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An American National Standard

Standard Guide for Main Propulsion Medium Speed Marine Diesel Engines Covering Performance and Minimum Scope of Assembly[1]

This standard is issued under the fixed designation F 1338; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers performance and minimum scope of assembly of all medium speed marine diesel engines intended for main propulsion of single or multiple screw propelled marine vessels or for vessels using other than screw propeller-type main propulsion.

1.2 This guide is intended to supplement the regulations of legally constituted regulating authorities. In the event of any conflict, which may become apparent after publication of this guide, with such legally constituted regulations, the latter shall take precedence, as may be applicable within the jurisdiction of such authorities and specific to each case, unless such latter regulations are formally waived by proper cognizant authority.

1.3 This guide is not intended to relieve the purchaser of the obligation fully to advise the engine builder of all of the purchaser's unique operational considerations to allow those considerations to be satisfied.

2. Referenced Documents

2.1 *ABS Standard:*[2]

Rules for Building and Classing Steel Vessels

2.2 *IEEE Standard:*[3]

Standard No. 45, Recommended Practice for Electrical Installations on Shipboard

2.3 *ISO Standard:*[4]

ISO 3046/1 Reciprocating Internal Combustion Engines—Performance

2.4 *Code of Federal Regulations:*[5]

United States Coast Guard Regulations as Published in Code of Federal Regulations No. 46 (CFR 46)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *diesel engine*—a reciprocating or rotary engine in which ignition of the main fuel charge, as it is introduced to the combustion chamber, shall be by the heat of compression of the charge of combustion air, during regular operation of the engine from idle speeds up to full speed, regardless of whether miscellaneous methods to augment such heat of compression are used to facilitate starting of the engine under normal conditions or under low ambient temperature conditions or low intake air temperature conditions. Engines that are designed to operate with a continuously hot spot or bulb or other device to facilitate ignition or combustion, or both, of low cetane fuels, or any fuels slow to ignite or to burn, or both, shall be considered to be diesel engines for purposes of this guide.

3.1.2 *engine assembly*—contains, but is not necessarily limited to, that apparatus secured to or applied to a basic engine, which is needed to make the basic engine operable and capable of developing its rated power as indicated or to be indicated on the engine nameplate.

3.1.3 *fuel map*—a chart on which there is displayed a family of curves of various constant rates of specific fuel consumption, each curve of the family being plotted on a grid, the abscissa of which is engine r/min and the ordinate of which is brake horse power or brake mean effective pressure.

3.1.4 *medium speed diesel engine*—all diesel engines with crank-shaft rotative speeds encompassed by the maximum continuous speed bracket of 400 to 600 r/min (see Appendix X1).

4. Significance and Use

4.1 Comparison of brake horsepower developed and of specific fuel consumption rates from engine to engine may be made by use of data based upon a standard for composition of an engine assembly.

4.2 The purchaser of the engine assembly will be fully advised of the minimum scope of assembly which the purchaser may rightfully expect to be encompassed by a response to a request for quotation and to be delivered in response to a

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[2] Available from American Bureau of Shipping (ABS), ABS Plaza, 16855 Northchase Dr., Houston, TX 77060.

[3] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 1828 L St., NW, Suite 1202, Washington, DC 20036-5104.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[5] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

purchase order unless the engine builder in the proposal or in the offer to sell has clearly advised otherwise.

4.3 It will be made apparent to the purchaser that additional auxiliary and accessory equipment will be needed to supplement the defined engine assembly when full consideration is given to the application of the engine assembly as a prime mover in a specific vessel.

5. Regulations, Conventions, and Standards

5.1 *Specific*—The regulations, conventions, and standards to which a commercial marine vessel may be subject in regard to the main propulsion prime movers will vary depending upon the flag of registry of the vessel.

5.2 *General*:

5.2.1 There may be regulations, conventions, and standards and such applicable international treaties to which the country of registry may subscribe which shall be taken as forming a part of this guide to the extent specified herein and to the extent they shall be deemed applicable to the vessel by the country of registry.

5.2.2 Typical examples applicable to vessels of the United States of America registry are as follows: Institute of Electrical and Electronic Engineers Standard No. 45 (IEEE No. 45); Rules of the American Bureau of Shipping; Rules of the United States Coast Guard as printed in various Part Numbers of Title 46 CFR of the United States of America and formerly commonly known as CG-115 (Marine Engineering Regulations, also known as Sub-chapter F); and CG-259 (Electrical Engineering Regulations, also known as Sub-chapter J).

6. Ordering Information

6.1 Orders for machinery under this guide shall include the following:

6.1.1 ASTM designation, title, and date of this guide.

6.1.2 Quantity, and

6.1.3 Packaging or packing and preservation requirements, or both.

7. Minimum Scope of Assembly

7.1 Each engine assembly to meet this guide shall include the following:

7.1.1 The basic power producing unit or engine, be it that formed by an internal combustion reciprocating engine or by an internal combustion rotary engine.

7.1.2 An engine-mounted intake manifold or manifolds to conduct air for combustion to the basic engine, with such manifold properly secured to the basic engine and properly gasketed for the service intended, which is the efficient conduction of air to the basic engine when it is installed in a marine environment for main propulsion of a vessel.

7.1.3 An engine-mounted exhaust manifold properly insulated (including insulation by use of a water jacket application) as may be required by laws and regulations discussed in 2.2 herein [such as the requirements of USCG-115, paragraph 56.50-1 (k), Parts 50–60, Title 46 CFR].

7.1.4 One or more engine-driven and engine-mounted scavenging air blowers, if required by engine design concept, or one or more single shaft assemblies of an exhaust gas-driven turbine and combustion air blower, or both, if required by engine design concept, to provide a supply of air for scavenging or supercharging, or both, and for basic combustion of the fuel. The single-shaft exhaust gas-driven turbochargers may be engine mounted or separately mounted. The intended method of mounting of such turbochargers shall be clearly described to the prospective purchaser by the engine builder in any response to an inquiry so that the impact on installation cost and responsibility, if any, will be apparent. Turbocharger arrangements, for water-washing or other routine maintenance procedures recommended by the engine builder, shall be provided.

7.1.5 An engineered arrangement of sufficient drilled and tapped holes, properly plugged during shipment, to allow measurement of combustion air and exhaust gas temperatures and pressures at appropriate points in the engine assembly.

7.1.6 One or more air cooler assemblies, if required by engine design concept and power rating, designed to accept all of the air for combustion and scavenging and to cool such air to appropriate temperatures as required by design of the basic engine and by the predicted range of brake horsepower output and concurrent specific fuel consumption rate range. Following the logic of 7.1.4, the air cooler assembly might be offered as a remotely mounted device along with its associated turbochargers. If so, as in the case of the turbocharger, the intended method of mounting shall be clearly described to the prospective purchaser by the engine builder so the impact on installation cost and responsibilities, if any, will be apparent.

7.1.6.1 Such cooler assemblies, commonly referred to as intercoolers or aftercoolers, shall be arranged, if required by overall engine design and application, to limit cooling or to add heat energy to the charge of air for combustion to allow operation of the engine at low continuous power ranges as indicated by the engine builder on a chart of the descriptive curves of performance of the engine (see 4.1 and 4.2).

7.1.7 A jacket water-circulating pump and any other closed circuit fresh water pumps required for operation of the engine. If this pump is not engine mounted and engine driven as parasitic load, the specific fuel rate for the engine on the factory test stand shall be corrected logically and accurately to increase appropriately the specific fuel rate demonstrated on the factory test stand and thereby to allow comparison to other engines (see Section 8).

7.1.8 One or more pressure pumps for main engine lubricating oil supply of each engine unit and, if required by design, for piston cooling service. If this pump(s) is not engine mounted and engine driven as parasitic load, the specific fuel rate for the engine on the factory test stand shall be corrected logically and accurately to increase appropriately the specific fuel rate demonstrated on the factory test stand and thereby to allow comparison to other engines (see Section 8).

7.1.9 A full flow lubricating oil duplex discharge strainer or filter for each engine unit to transmit all oil delivered to the engine by the main lubricating oil pressure pump; or, if required by engine design, lubricating oil supplied to the subordinate and discrete systems of the engine may be supplied via an additional separate duplex lubricating oil strainer. Such strainers need not necessarily be supplied as engine mounted.

7.1.10 An integral, lubricating oil sump, suitable for operation of that engine when installed in a horizontal position but of a limited capacity with respect to total oil charge. Such a sump may be provided with two or more openings which, if left open for connection to a drain, will allow use of a remote oil sump of larger capacity as suggested by the engine builder.

7.1.11 A duplex suction strainer of mesh as recommended by the engine builder to be located on the suction side of the main lubricating oil pressure pumps. Such a strainer need not necessarily be engine mounted.

7.1.12 A force feed cylinder or valve stem lubricator system, or both, if required by engine builder's design, or by the service intended, or both, or by main engine fuel intended, with both of the latter as stated by the purchaser.

7.1.13 Crankcase pressure relief valves or covers as recommended by the engine builder to meet standards of cognizant marine inspection and classification authority as identified by the purchaser.

7.1.14 An engine-barring device which shall be power driven unless clearly identified to the purchaser by the engine builder as required to be operated by manual effort only.

7.1.15 An engine-mounted flywheel secured to the drive end of the crankshaft complete and sufficient to carry timing marks. If required by drive system arrangement to the reduction gear (or to the propeller shafting if no reduction gear is to be used), the flywheel shall be complete and sufficient to accept mounting of the adjacent flange or coupling component. The machining of the flywheel to accept the adjacent flange or coupling component is part of an engine assembly. The associated set of bolts required shall not be part of an engine assembly.

7.1.16 *Propeller Thrust Bearing*—NO propeller thrust bearing shall be incorporated into the engine assembly for medium speed main propulsion marine diesel engines except as a result of a specific contractual requirement placed on the engine builder as a result of negotiation with the purchaser.

7.1.17 *Governors*:

7.1.17.1 The engine builder shall provide the primary engine speed governor. The actuator portion of the governor with its power unit and the speed-sensing portion shall be engine mounted. Nothing in the specification is intended to prevent off-engine location of electro/electronic portions, if any, of the governor system. The required functions or other characteristics, or both, of the governor shall be specified to the engine builder by the purchaser.

7.1.17.2 The engine builder shall provide an overspeed automatic shutdown device or overspeed self-resetting device separate and distinct from the governor of 7.1.17.1 and it shall be engine mounted.

7.1.18 *Start-Stop Controls*:

7.1.18.1 The engine builder shall provide an engine-mounted system either for complete local control only of the engine or adaptable for local control and remote control from the bridge or the engine room control console, or both. The scope of the remote control features required by the purchaser must be clearly presented to the engine builder in the purchase specification, and requirements of the therein identified cognizant regulatory bodies must be met by the engine builder.

7.1.18.2 If the main propulsion engine(s) are to be direct-reversible engines, the engine builder shall include the feature of reversibility and the engine mounted controls to accomplish stopping and prompt reversing adjustment and restarting of the engine in the opposite direction of rotation. Such controls may be either for complete local control only, of the engine, or adaptable for local control and remote control from the bridge or the engine room console, or both. The scope of the remote control features required in this case also must be clearly presented by the purchaser to the engine builder in the purchase specification and requirements of the therein identified cognizant regulatory bodies must be met by the engine builder with respect to components supplied by the engine builder.

7.1.18.3 All required engine-mounted components and piping for compressed control air and starting air or hydraulic oil supplied shall be engine mounted by the engine builder including, but not necessarily limited to, a duplex filter with a line lubricator for air to the starting air distributor; pilot-operated main starting air valve; pilot air distribution lines; a starting air-reducing valve, if required; and starting air manifolds or headers. All such piping shall be terminated at flanges or other fitting in a workmanlike manner for connection to ship's lines by others.

7.1.19 *Fuel Oil System*:

7.1.19.1 An engine-mounted, engine-driven, fuel oil booster pump (service pump) shall be provided, if required, by the engine builder's design; however, such a pump may be motor driven for this class of engine and not integral with the engine assembly as shipped. It is, however, to be an item furnished and to be treated as a parasitic load.

7.1.19.2 A duplex final fuel filter or strainer, as specified by the engine builder, shall be supplied by the engine builder. If engine mounted, it shall be properly protected for shipment so that the engine-mounted fuel distribution piping is maintained in a thoroughly clean condition during shipment and installation of the engine.

7.1.20 *Engine-Mounted Piping*—All required engine-mounted piping for jacket water, raw water, lubricating oil, fuel oil, starting air, control air or hydraulic oil, or a combination thereof, for controls shall be terminated in a workmanlike manner in a flange or other connection arrangement on the engine assembly, and all nonstandard companion flanges or other fittings shall be included by the engine builder.

7.1.21 All special tools not readily obtainable by an owner of a vessel but required for day-to-day maintenance efforts shall be included with the engine assembly as shipped. The engine builder shall provide a fully descriptive list of such special tools as part of a response to any request for a proposal for the machinery.

7.1.22 *Spares*—No spares are required as part of an engine assembly. However, governmental agencies, the purchaser, the cognizant classification society, and the engine builder all have either authority or interest to see that an appropriate set of spares is provided on board the vessel before final approval to operate is given.

7.1.23 *Instrumentation*:

7.1.23.1 Engine-mounted instrumentation for local observation. A set of engine-mounted instruments for local observation

shall be provided to meet regulatory body requirements and the requirements of the purchaser. Also, a tachometer drive arrangement shall be provided as well as arrangements to allow measurement of cylinder pressures using a portable pressure measuring device, but not including such device.

7.1.23.2 Engine-mounted sensors for remote readout systems are not part of the engine assembly. However, a special set of instrument wells or drilled, tapped, and plugged openings may be required on the engine-mounted piping and components to accommodate remote reading instruments, and such requirements should be developed separately by discussion between the purchaser and the engine builder.

7.1.24 *Cylinder Pressure Relief Valves*—Such valves are usually required by the cognizant classification society, whose requirements must be ascertained and met for any specific order for a main propulsion engine.

7.1.25 *Drawings*—The following should be included in the supply of an engine: engine arrangement drawing including data with respect to engine weight; location of vertical, horizontal, and longitudinal centers of gravity; principal dimensions; size and location of connection points or engine-mounted piping terminations which are to be connected to external piping, tubing, or ducts by others, as well as any special data with respect to such connections; engine bolting and chocking plan; schematic drawings of engine support piping systems showing design restrictions or data important to the installing shipyard.

7.1.26 *Manuals and Books*—An engine instruction manual covering all components described herein as constituting an engine assembly, and parts books of equal scope, providing information required to operate and maintain the equipment.

7.1.27 *Vibration Analysis*:

7.1.27.1 The engine builder shall include an analysis of the mass-elastic system of the engine with respect to torsional vibrations. When any or all of the driven equipment system is supplied by others, it is the responsibility of the purchaser to provide, in a timely manner to the engine builder, accurate and complete data with respect to such items of the driven equipment system.

7.1.27.2 Consideration of axial vibration of shafting, lateral shaft vibration, propeller excited vibration, or induced hull vibrations, or a combination thereof, are not in the province of the engine builder's unique expertise and knowledge to the same extent as is consideration of torsional vibration. If the engine builder is to be required to accept these additional responsibilities, it should be a matter of negotiation and mutual agreement between the purchaser and the engine builder and should be an item in the contract to purchase.

8. Treatment of Parasitic Loads

8.1 *General*—A recognized and accepted basis, by reference to which a comparison of performance test results may be made, is necessary. The heart of such basis of comparison is consistent and accurate treatment of the parasitic loads of those items of power consuming auxiliary apparatus which are defined in Section 6 to be part of an engine assembly. In summary, such items are:

8.1.1 Scavenging air blowers,

8.1.2 Lubricating oil circulation pumps,

8.1.3 Jacket water-circulating pumps,

8.1.4 Fuel oil service (booster) pumps, and

8.1.5 Engine governor system: component(s) to actuate fuel rack controls.

8.2 If any of the above are required to allow the engine assembly to operate and are not engine driven during such factory tests as are carried out to verify engine brake horsepower and engine specific fuel consumption data, then appropriate, logical, consistent, and accurate treatment is necessary to allow comparison of performance data from engine to engine.

8.2.1 The formula or technique for such correction shall be agreed upon mutually by the potential purchaser and the responding engine builder(s) during the development of a contract to purchase. In the development of such formula, attention should be given to cost of fuel to be burned by the extraneous power source in the proposed vessel and the specific fuel rate of that extraneous source, which, in most cases, will be another prime mover or a ship's service diesel generator set.

8.2.2 The permutations and combinations are such that detailed treatment is not feasible herein. However, a competent marine engineer can carry on such specific study or review for a purchaser.

9. Performance of an Engine

9.1 The maximum continuous rating (MCR) (see Appendix X1) of an engine shall be shown on the engine nameplate and on all appropriate engine documents. It shall be expressed in brake kilowatts (international) and in British brake horsepower units of 33 000 ft-lb/min. This dual expression of power shall be maintained herein indefinitely until adoption of the designation of power in brake kilowatts is universally and commonly accepted instead of brake horse power (British) or brake horse power (metric). It shall be that power which the engine will deliver continuously, in commercial marine service, at its flywheel (or other coupling flange) at rated revolutions per minute (r/min) when in good operating condition and under standard conditions (see Section 11) with respect to heat content of the fuel burned; and further, under standard atmospheric conditions with respect to ambient air temperature and ambient air pressure at the intake point for combustion air; and further provided that the exhaust back pressure at the exhaust outlet flange provided on the engine by the engine builder does not exceed the limit specified by the engine builder; and further provided that the pressure drop through the air intake system as measured at the air intake flange provided on the engine by the engine builder does not exceed the limit specified by the engine builder.

9.2 At any of the revolutions per minute encompassed by the bracket between maximum continuous r/min and minimum continuous r/min as defined by the engine builder and illustrated on the engine builder's chart of the descriptive curves of performance of the engine, there shall also exist maximum continuous ratings of lesser values, and special restrictions, if any, must be clearly presented by the engine builder. Performance data provided shall include air borne and structure borne noise data.

9.3 *Overload Ratings*—If the prospective purchaser requires an overload rating, his request for proposal should clearly present the overload conditions desired to be permissible. Without such clarification, no overload rating is to be expected as a standard of the engine builder. If the engine is ordered and delivered with an overload rating, such rating shall be shown on the engine nameplate and on all appropriate engine documents.

10. Mechanical Efficiency of the Engine Assembly

10.1 The engine builder will identify in his proposal to the purchaser, the mechanical efficiency of the offered engine assembly as that term is used herein, with due allowance made in developing that number, for missing or non-engine driven power consuming parasitic loads, if any, as discussed in the foregoing herein. The engine builder shall later demonstrate in a timely report to the purchaser, based upon the test stand data and sophisticated recording of indicator cards, both applying to that specific engine, that the brake power as measured by the dynamometer is related to the indicated power by that efficiency factor (that is, brake power divided by efficiency in decimal form equals the indicated power).

11. Standard Conditions for Factory Test of Engines for Contractual Purposes

11.1 *Standard for Heat Content of Diesel Fuel Used*:

11.1.1 Fuel used shall conform to the engine manufacturer's recommendations.

11.1.2 The reported specific fuel consumption of a liquid fuel engine, as determined by factory test, shall be corrected to reflect the lower calorific value (lower heat value/LHV) of that fuel when it is compared to a standard fuel of a lower calorific value of 42 000 kJ/kg (kilo-joules per kilogram), which lower calorific value may alternately be stated as 10 030 k-cal/kg (kilo-calories per kilogram). When related to practice common in the United States, inote that the lower heat value (LHV) of the standard fuel will be found to be 18 057 Btu/lb, which implies an approximate high heat value (HHV) of 19 175 Btu/lb.

11.1.2.1 Either system of defining the heat content of the test fuel and the standard fuel may be used, but it shall be defined in the contract documents to the satisfaction of all parties.

11.1.2.2 It is strongly recommended that fuel consumption data be presented in the form of a fuel map for guidance of purchaser, but fuel consumption guarantees shall be only as precisely defined in the proposal, offer to sell, or resulting contract, or a combination thereof.

11.1.3 Correction formulae shall be as follows:

11.1.3.1 When working with units for LHV in Btu/lb, the specific fuel consumption reported to the purchaser shall be equal to the specific fuel consumption measured on the factory test stand after it is multiplied by a factor, the numerator of which is the LHV in Btu/lb of the fuel used, and the denominator of which is 18 057. Correction for other variations from standard conditions set forth later herein shall be applied to the specific fuel consumption figure derived as described immediately above.

11.1.3.2 When working with units for LHV in SI units of kJ/kg for the lower calorific value, the specific fuel consumption reported to the purchaser shall be equal to the specific fuel consumption measured on the factory test stand after it is multiplied by a factor, the numerator of which is the lower calorific value in kilo-joules per kilogram of the fuel used and the denominator of which is 42 000. Correction for other variations from standard conditions set forth later herein shall be applied to the specific fuel consumption figure derived as described immediately above.

11.2 *Standard for Ambient Air Temperature at the Air Intake of the Engine*:

11.2.1 The standard for comparison of output of engines in units of brake kilowatts (bkw) or brake horsepower (bhp) shall be 305.37K (32.22°C/90°F). ISO 3046/1 provides for treatment of test results obtained under diverse ambient air temperature conditions in paragraph 10.2 and elsewhere in that standard. Those methods are incorporated into this standard for adjustment of factory test results from actual ambient air temperature conditions to standard ambient air temperature conditions.

11.2.2 The maximum continous brake horsepower (bhp) discussed in 4.1 preceding herein, and specific fuel consumption, discussed in Section 8 shall be guaranteed for circumstances wherein the temperatures of the air for combustion, as measured at the turbo-compressor inlet, are within a range identified to the purchaser by the engine builder in the proposal, offer to sell, or resulting contract, or a combination thereof.

11.3 *Standard for Ambient Air Relative Humidity*—Unless otherwise treated in the proposal or contract, the standard for ambient air relative humidity near the air intake of the engine shall be 30 % and shall be used as 0.3 as in ISO 3046/1, wherein provision is made for treatment of test results under diverse ambient air relative humidity conditions. Treatment of test results under diverse relative humidity conditions is provided by ISO 3046/1, page 4, paragraph 10. That method is incorporated into this guide for adjustment of factory test results from actual to standard relative humidity.

11.4 *Standard for Ambient Air Total Barometric Pressure*—Unless otherwise treated in the proposal or contract, the standard for ambient air total barometric pressure near the air intake of the engine shall be 95.665 kPa (28.25 Hg). Treatment of test results under diverse total barometric pressure conditions is provided by ISO 3046/1, page 4, paragraph 10. That method is incorporated into this guide for adjustment of factory test results from actual total barometric pressure conditions. Note that the tabular solutions in Annex E of ISO 3046/1 are applicable indirectly, if the standard total barometric pressure condition assumption varies from 100 KPa.

11.5 *Standard for Temperature of Water to the Intercooler*—Unless otherwise treated in the proposal or contract, the standard for temperature of water to the intercooler shall be 305.3K (32.22°C/90°F). ISO 3046/1 provides for treatment of test results obtained under diverse conditions of temperature of water to the intercooler. Such treatment is to be found in paragraph 10.2 and elsewhere in that standard. Those methods

are incorporated into this guide for adjustment of factory test results from actual intercooler water temperature conditions to standard conditions.

12. Turbocharger Performance

12.1 The engine builder shall submit to the purchaser, as a contract data item, a conventional compressor characteristic charge wherein the ordinate scale shall be pressure ratio and the abscissa scale shall be a mass flow parameter. There shall be plotted thereon points of pressure ratio as mass flow varies and the speed (r/min of the turbocharger assembly) parameter is constant. Superimposed on this, there shall be a family of curves or contours of compressor constant "total to total" isentropic efficiency (or alternately "total to static").

12.1.1 The surge line, with sufficient margin, shall be clearly shown and the operating line, as matched to the engine for a propeller load curve, shall be shown. If this latter graphical superposition indicates a possible surge phenomenon for the proposed propulsion system, the purchaser and the engine builder shall consult together with respect to a solution, in light of the then-existing contract for purchase of the engines.

12.2 If surge conditions are possible, as a result of purchaser's unique speed/power program for propeller revolutions per minute and propeller pitch incorporated into a control arrangement for a controllable and reversible pitch propeller, the engine builder shall provide an automatic combustion air bypass. Such bypass shall function as a result of joint measurement and integration of air header pressure and engine crankshaft revolutions per minute, such that turbo-compressor surge will be eliminated for a propulsion system, all components of which are in good order. The cost of such system modification shall be negotiated between the engine builder and the purchaser.

12.3 During factory test, surge tendencies will be investigated by sudden reduction of speed and power by percentage reductions and at a time rate to be selected by mutual agreement between the purchaser and the engine builder.

13. Special Fuel Tests

13.1 Medium speed marine propulsion diesel engines, purchased to burn blended or degraded fuels, are not usually subjected to factory test on such fuels before shipment.

13.2 If the purchaser desires such factory test, the requirement therefore and the cost therefore should be a negotiated item of the sales contract. The test agenda for such special test effort shall be negotiated between the engine builder and the purchaser.

13.3 While durability of the engine, if operated on blended or degraded fuels, cannot be demonstrated by a brief factory test, base data on performance characteristics of the engine, when operated on such fuels, should be established and provided to the purchaser as part of any factory test of the engine on such fuels.

13.4 The blended or degraded fuels to be used should be carefully specified and mutually agreed upon between the engine builder and the purchaser. The characteristics of the actual fuel supply used during such tests should be verified by laboratory analysis and provision of those data to the purchaser should be a contractual requirement.

13.5 Contract auxiliary engineered components may be used during such factory tests upon agreement between the engine builder and the purchaser. Such equipment, if used, shall be, as a contractual item, completely cleaned or rehabilitated, or both, before delivery to the purchaser.

13.6 Posttest inspection of the auxiliary or ancillary equipment used, if any, and of the engine assembly, shall be as agreed between the engine builder, the purchaser and the cognizant inspection society or classification society, or both.

13.7 Performance characteristics of the engine to be verified, when operating on blended or degraded fuels, should include, but are not necessarily limited to the following:

13.7.1 Emissions analysis to meet the specified requirements, if any, of the purchaser, and

13.7.2 Brake horse power developed without violation of the engine builder's limits on such as, but not necessarily limited to, peak firing pressures; preturbine exhaust gas temperatures; injection pressures; air header temperatures; air header pressures; and turbocharger revolutions per minute; all for a spectrum of r/min and power levels.

14. Operating Parameters

14.1 The engine builder shall establish maximum or minimum readings for certain operating parameters for an engine of the model and number of cylinders under consideration, which will not be exceeded, or will be attained in the case of minimum values, when an engine in good operating condition and of that model and number of cylinders, is running and developing any point of power and revolutions per minute to be found within the acceptable operating area as delineated on the engine builder's performance curves discussed in Section 4.

14.2 Such operating parameter maximums or minimums shall be regarded as contractual, whether embodied in the original contract or provided later as a constructive change to the contract, and shall include, but not necessarily be limited to, the following: brake mean effective pressure; mean piston speed/revolutions per minute of the engine crankshaft; combinations of brake mean effective pressure and revolutions per minute of the engine crankshaft as shown in the engine builder's performance curves; maximum firing pressures as measured by the device and method recommended by the engine builder; individual cylinder exhaust gas temperature limits and the preturbine temperature limits for the mixture of all cylinder exhaust gases just upstream of the entrance to the turbocharger(s), if the engine is so equipped; maximum lubricating oil temperature in the lubricating oil header or an equivalent to a header; minimum lubricating oil pressure at a point in the system designated by the engine builder; temperature of the combustion air supply in the air inlet manifold; maximum viscosity of fuel at the suction of the fuel injection pump(s); minimum and maximum jacket water temperatures at a point in the system designated by the engine builder; and minimum jacket water pressure at a point in the system designated by the engine builder.

15. Keywords

15.1 brake horsepower of an engine; diesel; diesel engine; direct-reversible engine; engine assembly; engines; fuel map; fuel; internal combustion engine; main propulsion engine; map; marine engine; mass-elastic system; mechanical efficiency of an engine; medium speed diesel engine; parasitic loads; propulsion; surge line; torsional vibration; turbocharger; vibration analysis

APPENDIX

(Nonmandatory Information)

X1. Speed Ranges and MCR Information

X1.1 This guide was directed to be conceived and developed as the first of a group of guides, with follow-on guides to be developed subsequently. To proceed, main propulsion marine diesel engines were divided into classes defined by crankshaft revolutions per minute speed ranges as follows:

Very low speed:	80 to 120 r/min
Low speed:	150 to 360 r/min
Medium speed:	400 to 600 r/min
High speed:	700 to 900 r/min
Very high speed:	1200 r/min and higher

The end points between the defined speed ranges are deliberate and represent a strong influence by 60-Hz alternating current electric power generator design characteristics.

X1.2 With respect to MCRs, it must be kept in mind that the power required to develop a given vessel speed through the water, will generally tend to increase over the life of the vessel and will increase markedly as a result of bottom fouling between drydock and bottom cleaning and painting intervals. Therefore, it is not prudent in the general case to install a diesel engine as a main propulsion engine in a situation in which the screw propeller or other thrust-producing device requires the engine to operate at the MCR, when the vessel is new and the hull is clean, to achieve the speed through the water required for the vessel to be economically successful in its proposed trade. System analysis by a competent marine engineer, with respect to propeller, vessel speed, and engine-installed power, should be arranged by the purchaser.