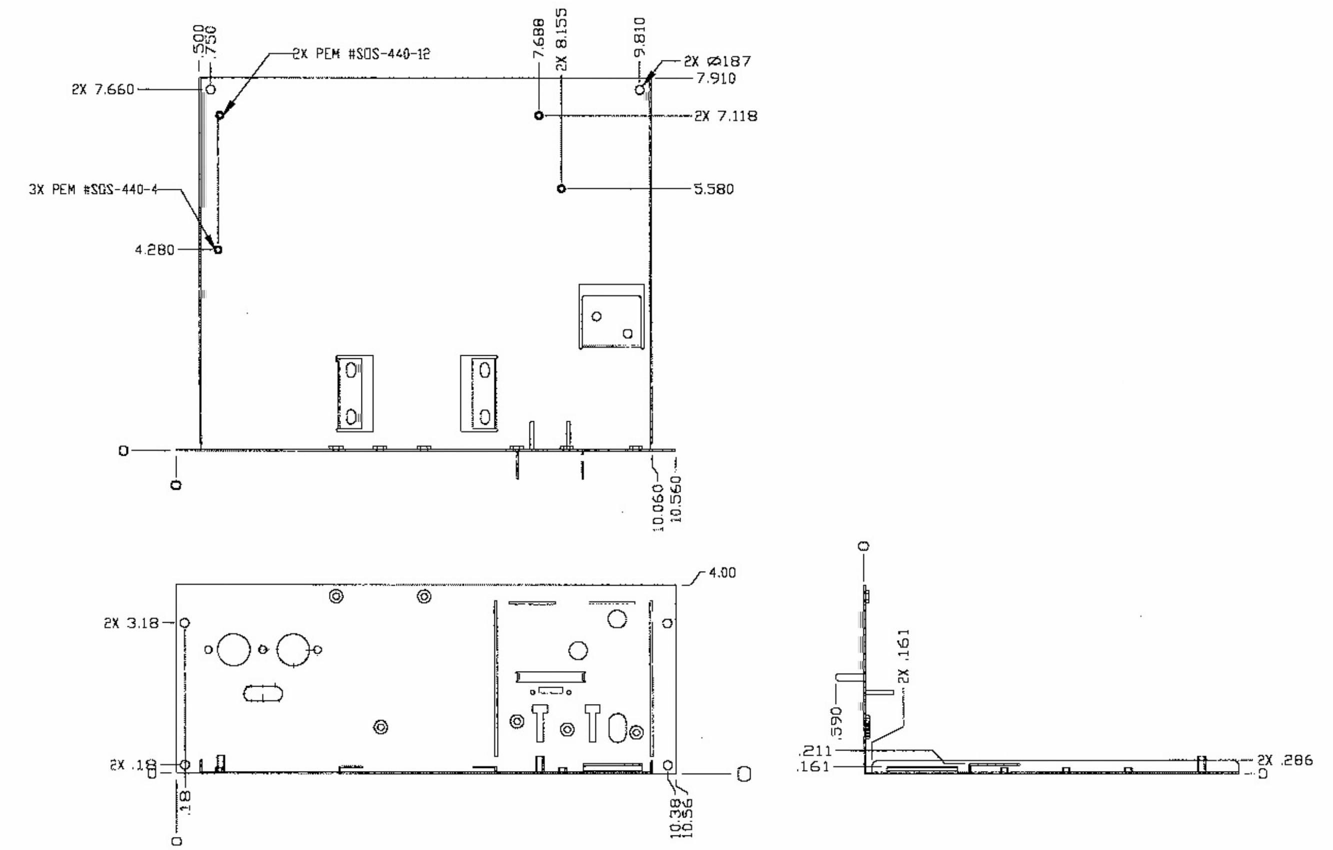


Outline and Mounting Dimensions Model 6500/6510



NOTE: ⌀ **Mounting hole diameter = .129" max**

Outline and Mounting Dimensions Model 6900



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Chapter 6 — Sample Delivery

Pneumatics Ports

The number of 6900 subsystem pneumatics ports, and their specific use, depends on the $F1 configuration mode in use. The standard version of the Model 6900 is shipped in OIML configuration. Other custom modes and assemblies can be special ordered; consult with the factory for quotes and details.

Hose and Probe Sample Gas Port

The Andros or OEM hose and probe assembly connects to hose and probe port, which is built into the 6900 water trap/filter assembly.

Room Air Port

Room air is typically used for zero calibration. BAR-97 programs, however, require sampling room air and measuring background HC.

BAR-97 6900 Mode: Room air is passed through a particulate filter (***customer supplied***).

OIML 6900 Mode: Room air is passed through a charcoal filter (***customer supplied***) to remove hydrocarbons.

Solenoid 1 is used to switch between room air and exhaust in either mode.

Calibration Gas Port

Multi-gas cocktails or binary gas mixtures are used for span calibration of the CO_2, CO, HC and NO_X channels.

BAR-97 6900 Mode: Calibration gas can be switched in or out of the analyzer's pneumatic path by ***customer supplied*** solenoids.

Basic 6900 OIML Mode: Calibration gas is not switched by a solenoid valve. Since the calibration gas port is always "in circuit" it is capped on the outside during normal operation.

Calibration gas should be regulated from 5 to 25 psig to correspond to a flow rate of 2 liters per minute maximum.

Zero Gas Port

BAR-97 6900 Mode: Zero gas (typically 20.9% O_2 balance dry N_2) is used for zero calibration.

OIML 6900 Mode: Not included.

Basic 6900 Mode: Not included.

Zero gas should be regulated from 5 to 25 psig to correspond to a flow rate of 2 liters per minute maximum.

Calibration Check Gas Port

BAR-97 6900 Mode: Calibration check gas is used by a BAR-97 host system immediately after span calibration to verify that no problem (e.g., leaks or empty calibration gas bottle) has caused incorrect calibration.

OIML 6900 Mode: Not included.

Basic 6900 Mode: Not included.

Calibration check gas should be regulated from 5 to 25 psig to correspond to a flow rate of 2 liters per minute maximum.

Exhaust Gas Port

The 6900 exhaust gas exits the 6900 via a 1/4" ID tube. The Model 6500/6510-sample cell exhaust fitting accommodates 1/8" ID tubing.

It is important that the exhaust gas tubing ID never be smaller than 1/4". The exhaust tubing length—measured from the O_2/NO_X sensor manifold—should not be less than 6 inches or greater than 72 inches of 1/4" ID tubing.

Water Drain Port

The 6900 water drain exits the 6900 via a 1/4" ID tube.

Pump

The 6900 pneumatics pump has two separate pump heads driven by a common motor.

The dry- and wet-side pump heads support flow rates matched to their function.

Room Air Filtration

In all 6900 sample delivery configurations, room air should be filtered.

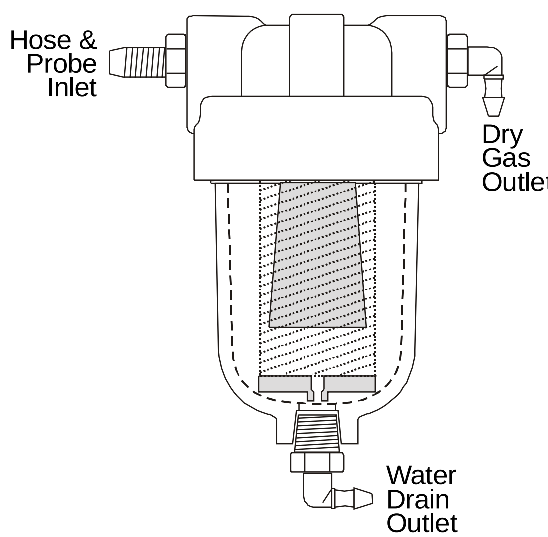
Basic Room Air: No internal filter. OEM designers should add the room air filtration of their choice either internally or externally.

OIML Room Air: Internal or external charcoal filter. OEM designers should add the room air filtration of their choice.

Water Trap / Filter Assembly

The end-user serviceable 6900 water trap/filter assembly performs the following functions:

- The Andros- or OEM supplied hose and probe assembly is connected to the 6900 water trap/filter assembly's inlet port.
- Liquid water is separated from the gas sample and collected in the water trap bowl. The water trap bowl is automatically drained by the wet side of the 6900 pump whenever it is turned ON.
- The 6900 water trap/filter assembly includes a float type water shutoff valve. If, for any reason, the water trap bowl fills with water, the shutoff valve closes to prevent liquid water from being drawn into the Model 6500/6510 analyzer sample cell.
- The 6900 water trap/filter assembly includes an end-user replaceable particulate filter element. In addition to participating in the water separation function, it filters out particles that should not be drawn into the Model 6500/6510 analyzer.

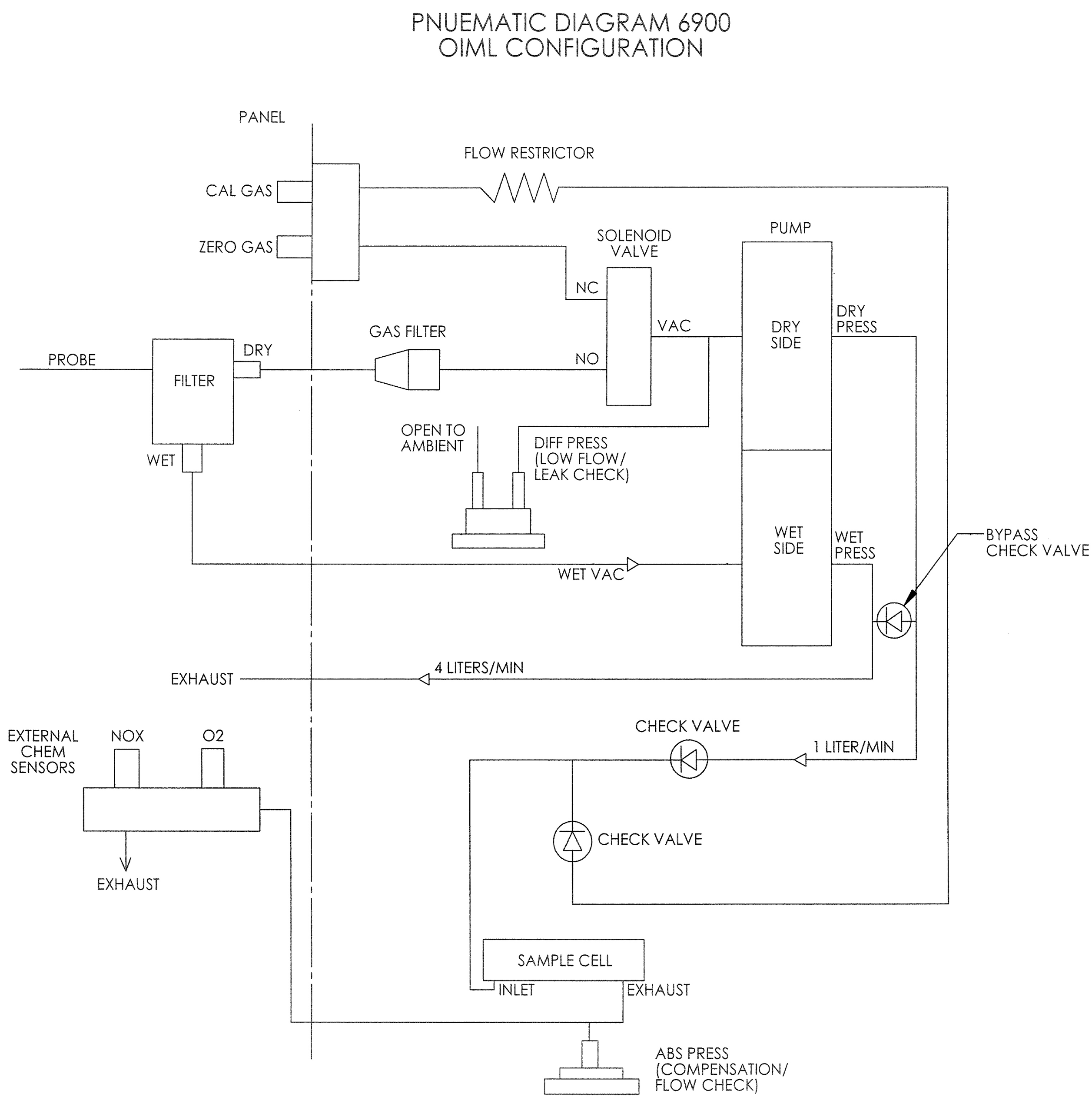


Sample Delivery Configurations

The 6900 is available in one application-oriented sample delivery configuration. Other sample delivery configurations have corresponding $F1 configuration modes.

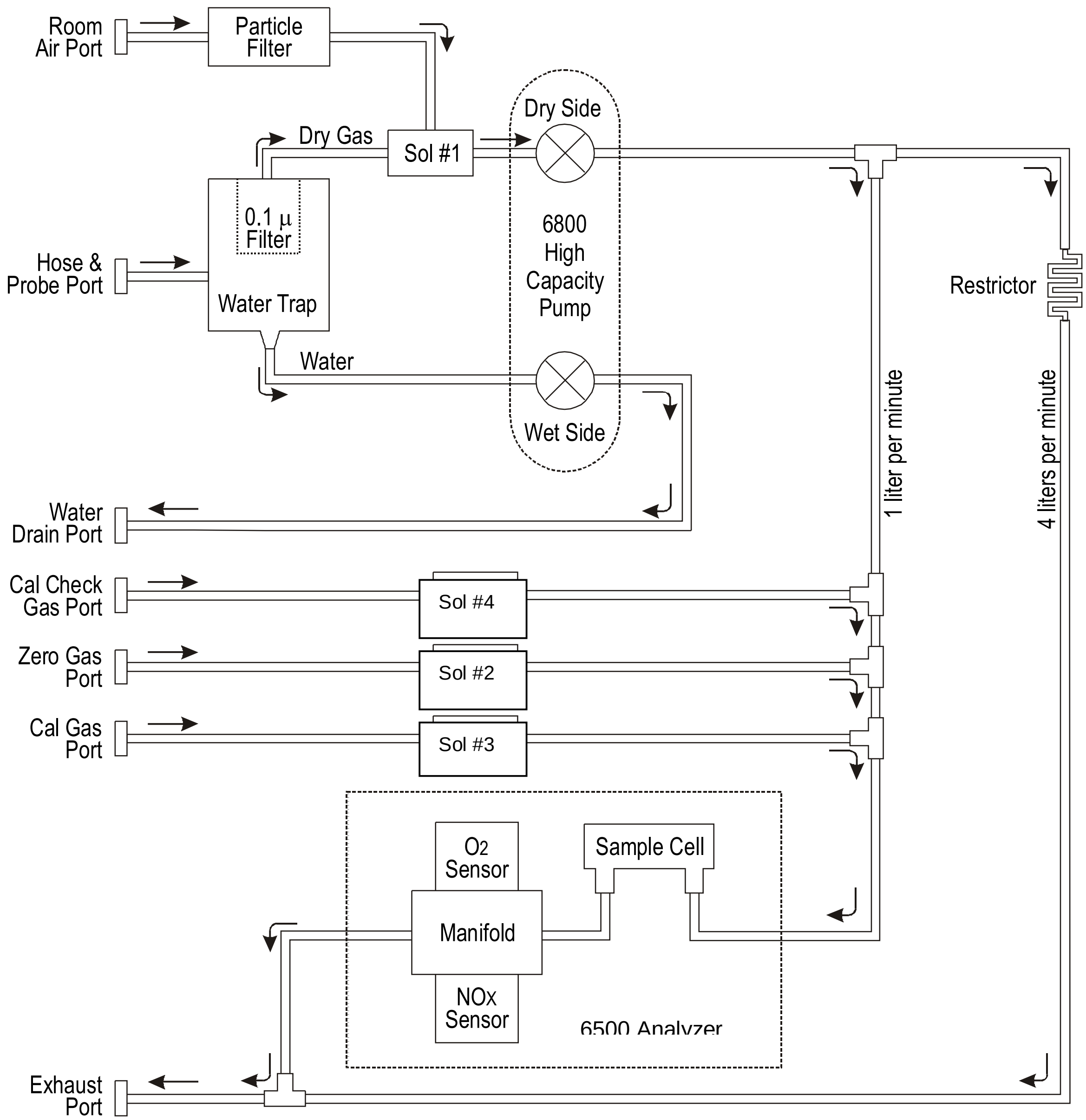
The sample delivery configurations differ in the number of solenoid valves and type of room air filtration. All configurations use the same pump and water trap/filter assembly.

OIML 6900 Pneumatics Configuration (standard)



BAR-97 6900 Pneumatics Configuration (customer option)

Contact Andros Technical Support for additional information related to implementation of BAR-97.

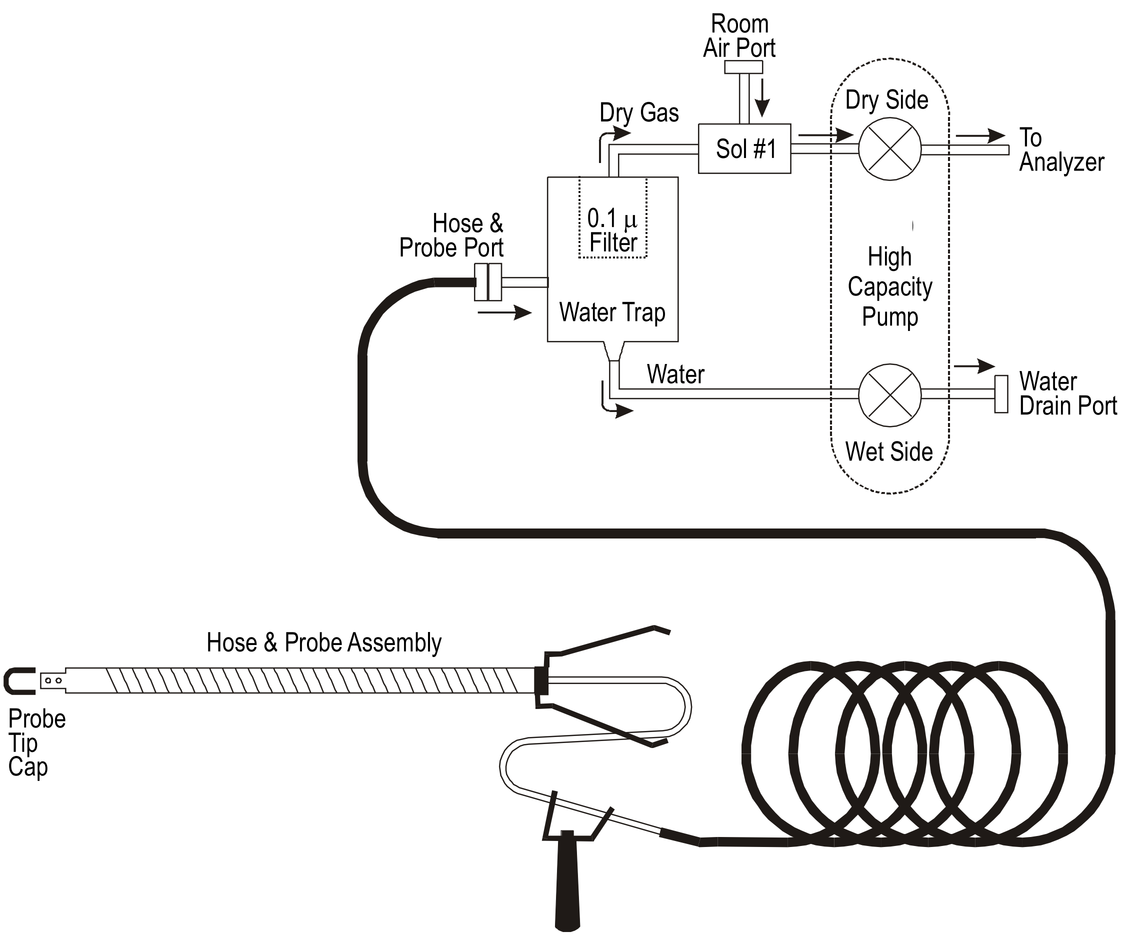


Performing Leak Test

The $0B Leak Test applies only to 6900 $F1 configuration modes (i.e., $F1–CMT = $05 or $07). It checks for leaks between the capped probe tip and the 6900 pump. Leaks in this section of the pneumatic path can cause dilution of the gas sample and resultant gas concentration measurement errors.

A leak test is performed using the following procedure:

1) The 6900 subsystem should be warmed up and in either normal or standby operating mode.
2) The operator must cap the probe tip. It is critical that the cap has an airtight seal or the leak test can fail.
3) The host system transmits the $0B Leak Test command to the 6900.
4) When the 6900 receives the $0B command, it checks system status.
    a) The following conditions cause the 6900 to refuse to execute the leak test command and to transmit a $0B Leak Test NAK response to the host system:
        i) System Fault (STAT1–7,6 = 11): NAK error code $00 (System Fault).
        ii) Start-up mode (STAT1–7,6 = 01): NAK error code $02 (Not Allowed).
        iii) Process In Progress (STAT1–4 = 1): NAK error code $02 (Not Allowed).
        iv) Program Mode Active: NAK error code $44 (Not Allowed, Boot Program Mode).
    b) If all conditions for leak test are met, the 6900 performs the following:
5) The $0B Leak Test command's VACTIME, WAITTIME, and DELTA parameters are checked for validity. If one or more is outside its valid range, the 6900 refuses to execute the leak test command and transmits a $0B Leak Test NAK response to the host system (NAK error code $01, Illegal Data Value).



6) If any of the following error status bits are set true, they are cleared (“0”).
   a) In Flow Fault (STAT4–7).
   b) Out Flow Fault (STAT4–3).
   c) Low Flow Fault (STAT4–1).
   d) Leak Test Fault (STAT4–0).
7) The Process In Progress status bit is set true (STAT1–4 = 1).
8) The $0B Leak Test ACK response is transmitted to the host system.
9) The current 6900 pump and solenoid valve states are memorized.
10) If necessary, the pump is turned OFF and solenoid valve #1 is activated.
11) The current ambient atmospheric pressure is measured and stored.
12) Solenoid valve #1 is deactivated and the pump is turned ON. Since the 6900 is pumping against the capped hose and probe, the 6900 is creating a vacuum.
13) The pump is turned ON for a period of time defined by VACTIME (default = 10 seconds).
14) The pump is turned OFF and the sample system pressure is measured and saved. This “baseline” measurement represents the 6900 maximum vacuum under full occlusion, and is used in three ways:
   a) If this vacuum measurement does not exceed a fixed minimum, a massive leak (or a bad pump) has been detected. The Leak Test Fault status bit is set true (STAT4–0 = 1) and the $0B Leak Test procedure is aborted.
   b) This vacuum measurement will be used in step 16 below to check for smaller leaks (i.e., a vacuum degradation).
   c) It is used during normal operation to check for a Low Flow Fault condition (STAT4–1 = 1).
15) The 6900 waits for a period of time defined by WAITTIME (default = 10 seconds).
16) The sample system pressure is measured again and compared to the baseline measurement made during step 14. If the difference in these two pressure measurements exceeds the parameter DELTA (default = 11.5 PSI) a leak has been detected and the Leak Test Fault status bit is set true (STAT4–0 = 1).
17) The pump and solenoid valves are returned to their memorized states.
18) The Process in Progress status bit is cleared (STAT1–4 = 0).
19) The operator may then remove the cap from the hose and probe assembly.
20) See page 60, software command $0B – Leak Test

Chapter 7 — Host Communications

Communications Protocol

The host system transmits commands to the 6900 subsystem as a series of bytes defined by the host command format. The host system must wait for an analyzer acknowledge (ACK) or negative acknowledge (NAK) response before transmitting another command. 6900 ACK/NAK responses are transmitted within 2 seconds of receiving a host command, unless otherwise specified in the command's description. For continuous data transmission, the ACK/NAK response time applies to the first ACK response. The host system can transmit commands to the 6900 during an on-going stream of continuous data ACK responses. Unless otherwise specified, all data fields are signed, 2's-complement numbers.

The 6900 will respond to host system transmissions in the following manner:

Command	Description
ACK	The command has been received and will be performed. The message is correctly formatted, the command is recognized, the command is allowed, the checksum is correct, and a system error condition does not prevent command execution. The ASCII code for ACK is $06. Refer to individual command descriptions for detailed information concerning ACK responses.
NAK	The command cannot be executed. Where appropriate, the NAK response includes an error code specifying why the command cannot be executed. The ASCII code for NAK is $15. Refer to individual command descriptions for detailed information concerning NAK responses.
No Response	The 6900 will not transmit a response to the host system if any of the following is true: ♦ No command was received and continuous data/status reporting is not activated; ♦ Signals on the Serial-Data input line do not conform to the RS232 character format; ♦ A command is received while a response to a previous command is pending; ♦ The device identification byte (DID) is not equal to $02 or $22; ♦ The checksum byte (CS) was incorrect. ♦ The 6900 is running a self-test (0.15 to 1.50 seconds after power-on/reset (POR); ♦ Continuous Data/Status is requested too soon (up to 3.9 seconds after POR); ♦ The 6900 is performing flash-memory maintenance (up to 10 seconds after POR).

Host Command Format

A host system command consists of four or more bytes, which are formatted as follows:

DID—LB—CMD—[DF]—CS	
DID	The device identification number. The 6900 DID is $02. Every command except $26, $27, and $28 begin with the $02 DID byte. The DID is considered a "start of transmission" indicator. The DID for Boot Mode commands ($26, $27, $28) is $22.
LB	Length Byte: The number of bytes in the rest of the message, excluding the checksum byte.
CMD	The command code.
[DF]	A data field that varies in length from command to command. Not every command contains a data field. Refer to individual command descriptions for detailed information concerning [DF] bytes.
CS	The checksum byte, which can be used to verify that a command has been received without error. The checksum is determined as follows: CS = not (DID + LB + CMD + [DF]) +1 This is equivalent to a modulo 256, 2's complement of the sum of the bytes in the command.

ACK Response Format

ACK—CMD—LB—[DF]—CS	
ACK	The acknowledgment that a command was received and will be performed. The ASCII code for ACK is $06.
CMD	The code of the command being responded to.
LB	Length Byte: The number of bytes in the rest of the message, excluding the checksum byte.
[DF]	A data field that varies in length from ACK response to ACK response. Not every ACK response contains a data field. Refer to individual command descriptions for detailed information concerning [DF] bytes.
CS	The checksum byte, which can be used to verify that a command has been received without error. The checksum is determined as follows: CS = not (ACK + CMD + LB + [DF]) +1 This is equivalent to a modulo 256, 2's complement of the sum of the bytes in the reply.

NAK Response Format

NAK—CMD—LB—EC—CS	
NAK	The negative acknowledgment that a command was received without formatting error, but cannot be executed. The ASCII code for NAK is $15.
CMD	The code of the command being responded to.
LB	Length Byte: The number of bytes in the rest of the message, excluding the checksum byte ($01).
EC	The error code indicating why the command could not be executed.
CS	The checksum byte, which can be used to verify that a command has been received without error. The checksum is determined as follows: CS = not (NAK + CMD + LB + EC) +1 This is equivalent to a modulo 256, 2's complement of the sum of the bytes in the reply.

NAK Error Codes

NAK Error Code	NAK Error Code Description	Associated Commands
$00	System fault.	$02, $03, $09, $0A, $0B, $11, $F1
$01	Illegal data value.	$01, $03, $09, $0B, $11, $13, $14, $15, $17, $F1
$02	Not allowed at this time: standby mode; start-up mode; process in progress.	$02, $03, $09, $0A, $0B, $11, $F1
$03	Sample delivery problem.	$02, $07
$10	Bad command length for command code.	$01, $02, $03, $04, $05, $07, $08, $09, $0A, $0B, $25, $F0, $F1
$41	Flash memory erase failure.	$26
$42	Flash memory write failure.	$09, $26, $27, $13, $15, $42, $F1
$43	Flash download not initiated.	$27
$44	Not allowed at this time; boot program mode active.	$01, $02, $03, $04, $05, $07, $08, $09, $0A, $0B, $11, $12, $13, $14, $15, $16, $17, $F1
$FF	Bad command code.	All undefined command codes.

Command Set

A detailed description of each command's syntax, function, and parameter definition is provided in the following paragraphs.

Command Set Summary

Command Code (Hex)	Command Name	Associated NAK Error Codes
$01	Data/Status	$01, $10, $44
$02	Zero/O_2 Span Calibration	$00, $02, $03, $10, $44
$03	Span Calibration	$00, $01, $02, $10, $44
$04	System ID	$44, $10
$05	Miscellaneous Data	$44, $10
$07	Pump On/Off	$02, $03, $10
$08	Device Control	$10, $44
$09	Reset Span	$00, $01, $02, $10, $42
$0A	New NO_X Sensor	$00, $02, $10, $44
$0B	Leak Test	$00, $01, $02, $10, $44
$F0	Reset	$10
$F1	Configuration Mode Control	$00, $01, $02, $10, $42, $44
New Model 6500/6510 Commands		
$06	Extended Data/Status	$01, $10, $44
$11	1 Point Pressure Span/Reset Span Calibration	$00, $01, $02, $44
$12	Raw NOx and O2 Data	$44
$13	Channel Switch ON/OFF	$01, $42, $44
$14	Read User Memory	$01, $44
$15	Write User Memory	$01, $42, $44
$16	Pressure Data	$44
$17	Standby Enable/Disable	$01, $42, $44
$18	SW Checksum	$44

Note: Other commands exist, but are to be used only by Andros personnel. These Engineering Commands are not described in this Product Manual. Since these Engineering Commands can be subject to change without notice, Andros assumes no responsibility for the use of commands not listed here.

$01 — Data/Status

Command	$01 – Data/Status
Command Format	$02–$03–$01–DR– DT–CS
ACK Format	$06–$01–$10–STAT1– STAT2– STAT3– STAT4– $CO_2$1–$CO_2$2–CO1–CO2–HC1–HC2–HC3–HC4– $O_2$1–$O_2$2–NO_X1–NO_X2–CS
NAK Format	$15–$01–$01–EC–CS
NAK Error Codes	$01 = Illegal data value. $10 = Bad command length. $44 = Not allowed at this time; boot program mode active.

The Data/Status command provides the following functions:

- Allows the host to specify the data/status ACK response transmission rate (DR) as single packet, continuous or stop continuous transmission.
- Allows the host system to specify HC data type (DT) as either n-hexane or propane.
- Reports system, data, and problem status.
- Reports CO_2, CO, HC, O_2, and NO_X gas concentrations
- Controls transitions between standby and normal operating modes. The 6900 powers up in start-up mode. If no system fault exists, the 6900 enters normal mode, in which it can report valid data, within 90 seconds after power-on/reset (POR). If no $01 command is issued for approximately 2 minutes while the 6900 is in normal mode (and not transmitting continuous data), it enters standby mode. In standby mode, if continuous or single-packet $01/data/status is requested, the 6900 goes to start-up mode for approximately 20 seconds, and then back to normal mode. During standby operating mode, the pump and IR source are turned OFF to increase their lifetimes. Note: If standby mode was activated by a sample cell over-temperature condition, the only way to resume normal operation is via a software ($F0) or hardware reset.

DR (Data Rate):

The DR byte specifies the following:

$00	Stop continuously transmitting $01 data and status. If no new $01 Data/Status command is issued during the next two minutes, the Model 6500/6510 analyzer is transitioned from normal to standby operating mode, turning OFF the pump and IR source.
$01	Transmit one packet of $01 data and status. If necessary, the 6500/6510 analyzer is transitioned from standby through warm-up to normal operating mode, turning ON the pump and IR source. The new mode is reported immediately. However, if the Model 6500/6510 is not already in normal mode, gas concentrations are reported as zero. Continuous data/status transmission, if active, is stopped.
$02	Start continuous transmissions of $01 data and status. One ACK response will be sent every second. If necessary, the Model 6500/6510 analyzer is transitioned from standby through start-up to normal operating mode, turning ON the pump and IR source. Note: The Model 6500/6510 may not respond to a Continuous Data/Status request issued less than 4.0 seconds after a hardware or software Reset.
$03–$FF	Reserved. ($01 command returns NAK with error code $01.)

DT (Data Type):

The DT byte specifies the following:

$00	HC channel data reported as HC (n-hexane).
$01	HC channel data reported as propane.
$02–$FF	Reserved. ($01 command returns NAK with error code $01.)

STAT1: The System Status (STAT1) byte specifies the following.

Bit or Field Name	Byte–Bit	Status Bit Definition and Comments
System Status	STAT1–7,6	00 = Normal operating mode. 01 = Start-up operating mode. Start-up mode duration is approximately 90 seconds (cold start or $F0 Reset command) or approximately 20 seconds (transitioning from standby mode to normal mode). 10 = Standby Mode. During standby mode, the 6900 pump and IR source are turned OFF. The 6900 enters standby mode under the following conditions: 1) Approximately 2 minutes after POR (power-on reset) if continuous data ($01–DR = $02) is not turned on and single-packet data ($01–DR = $01) is not requested. 2) Approximately 2 minutes after continuous data transmission is halted ($01–DR = $00) or single-packet data ($01–DR = $01) is requested. 3) Sample cell temperature exceeds 75°C. Standby mode is terminated when continuous data ($01–DR = $02) or single-packet data ($01–DR = $01) is requested. If standby mode was activated by a Sample cell over-temperature condition, a reset is required to return to normal operation. When standby mode is terminated, the 6900 enters start-up mode. Note that the DR parameter, by controlling System Status, provides the simplest means of controlling pump and IR source operation. 11 = System fault. System fault is set if any of the following conditions is true: 1) ADC data acquisition error. 2) Flash memory error (erase fail, write fail, data corrupted).
Zero Request	STAT1–5	1) Zero calibration not requested. 2) Zero calibration requested. One of the following has occurred since the last Zero calibration: a) POR, b) Transition from standby to start-up operating mode, c) Expiration of the first 3 minute, 6 minute or subsequent 30 minute zero calibration interval timer. d) ±3°C detector temperature change, e) ADC input range error on one or more IR channels (CO_2, CO, HC, reference), f) $09 Reset Span command.
Process In Progress	STAT1–4	0 = Zero calibration, span calibration, or leak test not in progress. 1 = Zero calibration, span calibration, or leak test in progress.
	STAT1–3,2	Reserved.
Pump On/Off	STAT1–1	0 = Pump set to OFF. 1 = Pump set to ON. 6900 BAR-97/6900 OIML/6500 Mode: External, 6900 shelf-mounted high-capacity pump controlled via $07 Command. 6510 Mode/6900 Basic Mode: Not applicable.
HC Data Type	STAT1–0	0 = HC channel reports HC (n-hexane) concentration. 1 = HC channel reports propane concentration.
Any status bit listed as reserved is returned as “0”.		

STAT2: The Data Status 1 (STAT2) byte specifies the following:

Bit or Field Name	Byte–Bit	Status Bit Definition and Comments
CO_2 Data	STAT2–7,6	00 = CO_2 channel operation normal. 01 = CO_2 data invalid. Refer to the chart at the bottom of this page. 10 = CO_2 span fail. The new CO_2 span constant differs by >±30% from the factory value. 11 = CO_2 zero fail. During zero calibration (1) the CO_2 or reference gain could not be set.
CO Data	STAT2–5,4	00 = CO channel operation normal. 01 = CO data invalid. Refer to the chart at the bottom of this page. 10 = CO span fail. The new CO span constant differs by >±30% from the factory value. 11 = CO zero fail. During zero calibration (1) the CO or reference gain could not be set.
HC Data	STAT2–3,2	00 = HC channel operation normal. 01 = HC data invalid. Refer to the chart at the bottom of this page. 10 = HC span fail. The new HC span constant differs by >±30% from the factory value. 11 = HC zero fail. During zero calibration (1) the HC or reference gain could not be set.
O_2 Data	STAT2–1,0	00 = O_2 channel operation normal. 01 = O_2 data invalid.
Any status bit listed as reserved is returned as “0”.		

Causes of Data Invalid Errors					
	CO_2 Data Invalid	CO Data Invalid	HC Data Invalid	O_2 Data Invalid	NO_X Data Invalid
System Fault	✓	✓	✓	✓	✓
CO_2 ADC Range Input Error	✓				
CO ADC Range Input Error		✓			
HC ADC Range Input Error			✓		
Reference Channel ADC Range Input Error	✓	✓	✓		
IR Gas Concentration Software Processing Error	✓	✓	✓		
IR Detector Temperature Error	✓	✓	✓		
Sample Gas Temperature Error	✓	✓	✓		
IR Signal Lost	✓	✓	✓		
NO_X Sensor Temperature Error					✓
O_2 Input Open or Shorted				✓	

STAT3: The Data Status 2 (STAT3) byte specifies the following:

Bit or Field Name	Byte–Bit	Status Bit Definition and Comments
NO_X Data	STAT3–7,6	00 = NO_X channel operation normal. 01 = NO_X data invalid. One or more of the following conditions is true: 1) System Fault (STAT1–7,6 = 11). 2) NO_X sensor temperature out of range. 3) After performing $03 NOX span calibration, the full-scale output of the NOX sensor has dropped by ≥25% since installation. 10 = NO_X span fail. After performing $03 NOX span calibration, the full-scale output of the NOX sensor has dropped by ≥30% since installation. 11 = NO_X Zero fail. Out Flow Fault (STAT4–3 = 1) detected during last zero calibration.
Sample Cell Temperature Out of Range	STAT3–5	0 = Sample Cell Temperature OK (0°C- 75°C). 1 = Sample Cell Temperature out of range. Bench goes into standby mode until reset.
	STAT3–4-0	Reserved.
Any status bit listed as reserved is returned as “0”.		

STAT4: The Problem Status (STAT4) byte specifies the following:

Bit or Field Name	Byte–Bit	Status Bit Definition and Comments
In Flow Fault	STAT4–7	0 = Normal sample delivery system In Flow OK. 1 = Sample delivery system In Flow Fault. Model 6900/6500/6510 Modes: In-Flow Fault is set whenever a substantial reduction in inlet side pressure is detected. Causes of 6900 mode In-Flow Fault include dirty filters; damaged hose and probe; and inlet side occlusions. If this fault persists for 2 minutes, the Pump Driver output is switched OFF. In-Flow Fault is cleared automatically when inlet-side pressure returns to its normal operating range.
New NO_X Sensor Required	STAT4–6	0 = NO_X sensor output normal, or either POR has occurred or New NO_x Sensor command ($0A) has been received since the latest NO_x span calibration 1 = Low NO_X Sensor output. After performing $03 NO_X span calibration, the full-scale output of the NO_X sensor has dropped by ≥20% since installation. The NO_X sensor should be replaced as soon as possible.
New O_2 Sensor Required	STAT4–5	0 = O_2 sensor output normal after O_2 span calibration during execution of the $02 Zero/$O_2$ Span Calibration command. 1 = Low O_2 Sensor output. During $02 Zero / O_2 Span execution, the O_2 sensor output (in the presence of room air, 20.95% O_2) is less than 5 millivolts. The O_2 sensor should be replaced as soon as possible.
IR Signal Lost	STAT4–4	0 = IR signal OK. 1 = IR signal lost or weak. Sample cell or sample cell windows may be dirty (during zero only).
Out Flow Fault	STAT4–3	0 = Normal sample delivery system "Out Flow" OK. 1 = Sample delivery system "Out Flow" Fault. Out Flow Fault is set if the difference between sample cell and ambient pressure is greater than a flash memory resident limit. The Pump Driver output is switched OFF. Causes of Out Flow Fault include outlet occlusion (down stream from the pump) or defective system board. Out Flow Fault is cleared after (1) sample-cell pressure returns to its normal operating range, and (2) the pump is re-started using Pump On/Off Command $07.
Ambient Temp. Out of Range	STAT4–2	0 = Ambient temperature (as measured at the IR detector/filter) OK (0 to 50°C). 1 = Ambient temperature out of range. Specified measurement accuracy may be affected.
Low Flow Fault	STAT4–1	0 = Pneumatic flow rate OK. 1 = Pneumatic flow rate out of range. Specified measurement accuracy or response time may be affected. 6900 Mode: An inlet-side pneumatic pressure reduction has been detected. Causes of 6900 mode Low-Flow Fault include dirty filters; damaged hose and probe; and inlet side occlusions.
Leak Test Fault	STAT4–0	0 = Leak test performed successfully. 1 = Leak test failure.
Any status bit listed as reserved is returned as "0".		

Data Field Name	Data Description
$CO_2$1, $CO_2$2:	The $CO_2$1 and $CO_2$2 bytes represent a signed, 16-bit integer value reporting the calculated CO_2 concentration. $CO_2$1 is the most significant byte. CO_2 data is reported in hundredths of volume percent. Example: $CO_2$1, $CO_2$2 = $01F4 = 5.00% CO_2. Prior to the first successful zero calibration, and during start-up, standby and system fault modes, the CO_2 channel will report 0.00% CO_2.
CO1, CO2:	The CO1 and CO2 bytes represent a signed, 16-bit integer value reporting the calculated CO concentration. CO1 is the most significant byte. CO data is reported in thousandths of volume percent. Example: CO1, CO2 = $0870 = 2.160% CO. Prior to the first successful zero calibration, and during start-up, standby and system fault modes, the CO channel will report 0.000% CO.
HC1, HC2, HC3, HC4:	The HC1 through HC4 bytes represent a signed, 32-bit integer value reporting the calculated HC concentration. If $01–DT = $00, the HC channel reports n-hexane concentration. If $01–DT = $01, the HC channel reports propane concentration. HC1 is the most significant byte. HC data is reported in ppm. Example: HC1, HC2, HC3, HC4 = $00000034 = 52 ppm HC. Prior to the first successful zero calibration, and in start-up, standby and system fault modes, the HC channel will report 0 ppm HC.
$O_2$1, $O_2$2:	The $O_2$1 and $O_2$2 bytes represent a signed, 16-bit integer value reporting the calculated O_2 concentration. $O_2$1 is the most significant byte. O_2 data is reported in hundredths of volume percent. Example: $O_2$1, $O_2$2 = $082F = 20.95% O_2. Prior to the first successful $02 Zero/$O_2$ Span calibration, and in start-up, standby and system fault modes, the O_2 channel will report 0.00% O_2.
NO_X1, NO_X2:	The NO_X1 and NO_X2 bytes represent a signed, 16-bit integer value reporting the calculated NO_X concentration. NO_X1 is the most significant byte. NO_X data is reported in ppm. Example: NO_X1, NO_X2 = $03E8 = 1000 ppm NO_X. Prior to the first successful zero calibration, and in start-up, standby and system fault modes, the NO_X channel will report 0 ppm NO_X.

$02 — Zero/$O_2$ Span Calibration

Command	$02 – Zero/$O_2$ Span Calibration
Command Format	$02–$02–$02–PT–CS
ACK Format	$06–$02–$00–CS
NAK Format	$15–$02–$01–EC–CS
NAK Error Codes	$00 = System fault. $02 = Not allowed at this time. $03 = Sample delivery problem. $10 = Bad command length. $44 = Not allowed at this time; boot program mode active.

The $02 Zero/$O_2$ Span Calibration command performs the following functions:

- ♦ Zero calibration of the CO, HC, CO_2, and NO_X channels.
- ♦ Span calibration of the O_2 channel. (The O_2 sensor does not require a zero calibration.)

There are functional differences depending on which $F1 configuration mode is in effect:

6500/6510 Mode: The $02 Zero/$O_2$ Span Calibration turns the pump ON but otherwise does not control sample delivery. Delivery of zero gas (e.g., room air via solenoid 1) is under host system control.

Basic 6900 Mode: The $02 Zero/$O_2$ Span Calibration does not control sample delivery. Delivery of zero gas (e.g., room air) is under host system control. Zero calibration and O_2 span calibration are performed using the gas provided by the host system.

BAR-97 6900 Mode: The $02 Zero/$O_2$ Span Calibration command controls the 6900 high capacity pump, the Sample/Room Air solenoid valve, and the Zero Gas solenoid valve. Zero calibration and O_2 span calibration are performed using zero gas (nominally 20.95% O_2 balance dry N_2).

OIML 6900 Modes: The $02 Zero/$O_2$ Span Calibration command controls the 6900 high capacity pump and the Sample/Room Air solenoid valve. Zero calibration and O_2 span calibration are performed using room air.

PT (Purge Time): The purge time (PT) byte is used to lengthen the standard purge portion of the zero calibration cycle. PT increases the purge time by 1 second per PT unit. Minimum purge time (with $02–PT = 0) depends on which $F1 configuration mode is in effect:

Basic 6900/6500/6510 Mode:	8 seconds; calibrate 8 + PT seconds after command.
OIML 6900 Mode:	10 seconds; calibrate 10+PT seconds after command.
BAR-97 6900 Mode:	18 seconds; calibrate 18+PT seconds after command.

Zero Calibration Procedure Status: $01–STAT1–4 (Process In Progress) is true for the duration of an $02 Zero/$O_2$ Span Calibration command, including the Purge Time and 20 seconds of calibration.

Reporting of Zero Calibration Failures: If a $02 Zero/$O_2$ Span Calibration command fails, one or more of the following status values may be reported:

CO_2 Zero Calibration Failure:	STAT2–7,6 = 11.
CO Zero Calibration Failure:	STAT2–5,4 = 11.
HC Zero Calibration Failure:	STAT2–3,2 = 11.
O_2 Data Invalid:	STAT2–1,0 = 01.
NO_X Zero Calibration Failure:	STAT3–7,6 = 11.
New O_2 Sensor Required:	STAT4–5 = 1.

$03 — Span Calibration

Command	$03 – Span Calibration
Command Format	$02–LB–$03–TVM–TV1–TV2–[TV1–TV2]–CS
ACK Format	$06–$03–$00–CS
NAK Format	$15–$03–$01–EC–CS
NAK Error Codes	$00 = System fault. $01 = Illegal data value. $02 = Not allowed at this time. $10 = Bad command length. $44 = Not allowed at this time; boot program mode active.

The $03 command enables the host system to perform single-point span calibration of the CO, HC, CO_2, NO_X, and O_2 channels. Note that the O_2 channel is span calibrated using the $02 Zero/$O_2$ Span Calibration command. It is not necessary to perform O_2 span calibration with the $03 command.

There are functional differences depending on which $F1 configuration mode is in effect:

6500/6510 Mode and Basic 6900 Mode: The $03 Span Calibration command does not control sample delivery. Delivery of span calibration gas is under host system control. Span calibration is performed using the gas provided by the host system to the standard sample gas inlet tube.

6900 Modes (BAR-97, OIML): The $03 Span Calibration command turns off the 6900 high capacity pump, closes the Sample/Room Air solenoid valve and opens the Cal Gas solenoid valve. Span calibration is performed using bottled calibration gas plumbed to the Cal Gas port.

Single-Point Span Calibration: Single-point span calibration calculates a straight-line slope value through zero and the specified span point. One calibration gas cocktail is required.

HC Channel Span Calibration Using Propane: Andros recommends that propane be used when span calibrating the HC channel. The data type specified in the $01 or $06 Data/Status command (propane or n-hexane) is used by the $03 Span Calibration command during span calibration.

Channel Precedence: When more than one channel is being span calibrated, the TV1, TV2 byte pairs must be transmitted in a specific channel order. Channel precedence order is CO_2, CO, propane, NO_X, and O_2.

TVM (Tag Value Mask): The TVM byte specifies which channels are being span calibrated. Each channel's calibration gas tag value is specified by associated TV1, TV2 bytes.

TVM–7 Reserved.
TVM–6 Reserved.
TVM–5 Reserved.
TVM–4 1 = O_2 Tag Value follows.
TVM–3 1 = NO_X Tag Value follows.
TVM–2 1 = HC Tag Value (propane or n-Hexane) follows.
TVM–1 1 = CO Tag Value follows.
TVM–0 1 = CO_2 Tag Value follows.

TV1, TV2 (Tag Value Bytes): The TV1 and TV2 bytes make up an unsigned, 16-bit number specifying the tag value of the gas specified in the preceding TVM byte. TV1 is the most significant byte and TV2 is the least significant byte. There must be a two-byte tag value for each channel specified in the TVM byte, otherwise the command will return NAK code $01 or (if LB is less than $04) NAK code $10. Valid tag value ranges and the required order of precedence are defined in the following table:

CO_2:	1.00 to 20.00% CO_2.
CO:	0.500 to 15.000% CO.
HC (Propane):	100 to 60,000 ppm propane*
HC (n-Hexane):	100 to 30,000 ppm n-hexane*
NO_X:	100 to 5,000 ppm NO_X
O_2:	1.00 to 25.00% O_2

Note that when more than one channel is specified in the $03–TVM byte, the TV1, TV2 code $10 tag value byte pairs must follow the order shown above (CO_2 first, O_2 last).

*Although the Data/Status commands $01 and $06 report HC using a four-byte signed value, a two-byte unsigned value should be transmitted for each channel to be span calibrated.

Calibration Gases: Room air (20.95% O_2) is used for span calibration of the O_2 channel during the zero calibration performed with the $02 command. The correct calibration gas is based on the system application. An example of calibration cocktail gases for the CO_2, CO, HC, and NO_X channels is shown below:

CO_2:	12.09%.
CO:	8.085%.
Propane:	3,200 ppm.
NO_X:	3,000 ppm.

After a Data/Status command such as the following, to establish Data Type as propane

$02–$03–$01–$01–CS,

the Span command for the above cocktail would be:

$02–$0A–$03–$0F–$04–$B9–$1F–$95–$0C–$80–$0B–$B8–CS

Span Calibration Procedure Status: $01–STAT1–4 (Process In Progress) is true during the performance of an $03 Span Calibration command.

Reporting Of Span Calibration Failures: If an $03 Span Calibration command fails, one or more of the following error status bits are set true:

CO_2 Span Calibration Failure:	STAT2–7,6 = 1,0.
CO Span Calibration Failure:	STAT2–5,4 = 1,0.
HC Span Calibration Failure:	STAT2–3,2 = 1,0.
New NO_X Sensor Required:	STAT4–6 = 1.

$04 — System ID

Command	$04 – System ID
Command Format	$02–$01–$04–CS
ACK Format	$06–$04–$22– SN1–SN2–SN3–SN4–SN5–SN6– MOD1–MOD2–MOD3–MOD4– HWPN1–HWPN2–HWPN3–HWPN4–HWPN5– HWPN6–HWPN7–HWPN8–HWPN9–HWPN10– HWREV1–HWREV2– SWPN1–SWPN2–SWPN3–SWPN4–SWPN5– SWPN6–SWPN7–SWPN8–SWPN1–SWPN10– SWREV1– SWREV2–CS
NAK Format	$15–$04–$01–EC–CS
NAK Error Codes	$10 = Bad command length. $44 = Not allowed at this time; boot program mode active.

The $04 System ID command returns system identification data, as programmed by Andros, to the host system.

SN1 – SN6: Serial number returned as six ASCII characters.

Example: “123456”.

MOD1 – MOD4: Model number returned as four ASCII characters.

Example: “6500"

HWPN1 – HWPN10: Hardware part number returned as ten ASCII characters.

Example: “451197-000”.

HWREV1 – HWREV2: Hardware revision level returned as two ASCII characters.

Example: “0A”.

SWPN1 – SWPN10: Software part number returned as ten ASCII characters.

Example: “878270-000”.

SWREV1 – SWREV2: Software revision level returned as two ASCII characters.

Example “15”.

$05 — Miscellaneous Data

Command	$05 – Miscellaneous Data
Command Format	$02–$01–$05–CS
ACK Format	$06–$05–$0C– AMBTEMP1–AMBTEMP2– PEF1–PEF2– ADC1-1–ADC1-2– ADC2-1–ADC2-2– RPM1–RPM2– RSVD1–RSVD2–CS
NAK Format	$15–$05–$01–EC–CS
NAK Error Codes	$10 = Bad command length. $44 = Not allowed at this time; boot program mode active.

AMBTEMP1, AMBTEMP2: AMBTEMP1 and AMBTEMP2 represent a signed, 16-bit integer value reporting detector temperature as monitored by a thermistor on the Model 6500/6510 preamplifier board. AMBTEMP1 is the most significant byte. Ambient temperature is reported in tenths of a degree Celsius.

Example: AMBTEMP1, AMBTEMP2 = $00FB = 25.1°C.

PEF1, PEF2: PEF1 and PEF2 represent a signed, 16-bit integer value reporting the calculated propane equivalency factor. PEF1 is the most significant byte. The propane equivalency factor is reported in thousandths of a unit. This internally computed PEF value is dynamically determined, and varies depending on HC concentration and temperature.

Example: PEF1, PEF2 = $01FF = 0.511 PEF.

ADC1-1, ADC1-2: ***6500/6510 Modes:*** ADC1-1 and ADC1-2 represent a signed, 16-bit integer value reporting the digitized value of the external analog signal (ADC1) connected to 6500/6510-board connector J17-1. ADC1-1 is the most significant byte. ADC1 is reported in millivolts within the range 660 to 4,000 mVDC.

Example: ADC1-1, ADC1-2 = $0C62 = +3.170 VDC.

ADC2-1, ADC2-2: ***6900/6510 Modes:*** ADC2-1 and ADC2-2 represent a signed, 16-bit integer value reporting the digitized value of the external analog signal (ADC2) connected to J17-2. ADC2-1 is the most significant byte. ADC2 is reported in millivolts within the range 660 to 4000 mVDC. Positive readings are accurate to within ± 100 mV.

Example: ADC2-1, ADC2-2 = $03E8 = +1.000 VDC; Applied voltage is 0.900 to 1.100 V.

RPM1, RPM2: RPM1 and RPM2 represent a signed, 16-bit integer value reporting the pulse-per-minute measurement of the TTL signal connected to J17-8. RPM is reported in whole pulses-per-minute. RPM1 is the most significant byte.

Example: RPM1, RPM2 = $05DC = 1500 RPM.

RSVD1, RSVD2: Reserved for future use.

$06 —Extended Data/Status

Command	$06 – Extended Data/Status
Command Format	$02–$03–$06–DR– DT–CS
ACK Format	$06–$06–$1A–STAT1– STAT2– STAT3– STAT4– $CO_2$1–$CO_2$2–CO1–CO2–HC1–HC2–HC3–HC4– $O_2$1–$O_2$2–NO_X1–NO_X2– GAGEPRESS1–GAGEPRESS2– ABSPRESS1–ABSPRESS2–$RO_2$1–$RO_2$2– RNO1–RNO2– RNO3– RNO4–AMBTEMP1-AMBTEMP2-PEF1-PEF2-CS
NAK Format	$15–$06–$01–EC–CS
NAK Error Codes	$01 = Illegal data value. $10 = Bad command length. $44 = Not allowed at this time; boot program mode active.

DR (Data Rate): As defined for command $01 — Data/Status.
Starting $06 continuous data automatically stops $01 continuous data, and vice versa.
Stopping (or requesting a single packet of) either type will stop all continuous data transmission.

DT (Data Type): As defined for command $01 — Data/Status.

STAT1 – NOx2: As defined for command $01 — Data/Status.

GAGEPRESS1 – ABSPRESS2: As defined for command $16 — Pressure Data.

AMBTEMP1 – PEF2 As defined for command $05 – Miscellaneous Data

$RO_2$1 – RNO4: As defined for command $12 — Raw NOx and O2 Data.

$07 — Pump On/Off

Command	$07 – Device Control
Command Format	$02–$02–$07–PC–CS
ACK Format	$06–$07–$01–PS–CS
NAK Format	$15–$07–$01–EC–CS
NAK Error Codes	$02 = Not allowed at this time. $03 = Sample delivery problem $10 = Bad command length. $44 = Not allowed at this time; boot program mode active.

The $07 Pump On/Off command explicitly turns ON or OFF the pneumatics pump. The actual pump controlled (if any) depends on the $F1 mode configuration in effect. In $F1 mode 3, PS (Pump State) is always returned as $00.

6900 Modes: The high capacity 6900 subassembly chassis mounted pump is turned ON or OFF.

6500/6510 Mode: The Model 6500/6510 pump current sink (J15-10) goes to a high-impedance state, turning OFF any OEM pump driven by this signal.

PC (Pump Control): The PC byte valve specifies the commanded pump state.

PC = $00 Turn pump OFF.

PC = $01 Turn pump ON.

PC = $02 or higher No change in pump state.

PS (Pump State): The PS byte value reports the current pump state.

PS = $00 Pump OFF.

PS = $01 Pump ON.

Note: Andros strongly recommends that the $01 Data/Status command be used to turn either pump ON or OFF (along with data/status transmission) except during recovery from an Out-Flow fault, when it must be explicitly commanded ON. Note that if you turn the pump OFF via the $07 Pump On/Off command, and then perform the $02 Zero/$O_2$ Span Calibration, the pump will be left turned ON at the end of the $02 procedure ($F1–CMT 5 or 7).

The $07 Pump On/Off command will clear the following sample delivery system status bits to "0" once the cause for the Flow Fault has been cleared by other means. For example, the 6900 filter/water trap can cause a vacuum (In-Flow/Low-Flow) to be maintained if the float has sealed the outlet due to a high level of water in the trap. Removing the high vacuum condition will allow clearing of the associated status bits when the Pump On command is issued.

STAT4–7 = 1 In-Flow Fault

STAT4–3 = 1 Out-Flow Fault

STAT4–1 = 1 Low-Flow Fault

$08 — Device Control

Command	$08 – Device Control
Command Format	$02–$03–$08–DCM– DC–CS
ACK Format	$06–$08–$01–DCLS–CS
NAK Format	$15–$08–$01–EC–CS
NAK Error Codes	$10 = Bad command length. $44 = Not allowed at this time; boot program mode active.

The Device Control command enables host software to control solenoids (as supplied with Model 6900) or external devices. Models 6500 and 6900 provide switchable return-current paths from up to four 12-V devices to power ground, and two auxiliary TTL output lines. The devices may be connected and addressed as follows.

Signal Name	Device (typ.)	Nom, Voltage	Return path
	Bit 0 is not mapped to the hardware.		
AUXOUT1	12-V Soln 1 (Sample Gas / Room Air)	+12 at J15-1	J15-2 (switched)
AUXOUT2	12-V Soln 2 (Cal Gas)	+12 at J15-3	J15-4 (switched)
AUXOUT3	12-V Soln 3 (BAR-97 Zero Gas)	+12 at J15-5	J15-6 (switched)
AUXOUT4	12-V Soln 4 (BAR-97 Cal Check Gas)	+12 at J15-7	J15-8 (switched)
AUXOUT5	TTL (User-defined)	+3.3V at J17-5	J17-4 (analog ground)
AUXOUT6	TTL (User-defined)	+3.3V at J17-6	J17-4 (analog ground)
	Bit 7 is not mapped to the hardware.		

The OEM system designer determines what additional device-control circuitry is required by the final system and application.

All auxiliary output lines are initially clear (OFF) by POR default. During the next 6 seconds, however, hardware initialization routines in the analyzer's firmware may supersede any $08 — Device Control command(s). The solenoid states may also be affected by the firmware when executing various commands. To explicitly change an auxiliary output line, the host software must (1) select it by setting a bit in the mask byte DCM, and (2) specify the new state in the corresponding bit of control byte DC.

Note that the $08 Device Control ACK response indicates all current auxiliary device control line states, as affected by execution of the current command. If the DCM mask byte is $00, no auxiliary-device control line is affected but the current line status is reported.

In configurations ($F1 – CMT) $05 and $07, only one of Soln1, Soln2 or Soln3 can be energized at one time. If an $08 command would turn more than one of these three ON, the lowest-numbered one that is selected and commanded ON will be energized. If one of them is ON, the $08 command cannot turn on either of the others unless it simultaneously turns that one OFF.

Example (CMT 5 or 7):

Time	DCM	DC	Devices ON	→ DCLS
0	$FF (bits 7, 6, … 0)	$0C (bits 3, 2)	2 only	$04 (bit 2)
1	$02	$02 (bit 1)	2 only (still)	$04
2	$04	$00	None (3, 1 forgotten)	$00
3	$04	$FF	2	$04
4	$FF	$0A (bits 3, 1)	1 (turning 2 off)	$02
5	$FF	$FF	1, 4, 5, 6	$F3 (ignore bits 7, 0)
6	$FF	$00	None	$00

DCM: The Device Control Mask byte specifies the Model 6900/6500 output lines that will be affected by the command. DCM byte functions are defined below.

DCM Bit	Signal Name	Pin #	6900 Function	Auxiliary Device Control Mask Function
DCM–7	None	None	None	No hardware effect. Tracked by software as if "AUXOUT7" existed.
DCM–6	AUXOUT6	J17-6	None	1 = Set to TTL high or clear to TTL low as specified in the DC byte. 0 = Do not change the state of the auxiliary control output.
DCM–5	AUXOUT5	J17-5	Sol #5 Reserved	1 = Set to TTL high or clear to TTL low as specified in the DC byte. 0 = Do not change the state of the auxiliary control output.
DCM–4	AUXOUT4	J15-8	Sol #4 Cal Check	1 = Set (on) or clear (off) as specified in the DC byte. 0 = Do not change the state of the auxiliary control output.
DCM–3	AUXOUT3	J15-6	Sol #3 Zero Gas	1 = Set (on) or clear (off) as specified in the DC byte. 0 = Do not change the state of the auxiliary control output.
DCM–2	AUXOUT2	J15-4	Sol #2 Cal Gas	1 = Set (on) or clear (off) as specified in the DC byte. 0 = Do not change the state of the auxiliary control output.
DCM–1	AUXOUT1	J15-2	Sol #1 Room Air / Sample	1 = Set (on/room air) or clear (off/sample) as specified in the DC byte. 0 = Do not change the state of the auxiliary control output.
DCM–0	None	None	None	No hardware effect. Tracked by software as if "AUXOUT0" existed.

DC: The Device Control byte specifies whether an auxiliary output line (named in the DCM byte) is set or cleared. An auxiliary output line not named in the DCM byte is unaffected; regardless of its DC bit state.

DC Bit	Signal Name	Pin #	6900 Function	Auxiliary TTL Device Control Output State
DC–7	None	None	None	No hardware effect. Tracked by software as if "AUXOUT7" existed.
DC–6	AUXOUT6	J17-6	None	1 = Set to TTL high if named in the DCM byte. 0 = Clear to TTL low if named in the DCM byte.
DC–5	AUXOUT5	J17-5	Sol #5 Reserved	1 = Set to TTL high if named in the DCM byte. 0 = Clear to TTL low if named in the DCM byte.
DC–4	AUXOUT4	J15-8	Sol #4 Cal Check	1 = Set (on) if named in the DCM byte. 6900 mode: Activates solenoid valve #4 and routes BAR-97 calibration check gas to the 6500/6510 analyzer. 0 = Clear (off) if named in the DCM byte. 6900 mode: Deactivates solenoid valve #4 (POR default).
DC–3	AUXOUT3	J15-6	Sol #3 Zero Gas	1 = Set (on) if named in the DCM byte. 6900 mode: Activates solenoid valve #3 and routes BAR-97 zero gas to the Model 6500/6510 analyzer. 0 = Clear (off) if named in the DCM byte. 6900 mode: Deactivates solenoid valve #3 (POR default).
DC–2	AUXOUT2	J15-4	Sol #2 Cal Gas	1 = Set (on) if named in the DCM byte. 6900 mode: Activates solenoid valve #2 and routes calibration gas to the Model 6500/6510 analyzer. 0 = Clear (off) if named in the DCM byte. 6900 mode: Deactivates solenoid valve #2 (POR default).
DC–1	AUXOUT1	J15-2	Sol #1 Room Air / Sample	1 = Set (on / room air) if named in the DCM byte. 6900 mode: Activates solenoid valve #1 and routes room air to the 6500/6510 analyzer. 0 = Clear (off / exhaust sample) if named in the DCM byte. 6900 mode: Deactivates solenoid valve #1 (POR default) and routes vehicle exhaust sample gas from the water trap/filter to the Model 6500/6510 analyzer.
DC–0	None	None	None	No hardware effect. Tracked by software as if "AUXOUT0" existed.

DCLS: The Device Control Line Status byte reports whether an auxiliary output line is currently ON or OFF.

DCLS Bit	Signal Name	Pin #	6900 Function	Auxiliary TTL Device Control Line Status
DCLS–7	None	None	None	None (tracks state of bit DC-7 when DCM-7 is set(1))
DCLS–6	AUXOUT6	J17-6	None	1 = Set (1) if named in the DCM byte. 0 = Clear (0) if named in the DCM byte.
DCLS–5	AUXOUT5	J17-5	Sol #5 Reserved	1 = Set (1) if named in the DCM byte. 0 = Clear (0) if named in the DCM byte.
DCLS–4	AUXOUT4	J15-8	Sol #4 Cal Check	1 = Set if named in the DCM byte. 6900 mode: Solenoid valve #4 activated. BAR-97 calibration check gas routed to the Model 6500/6510 analyzer. 0 = Clear (0) if named in the DCM byte. 6900 mode: Solenoid valve #4 deactivated (POR default).
DCLS–3	AUXOUT3	J15-6	Sol #3 Zero Gas	1 = Set (1) if named in the DCM byte. 6900 mode: Solenoid valve #3 activated. BAR-97 zero gas routed to the Model 6500/6510 analyzer. 0 = Clear (0) if named in the DCM byte. 6900 mode: Solenoid valve #3 deactivated (POR default).
DCLS–2	AUXOUT2	J15-4	Sol #2 Cal Gas	1 = Set (1) if named in the DCM byte. 6900 mode: Solenoid valve #2 activated. Calibration gas routed to the Model 6500/6510 analyzer. 0 = Clear (0) if named in the DCM byte. 6900 mode: Solenoid valve #2 deactivated (POR default).
DCLS–1	AUXOUT1	J15-2	Sol #1 Room Air / Sample	1 = Set (1) if named in the DCM byte. 6900 mode: Solenoid valve #1 activated. Room air routed to the Model 6500/6510 analyzer. 0 = Clear (0) if named in the DCM byte. 6900 mode: Solenoid valve #1 deactivated (POR default). Vehicle exhaust sample gas routed through the water trap/filter to the Model 6500/6510 analyzer.
DCLS–0	None	None	None	None (tracks state of bit DC-0 when DCM-0 is set(1))

$09 — Reset Span

Command	$09 – Reset Span
Command Format	$02–$02–$09–RSCM–CS
ACK Format	$06–$09–$00–CS
NAK Format	$15–$09–$01–EC–CS
NAK Error Codes	$00 = System fault. $10 = Bad command length. $42 = Write flash failed. $44 = Not allowed at this time; boot program mode active.

The host system can use the $09 Reset Span command to reset one or more field-span calibration factors to the original factory setting.

RSCM: The Reset Span Channel Mask (RSCM) byte specifies the data channel field-span factor that is being reset.

RSCM Bit	RSCM Bit Definition
RSCM–7	Reserved.
RSCM–6	Reserved.
RSCM–5	Reserved.
RSCM–4	Reserved.
RSCM–3	Reserved.
RSCM–2	1 = Reset HC channel span factor constants.
RSCM–1	1 = Reset CO channel span factor constants.
RSCM–0	1 = Reset CO_2 channel span factor constants.

The O_2 and NO_X fuel cell sensors have a finite life. Over time their full-scale output degrades and their field-span factors are recalculated each time a $03 Span Calibration command is executed. Therefore, there is no meaningful "original factory setting" for the O_2 and NO_X channel span factor values.

\$0A — New NO_X Sensor

Command	\$0A – New NO_X Sensor
Command Format	\$02–\$01–\$0A–CS
ACK Format	\$06–\$0A–\$00–CS
NAK Format	\$15–\$0A–\$01–EC–CS
NAK Error Codes	\$00 = System fault. \$02 = Not allowed at this time. \$10 = Bad command length. \$44 = Not allowed at this time, boot program mode active.

The \$0A New NO_X Sensor command informs the Model 6500/6510 analyzer that a new NO_X sensor has been installed.

> **Important Note**: The \$0A command is used **after** a new NO_X sensor is installed **and** a successful NO_X span calibration is performed. The \$0A command should **not** be used after subsequent NO_X span calibration during the life of the NO_X sensor.

The \$0A command results in a calculated value that represents 80% of the new NO_X sensor's full-scale (5000 ppm NO_X) output. This value is stored in flash memory (Low NO_X Sensor Level) and used as the limit indicating that a new NO_X sensor is required.

After each NO_X channel span calibration, a new full-scale NO_X output value is calculated, saved in flash memory as Current Full Scale NO_X Output, and compared to the Low NO_X Sensor Level value in flash memory. If the current value is equal to or less than the Low NO_X Sensor Level, New NO_X Sensor Required is set true (\$01–STAT4-6 = 1), indicating that a new NO_X sensor is required. When the New NO_X Sensor Required status bit is set true, the sensor should be replaced as soon as possible. During each Model 6500/6510 power-on reset self-test execution, the flash memory resident values for Current Full Scale NO_X Output and Low NO_X Sensor Limit are compared. If the Current Full Scale NO_X Output is equal to or less than the Low NO_X Sensor Level, \$01–STAT4-6 is set true.

$0B — Leak Test

Command	$0B – Leak Test
Command Format	$02–$04–$0B–VACTIME–WAITTIME–DELTA–CS
ACK Format	$06–$0B–$00–CS
NAK Format	$15–$0B–$01–EC–CS
NAK Error Codes	$00 = System fault. $01 = Illegal data value. $02 = Not allowed at this time. $10 = Bad command length. $44 = Not allowed at this time, boot program mode active.

The $0B Leak Test command tests the pneumatics path between the probe tip and the 6900 pump for leaks.

The $0B Leak Test command will be executed only under 6900 subsystem $F1 configuration modes (i.e., $F1–CMT = $05 or $07). When Model 6500/6510 analyzer $F1 configuration modes (i.e., $01) are in effect, the $0B Leak Test command is NAK'd (NAK error code $02).

At this time all 6900 subsystem $F1 configuration modes execute the same $0B Leak Test procedure. A leak test performed during standby mode returns the 6900 to standby mode.

Refer to the *Leak Test* discussion in the *Sample Delivery* chapter for a complete description of the leak test procedure.

Three $0B command bytes are provided so that host system designers can modify or create leak tests as appropriate for their unique subsystems or to conform to new governmental program requirements. A default value (given below) is used for any parameter whose data field is given as $00 in the $0B command.

VACTIME: The leak test creates a vacuum by pumping against the capped hose and probe. VACTIME defines how long the pump is turned ON in increments of seconds. Maximum VACTIME value is $1E (30 seconds). A VACTIME value >$1E causes the $0B command to be NAK'd (NAK error code $01). VACTIME = $00 executes the default 6900 VACTIME of ten seconds.

Example: VACTIME = $0C commands twelve seconds of pump down.

Example: VACTIME = $11 commands seventeen seconds of pump down.

Default: VACTIME = $0A. Ten seconds of pump down.

WAITTIME: Two pressure measurements are made during the leak test. The first is immediately after creating the vacuum and turning the pump OFF. The second pressure measurement is made after a delay defined by the WAITTIME byte. WAITTIME is specified in increments of whole seconds. Maximum WAITTIME value is $1E (30 seconds). A WAITTIME value >$1E causes the $0B command to be NAK'd (NAK error code $01). WAITTIME = $00 executes the default 6900 WAITTIME of ten seconds.

Example: WAITTIME = $09 commands nine seconds of leak test delay time.

Example: WAITTIME = $21 commands thirty three seconds of leak test delay time.

Default: WAITTIME = $0A. Ten seconds of leak test delay time.

DELTA: Leak test pass or fail is determined by comparing the difference between the two leak test pressure measurements and a limit defined by the parameters WAITTIME and DELTA. DELTA is the maximum allowed reduction in vacuum over one minute. Delta is specified in tenths of one PSI per minute. Valid DELTA range is $00–$FA (0–25.0 PSI/min). Illegal values of DELTA cause the $0B command to be NAK'd (NAK error code $01). If WAITTIME is $0A (ten seconds) and DELTA is $78 (12.0 PSI/min), then the maximum leak tested for is defined as 2.0 PSI in ten seconds.

Example: DELTA = $57 specifies an 87 psi (100 mbar) per minute maximum vacuum reduction, worst case.

Example: DELTA = $50 specifies an 8.0 PSI per minute maximum vacuum reduction.

Default: 11.5 PSI per minute maximum vacuum reduction (equivalent to DELTA = $73).

$F0 — Reset

Command	$F0 – Reset
Command Format	$02–$01–$F0–CS
ACK Format	$06–$F0–$00–CS
NAK Format	$15–$F0–$01–EC–CS
NAK Error Codes	$10 = Bad command length.

The $F0 Reset command causes the Model 6900/6500/6510 to perform a system reset that is equivalent to a POR (power-on reset). During POR the Model 6500/6510 is initialized, performs self-test, and goes through a warm-up period. Warm-up takes less than 35 seconds from a cold start.

Model 6500/6510 initialization leaves the Model 6500/6510 in the following state:

Communications:

TXD (transmit data) OFF, no data transmission.
RXD (receive data) ready to receive data.
RTS (6900 to host system handshaking) OFF, ready to receive commands.
CTS (host system to 6900 handshaking) ignored.
Data rate = 19,200 bps (default) Other factory-set data rates are available.

Pump:

OFF

Auxiliary TTL Output Lines:

AUXOUT0-7 are turned OFF; TTL high. This deactivates any 6900 solenoid valve, routing sample gas from the water trap filter cartridge to the Model 6500/6510.

Operating Mode:

At the end of the POR sequence (including warm-up) the Model 6500/6510 is in normal operating mode waiting for the host system to command operation. If two minutes pass without $01 Data/Status being requested (either continuous or single-packet) the Model 6500/6510 transitions to standby operating mode (pump and IR source OFF).

$01 Data/Status Transmission:

Continuous data/status transmission turned OFF.

Status:

System Status = NORMAL OPERATING MODE.
(Changes to STARTUP OPERATING MODE after 3 to 4 seconds)
Zero Request = TRUE (after 4 seconds).
Process In Progress = FALSE.
Pump On/Off = OFF (after 4 seconds) then back ON
CO_2, CO, HC, O_2, NO_X Data = NORMAL or DATA INVALID.
(DATA INVALID may be momentarily indicated for the IR channels (CO_2 CO and HC) if Continuous Data/Status is requested less than 5 seconds after POR.)
In Flow Fault = FALSE.
New NO_X Sensor Required = TRUE or FALSE per latest NO_X span calibration.
New O_2 Sensor Required = FALSE.
IR Signal Lost = TRUE or FALSE.
Out Flow Fault = FALSE.
Ambient Temperature Out Of Range = TRUE or FALSE.
Low Flow Fault = FALSE.
Leak Test Fault = FALSE.

$F1 — Configuration Mode Control

Command	$F1 – Configuration Mode Control
Command Format	$02–$03–$F1–CMC–CMT–CS
ACK Format	$06–$F1–$01–CMS–CS
NAK Format	$15–$F1–$01–EC–CS
NAK Error Codes	$01 = Illegal data value. $02 = Not allowed at this time. $10 = Bad command length. $42 = Flash memory write error. $44 = Not allowed at this time, boot program mode active.

The $F1 Configuration Mode Control command establishes the Model 6900/6500/6510's mode of operation. Typically, the $F1 command is used only at the following times:

- ***Andros Manufacturing Process***. Andros analyzers and subsystems are built to order. Near the end of a Model 6500/6510 manufacturing process, it is committed to an order and its configuration is established. This includes adding either or both of the fuel cell sensors (O_2 and NO_X) and setting the configuration mode using the $F1 command.
- ***OEM Manufacturing Process***. If an OEM uses the Model 6900/6500/6510 in different applications (e.g., hand-held analyzer, BAR-97 subsystem, OIML subsystem) the ability to reconfigure it will be quite useful.
- ***Engineering Evaluation and Test***. OEM system design and test engineers can use the $F1 command to experiment with the different Model 6500/6510 configuration modes.
- ***Field or Depot Service***. If an OEM's service strategy includes replacing Model 6900/6500/6510 analyzers in the field, there may be a need to verify or change the replacement Model 6500/6510 configuration mode.

BAR-97 6900 Mode: CMT = $07
The Model 6500/6510 based subsystem is designed to support the California BAR-97 program. A BAR-97 6900 subsystem includes DC-DC power conversion, two dual-headed (wet and dry side) pneumatic pumps, and four solenoid valves (sample gas/room air, calibration gas, zero gas, calibration check gas).

OIML 6900 Mode: CMT = $05
The Model 6500/6510 based subsystem designed to support the OIML Class 0 and Class 1 specifications. An OIML 6900 subsystem includes DC-DC power conversion, dual-headed (wet and dry side) pneumatic pumps, and one solenoid valve (sample gas/room air).

Basic 6900 Mode: CMT = $03
The Model 6500/6510 based subsystem designed to support the lowest cost subsystem requirements. A basic 6900 subsystem includes DC-DC power conversion and one solenoid valve (sample gas/room air).

6500/6510 Mode: CMT = $01
A Model 6500 subsystem contains driver circuitry for customer-supplied pump and solenoid(s), which should be connected to J15 and must be explicitly controlled using commands $07 and $08. A 6510 subsystem contains no pump, solenoids or associated driver circuitry.

CMT (Configuration Mode Type):
The CMT byte specifies which configuration mode is being set.

$05 = Single-solenoid 6900 subsystem mode, new and Basic 6900 mode

$07 = Multi-solenoid 6900 subsystem mode, new

$08-$FF = Reserved for future use. The $F1 command will be NAK'd (NAK error code $01).

CMC (Configuration Mode Control):

The CMC byte specifies the exact action the $F1 command will execute.

$00 = No configuration mode change. The CMT byte is ignored. Issuing the $F1 command with CMC = $00 allows the host system to confirm which configuration mode is in effect without changing the configuration mode.

$01 = Temporary configuration mode change. The configuration mode is changed but not stored in flash memory. The next POR (power on reset) reestablished the original configuration mode. Issuing the $F1 command with CMC = $01 is useful during test and experimentation where a permanent configuration mode change is not wanted.

$02 = Permanent configuration mode change. The configuration mode is changed and stored in flash memory. Subsequent POR resets result in establishing the new configuration mode.

$03–$FF = Reserved for future use. The $F1 command will be NAK'd (NAK error code $01).

CMS (Configuration Mode Status):

The CMS byte reports which configuration mode is currently in effect (after any change specified by this execution of the $F1 command).

$01 = 6500/6510 subsystem.

$03 = Basic 6900 subsystem.

$05 = Single-solenoid 6900 subsystem mode, new.

$07 = Multi-solenoid 6900 subsystem mode, new

$08-$FF = Reserved for future use. The $F1 command will be NAK'd (NAK error code $01).

The $F1 Configuration Mode Control command can be used when the 6900 is in standby mode. Standby mode is not terminated.

After using the $F1 command to change the analyzer's configuration mode permanently, you should command a $F0 Reset.

$11 —1 Point Pressure Span/Reset Span Calibration

Command	$11 —1-Point Pressure Span Calibration
Command Format	$02—$04—$11—TVM—TV1—TV2—CS
ACK Format	$06—$11—$00—CS
NAK Format	$15—$11—$01—EC—CS
NAK Error Codes	$00 = System fault. $01 = Illegal data value. $02 = Not allowed at this time. $44 = Not allowed at this time, boot program mode active.

The $11 command is used by the host system to perform a 1 point span or Reset Span on Pressure channel.

Tag Value Mask Byte: The TVM byte specifies whether 1 point span or reset span sequence shall be performed.

TVM = $01 specifies 1 point pressure span.

TVM = $02 specifies reset span on pressure channel.

Tag Values Bytes: Tag value bytes are used only in case of 1-point span. The TV1 and TV2 bytes make up a single 16-bit number specifying the pressure tag value. TV1 is the most significant byte.

Valid Tag Value Range:

The valid pressure channel tag value range for the pressure span is 500 to 850 torr (mmHg).

Meters	Feet	Pressure mB	Pressure mmHg	Air Temp Deg C	Air Temp Deg F	Typical Environment
0	0	1013	760	15.0	59.0	Sea level
1,000	3,281	899	674	8.5	47.3	
2,000	6,562	795	596	2.0	35.6	Foothills
3,000	9,843	701	526	-4.5	23.9	
4,000	13,123	616	462	-11.0	12.2	European Alps
5,000	16,404	540	405	-17.5	0.5	
6,000	19,685	472	354	-24.0	-11.2	Andes
7,000	22,966	411	308	-30.5	-22.9	
8,000	26,247	356	267	-37.0	-34.6	Himalaya
9,000	29,528	307	230	-43.5	-46.3	
10,000	32,808	264	198	-50.0	-58.0	Aircraft (outside)

Span Calibration Procedure Status: $01—STAT1–4, Process In Progress, is true during the execution of each $11 1-point Pressure Span/Reset Span Calibration command. Typical Pressure Span calibration shall take 10 seconds.

$12 —Raw NOx and O2 Data

Command	$12 — Raw NOx and O2 Data
Command Format	$02—$01—$12—CS
ACK Format	$06—$12—$06— RO21—RO22— RNO1—RNO2— RNO3—RNO4—CS
NAK Format	$15—$12—$01—EC—CS
NAK Error Codes	$44 = Not allowed at this time, boot program mode active.

RO21, RO22: RO21 and RO22 represent a single signed, 16-bit value reporting the calculated raw O2 channel value. RO21 is the most significant byte. Raw O2 data is reported in thousandths of volts. Note that the O2 voltage reported is the one measured by the O2 circuit and not the raw output of the O2 sensor. The raw output can be computed by dividing the reported value by 200 (the gain of the circuit). For example, if RO21 and RO22 reported 550 then the circuit reading corresponds to 550/1000 = 0.55 volts. The raw O2 is then 0.55volts / 200 = 0.0028 volts or 2.8 millivolts.

RNO1, RNO2, RNO3, RNO4: RNO1, RNO2, RNO3 and RNO4 represent a long, 32-bit value, reporting the calculated raw NO channel value. RNO1 is the most significant byte. Raw NO data is reported in nanoamperes

$13 —Channel Switch ON/OFF command

Command	$13 —Channel Switch ON/OFF
Command Format	$02—$02—$13— CM—CS
ACK Format	$06—$13—$01— CM —CS
NAK Format	$15—$13—$01—EC—CS
NAK Error Codes	$01 = Illegal data value. $42 = Write flash failed. $44 = Not allowed at this time, boot program mode active.

The $13 command is used to switch ON/OFF compensated data reporting by commands $01 Data/Status and $06 Extended Data/Status. If the data is switched ON by $13 command the real compensated data is reported by commands $01 and $06. If the data is switched OFF by $13 command, zero value shall be reported for the selected channels in $01 and $06 commands. Errors for the channels that are switched off shall not be reported.

Caution: This command saves the new configuration to flash.

Note: The Channel Switch command takes effect after a delay of 2 to 3 seconds due to data buffering.

Channel Mask Byte: The CM byte specifies the channels that shall be reported by commands $01 and $06.

CM (Channel Mask)	
CM Bit	**CM Bit Definition**
CM–7	1 = Write, 0 = Read
CM–6	Reserved.
CM–5	Reserved.
CM–4	1 = O_2 Value Displayed.
CM–3	1 = NO Value Displayed.
CM–2	1 = Propane/Hexane Value Displayed.
CM–1	1 = CO Value Displayed.
CM–0	1 = CO_2 Value Displayed.

The CM byte in the ACK response shall report the current setting of each channel ON/OFF switch. If bit 7 is clear (0) in the CM byte of the command, bits 4 through 0 are ignored and the current switch states are reported in the reply. Only in the write mode are the other bits of the CM byte from the command used to select or unselect channels.

$14 — Read User Memory

Command	$14 – Read User Memory
Command Format	$02—$02—$14—LOC—CS
ACK Format	$06—$14— $14—UM1 — … — UM20 —CS
NAK Format	$15 – $14 – $01 – EC – CS
NAK Error Codes	$01 = Illegal data value. $44 = Not allowed at this time, boot program mode active.

The Analyzer dedicates 5 locations, 20 bytes each of Flash memory to customer use. Depending on location requested 10 bytes are returned in the ACK response.

LOC: The valid value for this byte is 1, 2, 3, 4, or 5.

UM1- … - UM20: ASCII and Binary characters at given location.

The $14 Read User Memory command is available in all operating modes.

$15 — Write User Memory

Command	$15 – Read User Memory
Command Format	$02—$16—$15—LOC— UM1 — … — UM20 —CS
ACK Format	$06—$15— $00—CS
NAK Format	$15 – $15 – $01 – EC – CS
NAK Error Codes	$01 = Illegal data value. $10 = Bad command length. $42 = Write flash failed. $44 = Not allowed at this time, boot program mode active.

The Analyzer dedicates 5 locations, 20 bytes each of Flash memory to customer use.

LOC: The valid value for this byte is 1, 2, 3, 4, or 5.

UM1- … - UM20: User selected ASCII and Binary characters.

The $15 Write User Memory command is available in all operating modes.

$16 —Pressure Data

Command	$16 — Pressure Data
Command Format	$02—$01—$16—CS
ACK Format	$06—$16—$06— GAGEPRESS1—GAGEPRESS2—ABSPRESS1—ABSPRESS2—AMBPRESS1—AMBPRESS2 —CS
NAK Format	$15—$16—$01—EC—CS
NAK Error Codes	$44 = Not allowed at this time, boot program mode active.

GAGEPRESS1, GAGEPRESS2: GAGEPRESS1 and GAGEPRESS2 represent a single signed, 16-bit value reporting the calculated gage pressure (current gage pressure – gage pressure at zero time). GAGEPRESS1 is the most significant byte. Gage pressure is reported in thousandths of psi.

ABSPRESS1, ABSPPRESS2: ABSPRESS1 and ABSPRESS2 represent a single signed, 16-bit value reporting the calculated absolute pressure. ABSPRESS1 is the most significant byte. Absolute pressure is reported in tenths of torr.

AMBPRESS1, AMBPRESS2: AMBPRESS1 and AMBPRESS2 represent a single signed, 16-bit value reporting the calculated ambient pressure. AMBPRESS1 is the most significant byte. Ambient pressure is calculated during zero and is reported in tenths of torr (mm Hg).

$17 — Standby Enable / Disable command

Command	$17 —Standby Enable / Disable
Command Format	$02—$02—$17— SM1—CS
ACK Format	$06—$17—$01— SM2 —CS
NAK Format	$15—$17—$01—EC—CS
NAK Error Codes	$01 = Illegal data value. $42 = Write flash failed. $44 = Not allowed at this time, boot program mode active.

The $17 command is used to enable or disable standby mode.

Standby Mode Byte1: The SM1 byte specifies the current setting for standby mode.

SM1	
SM1 Bit	**SM1 Bit Definition**
SM1–7,6	10 = Enabled, 01 = Disabled, 00 = Read
SM1–5	1 = Permanent, 0 = Temporary
SM1–4-0	Reserved.

Standby Mode Byte2: The SM2 byte returns the current setting for standby mode.

SM2	
SM2 Bit	**SM2 Bit Definition**
SM2–7,6	10 = Enabled, 01 = Disabled
SM2–5-0	Reserved.

$18 — SW Checksum

Command	$18 – SW Checksum
Command Format	$02–$01–$18–CS
ACK Format	$06–$18–$08– SWCHKSUM1–SWCHKSUM2–SWCHKSUM3- SWCHKSUM4-CS
NAK Format	$15–$18–$01–EC–CS
NAK Error Codes	$44 = Not allowed at this time, boot program mode active.

The $18 SW Checksum command returns the software checksum identification.

SWCHKSUM1-SWCHKSUM8: 2's complement checksum based on the locations and images of the beginning and ending code markers for the metrological computation algorithm plus the two bytes code revision returned as four ASCII characters..

Example: "F4D4" returned as 46 34 44 34.

Example:
02 01 18 e5 06 18 04 46 34 44 34 ec

Chapter 8 — Service Procedures

Maintenance and Service

The 6900 water trap/filter, room air filter, pump, chemical sensors, and sample cell may be serviced in the field. Maintenance procedures are performed using common hand tools and spare parts available from Andros. Repairs other than those defined in this chapter are performed by an Andros service center. Refer to the Product Support chapter for information concerning warranty and non-warranty repair programs. The maintenance procedures described in this chapter assume that the 6900 is removed from the final OEM system.

General Maintenance Considerations

Cleanliness is very important when performing 6900 maintenance procedures.

The Model 6500/6510 analyzer measures levels of hydrocarbon molecules in parts-per-million. When installing, operating, or servicing the 6900, care must be taken to avoid introduction of unwanted hydrocarbon molecules into the gas sample. Materials such as oil, grease, and hand cream contain hydrocarbons. If introduced into the 6900 sample gas path, even small amounts of these substances can cause HC channel measurement errors.

Hands should be washed before each maintenance activity. The use of white cotton gloves is an excellent method of avoiding contamination during 6900 service.

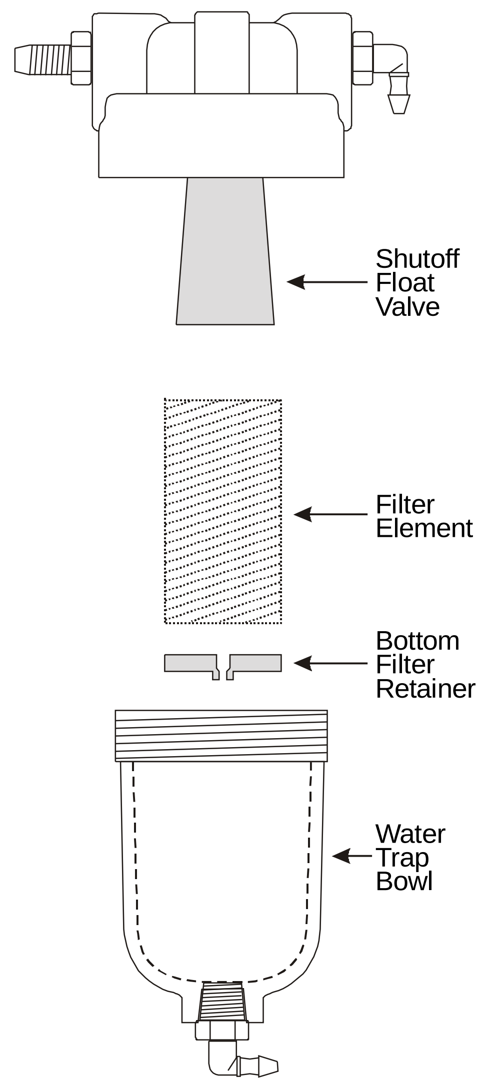
Water Trap / Filter Element Replacement

The 6900 water trap/filter assembly performs the following functions:

- The Andros or OEM supplied hose and probe assembly is connected to the 6900 water trap/filter assembly's inlet port.
- Liquid water is separated from the gas sample and collected in the water trap bowl. The water trap bowl is automatically drained by the wet side of the 6900 pump whenever it is turned ON.
- The 6900 water trap/filter assembly includes a float type water shutoff valve. If, for any reason, the water trap bowl fills with water the shutoff valve closes and prevents liquid water from being drawn into the Model 6500/6510 analyzer.
- The 6900 water trap/filter assembly includes a particulate filter element. In addition to participating in the water separation function, it filters out particles that should not be drawn into the Model 6500/6510 analyzer.

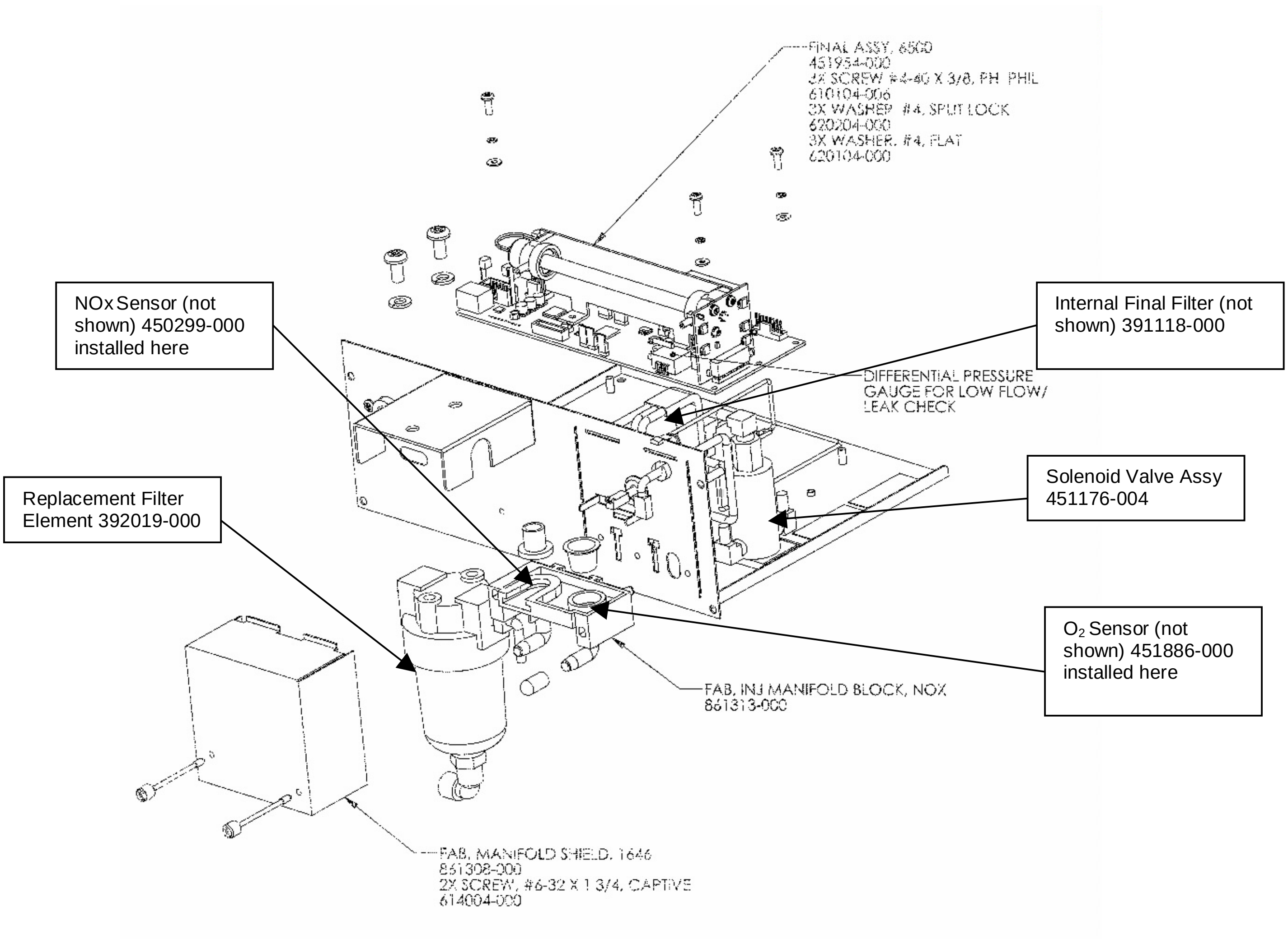
The 6900 water trap/filter assembly's filter element must be periodically replaced. When it is replaced depends on many variables. Filter element replacement guidelines include the following:

- The 6900 is reporting occlusions (In Flow Fault, STAT4–7 = 1 or Low Flow Fault, STAT4–1 = 1).
- The particulate filter's appearance is "very dark" or in any other way abnormal.
- Every 80 vehicle tests or once per week, whichever comes first.

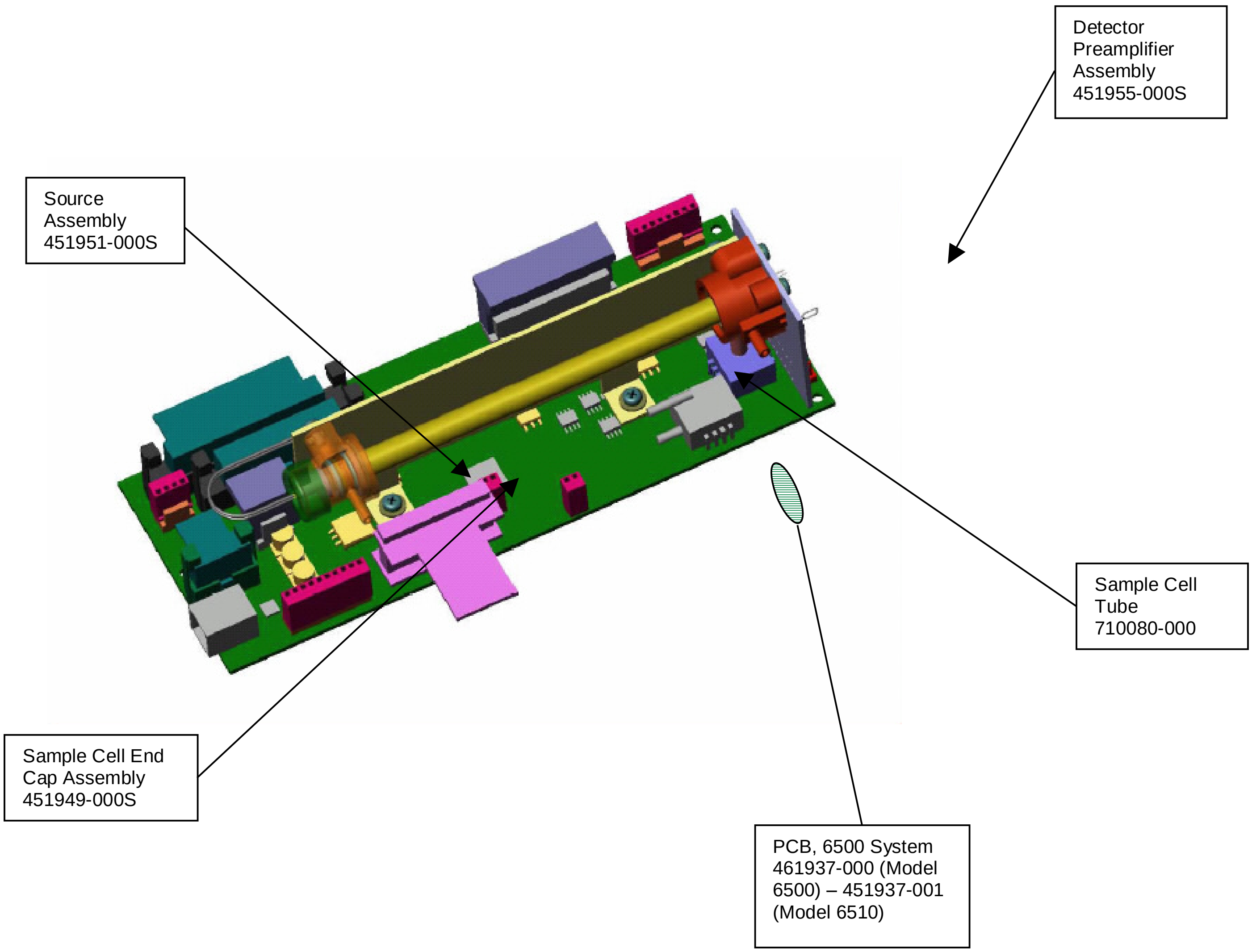


1) If necessary, run the 6900—with its hose and probe in free room air—until the bowl has been emptied.
2) Turn OFF the 6900.
3) Remove the drain tube from the water trap bowl's barb fitting.
4) Unscrew and remove the water trap bowl.
5) Remove the filter element from the water trap/filter top assembly.
6) Remove the plastic bottom filter retainer from the filter element. Do not throw the retainer away when you discard the filter element.
7) Insert the bottom filter retainer in a new filter element. It is a friction fit.
8) Insert the new filter element into the water trap/filter top assembly. It is a friction fit onto the top filter retainer.
9) Screw on the water trap bowl.
10) Replace the water drain tubing on the water trap bowl's barb fitting.

6900 Subassembly Maintenance Items



Model 6500/6510 Analyzer Maintenance Items



O_2 or NO_X Fuel Cell Sensor Replacement

The 6900 O_2 and NO_X fuel cell sensors have an expected life of 18 months under normal operating conditions. Follow the procedure defined below to replace either the 6900 O_2 or NO_X sensor.

1) ***Gain Access:***
   a) Verify that 6900 input power is turned OFF.
   b) If necessary, remove the 6900 from the final OEM system.
   c) Remove manifold shield cover.
2) ***Sensor Removal***:
   a) Each cell sensor includes a pull tab. Be careful not to tear it.
   b) Carefully pull on the tab and remove the 1 sensor from the Model 6500/6510 analyzer external manifold.
3) ***Sensor Installation***:
   a) Position the cell sensor at the sensor manifold. Ensure that the sensor's connector pins are aligned with the Model 6500/6510 bulkhead connector.
   b) Carefully push on the fuel cell sensor to seat it in the Model 6500/6510 sensor manifold.
   c) Replace the 6900 sensor access cover.
4) ***Sensor Calibration***: Power up the 6900 and perform the following functions:
   a) O_2 or NO_X sensor: Perform $02 zero calibration.
   b) NO_X sensor only: Perform $03 NO_X span calibration.
   c) NO_X sensor only: Transmit the $0A New NO_X Sensor command. Note that the $0A New NO_X Sensor command should not be used again until another new NO_X sensor is installed.
5) ***Verification***: Transmit a $01 Data/Status command. Verify that no errors are reported.

Sample Cell Cleaning

Under normal operating conditions, the Model 6500/6510 analyzer's sample cell should be cleaned every 12 months. Follow the procedure defined below to clean the sample cell.

1) ***Model 6500/6510 Access:***
   a) Verify that 6900 input power is turned OFF.
   b) If necessary, remove the 6900 from the final OEM system.
   c) Remove the Model 6500/6510 analyzer from the 6900 subassembly. In the 6900 it is not necessary to remove the Model 6500/6510 from the subassembly. This step may apply to specific installations.
   d) Remove the sample cell inlet hose from the sample cell source end cap.
   e) Remove the screws that secure the end cap to the mounting bracket.
   f) Carefully lift up on the sample cell (by its end cap) to unseat the sample cell assembly from the Model 6500/6510 detector/preamp end cap.
   g) Remove the source end cap.
2) ***Sample Cell Cleaning:***
   a) Clean the cell shaft and end-cap windows using a long cotton tipped swab or long, soft brush.
   b) Ensure that the cell and end caps are dry and free of contamination before reassembly.
3) ***Sample Cell Installation***:
   a) Insert one end of the glass tube into the detector/preamplifier end cap.
   b) Carefully install the source end cap onto the other end of sample cell tube making sure the tube is held parallel to the mounting bracket.
   c) Secure the source end cap to the mounting bracket using the screws removed in step 2g above.
   d) Reinstall the sample cell inlet tubing.
4) ***Assemble***:
   a) Replace the Model 6500/6510 analyzer in the 6900 subsystem if it was removed in step 1c.
   b) Replace the 6900 in the final OEM system (if removed in step 1b).
5) ***Verification***: Power up the 6900 and perform zero calibration. Transmit a $01 Data/Status command. Verify that no errors are reported for either command.

Bench Upgrade Download Procedure

The Model 6500/6510 analyzer includes flash memory that enables the operational firmware to be upgraded by the Andros Host 6500 software.. Andros firmware upgrades consist of a file that contains standard Motorola S-Records. The file contains only S2 records, with no header, terminator, or other records.

1) ***Configuring the Model 6500/6510 for Firmware Upgrade***: After the Andros supplied update file has been copied to the directory where HOST 6500 is stored, open HOST 6500 and set up communications with the appropriate communications port on the PC. Select the Bench Upgrade option in the Service Screens menu. After the Start Download button is pressed, type in the correct file location and file name then press OPEN to begin the download process.

   Boot/Program mode is controlled by a protected program in the boot sector of the flash memory. The boot program is separate from the main program. In the event of a programming failure, the boot program will remain intact and the download process may be attempted again. In the case of a missing or corrupt main program, Boot/Program mode is automatically entered. During Boot/Program mode, the Model 6500/6510 diagnostic LED provides a status in the form of a sequence of light pulses. The status/error code is determined by counting the number of pulses in the sequence. Pulse descriptions are provided below.

Status Code (pulse rate)	Description
LED 1	LED1 is always on as the lamp is off while in boot mode.
LED 2 and LED 3	LED2 and LED3 blink on/off every ½ seconds to indicate waiting for application download. During download, LED2 and LED3 blink on for 1.5 seconds and off for ½ second.
LED4	Always off

LED indication during normal operation

LED Number and Indication	Description
LED 1 at 1 HZ blink rate	LED1 displays the opposite of the lamp state. When the lamp is off, LED1 is on. When lamp is on, LED1 is off.
LED 2 at 1 Hz blink rate	LED2 blinks on/off every 1 second indicating the collection of 1-second data.
LED 3 appears On continuously	LED3 is used to indicate activity of the A/D conversion. LED3 appears to be on all the time but there is actually a 5 us off signal every 1 ms.
LED 4 normally Off	LED4 is the reset led and comes on when the board is in reset.

2) ***Reset the Model 6500/6510***: Transmit a $F0 (Reset) command to restart the Model 6500/6510 and run its new embedded program. The new program will perform initializing operations that affect flash memory. Allow 1 minute before power is removed from the Model 6500/6510 after the first reset or power-up.

3) ***Failure Reporting***: A 3-flash pulse from the diagnostic LED will indicate a failure of the programming operation. At 19,200 baud, a complete software download should be completed within 60 seconds. Note that the $26, $27, and $28 commands have a device identifier (DID) byte of $22 instead of the usual $02. In Boot/Program mode, only commands $25, $26, $27, $28, and $F0 are valid. Other commands that would normally be accepted by the main program will receive a NAK response (NAK error code $44; Not allowed At This Time, Boot Mode In Progress).

Troubleshooting Error Status

The 6900 error status bits and fields report both recoverable and unrecoverable fault conditions. Error status information is related to conditions that require host system response. Error status is used to isolate and correct 6900 operational problems.

6900 error status, causes and corrective actions are found in the following tables.

System Fault				
Error Name	**Status Set**	**Probable Cause**	**Corrective Action**	**Next Level Error**
System Fault	STAT1–7,6 = 11	Data invalid on all channels. ADC data acquisition error. Self-test failure. IR source failure (lamp blown or low output). Flash memory error (write error, erase error, data corrupted).	Non-recoverable error; unit requires factory service.	None.
Note: Conditions that produce a System Fault may also result in individual data channel errors being reported.				

CO_2, CO, HC and NO_X Data Invalid Errors				
Error Name	**Status Set**	**Probable Cause**	**Corrective Action**	**Next Level Error**
CO_2 Data Invalid CO Data Invalid HC Data Invalid	STAT2–7,6 = 01 STAT2–5,4 = 01 STAT2–3,2 = 01	IR signal lost. ADC range problem. Channel data or hardware failure.	Clean sample cell and windows. Perform zero calibration. Failed channels; unit requires factory service.	None.
NO_X Data Invalid	STAT3–7,6 = 01	NO_X sensor thermistor failure.	Replace NO_X sensor.	None.

Zero Calibration Errors				
Error Name	**Status Set**	**Probable Cause**	**Corrective Action**	**Next Level Error**
CO_2 Zero Fail CO Zero Fail HC Zero Fail	STAT2–7,6 = 11 STAT2–5,4 = 11 STAT2–3,2 = 11	***CO_2, CO, HC Zero Fail***: Signal level on IR gas channel and/or on IR reference channel is too high.	May be cleared by a successful zero calibration or a reset.	None.
O_2 Zero Fail	STAT2–1,0 = 01	***O_2, Zero Fail***: O2 sensor output < 5 mV.	Replace sensor. Note: STAT4–5 (New O2 Sensor Required) is set when sensor output < 7 mV..	
Out Flow Fault	(STAT4-3=1):	***All Channel Zero Fail:*** Sample gas path is blocked at outlet during zero calibration.	Clear outlet occlusion, issue ***Pump On*** Command then perform zero calibration.	None.

Span Calibration Errors				
Error Name	**Status Set**	**Probable Cause**	**Corrective Action**	**Next Level Error**
CO_2 Span Fail CO Span Fail HC Span Fail	STAT2–7,6 = 10 STAT2–5,4 = 10 STAT2–3,2 = 10	New span constant is significantly different from factory span constant. Operator error, leak, incorrect tag value.	Eliminate leaks; verify good calibration gas; verify correct tag value; verify correct pressures and flow rate. Perform new span calibration.	None.

Sample Delivery Errors				
Error Name	**Status Set**	**Probable Cause**	**Corrective Action**	**Next Level Error**
In Flow Fault	STAT4–7 = 1	Inlet filter occluded. Hose/probe occluded. Exhaust tubing occluded. Defective pump. Leaks. Defective system board.	Eliminate occlusion. Eliminate occlusion. Eliminate occlusion. Replace pump. Eliminate leaks. Replace system board.	None.
Out Flow Fault	STAT4–3 = 1	Sample gas path is occluded at outlet during zero calibration.	Eliminate outlet occlusion, issue ***Pump On*** Command then perform zero calibration.	CO_2 Zero Fail CO Zero Fail HC Zero Fail O_2 Zero Fail NO_X Zero Fail O_2 Span Fail
Low Flow Fault (6900 modes only)	STAT4–1 = 1	Inlet filter occluded. Hose/probe occluded. Defective pump. Leaks. Defective system board.	Eliminate occlusion. Eliminate occlusion. Replace pump. Eliminate leaks. Replace system board.	None.
Leak Test Fault (6900 modes only)	STAT4–0 = 1	Defective pump. Leaks. Defective system board.	Replace pump. Eliminate leaks. Replace system board.	None.

New Sensor Error				
Error Name	**Status Set**	**Probable Cause**	**Corrective Action**	**Next Level Error**
New NO_X Sensor Required	STAT4–6 = 1	Full-scale output of NO_X sensor is $\leq$ 80% of full-scale value when sensor was installed.	Replace the NO_X sensor.	None.
New O_2 Sensor Required	STAT4–5 = 1	The O_2 sensor output was below 5 mV during $02 Zero/$O_2$ Span Calibration.	Replace the O_2 sensor.	None.

IR Signal Error				
Error Name	**Status Set**	**Probable Cause**	**Corrective Action**	**Next Level Error**
IR Signal Lost	STAT4–4 = 1	Contaminated sample cell.	Clean sample cell and windows.	CO_2 Data Invalid CO Data Invalid HC Data Invalid

Ambient Temperature Error				
Error Name	**Status Set**	**Probable Cause**	**Corrective Action**	**Next Level Error**
Ambient Temperature Error	STAT4–2 = 1	Detector temperature out of range. Measurement accuracy may be affected.	Verify that analyzer is operated within a temperature range of 0 to 50°C. The temperature rise caused by final system packaging, ventilation, and cooling must be taken into account.	None.

Chapter 9 — Product Support

Technical Support and Training

Technical support, applications engineering support, and technical training is available to assist you in the use and system integration of your Andros product.

For assistance or more information, please contact Andros technical personnel at one of the following locations.

USA

Andros Incorporated
870 Harbour Way South
Richmond, CA 94804
USA
Voice (510) 837-3500
Fax (510) 837-3600

EUROPE

Andros Europe GmbH
Teichmatt 7
Renchen
D-77871 Germany
Voice 49 7843 993060
Fax 49 7843 993061

How To Return Products For Service

Before returning an Andros product for service or replacement, you must contact Andros and request a Return Material Authorization (RMA) number. Follow the appropriate procedure below depending on where you are, and which Andros Service location you will be using.

To Andros USA Service Depot From The USA

Before any product is returned to Andros for service or replacement, a Return Material Authorization (RMA) number must be obtained from the service depot. RMA numbers are valid for thirty (30) days after issuance. Serial numbers of all products must appear on the RMA.

1) Telephone or FAX the Andros USA Service Depot to obtain an RMA number.
   Voice: (510) 837-3500
   FAX: (510) 837-3600

2) When requesting the RMA, please provide the following information:
   a) Complete billing and shipping address.
   b) Purchase order number authorizing repair.
   c) Model, part number, and serial number of each product being returned.
   d) Reason for returning each product, including suspected cause of failure.
   e) Preferred method of return shipment.

3) Place the RMA number on the outside of the shipping container and on all accompanying documents (e.g., packing list, shipper, debit memo, failure report, etc.).

4) The responsibility for shipping charges varies depending on why the product is being returned.
   a) In all cases, you are responsible for any brokerage charges, or any fees levied by customs, connected with international shipment.
   b) **Products Rejected At Incoming Inspection**. Andros is responsible for the shipping costs in both directions. In the event of *Lot Sampling Plan Rejection*, Andros reserves the right to send Andros personnel to your location to 100% inspect the remainder of the lot. You are responsible for shipping costs in both directions on each returned product that is found not to be defective.
   c) **Service Covered By Andros Warranty**. Andros is responsible for return shipping costs. You are responsible for shipping costs to Andros. You are responsible for shipping costs in both directions on each returned product that is found not to be defective.
   d) **Non-Warranty Service**. You are responsible for shipping costs in both directions.

5) Ship the product to the following location:

   Andros Incorporated
   870 Harbour Way South
   Richmond, CA 94804

To Andros USA Service Depot From International Locations

Before any product is returned to Andros for service or replacement, a Return Material Authorization (RMA) number must be obtained from the service depot. RMA numbers are valid for thirty (30) days after issuance. Serial numbers of all products must appear on the RMA.

1) Telephone or FAX the Andros USA Service Depot to obtain an RMA number.
   Voice: (510) 837-3500
   FAX: (510) 837-3600

2) When requesting the RMA, please provide the following information:
   a) Complete billing and shipping address.
   b) Purchase order number authorizing repair.
   c) Model, part number, and serial number of each product being returned.
   d) Reason for returning each product, including suspected cause of failure.
   e) Preferred method of return shipment.

3) Complete a Commercial Invoice and a Foreign Shipper's Declaration. Mark all accompanying documents with the following statement:
   "Goods originated in the USA — Return to USA for repair."

4) Place the RMA number on the outside of the shipping container and on all accompanying documents (e.g., commercial invoice, foreign shipper's declaration, packing list, debit memo, failure report, etc.).

5) Specify "SFO International Airport" in the space provided for Airport of Destination on the International Airway Bill.

6) Ship the product to the following location:
   Andros Incorporated
   c/o Union Air Transport
   870 Harbour Way South
   Richmond, CA 94804
   USA
   Attention: Customer Service Department

7) All freight charges, duties, brokerage and handling fees are to be paid by you. Andros will ship the products back freight and duty collect.

8) The responsibility for shipping charges varies depending on why the product is being returned.
   a) **International Shipping Charges**. In all cases, you are responsible for any brokerage charges, or any fees levied by customs, connected with international shipment.
   b) **Products Rejected At Incoming Inspection**. Andros is responsible for the shipping costs in both directions. In the event of *Lot Sampling Plan Rejection*, Andros reserves the right to send Andros personnel to your location to 100% inspect the remainder of the lot. You are responsible for shipping costs in both directions on each returned product that is found not to be defective.
   c) **Service Covered By Andros Warranty**. Andros is responsible for return shipping costs. You are responsible for shipping costs to Andros. You are responsible for shipping costs in both directions on each returned product that is found not to be defective.
   d) **Non-Warranty Service**. You are responsible for shipping costs in both directions.

9) Forward to the address below, under separate cover, an exact copy of all documents that accompany the product shipment:
   Andros Incorporated
   870 Harbour Way South
   Richmond, CA 94804
   Attention: Customer Service Department

To Andros Europe Service Center

Before any product is returned to Andros for service or replacement, a Return Material Authorization (RMA) number must be obtained from the service depot. RMA numbers are valid for thirty (30) days after issuance. Serial numbers of all products must appear on the RMA.

1) Telephone or FAX the Andros European Service Center to obtain an RMA number.
   Voice: (49) 7843 993060
   FAX: (49) 7843 993061

2) When requesting the RMA, please provide the following information:

   a) Your **Name**. This name will be used as our primary contact for matters concerning the RMA.
   b) Your **Company Name**.
   c) Your **Phone Number**.
   d) Your **FAX Number**.
   e) Your **Purchase Order** or **Reference Number** authorizing the repairs.
   f) The **Andros Part Number** of the items to be returned.
   g) The **Quantity** of units that you are requesting to return for service.
   h) The **Serial Number** of each individual unit to be returned.

   RMA request forms and instructions are available in French, German and English.

3) Please reference the RMA number on each document or inquiry related to the shipment (e.g., freight papers, packing lists, correspondence, etc.).

4) Return units in their original shipping cartons.

5) The responsibility for shipping charges varies depending on why the product is being returned.
   a) **Inbound Shipping Charges**. In all cases, you are responsible for all inbound freight charges. This includes any customs duties, clearance charges, and/or brokerage fees connected with shipment. The Andros European Service Center will not accept freight collect shipments.
      Andros European Center
      Teichmatt 7
      Renchen
      D-77871 Germany
      Voice: (49) 7843 993060
      FAX: (49) 7843 993061
   b) **Service Covered By Andros Warranty**. Andros is responsible for return shipping costs. You are responsible for shipping costs to Andros. You are responsible for shipping costs in both directions on each returned product that is found not to be defective.
   c) **Non-Warranty Service**. You are responsible for shipping costs in both directions.

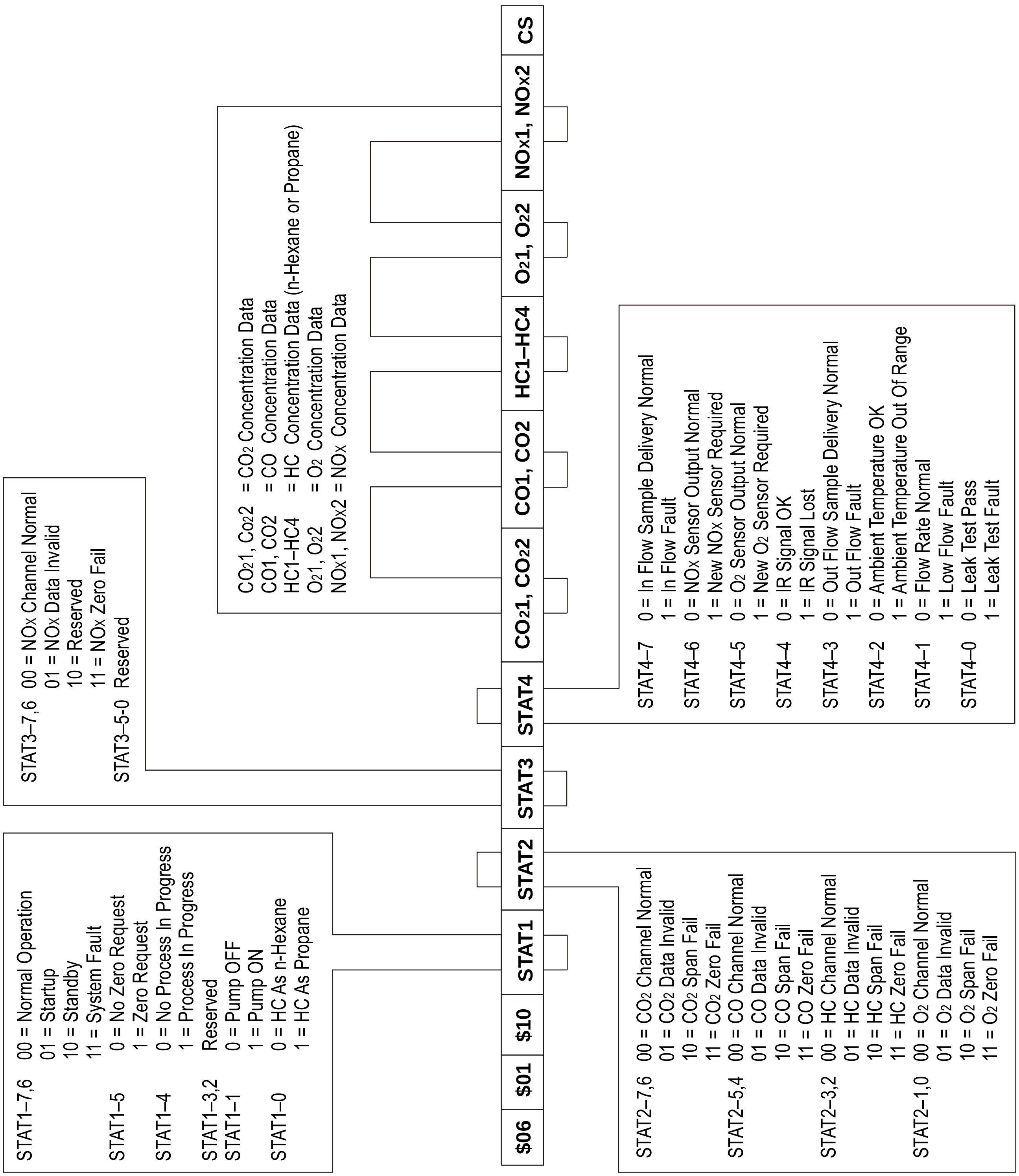
6) Once you have been given a Return Material Authorization (RMA) number, please ship the product to European Service Center address.
   Andros European Service Center
   Teichmatt 7
   Renchen
   D-77871 Germany
   Voice: (49) 7843 993060
   FAX: (49) 7843 993061

7) Unless otherwise requested, Andros will return repaired units to customers via the freight company of our choice. You will be billed separately for any applicable return shipping costs.

8)

Appendix A — Supplemental Documentation

$01 Data/Status Reference Chart



Appendix B — Supplemental Documentation

Model Number – Part Number - Connector Matrix

Model Number	Part Number	J1	J3	J7	J15	J16	J17	J18	J19	USB1
6500	451954-000	X	X	X	X	X	X	X	X	X
6510	451956-000	X	X	X						
6530	451956-013	X	X	X						

Model 6500 - 5 gas capable, HC, CO, CO2, O2, NO – Replaces Model 6602 – all I/O features installed

Model 6510 - 5 gas capable, HC, CO, CO2, O2, NO – Optically identical to Model 6500 – No Auxiliary I/O or pneumatics control

Model 6530 – Replaces Models 6230, 6231, 6241, 6231A, and 6241A - Optically identical to Model 6500 – No Auxiliary I/O or pneumatics control – Shipped configured as 62XX