| NOTICE OF |
| ADOPTION |

ADOPTION NOTICE 1
7 August 1992 for
ASME PTC 26-1962
November 9, 1962

ASME PTC 26-1962 was adopted on 7 August 1992 and is approved for use by the Department of Defense (DoD). The American Society of Mechanical Engineers has furnished the clearance required by existing regulations. Copies of the document are stocked at the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, for issue to DoD activities only. All other requestors must obtain copies from:

The American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017

Title of Document: Speed-Governing Systems for Internal Combustion Engine-Generator Units

Date of Specific Issue Adopted: November 9, 1962

Releasing Non-Government Standards Body: American Society of Mechanical Engineers

Military Coordinating Activity:
Navy - YD

(Project 28GP-N001)

FSC 28GP

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

PTC 26 - 1962

Speed-Governing Systems for Internal Combustion Engine-Generator Units

POWER TEST CODES

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
345 EAST 47th STREET NEW YORK 17, N.Y.

PTC 26 - 1962

Speed-Governing Systems for Internal Combustion Engine-Generator Units

POWER TEST CODES

Published by
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
United Engineering Center 345 East 47th Street New York 17, N.Y.

Printed in the United States of America

Foreword

POWER Test Code Committee No. 26 on Speed-Governing of Internal Combustion Engine-Generator Units was established by the ASME Power Test Codes Committee in 1955 to meet the needs for a test code for governing systems in the internal-combustion engine field.

In 1949 a Joint AIEE-ASME Committee was organized to develop the Recommended Specification for Speed-Governing of Internal Combustion Engine-Generator Units (AIEE No. 606, January, 1959). To assure the successful completion of their respective assignments, close coordination of the work of the two committees was accomplished by the appointment of personnel common to both groups.

The test code was approved by the Power Test Codes Committee on September 14, 1962. It was approved and adopted by the Council as a standard practice of the Society by action of the Board on Codes and Standards on November 9, 1962.

November, 1962

Personnel of Power Test Codes Committee No. 26 on Speed-Governing of Internal Combustion Engine-Generator Units

L. J. Moulton, *Chairman*
W. D. Speight, *Secretary*

H. K. Alberts, Major, U.S. Marine Corps, Department of the Navy, Washington 25, D. C.
J. K. Compton, Major, Department of the Air Force, Hq. USAF DCS/D, The Pentagon, Washington 25, D. C.
Robert Cramer, Jr., Mechanical Engineer, Murphy Diesel Company, 5317 W. Burnham Street, Milwaukee 19, Wisconsin
W. L. H. Doyle, Assistant Professor, Department of Mechanical Engineering, Bradley University, Peoria, Illinois *(deceased, January 22, 1960)*
H. D. Ege, Jr., Consulting Engineer, Burns & McDonnell Engineering Company, Box 173, Kansas City 41, Missouri
N. R. Fletcher, Mechanical Engineer, Ebasco Services Incorporated, 2 Rector Street, New York 6, N. Y.
W. M. Kauffmann, Chief Engineer, Buffalo Works, Worthington Corporation, P.O. Box 953, Buffalo 5, N. Y.
Paul R. Klender, Ground Electrical Power Branch, Air Research and Development Command, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio
T. O. Kuivinen,* Chief Engineer — Technical Division, The Cooper-Bessemer Corporation, Mount Vernon, Ohio
E. F. Mezera,* Chief Product Development Engineer, Construction Equipment Division, International Harvester Company, Melrose Park, Illinois
L. J. Moulton, Mechanical Engineer, S.A.E.D., General Electric Company, 1000 Western Avenue, West Lynn, Massachusetts
G. E. Parker, Mechanical Engineer, Woodward Governor Company, Rockford, Illinois
T. V. Pedersen, Chief Application Engineer, Diesel Engine Division, Fairbanks, Morse & Company, Beloit, Wisconsin
E. R. Rutenber, Assistant Chief Engineer, Waukesha Motor Company, Waukesha, Wisconsin
W. D. Speight,* Research Engineer, Research Department, Caterpillar Tractor Company, Peoria 8, Illinois

*Members of Editing Committee

Personnel of Power Test Codes Committee

W. G. McLean, *Chairman*
P. H. Knowlton, Jr., *Vice-Chairman*

J. H. Anderson
Theodore Baumeister
H. S. Bean
R. C. Dannettel
J. M. Driscoll
M. D. Engle
V. F. Estcourt
C. C. Franck, Sr.
Philip Freneau
H. D. Gibson
L. J. Hooper
R. M. Johnson
T. J. Judge
F. H. Light
J. F. McLaughlin, Jr.
R. T. Mathews
A. M. G. Moody
J. W. Murdock
W. A. Pollock
J. F. Sebald
B. G. A. Skrotzki
R. M. Watson

ASME POWER TEST CODES

Test Code for

Speed - Governing Systems for Internal Combustion Engine - Generator Units

CONTENTS

SECTION 0, INTRODUCTION

0.01 This Code provides standard procedures for commercial, routine, and acceptance tests for determination of speed-governing performance characteristics of internal combustion engine-generator units. This Code provides acceptable precision for those tests and measurements which are required to determine the functional and performance characteristics specified in AIEE-ASME, "Recommended Specification for Speed Governing of Internal Combustion Engine-Generator Units," (AIEE No. 606), January, 1959.

0.02 Unless otherwise specified, all references to other Codes refer to ASME Power Test Codes. The Code on General Instructions (PTC 1-1945) should be studies and adhered to in detail when formulating the procedure for testing of a specific speed-governing system. Attention is directed to the Code on Definitions and Values (PTC 2-1945) which defines certain technical terms and numerical constants used throughout this Code. These auxiliary documents, where and to the extent applicable, form a part of this Code.

SECTION 1, OBJECT AND SCOPE

1.01 The purpose of this code is to establish rules and procedures for the conduct of tests to determine the following speed-governing characteristics of internal combustion engine-generator units.

(*a*) Steady-state speed regulation
(*b*) Range of adjustment of steady-state speed regulation
(*c*) Steady-state incremental speed regulation
(*d*) Speed governing stability:
  (1) Steady-state governing speedband
  (2) Momentary overspeed
  (3) Momentary underspeed
  (4) Recovery time
(*e*) Range of adjustment of speed.

1.02 This Code does not cover the testing of emergency or overspeed governors.

SECTION 2, TERMINOLOGY -- DEFINITIONS AND DESCRIPTION OF TERMS

Par. No.	Term	Symbol	Description	Unit
			GENERAL	
			Speed-Governing System	
2.01	Speed-controlled power unit		The unit comprises the engine-generator unit considered as a combination of the speed-governing and speed-governed systems.	

Par. No.	Term	Symbol	Description	Unit
2.02	Speed-governing system		Includes a speed-governing element, a speed-governor actuated mechanism, and the speed-governor controlled fuel-metering equipment.	
2.03	Speed-governing element		The element which is sensitive to change in speed (frequency), or changes in speed (frequency) and load and which initiates the speed corrective action of the speed-governing system.	
2.04	Speed-governor actuated mechanisms		Mechanism elements which consist of levers, linkages, servomotor valves, and various interconnections, used to transmit the speed corrective action of the speed-governing element to the speed-governor controlled fuel-metering equipment of the engine.	
2.05	Speed-governor controlled fuel-metering equipment		Equipment which controls the energy input to the engine.	
2.06	Speed changer		A device by means of which the speed-governing system can be adjusted to change the speed or frequency of the engine-generator unit under conditions of independent operation, or to change the power output relationship of the unit with respect to other prime mover-generator units under conditions of parallel operation. It is adjustable while the unit is in operation.	
2.07	Speed-regulation changer		A device by means of which the steady-state speed regulation can be adjusted while the engine-generator unit is in operation.	
2.08	Load-limit changer		A device which provides an adjustable means for limiting the maximum fuel flowing to the engine and thereby limiting the power output of the engine to any desired maximum value. It is adjustable while the engine-generator unit is in operation.	
			Speed-Governed System	
2.09	Speed-governed system (prime mover)		The system includes the mechanical assembly of an internal-combustion engine and the direct-connected driven generator. This is considered as a prime mover assembly or device for developing power. It does not include the control means whereby the power developed by the engine is adjusted to meet changes in the load imposed on the engine.	

Par. No.	Term	Symbol	Description	Unit
			OPERATING CONDITIONS	
2.10	Steady-state operating conditions		Steady-state operating conditions exist when the engine-generator unit is functioning with any influences that are variable coming within limits that may have been specified or, if no limits have been specified, are as nearly constant as is practically possible. Included may be the limits that are defined in Pars. 2.11, 2.18, and 2.29 of this section.	
2.11	Specified or agreed operating conditions		Specified or agreed operating conditions include: the ambient temperature, humidity and barometric pressure conditions in which the engine-generator unit is to operate; and any specified or agreed temperature and pressure conditions of the fuel as supplied to the engine. Under this definition, it is presumed that the temperatures and pressures and other operating conditions associated with the engine-generator unit and its accessories, even though not separately specified or agreed, will meet the requirements of accepted standards and good practice.	
2.12	Sustained oscillation of speed or power		A sustained oscillation of speed or power consists of recurring changes with respect to a mean It is a periodic deviation of speed or power having alternating positive and negative values. Succeeding deviations are not necessarily of the same magnitude. The magnitude of the sustained oscillation is measured by the sustained periodic deviations of greatest amplitude.	
2.13	Independent operation		Independent operation is the condition that exists when an engine-generator unit under control of its speed-governing system is operating as the only source of energy for the electric power system to which it is connected.	
2.14	Parallel operation		Parallel operation is the condition that exists when an engine-generator unit is operating with its driven generator connected to an electric power system in common with generators of other prime mover-generator units.	

Par. No.	Term	Symbol	Description	Unit
			POWER	
2.15	Rated power output	P_c	Rated power output is the stated or guaranteed net electrical power output that is obtainable continuously from the engine-generator unit when it is functioning at rated speed under the specified or agreed operating conditions.	kw
2.16	Power output	P	Power output is the net electrical power that is obtained from the engine-generator unit. It is the electrical power output at the generator terminals after deductions have been made for the electrical energy used by any auxiliaries that by agreement are considered to function in effect as essential parts of the basic engine-generator unit.	kw
2.17	Electrical load		Electrical load is the power that the connected electrical system demands from the engine-generator unit. It is equal to the power output of the unit.	kw
2.18	Steady-state electrical load		Steady-state electrical load is any electrical load having a constant mean value. It may have random deviations not exceeding ±0.25 per cent of rated power output and/or periodic deviations not exceeding ±0.1 per cent of rated power output.	kw
2.19	Rated speed	n_r	Rated speed is the stated number of revolutions per minute corresponding to the rated power output.	rpm
2.20	Mean-governed speed		Mean-governed speed is the average rotative speed that occurs in a given period with the speed-governing system in control. It is the arithmetic mean of all the instantaneous values of speed occurring during the period under consideration.	rpm
2.21	Steady-state speed	n_1, n_2	Steady-state speed is the mean-governed speed occurring when the engine-generator unit is functioning with steady-state operating conditions as defined in Par. 2.10 of this section.	rpm
2.22	Speed at zero power output	n_o	Speed at zero power output is the mean-governed speed occurring under conditions at zero power output.	rpm

Par. No.	Term	Symbol	Description	Unit
2.23	Midspeed		Midspeed is the average speed obtained from the maximum and the minimum instantaneous speeds included in the observed speedband, Fig. 2, of an engine-generator unit, when operating under conditions of a steady-state electrical load.	rpm
2.24	Speed drift		Speed drift is a very gradual deviation of the mean-governed speed above or below the desired governed speed.	
2.25	Deadband		Deadband is the total speed change within which the speed-governing system makes no measurable correction to the setting of the fuel-metering equipment of the engine.	
	PERFORMANCE CHARACTERISTICS			
2.26	Steady-state speed regulation	R_s	Steady-state speed regulation is the increase in steady-state speed when the steady-state electrical load on an engine-generator unit is reduced from conditions of rated power output at rated speed to zero power output without any adjustment of the speed changer or speed-regulation changer. It is expressed in per cent of rated speed thus: $R_s = \left(\frac{n_o - n_r}{n_r}\right) \times 100, \%$ where: n_r = rated speed; n_o = speed at zero power output	per cent; rpm; rpm
2.27	Steady-state speed regulation test point		Steady-state speed regulation is determined under conditions of independent operation. Since the numerical value of the steady-state speed regulation may vary with different settings of the speed changer, the determination is made when the speed changer is set to obtain rated speed with rated power output.	
2.28	Stability		Stability of the speed-controlled power unit is that property which causes it to develop restoring forces among its electrical and mechanical elements to establish and maintain steady-state speed conditions. It is evaluated by observation of the steady-	

Par. No.	Term	Symbol	Description	Unit
			state governing speedband, the momentary overspeed, the momentary underspeed and the recovery time.	
2.29	Steady-state governing speedband	S_s	Steady-state governing speedband is a range of speeds which has upper and lower limits about a mean-governed speed. These limits represent, respectively, the maximum and minimum instantaneous speed deviations actually contributed by the speed-governing system of an engine-generator unit when operating under given steady-state conditions. This amplitude is expressed in per cent of rated speed $S_s = \pm\left(\frac{n_{max} - n_{min}}{2n_r}\right) \times 100, \%$	per cent
2.30	Prescribed speedband	S_p	Prescribed speedband is established by certain maximum and minimum limits for speed deviations. These limits represent, respectively, the values of the maximum and minimum instantaneous speeds to be used when determining the instant of termination of a recovery time observation, as defined in Par. 2.33 of this section. The values of these limits are specified by means of a magnitude which is taken with respect to the midspeed of the observed speedband as illustrated by *G*, Fig. 3. The magnitude is expressed in per cent of rated speed.	per cent
2.31	Momentary overspeed	S_o	Momentary overspeed is the maximum momentary increase in speed above the mean-governed speed occurring at the second operating condition incident to a sudden decrease between two given steady-state electrical loads having values within limits of the rated power output of the engine-generator unit. It is expressed in per cent of rated speed, thus: (*a*) for a load decrease from rated power output to zero power output $S_o = \left(\frac{n_{max} - n_o}{n_r}\right) \times 100, \%$	per cent

Par. No.	Term	Symbol	Description	Unit
			where: n_r = rated speed — rpm n_o = mean-governed speed at zero output — rpm n_{max} = maximum momentary speed incident to a sudden and complete loss of load from conditions at rated speed and a steady-state electrical load equal to rated power output. — rpm (*b*) for a load decrease having a value less than rated power output $S_o = \left(\frac{n_{max} - n_1}{n_r} \right) \times 100, \%$ where: n_r = rated speed — rpm n_1 = mean-governed speed at the second steady-state electrical load — rpm n_{max} = maximum momentary speed incident to a sudden reduction between two steady-state electrical loads. — rpm	
2.32	Momentary underspeed	S_u	Momentary underspeed is the maximum momentary decrease in speed below the mean-governed speed occurring at the second operating condition incident to a sudden increase between two given steady-state electrical loads having values within limits of the rated power output of the engine-generator unit. It is expressed in per cent of rated speed, thus: $S_u = \left(\frac{n_2 - n_{min}}{n_r} \right) \times 100, \%$ where: n_r = rated speed — rpm n_2 = mean-governed speed at the second steady-state electrical load — rpm n_{min} = minimum momentary speed incident to a sudden increase between two steady-state electrical loads — rpm	per cent

Par. No.	Term	Symbol	Description	Unit
2.33	Recovery time	T_r	Recovery time is the interval between two conditions of speed that occur with a given sudden change in the steady-state electrical load on an engine-generator unit. It is the time in seconds from instant of change from the initial load condition to instant when the decreasing oscillation of speed finally enters a prescribed speedband as defined in Par. 2.30 of this section. The prescribed speedband (refer to H in Fig. 4) is taken with respect to the midspeed of the observed speedband occurring at the subsequent steady-state load condition.	sec
2.34	Steady-state speed-power output curve		The steady-state speed power output curve for an engine-generator unit indicates the relationships between the mean-governed speeds and the corresponding steady-state power outputs. This curve indicates these relationships over the full range between zero and the agreed largest value of power output.	
2.35	Steady-state incremental speed-regulation	R_i	Steady-state incremental speed-regulation is the rate of change of speed with respect to power output under conditions of steady-state electrical load. It is represented by the slope of the tangent to a steady-state speed-power output curve with the point of power output under consideration obtaining at rated speed. It is expressed in per cent of rated speed when the difference in speed, expressed in per cent of rated speed, between any two points on the defined tangent is divided by the difference in the corresponding power outputs at these points expressed as a fraction of rated power output, thus: $R_i = \left(\frac{n_2 - n_r}{n_r}\right) \times \left(\frac{P_c}{P_1 - P_2}\right) \times 100, \%$ where: n_r = rated speed corresponding to the larger power output, P_1 — rpm; n_2 = speed corresponding to the lesser power output, P_2 — rpm; P_c = rated power output.	per cent

SECTION 3, GUIDING PRINCIPLES

3.01 For guidance in the general conduct of the test, the Code on General Instructions (PTC 1), the Code on Definitions and Values (PTC 2), and the Supplement on Instruments and Apparatus, Part 1 on General Considerations (PTC 19.1) should be used.

3.02 Items on Which Agreement Shall Be Reached. The object of the test should be clearly defined and stated in writing prior to the preparation for and the conduct of the test.

3.03 Prior to any tests, there shall be agreement on the exact method of testing and the methods of measurement.

3.04 Among the items not covered in this Code, upon which agreement should be reached are the following:

(*a*) Intent of test requirements, if ambiguities or omissions appear evident
(*b*) Apportionment of cost of test and allocation of responsibility
(*c*) Method of operating any auxiliary equipment, the performance of which may influence the test results
(*d*) Methods of maintaining constant operating conditions as near as possible to those specified
(*e*) Duration of operation under test conditions before test readings are started
(*f*) Duration of test runs including steady-state recording
(*g*) Repetition of test runs
(*h*) Test agenda, including definite values of test loads and rotating speeds of the unit at which each individual test run is to be concluded.

3.05 Preparation for Test. The plan of test and procedures shall be agreed upon in advance and shall be confirmed in writing, definitely covering the methods and procedures to be used in measuring all major factors. If experts are retained to take charge of one or more measurements, their responsibilities should be stated in the agreement.

3.06 Details of test procedures shall include statements of manner in which unit will be operated and the provisions that are to be made for transfer of load to other units and definite agreed values of loads required in the discharge of the test.

3.07 Records shall be made to identify and distinguish the equipment to be tested. Description, drawings, or photographs may all be used to give a permanent, explicit record.

3.08 Any dimensions or information regarding the physical conditions of parts of the equipment to be tested, which may be required for the report should be obtained and recorded before the test is made. This will include the conditions of any equipment or accesories affiliated with the unit and its speed-governing system which might influence performance when the test is made. Serial numbers and any plant data should be recorded to identify all equipment related to the test.

3.09 Test Personnel. Agreement shall be reached in advance as to the personnel required to conduct a test. All parties to the test shall be entitled to have present such members of their staff as may be required for them to be assured that the tests are being conducted and the observations taken in accordance with this Code and with any agreements made prior to the test.

3.10 Personnel shall include a sufficient number of competent observers to take and record the various readings. No observers shall be required to take so many readings that the lack of time may result in insufficient care and precision.

3.11 The parties to the test shall designate a person to direct the test and may designate a person to serve as arbitrator in the event of dispute as to calibration of instrumentation, test conditions or methods of operation.

3.12 Equipment Inspection. Careful inspection and checks shall be made before, during and after the test to insure the unit is operating properly.

3.13 The speed-governing system and all of its associated equipment shall be carefully checked and properly adjusted prior to the test.

3.14 Equipment and instruments should be examined thoroughly to assure acceptability for purposes of the test. Duplicates for those instruments or instrument parts liable to failure or breakage in service should be provided and calibrated as part of the preparation for the test.

3.15 Operation During Test. The parties to the test shall have agreed in advance as to what conditions will be permissible with respect to the safety of the unit including:

(*a*) Permissible acceleration rate
(*b*) Maximum speed
(*c*) Adverse vibrations
(*d*) Possible effect of the speed-governing system tests upon auxiliaries and other equipment.

3.16 Control by ordinary operating, indicating, recording or integrating instruments, the preparation of graphical logs and adequate supervision shall be established to assure that the equipment under test is operating in accordance with the intended conditions.

3.17 The parties to the test may agree to changes in test conditions while the test is in progress. All such special agreements shall be made in writing and included in the report of the test.

3.18 Any points of disagreement as to the conduct of the test shall be settled to the satisfaction of both parties and sufficient results of the test shall be computed and agreed upon as acceptable before the testing personnel shall have left the field and before the test shall be considered terminated or the test equipment removed. All results shall be agreed upon by both parties before they are embodied in the final report.

3.19 **Adjustments.** The adjustment of instruments, recording devices or other test apparatus, to the unit or to the speed-governing system shall be made only after full agreement is reached by the parties to the test with due consideration to the safety and performance of the unit. No corrections or changes in setting of the speed-governing system shall be permitted during the test except as otherwise set forth in the agreement.

3.20 **Operating Conditions.** The operating conditions shall be maintained within limits prescribed in this and other appropriate ASME Test Codes. Unless otherwise permitted by agreement between the parties to the test, or as specifically defined herein, operating conditions shall require:

(1) That the performance be observed under steady-state conditions with
   (*a*) Independent operation
   (*b*) An electrical load at the generator terminals as imposed by a constant or essentially unvarying electrical resistance for d-c systems, or a constant or essentially unvarying electrical resistance and electrical reactance for a-c systems
   (*c*) The mean-governed speed corresponding to the particular load as influenced by a preestablished steady-state speed regulation having the value as specified, no adjustment being made to the speed-governing system after having established rated speed at rated power output; and

(2) That all considerations of design, construction, operation, and maintenance of the engine-generator unit and any other details affecting its torque response or speed-power performance are in accordance with accepted standards and good practice.

3.21 **Preliminary Tests.** For Code tests, both parties to the test shall have reasonable opportunity to examine the equipment, to correct defects, and to render the equipment suitable in their judgment, to undergo test.

3.22 Preliminary test runs with log records are recommended to determine whether equipment is in condition to undergo test, to check instruments and methods of measurement, and to train personnel. Observations during preliminary test runs should be carried through to the calculation of results as an over-all check of procedure, layout, and organization. If mutually agreed, a preliminary test may be considered a Code test, provided it has complied with all the necessary requirements of the appropriate Power Test Code.

3.23 **Records.** Complete written records and chart recordings of the test shall be included in the Test Report. The test observations shall be of instrument chart recordings in so far as possible with other records entered on carefully prepared forms. The original chart recordings and log sheets, being documents of validity, should, therefore be such as to permit exact reproductions as, for example, by carbon copies or by photographic process. A complete set of exact reproductions of original log sheets and recorded charts shall become the property of each of the principal parties to the test, and of such others as may be agreed upon. The observations shall include the date and time of day. They shall be the actual readings without application of any instrument corrections. The log sheets should constitute a complete record including details that at the time may seem trivial or irrelevant. Particular care should be taken to record any adjustments made to any equipment under test whether made prior to a run or between the runs. The reason for each adjustment shall also be stated in the test record. Erasures on or destruction of any log sheet or chart recordings shall not be permitted under any circumstances. If correction is needed, the alteration shall be entered so that the original entry remains legible, and an explanatory note should forthwith be attached.

3.24 **Rejection of Test Results.** If the test results or other observations indicate malfunctioning of the unit or any of its accessories, the defects shall be corrected and the test series shall be repeated.

3.25 If, during the conduct of a test, or during the subsequent analysis or interpretation of observed data, an obvious inconsistency is found, the parties should make every reasonable effort to adjust or eliminate the inconsistency. Failure to reach an agreement requires repetition of the test.

SECTION 4, METHODS OF MEASUREMENT AND REQUIREMENTS FOR INSTRUMENTS

I -- Methods of Measurement

4.01 General. This section describes the measurements necessary to establish the performance characteristics of a speed-governing system and the required measuring instrument characteristics and calibrations.

4.02 It is necessary to measure and record the following:

(*a*) Time
(*b*) Speed or frequency
(*c*) Power output.

4.03 After stable operation has been established, the engine-generator unit shall be run at rated speed and rated power output in preparation for the following tests.

4.04 Steady-State Speed Regulation. Recordings of engine-generator unit speed (or frequency) and load are required under conditions of independent operation for this test. The speed changer shall be set to obtain rated speed with rated power. A recording of speed (or frequency) is then required at 100 per cent power output. The electric load on the unit shall be reduced to zero power output without any adjustment of the speed-governing system. A recording of speed (or frequency) is required at zero power output. The difference in speed (or frequency) between zero power output and 100 per cent power output can be read and the steady-state speed regulation determined. Tests with maximum and minimum adjustment or otherwise suitable adjustment of the speed regulation changer are required to verify steady-state speed regulation performance. Normal speed and power scales shall be used (see Pars. 4.14 and 4.22 and Fig. 1).

4.05 Steady-State Incremental Speed Regulation. Simultaneous recordings of speed (or frequency) and power output are required under conditions of independent operation. The determination of portions of several steady-state speed-power output curves is required for this test. The steady-state regulation shall be adjusted to the specified value. Without further adjustment of the steady-state speed regulation, the speed changer shall be set to obtain rated speed with corresponding specified or agreed value of power output for each test point. After recording the specified values, recordings shall be made while gradually decreasing the power output from an agreed power level greater than the specified value to an agreed power level lower than the specified value. Similar recordings are required with gradually increasing power output over the same range. For other test points, the speed changer shall be set to obtain rated speed at the other specified or agreed values of power output. It is recommended that test points be selected[1] at intervals of 10 per cent of rated load between 10 per cent rated power output less than the largest specified or agreed power output and 20 per cent rated power output. Intervals of 5 per cent rated power output are recommended between 20 per cent rated power output and 5 per cent power output. A total range of gradual power adjustment for each test point equal to twice the interval between the test point and the test point of next larger power output is recommended. For each test point, a decreasing load output versus speed curve and an increasing load output versus speed curve may be plotted. The mean of these two curves is a portion of a steady-state power output curve used as described in Par. 5.04 to evaluate steady-state incremental speed regulation.

4.06 Speed-Governing Stability.

(*a*) Steady-State Governing Speedband -- Recordings of speed (or frequency) and power are required under specified steady-state conditions and at the agreed power outputs. The speed (or frequency) recordings are to be made with expanded scale. (See Pars. 4.17 and 4.22 and Fig. 2.)

(*b*) Momentary overspeed, Momentary Underspeed, and Underspeed Recovery Time - - Recordings of speed (or frequency) and power are required during specified power output changes and specified steady-state speed regulation. These recordings are made with normal scale. (See Pars. 4.10, 4.12, 4.14, and 4.22 and Figs. 3 and 4.)

4.07 Speed Changer -- Adjustment Range. The engine-generator unit shall be operated over the specified speed (or frequency) range while carry-

[1] As a basis for determining the number of test points required under Par. 4.05, the following procedure is suggested: A steady-state speed-power output curve, with rated speed either at 80 or 100 per cent rated power output plotted as the mean of a decreasing power output versus speed curve covering the maximum agreed or specified power output ranges and an increasing power output versus speed curve covering the same ranges.

ing the specified power outputs. A record of steady-state speeds indicating the adjustable range is required. Normal speed and power scales shall be used (see Pars. 4.14 and 4.22).

II -- Requirements for Instruments

4.08 The complete measuring system is to provide continuous and simultaneous line records of speed (or frequency) and power output as functions of time under various operating conditions. Features which will provide means for instrument calibration are to be included.

4.09 The speed (or frequency) and power recordings are to be inscribed as separate traces. Required expanded scale recordings may be provided with separate traces. Superimposed recordings of the separate traces are acceptable. All traces are to be presented on a common strip which will serve as a time base. Several selectable speeds for the strip are desirable.

4.10 *For dynamic calibrations,* the strip which serves as a time base must have a speed of movement of at least 4.5 in. per sec and a time marking at least once every 0.1 sec. For *recovery time measurements,* the strip must have a speed of movement no less than 0.9 in. per sec and a time scale marking at least once every 1.0 sec. The error in the time representation caused by chart motion error in all cases shall not exceed ±2.0 per cent of the true time interval.

4.11 For static calibrations, standards of specified precision are required and shall be applied to the input of the complete measuring system. These standards are to provide scale markings on the recording strip.

4.12 For dynamic calibrations, specified step changes applied to the input of the complete measuring system must produce a recording deflection which, at a time not greater than 0.1 sec,[2] shall reach and remain in a band between 97 and 103 per cent of an average final deflection

4.13 Speed or Frequency Recordings. The speed (or frequency) signals may be obtained either from a d-c or a-c electric generator or other device, providing the output quantity used as a measure of speed is continuously directly proportional, within the range of measurement, to engine crankshaft speed. The proportionality must be such that the ratio of the output quantity to the true speed, throughout the range of measurement, will remain equal to the ratio at nominal speed within ±0.1 per cent.

4.14 Normal scale is considered to be the range of recording indicating ±15 per cent of the nominal speed (or frequency). Normal scale recordings will be made when the engine-generator unit is operating with variable power output including sudden and extreme changes in power output. The scale used for reading strip chart deflections shall have readable divisions, in this case, representing not more than 0.6 per cent of nominal speed (or frequency).

4.15 Static calibration standards, *normal scale,* are to provide deflection markings, indicating values of nominal speed (or frequency), nominal speed (or frequency) plus 15 per cent of nominal speed (or frequency) and nominal speed (or frequency) minus 15 per cent of nominal speed (or frequency). These standards shall provide a magnitude (or frequency) which is equal to the speed transducer output quantity at the same speed within ±0.1 per cent.

4.16 Dynamic calibration, *normal scale,* requires input step changes of 15 per cent of nominal speed (or frequency).

4.17 Expanded scale is considered to be the range of recording indicating ±1.5 per cent of any sustained mean speed (or frequency). Expanded scale recordings will be made with various steady-state (essentially constant) power outputs. The scale, used for reading strip chart deflections, shall have readable divisions, in this case representing not more than 0.06 per cent of nominal speed (or frequency).

4.18 Static calibration standards, *expanded scale,* are to provide deflection markings indicating values of nominal speed (or frequency) plus 1.5 per cent of nominal speed (or frequency) and nominal speed (or frequency) minus 1.5 per cent of nominal speed (or frequency). These standards shall provide a magnitude (or frequency) which is equal to the speed transducer output quantity at the same speed within ±0.01 per cent.

4.19 Dynamic calibration, *expanded scale,* requires input step changes of 1.5 per cent of nominal speed (or frequency).

4.20 Power Output Recordings. The generator power output recording and calibrating instruments shall be connected to the Engine-Generator Units under test in accordance with I & A, Part 6 on Electrical Measurements in Power Circuits (PTC 19.6–1955).

[2] The dynamic response of the complete measuring system has been defined in terms of settling response time. This value has been carefully chosen to meet the requirements of the AIEE-ASME "Recommended Specification for the Speed Governing of Internal Combustion Engine-Generator Units," (AIEE No. 606, January 1959).

4.21 The instrumentation[3] is to supply a record of watts of electrical power delivered by engine-generator units designed to supply d-c systems or designed to supply single or multiphase a-c power systems. These units may have possible speed (or frequency) deviations of ±10 per cent of their nominal speed (or frequency).

4.22 The normal power scale is considered to be the range in recording from zero power to rated power output, inclusive. Chart deflection for full scale power range is to be of such magnitude as to accommodate power output recordings in the range from 0 per cent to not less than 125 per cent of rated power output. The scale, used for reading strip chart deflections, shall have readable divisions representing not more than 5 per cent of rated power output.

4.23 A static calibration standard is to be used to measure rated power output when power is applied for chart calibration. This standard shall have an error not greater than ±1.5 per cent of rated power output.

4.24 Dynamic calibration requires input step changes of 100 per cent rated power outputs.

[3] If a recording wattmeter of suitable response characteristics is not available and providing that at any given load the voltage, power factor, and phase balance are constant, a current recording may be substituted if it meets the following requirements: The current recording must be annotated to satisfy Pars. 4.22 and 4.23 and conform with the dynamic calibration requirements of Par. 4.12 when input step changes of current corresponding to changes of 100 per cent rated power outputs are made.

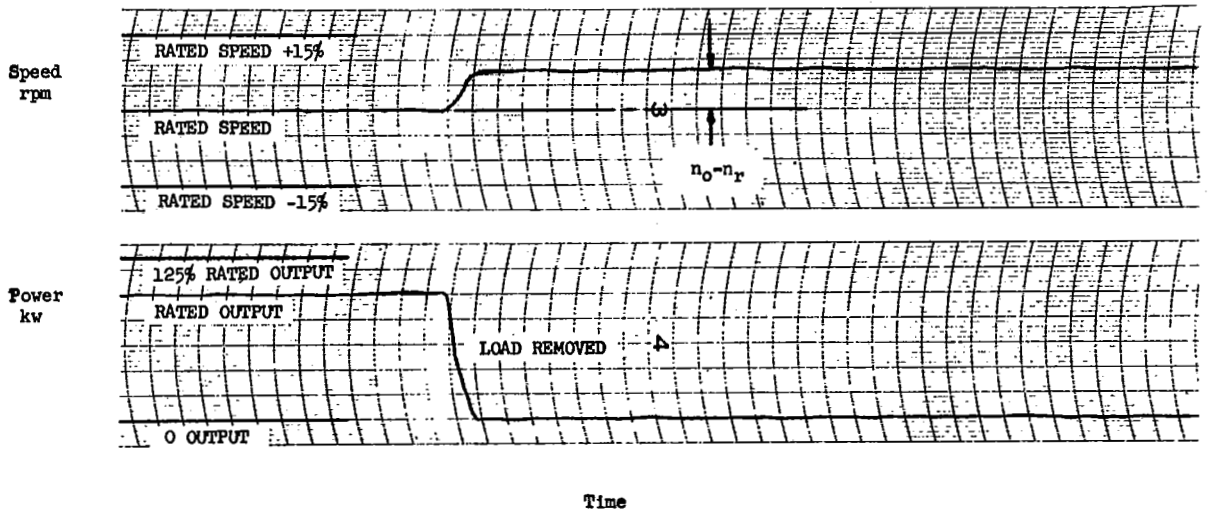

FIG. 1 Speed and Power Record Used for Determination of Steady-State Speed Regulation

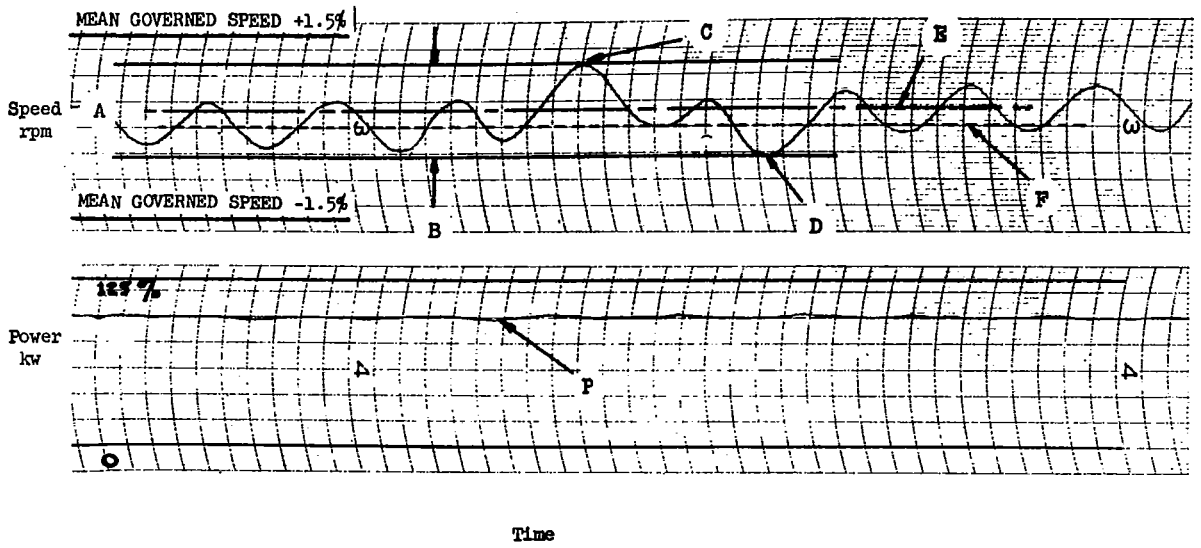

FIG. 2 Observed Speedband of an Engine-Generator Unit with "Constant Load"

A -- Expanded scale record of speed
B -- Steady-state governing speedband
C -- Maximum instantaneous speed
D -- Minimum instantaneous speed
E -- Midspeed of observed speedband. Equals one-half of speeds C plus D
F -- Mean-governed speed. Obtained with separate tachometer
P -- Record of power output

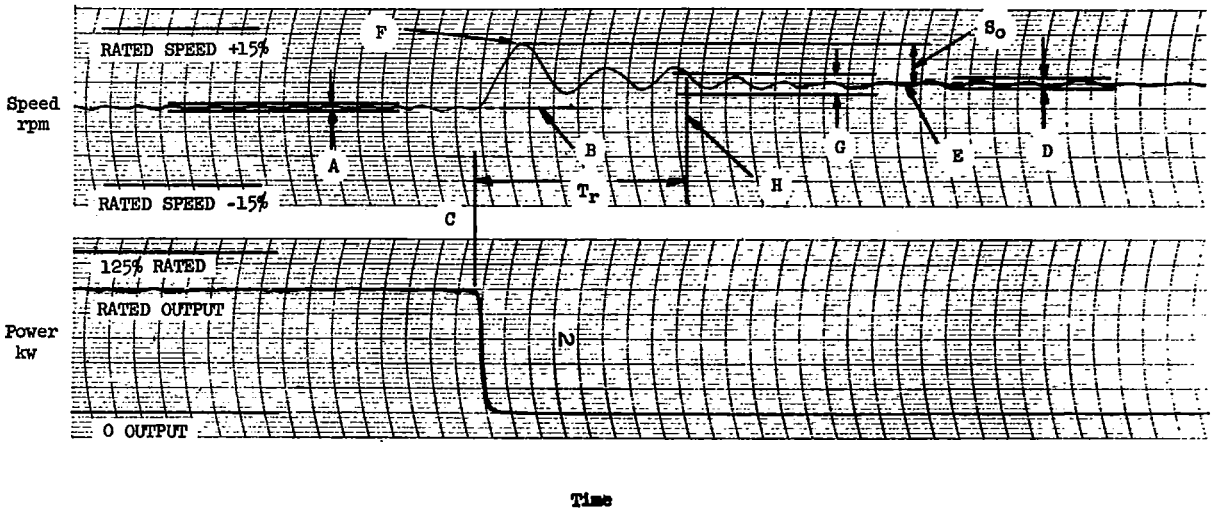

FIG. 3 Momentary-Overspeed, S_o, Following a Sudden and Complete Loss of Electrical Load from Steady-State Conditions at Rated Speed and Rated Power Output with a Pre-established Steady-State Speed Regulation, R_s, Having a Value Greater than Zero

A -- Steady-state governing speedband with initial steady-state electrical load
B -- Midspeed of speedband, A
C -- Instant of loss of electrical load
D -- Steady-state governing speedband with zero power output
E -- Midspeed of speedband, D
F -- Maximum instantaneous speed
G -- Prescribed speedband
H -- Instant decreasing oscillation of speed finally enters speedband, G, and indicated by speed recording instrument
T_r -- Coincident recovery time
-- Speed increase E minus B depends on steady-state speed regulation, R_s

Measurement of G, H, and recovery time, T_r, is not required for establishing stability in the case of complete loss of electrical load

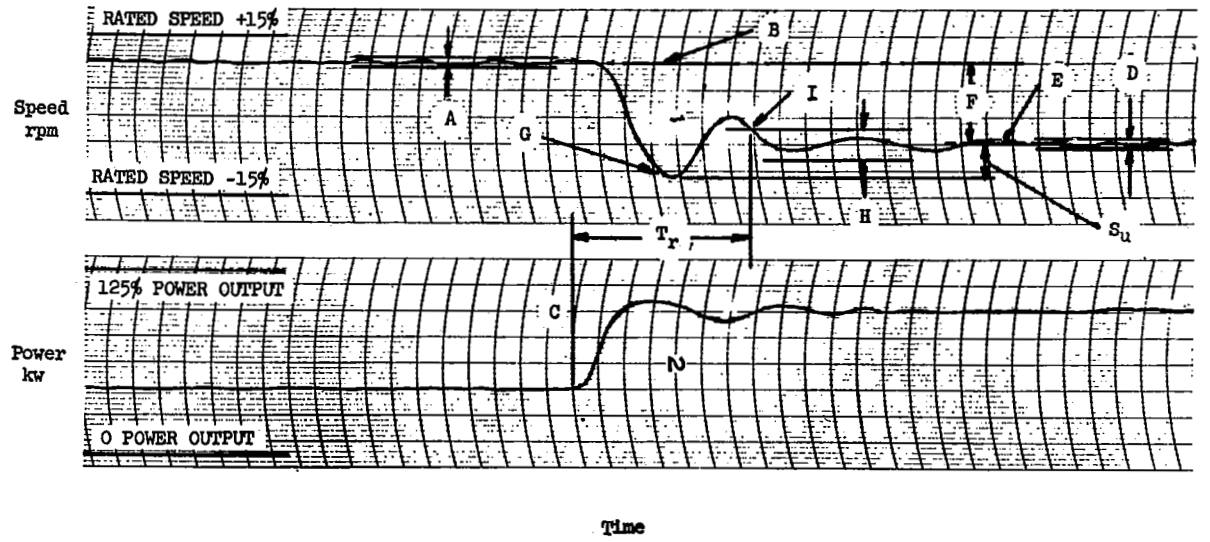

FIG. 4 Momentary-Underspeed, S_u, and Coincident Recovery Time, T_r, Following a Sudden Increase Between Two Steady-State Electrical Loads with a Pre-established Steady-State Speed Regulation, R_s, Having a Value Greater than Zero

A -- Steady-state governing speedband with initial steady-state electrical load
B -- Midspeed of speedband, A
C -- Instant of sudden increase in steady-state electrical load
D -- Steady-state governing speedband at subsequent steady-state electrical load
E -- Midspeed of speedband, D
F -- Reduction in speed-dependent on magnitude of pre-established steady-state speed regulation, R_s, and magnitude of increase in steady-state electrical load
G -- Minimum instantaneous speed
H -- Prescribed speedband
I -- Instant decreasing oscillation of speed finally enters speedband, H, as indicated by speed recording instrument
T_r -- Coincident recovery time

SECTION 5, COMPUTATION OF RESULTS

5.01 Computations. The computations shall be performed to obtain those quantities, required in the Report of Results, which are not directly recorded on instrument charts but derived therefrom.

(Values taken from instrument recording charts will be substituted into the proper expressions which are given in Section 2, Pars. 2.26 through 2.35.)

5.02 Symbols not defined in this section of the Code are explained in Section 2.

5.03 Steady-State Speed Regulation. The steady-state speed regulation is determined by substituting the values recorded in Par. 4.04 in the following formula:

$$R_s = \left(\frac{n_o - n_r}{n_r}\right) \times 100, \%$$

5.04 Steady-State Incremental Speed Regulation. Determination of steady-state speed versus power output curves is described in Par. 4.05. Draw tangents of the points of maximum and minimum slope between 0 and 10 per cent rated power output and at the points of maximum and minimum slope between 10 per cent rated power output and the largest power output which is separately agreed to. The mirror method[4] of establishing these tangents is recommended. Extend the tangents to determine suitable values for substituting in the following formula:

$$R_i = \left(\frac{n_2 - n_r}{n_r}\right) \times \left(\frac{P_c}{P_1 - P_2}\right) \times 100, \%$$

5.05 Speed-Governing Stability. The speed-governing stability is measured by four factors, three of which require determination by substitution of the values recorded in Par. 4.06 in the following formulas:

$$S_s = \pm\left(\frac{n_{max} - n_{min}}{2n_r}\right) \times 100, \%$$

$$S_o = \left(\frac{n_{max} - n_o}{n_r}\right) \times 100, \%$$

$$S_o = \left(\frac{n_{max} - n_1}{n_r}\right) \times 100, \%$$

$$S_u = \left(\frac{n_2 - n_{min}}{n_r}\right) \times 100, \%$$

5.06 Speed-Changer — Adjustment Range. Convert the values obtained under Par. 4.07 to per cent of rated speed, n_r. These are the limits of the speed-changer adjustment range.

[4] The mirror method of establishing a tangent (or normal) to a continuous curve requires the use of a flat first-surface mirror with a square, straight bottom edge. It must be supported in a holder which can be shifted easily about and so arranged that the mirror will be vertical to the surface of the graph with its straight edge firmly resting thereon, in such a manner that the straight edge may be used in tracing a line on the graph. It should be long enough (3 — 6 in.) so that a reasonable length of line can be established. Place the mirror in its holder on the graph so that the reflecting surface cuts the line of the curve at the point where the tangent (or normal) is to be established, and in a position such that the reflection of the line in the mirror visually appears as a continuous extension of the portion of the line of the curve without a break at the mirror's edge. The trace of the edge of the mirror in contact with the surface of the graph is the normal to the curve at the point of intersection. For the tangent, erect a line perpendicular to the normal at the point under consideration.

ASME POWER TEST CODES

Test Code for

Speed-Governing Systems for Internal Combustion Engine-Generator Units

SECTION 6, REPORT OF RESULTS

6.01 **General.** The Report of Test shall be prepared for the purpose of formally recording observed data and computed results. It shall contain sufficient supporting information and computation to prove that all objectives of any tests conducted in accordance with this Code have been attained.

6.02 Only those items required to satisfy the stipulated objectives need be reported.

6.03 The complete Report of Test shall contain, in addition to the tabulated test results, authenticated copies of the original log sheets. Instrument readings shall be recorded as observed. Corrections and corrected values shall be entered separately in the test record.

6.04 **Test Record Form.** Tests shall be reported in accordance with the applicable portions of the form presented herewith and shall include the following parts in the order given:

I Title page
II Table of contents
III Object of test
IV Conclusions
V Description of equipment tested
VI Agreed test conditions
VII Test methods
VIII Test performance
IX Observed data and computations
X Supporting data.

6.05 *Part I, Title Page.*

Test of speed-governing . . . . . .
Report No. . . . . .
Unit designation (No.) . . . . . .
Location (Plant) . . . . . .
Owner (Purchaser) . . . . . .
Supplier . . . . . .
Engine manufacturer . . . . . Generator manufacturer . . . . . .
Type . . . . . Type . . . . . .
Serial No. . . . . Serial No. . . . . .
Date supplier declares system ready for test . . . . . .
One party to the test (Purchaser's representative) . . . . . .
Other parties to the test (Supplier's representatives) . . . . . .
Test conducted by . . . . . .
Report prepared by . . . . . .
Report approved by . . . . . for . . . . . .
Report approved by . . . . . for . . . . . .
Statement that testing, computing and reporting have conformed to the ASME Test Code for Speed-Governing Systems for Internal Combustion Engine-Generator Units.

6.06 *Part II, Table of Contents.* This part aids in finding subdivisions of the report devoted to different objectives.

6.07 *Part III, Objects of Test.* This part shall include an explicit statement of the objects of the tests covered in the report as set forth in Par. 3.04 of this Code.

6.08 *Part IV, Conclusions.* This part shall include conclusions concerning the results of the test and any recommendations or supplementary comments.

6.09 *Part V, Description of Equipment Tested.* This part should include complete name plate data or rated conditions specified by the supplier for the complete engine-generator unit. Diagrams, drawings, and photographs should be used where advantageous.

6.10 *Part VI, Agreed Test Conditions.* Operating conditions which have been specified, as well as others agreed upon prior to each test, shall be reported.

6.11 *Part VII, Test Methods.* This part shall include a detailed description of the instruments and apparatus used to measure the quantities from which the primary objects are determined.

6.12 A description of any methods of measurement shall be included if different from the prescribed rules of this Code.

6.13 The following additional information shall be included:

(*a*) Statement of departures from the rules of this Code which have been agreed to by the parties to the test, including any extensions of permissible deviations from operating conditions of the test from those specified in this Code.

(*b*) Description of calibration methods if not carried out by a recognized authority or if methods have been used other than those prescribed in Section 4 of this Code or in ASME Supplements on Instruments and Apparatus.

6.14 *Part VIII, Test Performance.* In this part, final results of tests are reported in the form of graphs and tabular summaries, as specified in Section 5 of this Code.

6.15 *Part IX, Observed Data and Computations.* This section shall include a general log of the test recording the ambient conditions, the operating conditions of the engine-generator unit, adjustments of the governor, chronological record of the procedure, notes regarding deviations from procedure, etc. It shall include facsimiles of charts and recordings used in the computations of results. It shall also include record of observations, corrected for instrument calibrations and average conditions prevailing, correction values and calculations for each test run.

6.16 The final results are to be listed in the following order as required:

(1) Steady-state speed regulation: Maximum . . . . . %; Minimum . . . . . %

(2) Steady-state incremental speed regulation.
(Steady-state speed regulation set for 2%) . . . . . .

(*a*) Incremental regulation between 10% rated power output and largest power output agreed to: Maximum . . . . . %; Minimum . . . . . %

(*b*) Incremental regulation within the first 10% of rated power output: Maximum . . . . . %; Minimum . . . . . %

(3) Speed-governing stability:

(*a*) Steady-state governing speedband . . . . . ± . . . . . %

(*b*) Momentary overspeed . . . . . %

(*c*) Momentary underspeed . . . . . %, with sudden change of power output between . . . . . %, and . . . . . %

(*d*) Recovery time . . . . . sec (corresponding to (*c*))

(4) Speed-changer — adjustment range:

(*a*) At rated power output: 100 to 102% rated speed —
Yes . . . . . No . . . . . Range . . . . . .

(*b*) At proportionately reduced power output: 100 to 95% rated speed —
Yes . . . . . No . . . . . Range . . . . . .

(*c*) At zero power output: 90 to 106 or 107% rated speed —
Yes . . . . . No . . . . . Range . . . . . .

POWER TEST CODES

While providing for exhaustive tests, these Codes are so drawn that selected parts may be used for tests of limited scope.

A specially designed binder for holding these pamphlets is available.

A complete list of ASME publications will be furnished upon request.

Power Test Codes Now Available

Code on General Instructions	(1945)
Code on Definitions and Values	(1945)
Atmospheric Water Cooling Equipment	(1958)
Centrifugal, Mixed-Flow and Axial Flow Compressors and Exhausters	(1949)
Centrifugal Pumps	(1954)
Coal Pulverizers	(1944)
Displacement Compressors, Vacuum Pumps and Blowers	(1954)
Displacement Pumps	(1962)
Deaerators	(1958)
Determining Dust Concentration in a Gas Stream	(1957)
Diesel and Burner Fuels	(1958)
Dust Separating Apparatus	(1941)
Ejectors and Boosters	(1956)
Evaporating Apparatus	(1955)
Fans	(1946)
Feedwater Heaters	(1955)
Gaseous Fuels	(1944)
Gas Producers and Continuous Gas Generators	(1958)
Gas Turbine Power Plants	(1953)
Hydraulic Prime Movers	(1949)
Internal Combustion Engines	(1957)
Reciprocating Steam-Driven Displacement Pumps	(1949)
Reciprocating Steam Engines	(1949)
Safety and Relief Valves	(1958)
Solid Fuels	(1954)
Speed-Governing Systems for Internal Combustion Engine-Generator Units	(1962)
Speed-Governing Systems for Steam-Turbine Generator Units	(1958)
Stationary Steam-Generating Units	(1946)
Steam Condensing Apparatus	(1955)
Steam Turbines	(1949)
Appendix to Steam Turbine Code	(1949)