AEROSPACE RECOMMENDED PRACTICE

ARP1052™ REV. B

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Superseding ARP1052A

Selection Criteria for Internal Combustion Engines Used in Ground Support Equipment

RATIONALE

ARP1052B has been reaffirmed to comply with the SAE five-year review policy.

FOREWORD

The purpose of this Draft Technical Report is to give the technical community the opportunity to review, comment on and use its context prior to approval by SAE. Comments on this draft are welcome and should be submitted in writing to Secretary, Technical Standards Board, SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) is intended as a guide toward standard practice and is subject to change to keep pace with experience and technical advances.

1.1 Purpose

The purpose of this document is to establish a guideline for the selection of prime movers for use in aircraft ground support equipment. This document is recommended for use by those engaged in the design, selection, or purchase of ground support equipment.

1.2 Field of Application

This document is applicable to both four-stroke and two-stroke spark ignition and compression ignition engines.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1995 Engine Power Test Code - Spark Ignited and Compression Ignition - Gross Power Rating

2.1.2 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 3046/1 Reciprocating internal combustion engines - Performance - Part 1: Standard reference conditions and declarations of power, fuel consumption and lubrication oil consumption

2.2 Terminology

GROSS BRAKE POWER: The power of an engine when configured as a “basic” engine as defined in SAE J1995.

RATED GROSS POWER: Engine gross power as declared by the manufacturer at “rated speed”.

RATED SPEED: The speed determined by the manufacturer at which the engine power is rated.

BASIC ENGINE: A basic engine is an engine configured with only the built in equipment required for self-sustained operation. A basic engine does not include accessories that are necessary only to perform its intended service or that power auxiliary systems. Common “basic engine” accessory examples are listed in SAE J1995.

3. ENGINE PERFORMANCE RATING

All reciprocating prime movers proposed for use shall have been rated according to SAE J1995. A performance curve of the type exemplified by Figure 1 shall be available from the engine manufacturer and include the following:

a. Power and torque rating for intermittent operation

b. Power and torque rating for continuous operation

c. Specific fuel consumption

d. Type of fuel used

4. OPERATING CONDITIONS

The proper selection of an engine depends on analysis and recognition of the equipment load requirements, ambient conditions, accessories, and duty cycle.

4.1 Ambient Conditions

Unless more severe conditions are known to be required, the following conditions can be assumed:

a. Ambient temperatures of up to 45 °C (113 °F)

b. Altitudes of up to 1500 m above sea level

c. Stationary operation

4.2 Duty Cycle Classification

a. Intermittent duty cycle: The engine operates at varying loads and speeds.

b. Continuous duty cycle: The engine operates at a governed speed under relatively constant load.

5. POWER RATING REDUCTIONS

The adjusted power rating of the engine is derived from the basic engine rating, and allowances for the following:

a. Manufacturing tolerances

b. Accessory requirements

c. Ambient conditions

d. Type of fuel used

5.1 Manufacturing Tolerances

This allowance is made to account for variances in production that may accumulate in a way that reduces engine performance.

a. Value supplied by the manufacturer

b. If unknown, use 7.5%, or $f_{tol} = 0.925$

5.2 Accessory Requirements

SAE J1995 is a gross power rating and does not account for the power required to operate items such as a cooling fan, alternator, mechanical governor, power steering pump, etc. See SAE J1995 for a detailed explanation of how engines are equipped for a gross power rating. The manufacturer of a specific accessory can provide information regarding power requirements of the item.

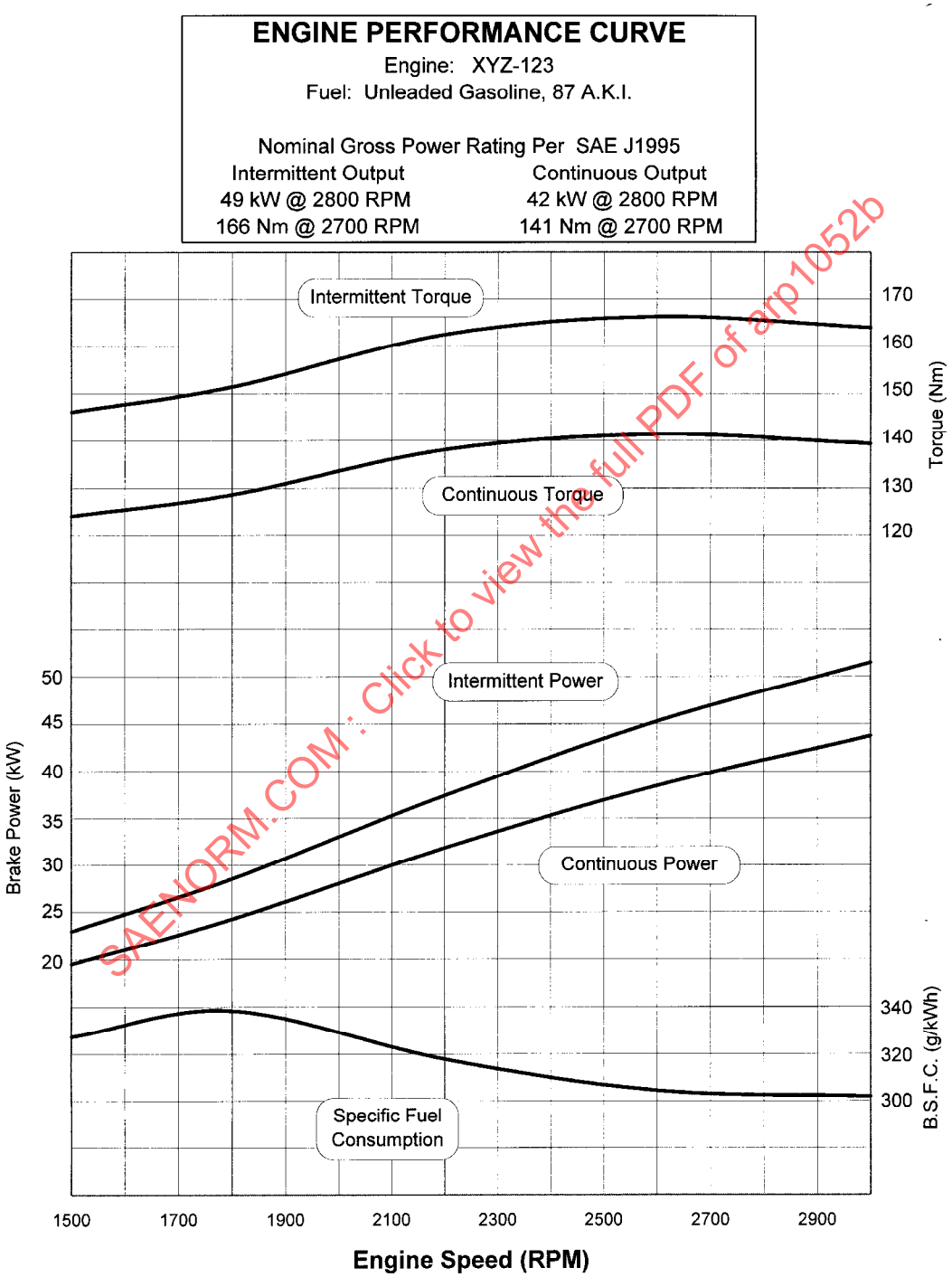

FIGURE 1 - ENGINE PERFORMANCE CURVE

Sample

5.3 Ambient Conditions

The power requirement of the engine must account for the most extreme ambient conditions that will prevail during operation. For conditions mentioned in 4.2, use 22%, or f_{amb} = 0.78. For conditions beyond the limits mentioned in 4.2, see below.

a. Deduct 1.5% per 5 °C, (9 °F) for ambient temperatures above 25 °C,(77 °F). For turbocharged applications, deduct 3%.

b. Deduct 4% per 300 m (984 ft) for altitudes over 150 m (492 ft) above sea level.

NOTE: If the air inlet is located inside the engine compartment, it will be necessary to consider the temperature at the inlet for the reductions mentioned above. Also, f_{amb} is the sum of the separate deductions for temperature and altitude, i.e., a 5% temperature deduction and 4% altitude deduction add for 9% deduction, or f_{amb} = 0.91.

c. With the widespread use of Electronic Control Modules, (ECM), many ambient conditions are now controlled by the ECM. For example Altitude adjustments are controlled by the ECM.

5.4 Summary of Recommended Reductions

The total reduction is the product of the incremental reductions that apply to the specific application.

$$P_{req} = [P_{dyn} \times f_{tol} \times f_{amb}] - P_{acc}$$

or:

$$P_{dyn} = [P_{req} + P_{acc}]/[f_{tol} \times f_{amb}]$$

Where P_{dyn} is the intermittent or continuous gross power rating of the engine, as provided from the manufacturer. P_{acc} is the accessory power required, as described in 5.2. P_{req} is the power requirement of the equipment, as determined by the equipment manufacturer. All other variables are described above.

6. ENVIRONMENTAL CONSIDERATIONS

6.1 Diesel Engine Emission Regulations Considerations

U.S., Europe and Japan Tier IV regulations require advanced technology to be in compliance. Previous regulations were met with technology within or on engine, such as High Pressure Common Rail, (HPCR), fuel systems, Charge-Air cooling, (Intercoolers, electronic controls, combustion advancements and exhaust Gas recirculation (EGR).

Tier IV/Stage IIIB regulations set forth by the Regulatory Agencies will require technology improvements internal to the engine and external technology located in the exhaust stream, (typically referred to as Aftertreatemnt)

a. Regulations

Regulatory Agencies have created similar regulations in NA,(US and Canada) EU Japan and other areas, (See Figure 2). Tier IV regulations are scheduled for two steps. They are broken down into HP Brackets with specific regulations for each bracket, with tier effect dates over several years.

New Requirements for Tier IV include:

Transient test added to the current steady state test

Ultra Low Sulfur Diesel (ULSD) Fuel Legislated

Engine Manufacture responsible for Tailpipe emissions

Crankcase emissions have to be account for

New Transition Program for Equipent manufacturers (TPEM) supports OEM phase-in

b. Engine Strategy Options

Combustion Optimization

Cooled or Hot EGR (NOx control)

Turbos machinery*

HPCR

Electronic controls

Crankcase filtration

Air Filtration systems

Charge-Air-Cooling

*Wastegate, Variable Geometry, Variable Flow, Two Stage Turbos

c. Aftertreatment Strategy Options	Purpose
Catalyzed Diesel Particulate Filter (DPF) passive/active	Particulate Matter (PM) control
Diesel Oxidation Catalyst (DOC)	PM control
Selective Catalytic Reduction (SCR)	NOx control
NOx adsorbers	NOx control

The engine manufacturers have not used the same technical recipe for Tier IV solutions, interim or final. This is also the case for Euro and Japan regulations. The recipe also varies based on the Regulations Horsepower brackets. Because engine manufacturers have chosen different technical paths, contacting the OEM and/or engine manufacturer for specific details on their solution is strongly recommended.

d. Diesel Fuel and Lubricants

The regulatory Agencies have legislated Ultra Low Sulfur Diesel (ULSD) fuel for Tier IV, Stage IIIB and Stage IV. Sulfur was reduced to ~15PPM to elminate potential acid build-up in cylinder and protect the aftertreatment. ULSD Fuel is backward compatible to older Tier engines.

Bio-diesel is acceptable for most Ties IV engines. Most engine manufacturers allow up to B20. Contact the OEM and/or engine manufacturer to confirm use and maximum percent mix.

Low Ash engine lubricants have been developed for Tier IV. Ash is a non-combustible metallic material found in almost all petroleum products. It is used in oil as an additive to protect against acid buildupl. Reducing the sulfur in diesel fuel reduces acid buildup in the engine oil. Over time ash builds up in the DPF and has to be removed periodically. Using low ash oil reduces ash buildup, extending maintenance intervals of the DPF. Low Ash Oil – N.A. API CJ-4 oil, EU – ACEA-E9 oil

e. Selective Catalytic Reduction System Fluids

The SCR system requires Urea to act as a catalyst in the chemical reaction to convert harmfull pollutants to harmless H2O and N2. Urea solution typically consists of 32.5% urea and de-ionized water. It is injected into the exhaust stream ahead of the SCR catalyst, converts into Ammonia, which in turn causes a chemaical reaction, converting NOx into H2O and N2. The commercial names for urea are Diesel Exhaust Fluid (DEF) in North America and AdBlue in Europe.