Emissions Terminology and Nomenclature—SAE J1145a

SAE Recommended Practice
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SAE Recommended Practice

Report of Automotive Emissions Committee approved August 1976 and last revised October 1977.

1. Purpose—This SAE Recommended Practice was prepared to standardize terminology and nomenclature in order to facilitate clearer understanding for engineering discussions, comparisons, and the preparation of technical papers.

2. Scope—This recommended practice applies to nomenclature of emissions and emissions reduction apparatus as applied to various engines and vehicles.

Modifying adjectives are omitted in some cases for the sake of simplicity. However, it is considered good practice to use such adjectives when they add to clarity and understanding.

3. Auxiliary Air Systems

3.1 Air Distribution Manifold—The manifolding which distributes and proportions air to the individual exhaust ports. NOTE: The manifolding may consist of external tubing or integral passageways.

3.2 Air Pump Diverter Valve—A valve which interrupts the delivery of air to the exhaust ports—typically during vehicle deceleration in order to prevent engine backfires.

3.3 Air Injection Tube—A tube in the exhaust manifold or cylinder head which directs injected air from the air distribution manifold to the vicinity of the exhaust valve.

3.4 Air Injection Relief Valve—A pressure relief valve, usually integral with the air pump or air pump diverter valve, which limits the maximum delivery pressure of the injected air.

3.5 Bypass Valve—Use Air Pump Diverter Valve.

3.6 Gulp Valve—A valve that briefly admits a metered flow of air to the intake manifold after a sudden closure of the throttle. NOTE: This prevents an over-rich mixture being caused when high vacuum evaporates liquid fuel in the manifold.

3.7 Pulsating Air System—A system which uses sub-ambient pressure pulses in the exhaust system to introduce ambient air into the exhaust system for the purpose of oxidizing HC and CO.

4. Catalytic Systems

4.1 Base Metal Catalyst—A catalyst in which the active catalytic material is one or more non-noble metals such as copper or chromium.

4.2 Catalyst—A substance which accelerates a chemical reaction but which itself undergoes no permanent chemical change. Note: For automotive emission control applications, catalysts are classified as oxidation catalysts (oxidizes HC and CO), reduction catalysts (reduces NO_x), or three-way catalysts (oxidizes HC and CO and reduces NO_x simultaneously).

4.3 Catalyst Poisoning—The deterioration of catalyst efficiency when foreign materials—such as lead, phosphorus, or sulfur—are introduced to the catalytic converter, lessening or eliminating the chemical action of the catalysts on the exhaust pollutants.

4.4 Catalytic Converter—An assembly, including such major components as a structural shell, substrate, and the catalyst material. Depending on the type of catalyst—oxidation, reduction, or dual—this assembly decreases HC and CO emissions, or NO_x emissions, or all three of these exhaust pollutants.

4.5 Catalyst Assembly—Use Catalytic Converter.

4.6 Catalytic Efficiency—Use Conversion Efficiency.

4.7 Conversion Efficiency—The percentage of a given exhaust constituent that is changed into chemically different species as a result of the operation of the convertor.

4.8 Converter Bypass—A method for routing exhaust gas around a catalytic converter—typically to prevent converter damage due to excessively high operating temperatures.

4.9 Dual-Catalyst System—A system that uses two catalyst beds, one oxidation and one reduction, to decrease the HC, CO, and NO_x pollutants in the engine exhaust. These two beds may be packaged together or in two separate containers.

4.10 Light-Off Temperature—The temperature at which the conversion efficiency reaches a given value.

4.11 Monolithic Substrate—A unitary catalyst substrate usually of honeycomb structure.

4.12 Noble Metal Catalyst—A catalyst in which the active material is made from a precious metal such as platinum, palladium, rhodium, or ruthenium.

4.13 Oxidation Catalyst—A catalyst that promotes the oxidation of HC and CO to form water vapor and carbon dioxide.

4.14 Pelleted Substrate—A catalyst substrate having such forms as pebbles, beads, small cylinders, or small spheres.

The ϕ symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

4.15 Rare Earth Catalyst—A catalyst in which the active material is a rare earth element such as lanthanum and cerium. NOTE: The rare earth elements range in atomic number from 57 to 71.

4.16 Reduction Catalyst—A catalyst that promotes the chemical reduction of nitrogen oxides (NO_x) by reaction with carbon monoxide (CO), free hydrogen (H_2) or hydrocarbon (HC). The desired products of the chemical reaction are nitrogen gas, carbon dioxide, and water.

4.17 Simultaneous Oxidation Reduction Catalyst—Use Three-Way Catalyst.

4.18 Space Velocity—The exhaust flow in ft^3/h (m^3/s), measured at standard temperature and pressure, divided by the catalyst volume in ft^3 (m^3) equals the space velocity.

4.19 Substrate—A thermally stable material, usually catalytically inert, to which the active catalyst is affixed, imbedded, or in some other way joined. Pellets and monolith represent two physical forms of substrate.

4.20 Three-Way Catalyst—A catalyst that simultaneously oxidizes HC and CO and reduces NO_x exhaust emissions. Note: For maximum conversion efficiencies, the engine must operate over a very narrow range of air-fuel ratios near stoichiometric conditions.

4.21 Washcoat—A material applied to the substrate by the catalyst manufacturer to provide increased surface area for depositing the catalyst.

5. Chemical Terms

5.1 Aldehyde—A class of chemical compounds having the general formula RCHO, where R is an alkyl (aliphatic) or aryl (aromatic) radical.

5.2 Aromatics—A hydrocarbon having a ring-type structure with the general formula C_nH_{2n-6} and containing three double bonds in the ring.

5.3 Methane—A hydrocarbon represented by the chemical formula CH_4.

5.4 Naphthenes (Cycloparaffins)—A hydrocarbon having a ring-type structure with only single bonds between the carbon atoms.

5.5 Olefin—A hydrocarbon having a chain structure with one or more double bonds between two of the carbon atoms. The general formula is C_nH_{2n}.

5.6 Oxides of Nitrogen (NO_x)—The sum total of the nitric oxide and nitrogen dioxide in a sample expressed as nitrogen dioxide.

5.7 Paraffin—A hydrocarbon having a chain structure, and the general formula C_nH_{2n+2}.

5.8 Polynuclear Aromatic Hydrocarbons (PNA)—Relatively high molecular weight compounds synthesized in all combustion processes. They consist of three or more fused carbocyclic rings, each of which contains five or six carbons. Benzo(a)pyrene has often been measured as an index to the total and was chosen because it is a potent carcinogen.

5.9 Stoichiometric—The exact proportions of substances for a specific chemical reaction that will combine with no excess of any reactant. Note: An example is the ratio of air and hydrocarbon fuel which ideally combines to form only N_2, CO_2, and H_2O.

5.10 Sulfate—An ion having the formula SO_4. Note: Exhaust constituents including SO_3, H_2SO_4, and some metallic sulfates, are measured as sulfate ion and hence are referred to as sulfate emissions.

5.11 Zero Grade Air (Air Zero Gas)—Air containing less than 1 ppm hydrocarbon on a methane equivalence basis, 1 ppm carbon monoxide, 400 ppm carbon dioxide, and 0.1 ppm nitric oxide. Note: This gas is normally used to zero hydrocarbon analyzers and may also be used to zero analyzers for carbon monoxide, carbon dioxide, and oxides of nitrogen. It should not be used to zero analyzers measuring at or near ambient concentration of carbon dioxide.

6. Engine Hardware

6.1 Air Gap Pipes—Double walled exhaust pipes with either an annular air space or other insulating material between two basically concentric pipes.

6.2 Air-Fuel Ratio Control Device—A device which limits the amount of fuel to that which can be burned with the air available during acceleration of a turbocharged diesel engine.

6.3 Anti-Diesel Device—A device to close the throttle further or block the idle fuel within the carburetor when the ignition is turned off.

6.4 Breakerless Ignition System—A system which differs principally from a conventional ignition system in the following two ways. First, the conventional cam and breaker points are replaced by a pulse generator. Second, a solid state electronic device uses the pulse generator signal to switch ignition coil primary current on and off.

6.5 Carburetor Deceleration Combustion Control Valve—Use Fuel Decel Valve.

6.6 Closed-Loop Control—Use Feedback System for Controlling Air-Fuel Ratios.

6.7 Coolant Override Valve—Use Thermal Vacuum Switch.

6.8 Deceleration Spark Advance Control—A device that advances spark timing during deceleration conditions.

6.9 Deceleration Throttle Modulator—A device which regulates the rate of closure of the carburetor throttle.

6.10 Dual Diaphragm Distributor—A distributor with two vacuum diaphragms which can either advance or retard spark timing depending on the vacuum signals applied to it. NOTE: Spark is often retarded at idle and during deceleration for emission control but advanced for part-throttle fuel economy.

6.11 Electronic Ignition System—Use Breakerless Ignition System.

6.12 Exhaust Gas Recirculation (EGR)—A system which returns a portion of the exhaust gases to the combustion chamber. The lower combustion temperatures in turn reduce the formation of oxides and nitrogen.

6.13 EGR Control Valve—The valve which controls the amount of recirculated exhaust gas entering the engine induction system.

6.14 EGR Vacuum Port—The carburetor port or opening from which vacuum to control the EGR system is sensed.

6.15 Exhaust Port Liner—A sheet metal or ceramic component inserted in the exhaust ports for the purpose of reducing heat losses from the exhaust gas.

6.16 Feedback System for Controlling Air-Fuel Ratios—A system which uses feedback signal generated from an exhaust gas sensor to control the air-fuel ratio of the combustion mixture.

6.17 Fuel Decel Valve—A valve which uses engine vacuum during deceleration to either open the throttle slightly or to meter an additional amount of air-fuel mixture from the carburetor around the closed throttle blades, thereby providing more complete combustion.

6.18 Heat Shield—A device, usually a sheet metal shield, placed adjacent to a high temperature component (exhaust system) to protect the surrounding environment.

6.19 Insulated Pipes—Use Air Gap Pipes.

6.20 Lean Reactor—A thermal reactor system that typically operates at air-fuel ratios leaner than stoichiometric.

6.21 Positive Crankcase Ventilation (PCV)—A system which routes gases from the crankcase (blowby and air) to the air induction system of the engine.

6.22 PCV Valve—A valve that regulates the flow of gases from the crankcase into the intake manifold.

6.23 Proportional Exhaust Gas Recirculation—An EGR system designed to recirculate a fixed percentage (based on engine air flow) of the exhaust gas.

6.24 Quick-Acting Choke—An electrical or mechanically operated device designed to shorten the choking period during engine start-up.

6.25 Quick-Heat Intake Manifold—An exhaust-heated intake manifold having relatively large crossover passages and, typically, a thin sheet metal section in the plenum floor. NOTE: The sheet metal floor may have fins, convolutions or similar means to obtain a high rate of heat transfer between the crossover exhaust and the intake charge. The objective of these manifolds is to provide rapid intake mixture warmup by promoting evaporation of fuel droplets.

6.26 Reactor Liner—A sheet metal or ceramic component inserted in the thermal reactor for the purpose of reducing heat losses from the exhaust gas.

6.27 Rich Reactor—A thermal reactor system that typically operates in the range of air-fuel ratios richer than stoichiometric.

6.28 Spark Advance—The number of degrees before top dead center at which the spark discharge occurs.

6.29 Spark Delay Device—Calibrated restrictor in the vacuum advance hose which delays the vacuum spark advance.

6.30 Spark Port—The carburetor port from which vacuum to control the distributor spark advance is sensed.

6.31 Speed Controlled Spark—A system, generally used with an automatic transmission, that controls the vacuum to the distributor preventing vacuum advance below a selected vehicle speed.

6.32 Stove—The portion of the intake manifold which is heated by exhaust gases. NOTE: This term may also denote a system which heats carburetor inlet air by passing it over the exhaust manifold. May also denote a heat exchanger that supplies hot air to the bimetal coil of an automatic choke (choke stove).

6.33 Temperature Modulated Air Cleaner—An inlet air system, usually consisting of a stove, tubes, and control valve, for controlling the temperature of the air entering the carburetor within a specified range.

6.34 Thermal Reactor—An enlarged exhaust manifold—often with interior flow passages and/or insulation—that permits the combustion process to continue after the exhaust gases leave the engine combustion chambers. NOTE: The reactor retains the exhaust gases at a high temperature for the time required to oxidize HC and CO.

6.35 Thermal Vacuum Switch—A coolant temperature sensing vacuum control valve which modulates distributor and EGR vacuum to increase spark advance either as an override or protection device.

6.36 Transmission Regulated Spark—Use Transmission Spark Control Valve.

6.37 Transmission Spark Control Valve—A valve that routes manifold vacuum to the distributor advance unit only when transmission is operating in one or more specific drive gear ratios.

6.38 Vacuum Control Valve—Use Thermal Vacuum Switch.

6.39 Venturi Vacuum Amplifier—A device which amplifies carburetor venturi vacuum in order to modulate manifold vacuum to control the EGR valve.

7. Exhaust Emissions

7.1 Black Smoke—Particles composed of carbon (soot), usually less than 1 μm in size, which have escaped the engine's combustion process.

7.2 Brake Specific Emissions—Mass (grams or pounds) of pollutant emitted per brake horsepower hour.

7.3 Diesel Smoke—Particles, including aerosols, suspended in the engine's gaseous exhaust stream which obscure, reflect, and/or refract light.

7.4 Emission Index—Grams of pollutant emitted per kilogram of fuel burned.

7.5 Exhaust Emissions—Any substance (but normally limited to pollutants) emitted to the atmosphere from any opening downstream from the exhaust port of the combustion chamber of an engine.

7.6 Parts per Million Carbon (ppmC)—The mole fraction times 10^6 of hydrocarbon measured on a methane equivalence basis.

7.7 White and Blue Smoke—Particles composed of essentially colorless liquid (droplets) which reflect and refract the observed light. NOTE: The observed color results from the refractive index of the liquid in the droplets and the droplet size. White smoke is usually due to condensed water vapor or liquid fuel droplets. Blue smoke is usually due to droplets resulting from the incomplete burning of fuel or lubricating oil.

8. Evaporative Emissions

8.1 Carbon Canister for Evaporative Emissions—A component of an evaporative control system which is used to collect and store evaporative hydrocarbon emissions from the fuel tank and/or carburetor.

8.2 Charcoal Canister—Use Carbon Canister for Evaporative Emissions.

8.3 Diurnal Breathing Losses—Fuel vapors emitted during the controlled increase in fuel tank temperature. NOTE: This temperature increase simulates the daily range of ambient temperatures which fuel tanks experience in service.

8.4 Evaporative Emissions—Fuel vapors emitted into the atmosphere from the fuel system, that is, gas tank, carburetor, etc., of the vehicle.

8.5 Fuel Tank Check Valve—A mechanical device at the fuel tank which prevents liquid fuel from entering the evaporative storage system.

8.6 Hot Soak Losses—Fuel vapors emitted during a specified period beginning immediately after the engine is turned off.

8.7 Purge Valve—A vacuum or electrically actuated device in the evaporative emission control system used to release entrapped hydrocarbons to the engine induction system.

8.8 Refueling Emissions—Hydrocarbon emissions that can occur during filling of the vehicle fuel tank. NOTE: These emissions are made up of displaced fuel tank vapor, entrained droplets in this vapor, liquid spillage, and nozzle drip during insertion and removal of the nozzle from the filler neck.

8.9 Running Losses—Fuel vapors emitted during operation of the vehicle under the specified test schedule.

8.10 Vapor Canister—Use Carbon Canister for Evaporative Emissions.

8.11 Vapor Separator—A trap in the evaporative emission control system to prevent liquid fuel from passing into the vapor storage device.

9. Fuel Systems

9.1 Filler Tube Restrictor—A device in the fuel tank filler pipe that will only admit a small diameter fuel filler nozzle dispensing non-leaded fuel.

9.2 Fuel Filler Cap—The cap on the fuel filler tube which normally provides a positive seal and may contain relief valves for pressure and vacuum venting.

9.3 Fuel System—The combination of fuel tank, fuel lines, pump, filter, and vapor return lines, carburetor or injection components, and all fuel system vents and evaporative emission control systems or devices.

10. General

10.1 Curb Weight—The weight of the vehicle in operational status with all standard equipment, the weight of fuel at nominal tank capacity, and the weight of optional equipment.

10.2 Diesel Engine—Any compression ignition internal combustion engine, using the basic diesel cycle, that is, combustion results from the spraying of fuel into air heated by compression.

10.3 Gas Turbine Engine—Any engine using the basic gas turbine or Brayton cycle consisting of adiabatic compression, constant pressure heating, and adiabatic expansion.

10.4 Gross Vehicle Weight (gvw)—The manufacturer's gross weight rating, consisting of the curb weight plus pay load.

10.5 Heavy Duty Engine—Any engine which the engine manufacturer could reasonably expect to be used for motive power in a heavy-duty vehicle.

10.6 Heavy-Duty Vehicle—Any motor vehicle designed primarily for transportation of property and rated at more than 6000 lb (2722 kg) gvw or designed primarily for transportation of persons and having a capacity of more than 12 persons.

10.7 Light-Duty Vehicle—A motor vehicle having a rating of 6000 lb (2722 kg) gvw or less and designed primarily for the transportation of persons on a street or highway and having a capacity of 12 persons or less.

10.8 Light-Duty Truck—A motor vehicle having a rating of 6000 lb (2722 kg) gvw or less and designed primarily for the transportation of property or designed for off-street or off-highway use.

10.9 Loaded Vehicle Weight—The manufacturer's estimated weight of a vehicle in operating condition. For the purpose of emission testing, it is the curb weight of a light-duty vehicle plus 300 lb (136 kg).

10.10 Spark Ignition Engine—Any internal combustion engine using the basic Otto cycle, with combustion initiated by an electric spark.

11. Test Procedure and Equipment

11.1 Analytical Train—The entire system required to obtain and analyze a particular constituent in exhaust gas. Typically, this train will include such items as sample piping, particulate filter, condenser, sample pump, analytical instrument, and flow meter.

11.2 Batch or Grab Sample—A sample taken in a sealed syringe over a short period of time for a composite analysis.

11.3 Beer-Lambert Law—For purposes of diesel smoke measurement, an equation expressing the relationship between the opacity of a smoke plume, the optical path length through the plume, and the opacity of the smoke per unit path length, may be used:

$$\text{Opacity} = 1 - e^{-KL}$$

where:

e = base of natural logarithms
K = attenuation (or extinction) coefficient
L = path length through the smoke, in.

11.4 Calibrating Gas—Gas of known concentration used to establish instrument response.

11.5 Chassis Dynamometer—A laboratory power absorption unit capable of simulating to a limited degree the road operation of a vehicle. The dynamometer possesses the capability to simulate the inertia and road-load power developed by a vehicle.

11.6 Chemiluminescent Analyzer—An instrument in which the intensity of light produced by the chemiluminescence of the reaction is proportional to the concentration of the component analyzed, as with the reaction of nitric oxide and ozone.

11.7 Constant Volume Sampling—A technique for sampling exhaust gas in which a sampling pump draws a constant volume flow rate. This flow is provided from both the exhaust of a vehicle and from dilution air. NOTE: The technique allows for monitoring of continuous emissions on a mass basis and also (with the addition of a second pump) provides an aggregate total mass sample from a vehicle operated through an entire test cycle.

11.8 Detector—That component in an analytical instrument which responds to a particular exhaust gas constituent.

11.9 Driver Aid—An instrument intended to guide the vehicle driver in operating the vehicle in accordance with the acceleration, deceleration, and cruise operating modes of a specific driving procedure.

11.10 Dynamic or Continuous Sampling—A technique in which a portion of the exhaust is continuously withdrawn and pumped through an analytical train.

11.11 Filter Cell—That portion of the NDIR instrument which is filled with a particular gas in order to reduce interference signals.

11.12 Flame Ionization Detector (FID)—A hydrogen-air diffusion flame detector that produces a signal proportional to the mass flow rate of hydrocarbons entering the flame per unit time.

11.13 Gas Chromatogram—The recorder output versus time of a detector signal from a gas chromatograph, which shows deflections to indicate, for example, the presence of individual hydrocarbons.

11.14 Hang-Up—A term to describe the phenomena whereby higher molecular weight hydrocarbons are retained in the sample train, causing an initial low analyzer reading, followed by higher readings in subsequent tests. Excessive hang-up causes errors in the analysis of the hydrocarbons in exhaust gas.

11.15 Gas Chromatograph—An instrument commonly used to detect individual gases in complex gaseous mixtures. Note: In automobile exhaust gas analysis such instruments can be used to separate and determine the concentration of individual hydrocarbon species in a complex hydrocarbon mixture.

11.16 Hexane Equivalent Concentration (ppm hexane)—The concentration of a propane calibrating gas in terms of its hexane equivalent concentration. For NDIR, hexane equivalent concentration has been established as propane concentration times 0.52. For FID, hexane equivalent concentration equals propane concentration times 0.50.

11.17 Idle Speed—The engine's low idle speed as specified by the manufacturer.

11.18 Inertia Weights—A series of weights on a chassis dynamometer used to simulate the test weight of a vehicle.

11.19 Intermediate Speed—The peak torque speed or 60% of the rated speed, whichever is higher.

11.20 Mode—A particular event (for example, acceleration, deceleration, cruise, or idle) of a vehicle test cycle.

11.21 Nondispersive Infrared (NDIR)—Electromagnetic radiation used as the light source in NDIR instruments capable of measuring CO, CO_2, NO, and unburned hydrocarbons in exhaust gas.

11.22 Nondispersive Ultraviolet (NDUV)—Electromagnetic radiation used as the light source in NDUV instruments capable of measuring NO_2 concentrations in exhaust gas.

11.23 Non-Methane Hydrocarbons (NMHC)—All organic hydrocarbon compounds, excluding methane, present in an exhaust sample.

11.24 Smoke Opacimeter—An optical instrument designed to measure the opacity of diesel exhaust gases. The full flow of exhaust gases passes through the optical unit. One such smoke opacimeter is described in SAE J255.

11.25 Span Gas—A single calibrating gas blend routinely used in calibration of an instrument such as those used for detecting hydrocarbons, carbon monoxide, and nitric oxide.

11.26 Steady-State Condition—An engine operating condition at a constant speed and load and at stabilized temperatures and pressures.

11.27 Opacity—The fraction of light transmitted from a source which is prevented from reaching the observer or instrument receiver, in percent (Opacity = [1 − Transmittance] × 100).

11.28 Photographic Smoke Measurement—A measurement technique which relies upon an instrumental or visual comparison of the photographic image of a smoke plume with an established scale of blackness or opacity to determine the opacity of the original smoke plume.

11.29 Probe—A device inserted into some portion of an engine or vehicle system in order to obtain a representative gas or liquid sample.

11.30 Proportional Sampling—A method of obtaining a composite sample of exhaust gas representative of all driving modes in a test cycle. This sample, when analyzed, will represent the average molar concentration of a constituent properly weighted for mass flow rates.

11.31 Rated Power—The maximum brake power output of an engine, in horsepower or kilowatts, as stated by the manufacturer.

11.32 Rated Speed—The engine speed at which the manufacturer specifies the rated brake power of an engine.

11.33 Rated Torque—The maximum torque produced by an engine, as stated by the manufacturer.

11.34 Reid Vapor Pressure—The vapor pressure of gasoline at 100°F (37.8°C) determined in a special bomb in the presence of a volume of air which occupies four times the volume of liquid fuel (ASTM procedure D 323).

11.35 Reference Cell—That portion of the NDIR instrument which provides the reference signal to the detector.

11.36 Resolution—The minimum distinguishable reading, for a given trace width and scale combination, expressed as a percent of full-scale.

11.37 Sample Cell—That portion of the NDIR instrument which contains the sample gas being analyzed.

11.38 Sampling—The technique of obtaining an accurate sample of exhaust gas for analysis. Sampling may be grab, continuous, or proportional.

11.39 Test Cycle—A sequence of an engine or vehicle operating modes usually designed to simulate road usage of the vehicle.

11.40 Test Fuel—A fuel for use in a given test and having specific chemical and physical properties required for that test.

11.41 Transmittance—That fraction of light transmitted from a source, through a smoke-obscured path, which reaches the observer or instrument receiver.