

MEMORANDUM:

DATE: September 3, 1998

SUBJECT: Summary of Proposed Definitions for Stationary Internal Combustion Engines

FROM: Reciprocating Internal Combustion Engine Work Group

TO: ICCR Coordinating Committee

The Reciprocating Internal Combustion Engine Work Group (RICE WG) compiled a list of recommended definitions which may pertain to the development of a MACT standard for RICE.

The definitions have been divided into two sections:

1. Definitions On Which Consensus Was Reached: These are definitions on which WG members reached consensus.
2. Definitions On Which Consensus Could Not Be Reached: These are definitions to which WG members had a greater amount of disagreement. This includes cases where certain members stated that the definition should not be forwarded, and other members felt the definition was important for the rulemaking.

The comments on “rich burn” are listed in a separate document, entitled “Definition of ‘Rich Burn Engine’ for the RICE MACT Standard,” because of the importance and length of comments of this definition. The definition for “lean burn” will be based on that of “rich burn.”

DEFINITIONS ON WHICH CONSENSUS WAS REACHED

- 1. Stationary Reciprocating Internal Combustion Engine:** any internal combustion engine which uses reciprocating motion to convert heat energy into mechanical work, that is not mobile. Stationary RICE differ from mobile RICE in that stationary RICE are not self propelled, intended to be propelled while performing their function, or portable or transportable as that term is identified in the definition of non-road engine at 40 CFR Section 89.2.
- 2. Emergency Power Unit:** any stationary reciprocating internal combustion engine that operates as a mechanical or electrical power source during emergencies, or for scheduled maintenance checks or operator training. Examples include 1) when electric power from the local utility is interrupted or becomes unreliable and 2) to pump water in the case of fire or flood. This subcategory would not include 1) peaking units at electric utilities; and 2) engines at industrial facilities that typically operate at low capacity factors, but are not confined to emergency purposes.
- 3. Dual-Fuel Engine:** any stationary RICE in which a liquid fuel (typically diesel fuel) is used for compression ignition and gaseous fuel (typically natural gas) is used as the primary fuel.
- 4. Brake Specific Fuel Consumption:** the input heat rate of the engine, based on the lower heating value of the fuel, expressed on the basis of power output (i.e., kJ/W-hr.).
- 5. Spark Ignition Engine:** a type of engine in which a compressed air/fuel mixture is ignited by a timed electric spark generated by a spark plug. Also known as Otto Cycle.
- 6. Two Stroke Engine:** a type of engine which completes the power cycle in a single crankshaft revolution by combining the intake and compression operations into one stroke and the power and exhaust operations into a second stroke. This system requires auxiliary scavenging and inherently runs lean of stoichiometric.
- 7. Four Stroke Engine:** a type of engine which completes the power cycle in two crankshaft revolutions, with intake and compression strokes in the first revolution and power and exhaust strokes in the second revolution.
- 8. Digester Gas:** a gaseous by-product of wastewater treatment, formed through the anaerobic decomposition of organic waste materials, and comprised principally of methane and CO₂. Other constituents may include, but are not limited to, trace amounts of hydrogen sulfide, ammonia, volatile organic compounds, particulate matter, chlorinated compounds, and siloxanes.
- 9. Landfill Gas:** a gaseous by-product of the land application of municipal refuse, formed

through the anaerobic decomposition of waste materials, and comprised principally of methane and CO₂. Other constituents may include, but are not limited to, trace amounts of hydrogen sulfide, ammonia, volatile organic compounds, particulate matter, chlorinated compounds, and siloxanes.

10. Liquefied Petroleum Gas: a liquefied hydrocarbon gas obtained as a by-product in petroleum refining or natural gas production.

11. Propane: a colorless gas derived from petroleum and natural gas, with the molecular structure C₃H₈, suitable for use in spark-ignited internal combustion engines.

12. Liquid Fuel: fuels in liquid form at standard temperature and pressure, including but not limited to diesel, residual/crude oil, kerosene/naphtha (jet fuel), and gasoline.

13. Natural Gas: a naturally occurring mixture of hydrocarbon and non-hydrocarbon gases found in geologic formations beneath the Earth's surface, of which the principal constituent is methane. May be field or pipeline quality.

14. Residual/Crude Oil: a liquid or semi-liquid fuel resulting from the distillation of petroleum and containing largely asphaltic hydrocarbons. Also known as asphaltum oil, liquid asphalt, black oil, petroleum tailings, and residuum.

15. Kerosene/Naphtha: a liquid fuel containing refined, partly refined or unrefined, petroleum products and liquid products of natural gas not less than 10 percent of which distill below 347 °F and not less than 95 percent of which distill below 464 °F.

16. Small Engine: any stationary engine with a manufacturer's nameplate rating of less than or equal to 200 brake horsepower.

17. Stoichiometric: the theoretical air to fuel ratio required for complete combustion.

18. NSCR: non-selective catalytic reduction; an add-on catalytic NO_x control device for rich burn engines that, in a two step reaction, promotes the conversion of excess oxygen, NO_x, CO and VOC into CO₂, nitrogen and water.

19. SCR: selective catalytic reduction; an add-on catalytic NO_x control device for lean burn engines that promotes the conversion of NO_x and a reducing agent, typically ammonia, into nitrogen and water.

20. Oxidation Catalyst: an add-on catalytic control device for lean burn engines that controls CO and volatile organic compounds by oxidation.

21. Air to Fuel Ratio: the ratio of the air mass flow rate to the fuel mass flow rate.

22. Natural Aspiration: a method of air intake using negative cylinder pressure and exhaust elimination using positive cylinder pressure.

23. Turbocharging: a method of air induction, using an exhaust gas driven turbine to power an auxiliary air compressor to increase the charge density of the air at the engine inlet.

DEFINITIONS ON WHICH CONSENSUS COULD NOT BE REACHED

1. Reference Ambient Conditions: standard air temperature (29.4°C, or 85°F), humidity (17 grams H₂O/kg dry air, or 75 grains H₂O/lb dry air), and pressure (101.3 kilopascals, or 29.92 in. Hg.).

Sam Clowney: The Work Group should forward only definitions where the group can provide technical input or where the group has discussed the use of the definition in the rule. This definition has not been discussed, it is not clear how it would be used in the rule, and therefore it should NOT be forwarded.

Bob Stachowicz teleconference comment: It is important to include this definition.

2. Peak Load: operation at 100 percent of the manufacturer's design capacity.

Bob Stachowicz: It is important to include this definition. While the phrase "... operation at 100 percent of the manufacturer's design capacity" seems clear it may be open to interpretation. Many manufacturers define a maximum engine load at each available engine speed. This could result in several "peak" loads being available. If you mean the maximum rating the engine is capable of, the definition may read better as "...operation at 100 percent of the manufacturer's design capacity at the maximum rated engine speed."

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Don Price: It is important to include this definition. In place of 100 percent of the manufacturer's design capacity, use maximum instantaneous operating load.

3. Diesel Engine: means any stationary reciprocating internal combustion engine which utilizes compression ignition as the firing initiator and burns a high boiling point liquid fuel.

Bob Stachowicz: EPA is adding language to the final rulemaking for tiers 2 and 3 of the Nonroad CI (37 kW) rule to define a CI engine as follows: "Compression ignition engine means an engine with operating characteristics significantly similar to the theoretical diesel combustion cycle. The non-use of a throttle to regulate intake air flow for controlling power during normal operation is indicative of a CI engine." See also the "Compression Ignition" definition, #16, on page 6. EPA should choose one consistent definition for a

diesel, or CI, engine.

Some of the fuels definitions appear to be inconsistent. See # 5, #7, and API suggested definitions on page 5. In #5, a diesel engine burns "a high boiling point liquid fuel". The API suggested definition for a high boiling point liquid fuel is a fuel "... which has a boiling point equal to or greater than diesel fuel" These are circular definitions.

Don Price: any stationary RICE in which a high boiling point liquid fuel injected into the combustion chamber ignites when the air charge has been compressed to a temperature sufficiently high for auto-ignition.

4. Compression Ignition: means a type of ignition which utilizes a relatively high compression ratio and resultant high temperatures to produce auto-ignition of fuel in the cylinder. Also known as Diesel Cycle.

Don Price: see diesel engine definition: any stationary RICE in which a high boiling point liquid fuel injected into the combustion chamber ignites when the air charge has been compressed to a temperature sufficiently high for auto-ignition.

5. Diesel: fuel for diesel engines obtained from distillation of petroleum. Also known as fuel oil number 2.

Bob Stachowicz: I would suggest that diesel fuel be more explicitly defined as "substantially equivalent to fuel oil #2" (see #30 on page 7) or incorporate an actual ASTM definition, or use cut points to define high temperature (see the definition for kerosene on page 7 -- which may have been extracted from an ASTM definition).

Don Price: (add fuel to the defined word: diesel fuel). a liquid obtained from the distillation of petroleum with a boiling point of approximately 150 to 360 °C. Also known as fuel oil number 2.

Bill Walker: If diesel engines are defined according to the fuel they use, defining diesel fuel as fuel oil #2 or higher doesn't work. In Alaska, and I expect in northern tier states such as Minnesota or North Dakota, lighter weight fuels may be used, especially but not only in the winter time. #1 or Jet A is used here. So is DFA, which is an arctic grade which I believe is based on military specifications, and is similar to #1. Lighter grades are used here because:

#2 gels in extreme cold;

#2 diesel made in Alaska still contains up to 0.5% sulfur; if an operator uses a lower

sulfur fuel to avoid causing violations of the ambient SO₂ standard or increment, the lower sulfur content may be achieved by blending with Jet A;

On the North Slope, the topping plants probably don't make diesel fuel as heavy as #2.

6. Gas Engine: means any stationary reciprocating internal combustion engine burning a gaseous fuel and ignited by an electric spark.

Don Price: any stationary RICE in which a gaseous fuel is ignited by an electric spark.

7. Unmanned Engine: means any stationary engine installed and operating at a location which does not have an operator regularly present at the site for 24 hour intervals.

Bob Stachowicz: Definitions #8, Unmanned Engine, and #9, Non-Remote Operation, appear to be the inverse of each other. I suggest that #9 be titled "Manned Engine" as whether or not an engine is "remote" (meaning distant) does not indicate if it will be manned or not.

Mike Milliet: It appears to me that these are complimentary definitions. Why not rename "Non-Remote Operation" to "Manned Engine" and define "Manned Engine" as "any engine installed and operating at a location which has an operator regularly present at the site for some portion of each 24-hour day". "Unmanned engine": "any engine installed and operating at a location which does not have an operator regularly present at the site for some portion of each 24-hour day".

Sam Clowney: The Work Group should forward only definitions where the group can provide technical input or where the group has discussed the use of the definition in the rule. This definition has not been discussed, it is not clear how it would be used in the rule, and therefore it should NOT be forwarded.

Don Price: any stationary RICE installed and operating at a location for which an operator is not regularly present at intervals of 24 hours or more.

8. Non-Remote Operation: means any engine installed and operating at a location which has an operator regularly present at the site for some portion of a 24-hour day.

Bob Stachowicz: Definitions #8, Unmanned Engine, and #9, Non-Remote Operation, appear to be the inverse of each other. I suggest that #9 be titled "Manned Engine" as whether or not an engine is "remote" (meaning distant) does not indicate if it will be manned or not.

Mike Milliet: It appears to me that these are complimentary definitions. Why not rename "Non-Remote Operation" to "Manned Engine" and define "Manned Engine" as "any engine installed and operating at a location which has an operator regularly present at the site for some portion of each 24-hour day". "Unmanned engine": "any engine installed and operating at a location which does not have an operator regularly present at the site for some portion of each 24-hour day".

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Don Price: any stationary RICE installed and operating at a location for which an operator is regularly present at intervals of less than 24 hours.

9. Rotary Engine: means any Wankel type engine where energy from the combustion of fuel is converted directly to rotary motions instead of reciprocating motion.

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Don Price: means any Wankel type engine where energy from the combustion of fuel is converted directly to rotary motions using rotary pistons.

10. Rich Burn: (see supplementary document for these comments)

11. Lean Burn: (will be defined subsequent to drafting the rich burn definition)

Bob Stachowicz: "Lean burn" should reflect that lean burn engines manufactured today typically have 7% or more exhaust oxygen content.

Don Price: (add "engine" to the defined word: lean burn engine). any two or four stroke spark ignited engine that is not a rich burn engine.

12. Peaking Engine: means an engine whose intended usage time is primarily standby operation, only for times of high demand.

Bob Stachowicz: Waukesha has no problem with these as written. If more elaborate definitions should be needed, however, I would refer you to Waukesha's Power Rating Chart (a copy of which you should have). This document contains several ratings definitions which could be used or adopted for ICCR purposes.

Sam Clowney: The Work Group should forward only definitions where the group can provide technical input or where the group has discussed the use of the definition in the rule. This definition has not been discussed, it is not clear how it would be used in the rule, and therefore it should NOT be forwarded.

Don Price: a standby engine intended for use during periods of high demand that are not emergencies.

Mike Horowitz: We should keep definitions of peaking unit and baseload unit because they are relevant to the definition of emergency power unit.

Bill Walker: This is an important definition. If an engine is used at all for peaking, then it should not be considered an emergency generator. Suggestion: "Peaking unit means a standby engine used during periods of high demand that are emergencies." Do not use "only for times of high demand." If an engine is actually used during high demand and at other times then it should not be considered an emergency unit.

13. Baseload Engine: means an engine whose intended usage time is continuous operation.

Bob Stachowicz: Waukesha has no problem with these as written. If more elaborate definitions should be needed, however, I would refer you to Waukesha's Power Rating Chart (a copy of which you should have). This document contains several ratings definitions which could be used or adopted for ICCR purposes.

Sam Clowney: The Work Group should forward only definitions where the group can provide technical input or where the group has discussed the use of the definition in the rule. This definition has not been discussed, it is not clear how it would be used in the rule, and therefore it should NOT be forwarded.

Don Price: an engine intended for continuous operation.

Mike Horowitz: We should keep definitions of peaking unit and baseload unit because they are relevant to the definition of emergency power unit.

14. Exhaust Gas Recirculation: means a fraction of the engine exhaust gases are recycled to the intake to dilute the fresh mixture for control of NO_x emissions.

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Don Price: a method of NO_x reduction that dilutes the fresh air/fuel mixture by recycling a fraction of the engine exhaust gas into the intake manifold.

15. Pre-Combustion Chamber: means an antechamber that ignites a relatively fuel rich mixture that propagates to the main combustion chamber and promotes thorough air to fuel mixing and complete combustion of the lean air to fuel ratio in the main chamber.

Bob Stachowicz: A PCC is not designed or intended to "promotes thorough air-to-fuel mixing" as stated in the proposed definition. If it did it would be by coincidence. The purpose of the PCC is to enhance ignition of the very lean air-to-fuel mixtures used by many lean burn engines. See the Rationale Document, page 4, Section 1.1.2.1.1. I would suggest text along these lines: "means an antechamber in which a spark plug ignites a relatively fuel rich mixture. These burning gasses propagate into the main chamber through one or more small orifices to consistently ignite the lean air-to-fuel bulk mixture and lead to complete combustion."

Sam Clowney: The Work Group should forward only definitions where the group can provide technical input or where the group has discussed the use of the definition in the rule. This definition has not been discussed, it is not clear how it would be used in the rule, and therefore it should NOT be forwarded.

Bob Stachowicz teleconference comment: It is important to include this definition.

Don Price: a method of NO_x reduction for lean burn engines in which the combustion of a fuel-rich mixture in an auxiliary combustion chamber propagates to the main combustion chamber, stabilizing main chamber combustion.

16. Operator: means an individual whose work duties include the operation, evaluation, and/or adjustment of the combustion system, i.e. internal combustion engine.

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Bob Stachowicz teleconference comment: It is important to include this definition.

Don Price: not needed.

17. Pre-Stratified Charge: means an add-on control device applicable to lean burn engines which utilizes an increased air content to act as a heat sink in order to lower combustion temperatures.

Bob Stachowicz: First, "Pre-Stratified Charge" is a trademarked name similar to Cooper-Superior's "Clean Burn" designation for their family of lean combustion engines. Second, PSC is applied to RICH burn engines to give them the operating characteristics of lean burn designed engines. Very briefly, in a PSC system, air (or a combination of air and EGR) is injected into the intake runners of an engine immediately upstream of the intake valves using special tubes. When this air is drawn into the combustion chamber -- along with the normally rich or just lean air/fuel mixture -- it "pre-stratifies" the charge and gives an OVERALL lean air-to-fuel ratio. Over 7% exhaust oxygen is not uncommon. This system allows an engine to retain its normally rich fuel system (cost saving) and still operate as a lean burn with attendant low NO_x. The definition would be acceptable if the words "lean burn" were changed to "rich burn". A final phrase "... to reduce NO_x emission." could be added to further clarify the purpose of this system.

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Don Price: an add-on NO_x control device applicable to rich burn engines that lowers combustion temperatures by injecting addition air into the intake manifold next to the intake valve as it opens at the start of a new cycle.

18. Gaseous Fuel: a material used for combustion which is normally a gas with a heating value at standard temperature and pressure.