ANSI/IEEE
Std 387-1977
(Revision of
IEEE Std 387-1972)

An American National Standard

IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations

Sponsor

Nuclear Power Engineering Committee of the
IEEE Power Engineering Society

Approved November 28, 1977
American National Standards Institute

387

Approved September 9, 1976

IEEE Standards Board

William R. Kruesi, *Chairman*

Irvin N. Howell, Jr., *Vice Chairman*

Ivan G. Easton, *Secretary*

William E. Andrus
Jean Jacques Archambault
Dale R. Cochran
Warren H. Cook
Louis Costrell
Jay Forster
Joseph L. Koepfinger

Irving Kolodny
Benjamin J. Leon
Anthony C. Lordi
John P. Markey
Thomas J. Martin
Donald T. Michael
Voss A. Moore
William S. Morgan

William J. Neiswender
Gustave Shapiro
Ralph M. Showers
Robert A Soderman
Leonard W. Thomas, Sr.
Charles L. Wagner
William T. Wintringham†

†Deceased

Foreword

(This foreword is not a part of IEEE Std 387-1977, Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations.)

This document is supplementary to IEEE Std 308-1974, Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations, and specifically amplifies paragraph 5.2.4, "Standby Power Supplies," of that document with respect to the application of diesel-generator units.

The IEEE has developed this document to provide the principal design criteria, design features, qualification considerations, and testing requirements for individual diesel-generator units including auxiliary equipment and controls within the scope of this document used in the standby power supply of a nuclear facility, which comply with the Nuclear Regulatory Commission's code of Federal Regulations (10 CFR 50). This document presents specific procedures and criteria applicable to qualifying the diesel-generator unit and supplements the criteria described in IEEE Std 323-1974, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations."

Operating experience is generally available on diesel-generator units similar to those covered by this document to support the position that when rated in accordance with this document the equipment should provide many years of continuous operating life. However, it should be noted that the application of these standby diesel-generator units for nuclear service is such that the actual operating time under loaded conditions may only be equivalent to one year continuous service in the 40 year life expectancy of the plant.

The principal concerns are the ability of the diesel-generator unit to operate at design loads whenever necessary during the life of the plant, and the ongoing maintenance procedures which should be followed to maintain this equipment in a "ready state." These concerns may be met by following the manufacturer's recommendations and performing periodic tests in accordance with this document and site testing programs.

Components that may deteriorate primarily with age, such as seals, hoses, gaskets, etc, can be replaced long before failure of these components is expected. Such components should be identified and documented, and the required action included as part of the maintenance program.

Engine auxiliaries, including electric motors, may be selected on a conservative basis, with recommendations for replacement periodically during the life of the plant. Replacement interval should be based on conservative judgement of component life supported by operating experience as described in IEEE Std 232-1974. The Generator excitation system, and other electrical equipment should be periodically inspected and tested, including insulation megger or leakage current tests, or both, where practical according to manufacturer's recommendations, and this information should be recorded and compared with previously recorded results to determine if there is any sign of degradation.

It is the intent of the IEEE to add a Section 5.6.4 entitled "Protection" at some future date. In the interim, users of this document are referred to IEEE Std 308-1974 for general requirements covering the area of protection.

Additional work is in progress to expand on the following sections of this document:

(a) Section 5.1.2 (3) and Section 6.4.2 — Light Load or No Load Operation.

(b) Section 5.5 — Design and Application Consideration. (Work is in progress to include interface considerations with associated systems outside the scope of this document.)

(c) Section 6.2 — Factory Production Tests.

(d) Section 6.7 — Preventive Maintenance, Inspection, and Testing.

NOTE: ANS59 is preparing a series of standards applicable to the fuel oil, combustion air, starting, coolant, and lube oil systems of the diesel-generator units, and these standards will be referenced, as appropriate, in future revisions of this document.

Adherence to these criteria may not suffice for assuring the public health and safety because it is the integrated performance of the structures, the fluid systems, the instrumentation systems, and

the electrical systems of the station that establishes the consequences of accidents. Each applicant has the responsibility to assure himself and others that this integrated performance is adequate.

Working Group 4.2C had the following membership at the time it prepared this standard:

L.C. Madison, *Chairman*

S. Chakraborty
D.H. Clark
H.W. Falter
A.R. Fleischer
L.H. Flisher
H.M. Hardy
F.H. Lamoureaux
M.R. Lane
B.R. Little
T. Luke
C. Manning
G.L. Miller
C.H. Moeller
F. Rosa
R.L. Spetka
G.J. Taras
H.F. Thieme
D.J. Williams
D.W. Wilson

At the time it approved this standard, the Nuclear Power Engineering Committee had the following membership:

T. J. Martin, *Chairman*

A. J. Simmons, *Vice Chairman*

L. M. Johnson, *Secretary*

R. E. Allen
J. F. Bates
J. T. Bauer
F. D. Baxter
J. T. Beard
R. G. Benham
J. T. Boettger
K. J. Brockwell
D. F. Brosnan
F. W. Chandler
C. M. Chiappetta
N. C. Farr
J. M. Gallagher
J. B. Gardner
R. I. Hayford
T. A. Ippolito
I. M. Jacobs
A. Kaplan
R. F. Karlicek
A. Laird
J. I. Martone
T. J. McGrath
G. M. McHugh
W. C. McKay
W. P. Nowicki
W. E. O'Neal
E. S. Patterson
J. R. Penland
D. G. Pitcher
H. V. Redgate
B. M. Rice
J. C. Russ
W. F. Sailer
J. H. Smith
A. J. Spurgin
L. Stanley
W. Steigelmann
H. K. Stolt
D. F. Sullivan
P. Szabados
H. A. Thomas

Contents

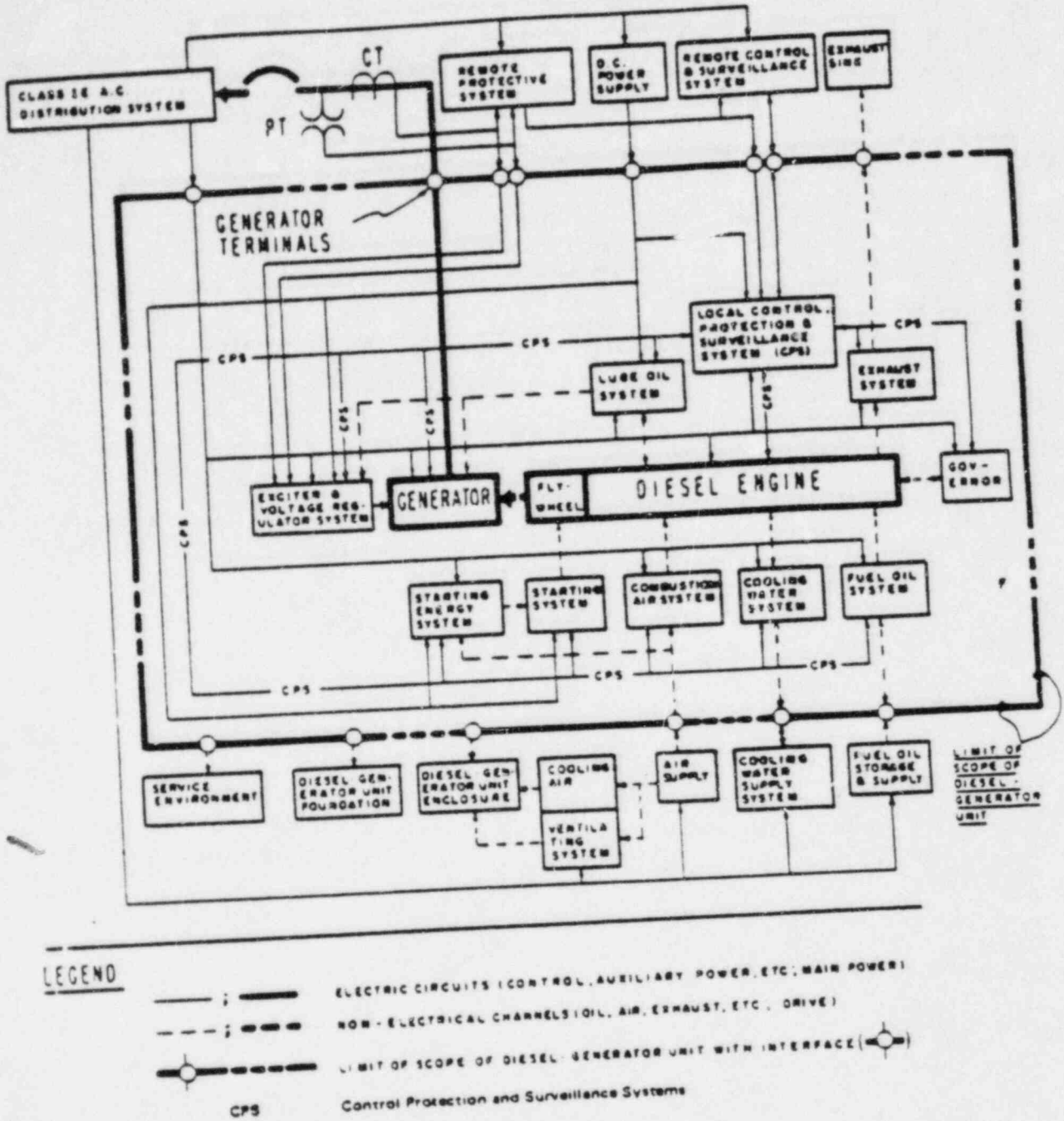

Fig. 1
Scope Diagram

[Abbreviations herein are in accordance with ANSI Y1.1-1972, "Abbreviations for Use on Drawings and in Text." Graphic Symbols and designations are in accordance with IEEE Std 315-1975 (ANSI Y32.2-1975), "Graphic Symbols for Electrical and Electronics Diagrams" (CSA Z99-1975).]

An American National Standard

IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations

1. Scope

1.1 General. This document applies to the application of diesel-generator units as individual units of the standby power supplies in stationary nuclear power generating stations.

1.2 Inclusions. The following are within the scope of this document:

(1) The diesel engine, including:
- (a) the flywheel
- (b) the combustion air system, starting at the engine air intake connection including the affects of any remote air intake filter or silencer, or both
- (c) the starting system
- (d) the starting system energy sources
- (e) the fuel oil system starting at the filters and strainers ahead of the engine fuel oil reservoir
- (f) the lubricating oil system
- (g) the cooling system, starting at the point where the cooling medium is introduced to the diesel-generator unit
- (h) the exhaust system to the downstream side of the exhaust silencer, but excluding piping from the engine exhaust connection to the inlet of the silencer and silencer tail pipe
- (i) the governor system.

(2) The generator, including:
- (a) the main leads stopping at the generator terminals
- (b) the excitation and voltage regulation systems.

(3) The control, protection, and surveillance systems associated with the diesel engine, the generator, and their auxiliary equipment and systems cited above.

(4) The ac and dc distribution systems associated with the diesel engine, the generator, and their auxiliary equipment and systems cited above, exclusive of the auxiliary power system beyond the generator terminals.

(5) Those elements of the unit necessary for maintaining the diesel-generator in a warm standby condition and essential to the safety function.

1.3 Exclusions. The following are outside of the scope of this document:

(1) The diesel-generator unit enclosure and foundations.

(2) The external service equipment and systems which are a part of or which are housed in the diesel-generator unit enclosure, other than those tabulated in 1.2, such as equipment for providing and conveying combustion air, ventilating air, etc, to the vicinity of the diesel-generator unit.

(3) The auxiliary power system beyond the generator terminals of the diesel-generator unit, including:
- (a) the conductors for conveying power from the generator
- (b) the diesel-generator unit main disconnecting and protective device
- (c) the generator circuit instrument transformers, whether furnished with the diesel-generator unit or not
- (d) the generator protective relays.

(4) The control, surveillance, and protection systems for:
- (a) initiating the "Start Diesel Signal"
- (b) loading the diesel-generator unit
- (c) protecting the loads energized by the diesel-generator unit
- (d) disconnecting the loads energized by the diesel-generator unit
- (e) prevention of common-mode failure between the preferred power supply and the standby power supply.

(5) Determination of the characteristics of the service environment.

1 Scope Diagram. The scope diagram presented in Fig. 1 illustrates the delineation of the scope that is stated above.

2. Purpose

The purpose of this document is to provide the principal design criteria, the design features, the qualification considerations, and the testing requirements for the individual diesel-generator units which enable them to meet their functional requirements as a part of the standby power supply under the conditions produced by the design basis events catalogued in the Plant Safety Analysis.

3. Definitions

3.1 acceptable. Demonstrated to be adequate by the safety analysis of the plant.

3.2 common failure mode. A mechanism by which a single design basis event can cause redundant equipment to be inoperable.

3.3 design basis events. Postulated events used in the design to establish the performance requirements of the structures and systems.

3.4 design load. That combination of electric loads, having the most severe power demand characteristic, which is provided with electric energy from a diesel-generator unit for the operation of engineered safety features and other systems required during and following shutdown of the reactor.

3.5 diesel-generator unit. The assembly or aggregate of assemblies of one or more single or multiple diesel-engine generators, associated auxiliary systems and control, surveillance, and protection systems that make up an individual unit of a diesel-generator standby power supply.

3.6 preferred power supply. That power supply that is preferred to furnish electric energy under accident or post-accident conditions.

3.7 rating of diesel-generator unit.

3.7.1 *continuous rating*. The electric power output capability that the diesel-generator unit can maintain in the service environment for 8760 h of operation per (common) year with only scheduled outages for maintenance.

3.7.2 *short time rating*. The electric power output capability that the diesel-generator unit can maintain in the service environment for 2 h in any 24-h period, without exceeding the manufacturer's design limits and without reducing the maintenance interval established for the continuous rating.

NOTE: Operation at this rating does not limit the use of the diesel-generator unit at its continuous rating.

3.8 redundant equipment or system. An equipment or system that duplicates the essential function of another equipment or system to the extent that either may perform the required function regardless of the state of operation or failure of the other.

3.9 service environment. The aggregate of conditions surrounding the diesel-generator unit in the diesel generator unit enclosure, while serving the design load during normal, accident, and post-accident operation.

3.10 standby power supply. The power supply that is selected to furnish electric energy when the preferred power supply is not available.

3.11 start diesel signal. That input signal to the diesel-generator unit start logic which initiates a diesel-generator unit start sequence.

3.12 surveillance. The determination of the state or condition of a system or subsystem.

3.13 qualified diesel generator unit. A diesel-generator unit that meets the qualification requirements of this document.

4. Reference Standards

4.1 Standards. The equipment and accessories of the diesel-generator unit shall conform to the applicable portions of the following stan-

dards and the latest revisions thereof, as of the date of approval of this document.[1]

[1] ANSI C50.5-1955, Rotating Exciters for Synchronous Machines.

[2] ANSI C50.10-1977, General Requirements for Synchronous Machines.

[3] ANSI C50.12-1965, Requirements for Salient Pole Synchronous Generators and Condensers.

[4] API Std 650, Welded Steel Tanks for Oil Storage.

[5] DEMA, Standard Practices for Low and Medium Speed Stationary Diesel and Gas Engines.

[6] IEEE Std 115-1965, Test Procedures for Synchronous Machines.

[7] IEEE Std 308-1974, Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

[8] IEEE Std 323-1974, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

NOTE: The requirements for qualification stated in IEEE Std 387-1977, Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations, are based on an interpretation of IEEE Std 323-1974, as applicable to these diesel-generator units.

[9] NEMA MG-1-1972, Motors and Generators.

[10] NFPA No 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.

[11] TEMA, Standards of Tubular Exchanger Manufacturers' Association.

[12] IEEE Std 344-1975, Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.

[1] *Legend for Standards Organization:*

ANSI — American National Standards Institute
API — American Petroleum Institute
DEMA — Diesel Engine Manufacturers' Association
IEEE — Institute of Electrical and Electronics Engineers
NEMA — National Electrical Manufacturers' Association
NFPA — National Fire Protection Association
TEMA — Tubular Exchanger Manufacturers' Association

4.2 Conflicts. Where conflicts occur between this standard and any reference standards listed in Subsection 4.1, the provisions set forth herein shall govern.

5. Principal Design Criteria

5.1 Capability.

5.1.1 *General.* When in service, each diesel-generator unit shall have the capability of performing as a redundant unit of a standby power supply, in accordance with the requirements stated in IEEE Std 308-1974 [7].

5.1.2 *Mechanical and Electrical Capabilities.* The diesel-generator unit shall also have each of the following specific capabilities:

(1) *Service Environment.* Operation in its service environment during and after any design basis event, without support from the preferred power supply.

(2) *Starting and Loading.* Starting, accelerating, and being loaded with the design load, within an acceptable time

(a) from the normal standby condition

(b) with no cooling available, for a time equivalent to that required to bring the cooling equipment into service with energy from the diesel-generator unit

(c) on a restart with an initial engine temperature equal to the continuous rating full-load engine temperature.

(3) *Light Load or No Load Operation.* Accepting design load following operation at light load or no load for an acceptable time.

(4) *Design Load Profile.* Carrying the design load for an acceptable duration of time.

(5) *Quality of Power.* Maintaining voltage and frequency at the generator terminals within limits that will not degrade the performance of any of the loads comprising the design load below their minimum requirements, including the duration of transients caused by load application or load removal.

5.2 Ratings.

5.2.1 *General.* The diesel-generator unit shall have continuous and short-time ratings which shall reflect the output capabilities of the diesel-

enerator unit as constrained by the capability equirements of 5.1 and the application rules f 5.2.2 and 5.2.3.

5.2.2 *General Application Rules* (See 3.7).

Rule 1. Inspections and scheduled maintenance shall be performed periodically using the manufacturer's recommendations and procedures or operating experience, or both.

Rule 2. Unscheduled maintenance shall be performed in accordance with need as indicated by the periodic inspections as suggested by the manufacturer's recommendations or as based on operating experience, or both.

5.2.3 *Operation Application Rule* (See 3.7.1 and 3.7.2). The diesel-generator units may be utilized to the limit of their power capabilities as defined by the continuous and short time ratings.

5.3 Interactions. Mechanical and electric system interactions between a particular diesel-generator unit and other units of the standby power supply, the nuclear plant, the conventional plant, and the Class 1E electric system shall be coordinated in such a way that the diesel-generator units design function, and capability requirements of 5.1, may be realized for any design basis event, except failure of that diesel-generator unit.

5.4 Qualification. The design of the diesel-generator unit for application as part of the standby power supply and requiring the capabilities listed in 5.1 shall be qualified in accordance with IEEE Std 323-1974 [3] and 6.3, Type Qualification Testing, based on the following considerations:

5.4.1 The effect of aging components on the capability to perform in accordance with Subsection 5.1 may be established by previous operating experience and a program for periodic preventive maintenance, inspection, testing, and parts replacement in accordance with 6.6 and 6.7, to be conducted throughout the operating life of the plant.

5.4.2 Major changes to a qualified engine such as differences in the number of cylinders, changes in stroke or bore, brake mean effective pressure, speed, or diesel-generator arrangement in unique or different configuration, shall be requalified in accordance with 6.3.

5.4.3 Modifications to a qualified diesel-generator unit such as governor, generator, overall system WR^2, excitation characteristics, and other accessories/auxiliaries that may change the capability or performance of a previously qualified engine-generator unit shall be qualified by analysis or further testing, or both.

5.4.4 Minor changes to a previously qualified engine-generator unit, such as component parts replacement, shall be qualified as follows:

(a) When replacement does not alter the original design, qualification shall be by analysis or testing, or both, in accordance with 6.6.

(b) When replacement alters the original design, qualification shall be by analysis or 6.3.1, Load Capability Qualification, and 6.3.3, Margin Qualification, or all.

(c) When replacement degrades the engine starting or load acceptance capability, qualification shall be in accordance with all requirements stated under 6.3.

5.5 Design and Application Considerations. Design and application considerations shall include but not necessarily be limited to the considerations listed in Table 1.

5.6 Design Features.

5.6.1 *Mechanical and Electrical Design Features.*

5.6.1.1 *Vibration.* Harmful vibration stresses shall not occur during acceleration or deceleration.

5.6.1.2 *Torsional Vibration.* Harmful torsional vibration stresses shall not occur within a range from 10 percent above to 10 percent below rated idle speed and from 5 percent above to 5 percent below rated synchronous speed.

5.6.1.3 *Overspeed.* Moving parts shall be designed to withstand, without damage, that level of overspeed that is caused by the following:

(1) Full short-time load rejection; plus

(2) Margin to allow the overspeed device to be set sufficiently high to guarantee that the unit will not trip on full short-time load rejection.

(3) As a minimum, the generator, exciter, and flywheel shall be designed to withstand an overspeed of 25 percent without damage.

5.6.1.4 *Governor Operation.* If the diesel engine is equipped to operate in either the iso-

chronous or the droop mode, provisions shall be included to automatically place the engine governor in an acceptable mode of operation when the diesel-generator unit is required to operate automatically.

5.6.1.5 *Voltage Regulator Operation.* If the voltage regulator is equipped to operate in either the paralleled or nonparalleled mode, provisions shall be included to automatically place the voltage regulator in an acceptable mode of operation when the diesel-generator unit is required to operate automatically.

5.6.2 *Control.*

5.6.2.1 *Control Modes.* The diesel-generator unit shall be provided with control systems permitting automatic and manual control.

5.6.2.2 *Automatic Control.* Upon receipt of a start-diesel signal the automatic control system shall provide automatic startup and automatic adjustment of speed and voltage to a ready-to-load condition.

(1) A start-diesel signal shall override all other operating modes and return control of

Table 1
Design and Application Considerations

Consideration	Of Intereset to User/ Designer	Manu-facturer
1. Common failure mode between units of the standby power supply	x	
2. Single failure criterion as applied to the standby power supply	x	
3. Matching of diesel engine, alternator, excitation system, and voltage regulator		x
4. Energy for operation of the control, surveillance, and protection systems	x	x
5. Control, surveillance, and protection systems	x	x
6. Lubrication system and equipment		x
7. Selection of air, water, or other means of cooling	x	
8. Supply of cooling medium	x	
9. Cooling system and equipment	x	x
10. Selection of electric, pneumatic, or other means of starting	x	
11. Supply of starting energy	x	x
12. Starting system and equipment		x
13. Supply of combustion air	x	
14. Combustion air system and equipment	x	x
15. Supply of fuel	x	x
16. Fuel supply system and equipment	x	x
17. Removal of products of combustion	x	x
18. Equipment design life	x	x
19. Service environment	x	x
20. Seismic design	x	x
21. Design load	x	x
22. Time available between receipt of start diesel signal and initiation of load sequence	x	
23. Description of loading sequence with time durations of application of individual loads	x	
24. Maximum time available between receipt of start diesel signal and acceptance of design load	x	
25. Accommodation of loading sequence and time duration for application of individual loads		x
26. Load performance characteristics	x	x
27. Continuous rating	x	x
28. Short time rating	x	x
29. Light load and no load operation	x	x
30. Diesel-generator unit performance characteristics		x
31. Electric fault conditions	x	x
32. Electric transients	x	x
33. Insulation and temperature rating of electric equipment insulation systems for operating and quiescent conditions		x
34. Creepage and clearance distances for electric equipment contacts		x
35. Electrically induced thermal effects		x
36. Mechanically induced thermal effects		x
37. Thermal shock		x
38. Mechanical shock		x
39. Operating cycles that may cuse thermally induced stresses	x	x
40. Physical configuration and mechanical support of attached auxiliaries, accessories, hardware, piping, wire and cable and raceways		x
41. Handling during manufacture, shipping, storage, and installation	x	x
42. Fire protection system	x	x

ıe diesel-generator unit to the automatic con-
rol system.

(2) A start-diesel signal shall not override ny manual nonoperating modes such as those or repair and maintenance.

5.6.2.3 *Control Points.* Provisions shall be nade for control from the control room and external to the control room.

5.6.3 *Surveillance.*

5.6.3.1 *Surveillance Systems.* The diesel-generator unit shall be provided with surveillance systems permitting romote and local surveillance and to indicate the occurence of abnormal, pretrip, or trip conditions.

5.6.3.2 *Modes Surveyed.* As a minimum the following conditions of operation shall be surveyed:

(1) unit not running
(2) unit running — not loaded
(3) unit running — loaded
(4) unit out of service.

5.6.3.3 *Surveillance Instrumentation.* The following systems shall have sufficient mechanical and electric instrumentation to survey the variables required for successful operation and to generate the abnormal, pretrip, and trip signals required for alarm of such conditions:

(1) starting system
(2) lubricating system
(3) fuel system
(4) primary cooling system
(5) secondary cooling system
(6) combustion air system
(7) exhaust system
(8) generator
(9) excitation system
(10) voltage regulation system
(11) governor system
(12) auxiliary electric system.

6. Requirements for Testing and Analyses

6.1 General.

6.1.1 *Implementation.* The requirements of Section 6 shall be implemented in accordance with a written test plan which shall be consistent with the reference standards listed in Section 4 of this document.

6.1.2 *Break-in Run.* Break-in runs shall be performed on each new diesel-generator unit for the length of time required to pass through the initial failure period of the unit. The break-in run on the diesel may be performed before the diesel is assembled to the generator.

Length of time shall be based upon previous operating and test experience of the manufacturer.

6.1.3 *Service Environment.* Results of tests shall be corrected to the condition of the service environment including site exhaust muffler and air intake air filter-silencer systems.

6.1.4 *Documentation.* Tests shall be completely documented, including records of failures, their repair, and retesting. *Type Qualification* test data shall contain the following:

(1) The equipment performance specifications.

(2) Identification of the specific feature(s) to be demonstrated by the test.

(3) Test plan.

(4) Report of test results. The report shall include:

(a) objective
(b) equipment tested
(c) description of test facility (test setup), instrumentation used including calibration records reference, and test environment
(d) test procedures
(e) test data and accuracy (results)
(f) summary, conclusions, and recommendations
(g) supporting data
(h) approval signature and date.

6.1.5 *Analyses.* Although testing is preferred, analyses may supplement or be substituted for tests, where testing is not practical, to demonstrate conformance to the criteria stated in Section 5 of this document.

6.1.6 If type qualification tests are performed at the engine manufacturer's or assembler's facilities, and not at the site, the exhaust muffler and intake air filter-silencer normally used for shop tests may be substituted in place of the equipment to be provided for a specific site, since it is not practical to duplicate the air intake and exhaust equipment and piping which will exist at the site, or future sites for which the diesel-generator unit is being qualified.

6.2 Factory Production Tests. The following minimum production tests shall be performed by the equipment manufacturers for each unit:

(1) *Diesel-Engine* — In accordance with manufacturer's standard test procedure.

(2) *Generator* — In accordance with the latest NEMA Publication MG-1-22.50.

(3) *Excitation, Control, and other Accessories/Auxiliaries* — In accordance with manufacturer's production test procedure.

6.3 Type Qualification Testing Procedures and Methods. Diesel-generators of types not previously qualified as a standby power source for nuclear power generating stations shall be subject to a *type qualification* testing program consisting of *load capability qualification*, *start* and *load acceptance qualification*, and *margin qualification*. It is preferred that these qualification tests be performed at the engine manufacturer's or assember's factory; however, they may be conducted at the site if certified calibrated instrumentation is provided to measure and record the same functions and characteristics normally measured under factory testing conditions. Qualification tests may be performed on one or more units, although qualification of one unit will qualify like units of that *type* for equal or less severe service. If *start* and *load acceptance qualification* tests (see 6.3.2) are paerformed using more than one identical unit, then each of these units must be tested for *load capability qualification* (see 6.3.1) and *margin qualification* (see 6.3.3).

Type Qualification tests on the complete diesel-generator unit included in scope diagram figure No 1 shall be performed in addition to seismic analysis or seismic testing by the equipment manufacturers in accordance with IEEE Std 344-1975 [12].

Type Qualification tests shall be performed following successful completion of the diesel break-in run, and the Factory Production Tests.

Following the successful completion of these *type qualification* tests, the equipment shall be inspected in accordance with the manufacturer's standard procedure, and inspection results shall be documented.

6.3.1 *Load Capability Qualification.* This test is to demonstrate the capability of the diesel-generator set to carry the following rated loads at rated power factor for the period of time indicated, and to successfully reject rated load in accordance with 6.4.5. One successful completion of the test sequence shall satisfy this particular *type qualification* requirement.

(1) Load equal to the continuous rating for the time required to reach engine temperature equilibrium, plus 22 h. The engine temperature equilibrium is defined as jacket water and lube oil temperatures within ±10° F (5½°C) of normal operating temperatures as established by the engine manufacturer.

(2) Immediately following the load in 6.3.1 (1), the rated short-time load shall be applied for a period of 2 h.

(3) The continuous rating load rejection test shall be performed. The load rejection test will be acceptable if the increase in speed of the diesel does not exceed 75 percent of the difference between nominal speed and the overspeed trip set point, or 15 percent above nominal, whichever is lower.

(4) Light load equal to the design basis light loads for the required duration.

6.3.2 *Start and Load Acceptance Qualification.* A series of tests shall be conducted to establish the capability of the diesel-generator unit to start and accept load within the period of time to satisfy the plant design requirement. An acceptable *start* and *load acceptance* test is defined as follows; however, other methods with proper justification may be found equivalent for the level of reliability to be demonstrated:

A total of 300 valid start and loading tests shall be performed with no more than 3 failures allowed. If the 300 tests are spread over more than one unit, each unit shall be started and loaded at least 100 times. Failure of the unit or units to successfully complete this series of tests, as prescribed, will require a review of the system design adequacy, the cause of the failures to be corrected, and the tests continued until 300 valid tests are achieved without exceeding the 3 failures allowed.

The start and load tests shall be conducted as follows:

(1) Engine cranking shall begin upon receipt of the start signal, and the diesel-generator set shall accelerate to specified frequency and voltage within the required time interval.

(2) Immediately following (1), the diesel-generator set shall accept a single step load equal to or greater than 50 percent of the generator nameplate continuous kW rating. Load may be totally resistive, or a combination of

resistive and inductive loads. Voltage and frequency shall stabilize to within specified limits within the required time interval.

(3) At least 270 of these tests shall be performed with the diesel-generator set initially at "warm standby," based on jacket water and lube-oil temperatures at or below values recommended by the engine manufacturer. After load is applied, the diesel-generator set shall continue to operate until jacket water and lube-oil temperatures are within ±10°F (5½°C) of the normal engine operating temperatures for the corresponding load.

(4) At least 30 tests shall be performed with the engine initially at normal operating temperature equilibrium defined as jacket water and lube-oil temperature within ±10°F (5½°C) of normal operating temperatures as established by the engine manufacturer for the correseponding load.

(5, If these tests are performed on more than one unit, the number of starts on each unit at "warm standby" and "normal operating temperature" shall be in proportion to the start tests stated under (3) and (4) above.

If the cause for failure to start or accept load in accordance with the preceding sequence falls under any of the categories listed below, that particular test may be disregarded, and the test sequence resumed without penalty following identification of the cause for the unsuccessful attempt:

(a) Unsuccessful start attempts which can definitely be attributed to operator error, including setting of alignment control switches, rheostats, potentiometers, or other adjustments that may have been changed inadvertently prior to that particular start test.

(b) A starting or loading or both tests performed for verification of a scheduled maintenance procedure required during this series of tests. This maintenance procedure shall be defined prior to conducting the *start* and *load acceptance qualification* tests and will then become a part of the normal maintenance schedule after installation.

(c) Tests performed in the process of troubleshooting (tests performed to verify correction of the problem may be counted as valid tests).

(d) Successful start attempts which were terminated intentionally without loading.

(e) Failure of any of the temporary service systems such as dc power source, output circuit breaker, load, interconnecting piping and wiring, and any other temporary setup which will not be part of the permanent installation.

6.3.3 *Margin Qualification.* Tests shall be conducted to demonstrate the diesel-generator set capability to start and carry loads that are greater than the most severe step load change within the plant design loading sequence. These tests may be combined with the *load capability* or *start* and *load acceptance* qualification tests. At least two margin tests shall be performed using either the same or different load arrangement. A margin test load at least 10 percent greater than the most severe single step load within the design load sequence is considered sufficient for the margin test. The frequency and voltage excursions recorded may exceed those values specified for the plant design load. The criteria for *margin qualification* are as follows:

(1) Demonstrate the ability of the generator and excitation system to accept the most severe electrical load (usually the low power factor, high inrush, starting current to a pump motor) without experiencing instability resulting in generator voltage collapse, or significant evidence of the inability of the voltage to recover.

(2) Demonstrate that there is sufficient engine torque available to prevent engine stall, and to permit the engine speed to recover, when experiencing the most severe load requirement.

6.4 Site Test Categories.

6.4.1 *Starting Test.* Starting tests shall demonstrate the capability to attain and stabilize frequency and voltage within the acceptable limits and time.

6.4.2 *Load Acceptance Test.* Load acceptance tests shall demonstrate the capability to accept the individual loads that make up the design load, in the desired sequence and time duration, and to maintain the voltage and frequency within the acceptable limits.

NOTE: If the diesel-generator unit has a light load or no load operation capability, the load acceptance test sequence shall include considerations of the potential effects on load acceptance following such operation.

6.4.3 *Rated Load Test.* Rated load tests shall demonstrate the capability of carrying the following loads for the indicated times without exceeding the manufacturer's design limits:

(1) A load equal to the continuous rating for a time required to reach a temperature equilibrium plus 1 h.

(2) A load equal to the short time rating for 2 h.

6.4.4 *Design Load Test.* Design load tests shall demonstrate the capability of carrying the design load for a time required to reach a temperature equilibrium plus 1 h, without exceeding the manufacturer's design limits.

6.4.5 *Load Rejection Test.* Load rejection tests shall demonstrate the capability of rejecting the maximum rated load without exceeding speeds or voltages which will cause tripping, mechanical damage, or harmful overstresses.

6.4.6 *Electrical Test.* Electrical tests shall demonstrate that the electrical properties of the generator, excitation system, voltage regulation system, engine governor system, and the control and surveillance systems are acceptable for the intended application.

6.4.7 *Subsystem Test.* Tests shall demonstrate the capability of the control, surveillance, and protection systems to function in accordance with the requirements of the intended application.

6.5 Site Acceptance Testing. After final assembly and preliminary startup testing, each diesel-generator unit shall be tested at the site to demonstrate that the capability of the unit to perform its intended function is acceptable.

6.5.1 *Test Loads.* Loads to be applied, carried, and rejected during site testing shall be the design load auxiliaries located at the station. Equivalent loads may be used if these auxiliaries cannot be operated for testing.

6.5.2 *Test Conduct.* Test loads shall be applied in the sequence and timing specified in the Plant Safety Analysis and shall be carried at least until a steady-state operating temperature is reached.

6.5.3 *Tests.* The tests to be given to the diesel-generator unit shall be as follows:

(1) starting tests
(2) load acceptance tests
(3) rated load tests
(4) design load tests
(5) load rejection tests
(6) electrical tests
(7) subsystem tests.

6.6 Periodic Testing. After being placed in service, the diesel-generator unit shall be tested periodically to demonstrate that the continued capability and availability of the unit to perform its intended function is acceptable.

6.6.1 *Availability Test.* The diesel-generator unit shall be started and loaded at intervals of no longer than 1 month to the capacity recommended by the manufacturer, operating for a period necessary to normalize all operating temperatures in order to demonstrate its continued availability for operation.

6.6.2 *Operational Test.* The diesel-generator unit shall be given one cycle of each of the following tests, at acceptable intervals, to demonstrate its continued capability of performing its required function:

(1) starting test
(2) load acceptance test
(3) design load test
(4) load rejection test
(5) subsystem tests.

6.7 Preventive Maintenance, Inspection, and Testing. Separate preventive maintenance, inspection, and testing programs shall be established for the engine-generator and all supporting systems based on manufacturer's recommendations, including time interval for parts replacement. These procedures shall be supplemented based upon operating experience. Procedures related to maintaining qualification of the unit in accordance with 5.4 shall be made mandatory provisions of this program.