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Reciprocating internal combustion engine driven alternating current generating sets —

Part 1: Application, ratings and performance

Groupes électrogènes à courant alternatif entraînés par moteurs alternatifs à combustion interne —

Partie 1: Application, caractéristiques et performances

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*.

This third edition cancels and replaces the second edition (ISO 8528-1:2005), which has been technically revised. The main changes compared to the previous edition are as follows:

— the new power ratings: DCP and MAX have been introduced;

— the 10% overload power in the prime power rating has been reintroduced.

A list of all parts in the ISO 8528 series can be found on the ISO website.

Reciprocating internal combustion engine driven alternating current generating sets —

Part 1: Application, ratings and performance

1 Scope

This document defines various classifications for the application, rating and performance of generating sets consisting of a Reciprocating Internal Combustion (RIC) engine, Alternating Current (a.c.) generator and any associated controlgear, switchgear and auxiliary equipment.

It applies to a.c. generating sets driven by RIC engines for land and marine use, excluding generating sets used on aircraft or to propel land vehicles and locomotives.

For some specific applications (e.g. essential hospital supplies, high-rise buildings), supplementary requirements can be necessary. The provisions of this document can be the basis for establishing any supplementary requirements.

For other reciprocating-type prime movers (e.g. sewage-gas engines, steam engines), the provisions of this document can be used as a basis for establishing these requirements.

Generating sets meeting the requirements of this document are used to generate electrical power for continuous, peak-load and standby applications. The classifications laid down in this document are intended to help understanding between manufacturer and customer.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3046-1, *Reciprocating internal combustion engines — Performance — Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods — Additional requirements for engines for general use*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Symbols and abbreviated terms

An explanation of the symbols and abbreviated terms used in this document is shown in Table 1.

Table 1 — Symbols and abbreviated terms

Symbol or abbreviated term	Term	Unit
a.c.	alternating current	1
COP	continuous power	kW
ESP	emergency standby power	kW
LTP	limited-time running power	kW
DCP	data centre power	kW
MAX	maximum power for low-power generating sets	kW
P	power	kW
P_{pa}	actual average power	kW
P_{pp}	permissible average power	kW
PRP	prime power	kW
p_r	total barometric pressure	kPa
T_{or}	charge air coolant temperature	K
T_r	air temperature	K
t	time	s
$Ø_r$	relative humidity	%
φ	power factor	1

5 Other regulations and additional requirements

For a.c. generating sets used by onboard ships and offshore installations, which need to comply with rules of a classification society, the additional requirements of the classification society shall be observed. The classification society name shall be stated by the customer prior to placing the order.

For a.c. generating sets operating in non-classified equipment, any additional requirements are subject to agreement between the manufacturer and customer.

If special requirements from any other regulatory authority (e.g. inspecting and/or legislative authorities) need to be met, the authority name shall be stated by the customer prior to placing the order.

Any additional requirements shall be subject to agreement between the manufacturer and customer.

6 General description

6.1 Generating set

6.1.1 General

A generating set consists of one or more RIC engines used to produce mechanical energy and one or more generators to convert the mechanical energy into electrical energy. The generating set includes any components used for coupling the mechanical prime mover(s) and electrical generator(s) (e.g. couplings, gearbox) and, where applicable, any load-bearing and mounting components.

NOTE A generator ready to be installed and only able to function as it stands after being mounted on a means of transport (e.g. an agricultural or forestry tractor) is considered to be a generating set.

6.1.2 Prime movers

For the purposes of this document, prime movers may be of two types:

a) compression-ignition engines; and

b) spark-ignition engines.

Depending on the generating set application, the following criteria, among others, can be important in selecting the prime mover to be used:

a) quality of fuel and fuel consumption;

b) exhaust gas and noise emission;

c) speed range;

d) mass and dimensions;

e) sudden electrical loading and frequency behaviour;

f) generator short-circuit characteristics;

g) cooling systems;

h) starting systems;

i) maintenance requirements;

j) waste heat utilization.

6.1.3 Electrical generators

For the purposes of this document, electrical generators may be of two types:

a) synchronous; and

b) asynchronous.

Depending on the generating set application, the following criteria, among others, can be important in selecting the generator to be used:

a) voltage characteristics during starting and normal operation as well as after load changes, taking into account the electrical power factor;

b) short-circuit behaviour (electrical and mechanical);

c) efficiency;

d) generator design and enclosure type;

e) parallel-operation behaviour;

f) maintenance requirements.

6.1.4 Control and switchgear

Equipment for the control, switching, operation and monitoring of the generating set shall be part of the associated controlgear and switchgear systems.

6.1.5 Auxiliaries

Auxiliaries are items of equipment additional to those already fitted/installed on the generating set as supplied but essential to its proper and safe operation, such as:

a) starting system;

b) air intake and exhaust gas systems;

c) cooling systems;

d) lubricating oil system;

e) fuel system (including fuel treatment where applicable);

f) auxiliary electrical power supply.

6.2 Power station

A power station comprises an installation of one or more generating sets and their auxiliary equipment, the associated controlgear and switchgear and, where applicable, the place of installation (e.g. a building, an enclosure or special equipment for protection from the weather).

7 Application criteria

7.1 Modes of operation

7.1.1 General

The generating set mode of operation can affect certain important performance characteristics (e.g. its economical and reliable operation, the intervals between maintenance and repair) and shall be taken into account by the customer when agreeing the requirements with the manufacturer (see Clause 12).

7.1.2 Continuous operation at constant load

Continuous operation at constant load is defined as operation of a generating set without time limit taking into account the maintenance period, where the applied electrical load is constant.

EXAMPLE Providing a base load for a combined heat and power plant.

7.1.3 Continuous operation at varying load

Continuous operation at varying load is defined as operation of a generating set without time limit, taking into account the maintenance period, where the applied electrical load is variable.

EXAMPLE Providing electrical power where there is no utility electrical power available or the utility electrical supply is uncertain.

7.1.4 Limited time operation at constant load

Limited time operation at constant load is defined as operation of a generating set within set time limits where the applied electrical load is constant.

EXAMPLE Peak shaving load management where a generating set operating in parallel with a utility supply takes a constant load during periods of peak power consumption.

7.1.5 Limited time operation at varying load

Limited time operation at varying load is defined as operation of a generating set within set time limits where the applied electrical load is variable.

EXAMPLE To provide a basic support function to a building electrical supply in the event of normal utility supply failure.

7.2 Site criteria

7.2.1 Land use

Land use applies to generating sets either fixed, transportable or mobile which are used on land.

7.2.2 Marine use

Marine use applies to generating sets used on board ships and offshore installations.

7.3 Single and parallel operation

7.3.1 General

Generating sets can have two types of operation as follows:

a) Single operation: This applies to generating sets, irrespective of their configuration or mode of start-up and control, which operate as the sole source of electrical power.

b) Parallel operation: This refers to the electrical connection of a generating set to another source of electrical supply with the same voltage, frequency and phase to share the power supply demand for the connected network. The characteristics of the normal utility electrical power supply, including voltage range and variation, frequency range and variation, impedance of the network, etc., shall be stated by the customer.

7.3.2 Generating set parallel operation

In this type of operation, two or more generating sets are electrically connected (not mechanically connected) after having been brought into synchronism. Generating sets with different outputs and speeds can be used.

7.3.3 Generating set operation in parallel with a utility supply

In this type of operation, one or more generating sets operating in parallel (as described in 7.3.1) are electrically connected to a utility supply.

In the case of public utility electrical power supply, permission for parallel operation shall be obtained. Protective equipment shall be provided.

NOTE This also applies to generating sets which, in order to periodically check their start-up function, need to operate by supplying power into the normal electrical power supply system for a time period laid down by the generating set manufacturer.

7.4 Modes of start-up and control

7.4.1 General

The modes of start-up and control involved in the operation of a generating set are normally:

a) starting;

b) monitoring;

c) voltage and frequency adjustment and synchronization where applicable;

d) switching;

e) stopping.

These can be fully or partly manual, or automatic (see ISO 8528-4).

7.4.2 Manual operation

Manual operation applies to generating sets which are started and controlled manually.

7.4.3 Semi-automatic operation

Semi-automatic operation applies to generating sets in which some of its functions are started and controlled manually and the remainder automatically.

7.4.4 Automatic operation

Automatic operation applies to generating sets which are started and controlled completely automatically.

7.5 Start-up time

7.5.1 General

The start-up time is defined as the elapsed time between the instant when power is first demanded and the instant when it is first available. The start-up time is usually specified in seconds. The start-up time shall meet the requirement of the particular application in which the generating set is being used.

7.5.2 Generating set with no specified start-up time

This is a generating set where, due to the conditions under which it operates, the start-up time is of no importance. Such generating sets are normally started manually.

7.5.3 Generating set with a specified start-up time

This is a generating set where the start-up time is specified. Such generating sets are normally started automatically. Such generating sets may be further classified as follows.

7.5.3.1 Long-break

This is a generating set with a specified start-up time. The elapsed time between power supply failure and power from the generating set becoming available is fairly long. In this case, the entire generating set is started from the stationary condition after electrical power is demanded.

7.5.3.2 Short-break

This is a generating set operating with rotating electrical machines where the electrical power supply is interrupted for a specific time (usually defined in milliseconds) while the necessary electrical transfer takes place. A source of stored mechanical energy is used to supply power to the rotating electrical machines for a short period and, where necessary, to start and accelerate the RIC engine.

7.5.3.3 No-break

This is a generating set operating with continuously running electrical machines so as to ensure an uninterrupted supply of electrical power in the event of utility failure. A source of stored energy is used to supply power to the connected equipment for a short period and, where necessary, to start and accelerate the RIC engine. As the drive is transferred from one power source to another, there can be a temporary deviation in frequency.

NOTE It is essential that the size of the permitted deviation in frequency during the transfer is agreed between the customer and manufacturer.

8 Performance classes

Four performance classes are defined in order to cover the various requirements of the supplied electrical systems as follows:

a) Class G1: This applies to generating set applications where the connected loads are such that only basic parameters of voltage and frequency need to be specified.

   EXAMPLE General-purpose applications (lighting and other simple electrical loads).

b) Class G2: This applies to generating set applications where its voltage characteristics are very similar to those for the commercial public utility electrical power system with which it operates. When load changes occur, there can be temporary but acceptable deviations of voltage and frequency.

   EXAMPLE Lighting systems, pumps, fans and hoists.

c) Class G3: This applies to applications where the connected equipment makes severe demands on the stability and level of the frequency, voltage and waveform characteristics of the electrical power supplied by the generating set.

   EXAMPLE Telecommunications and thyristor-controlled loads. Both rectifier and thyristor-controlled loads can need special consideration with respect to their effect on generator-voltage waveform.

d) Class G4: This applies to applications where the demands made on the stability and level of the frequency, voltage and waveform characteristics of the electrical power supplied by the generating set are exceptionally severe.

   EXAMPLE Data-processing equipment or computer systems.

9 Installation features

9.1 General

Local requirements can affect the design and installation of the generating set and shall be taken into account by the customer and manufacturer in addition to the requirements shown in 9.2 to 9.6.

9.2 Installation configurations

9.2.1 General

The installation configurations in 9.2.2 to 9.2.4 can either have all the necessary generating set auxiliary equipment integrally mounted or not.

9.2.2 Fixed

This configuration applies to generating sets which are permanently installed.

9.2.3 Transportable

This configuration applies to generating sets which are not permanently installed or are mobile.

9.2.4 Mobile

This configuration applies to generating sets which have an integral chassis fitted with wheels whereby the generating set can be moved from one location to another.

9.3 Generating set configurations

In order to simplify the contractual information required for specifying RIC engine–driven generating set applications, application configurations are as follows:

— A: without baseframe;

— B: with baseframe;

— C: with baseframe, integrally mounted controlgear, switchgear and auxiliaries;

— D: configuration as given in C with enclosure (see Clause 10);

— E: configuration as given in C having an integral set of wheels or mounted on a trailer (see 9.2.4).

9.4 Mounting types

The type of mounting to be used for the generating set shall be agreed between the customer and the generating set manufacturer. Some typical types of mounting are:

a) Rigid: In this type of installation, the generating set is installed on inflexible mounts. If foundations for mounting the generating set are installed on substrates of low elasticity (e.g. cork tiles) with no resilient layers inserted, the method of mounting is considered to be rigid.

b) Resilient: In this type of installation, the generating set is installed on resilient mountings that are able to, depending upon their characteristics, partially insulate it from vibration. For special applications (e.g. marine or mobile), restrained resilient mountings may be required.

   1) Fully resilient: In this type of installation, the generating set is mounted on a baseframe or a foundation fitted with mountings that provide insulation against vibration to a high level as agreed between the manufacturer and the customer.

   2) Semi-resilient: In this type of installation, the RIC engine is mounted resiliently and the electrical generator is mounted rigidly on a baseframe or foundation.

c) Mounting on resilient foundation: In this type of installation, the generating set is mounted on a resilient foundation (damping mass) which is isolated from the load-bearing foundation by, for example, anti-vibration mounts.

9.5 Connection between the RIC engine and electrical generator

9.5.1 General

The mechanical connection between the RIC engine and the electrical generator is determined by the level of power to be transmitted and the configuration of the installation. It is affected by such parameters as the design of the engine, design of the generator, mounting type, power to be transmitted, speed of rotation, out-of-balance requirements and whether a gearbox is used.

9.5.2 Coupling arrangements

Typical coupling arrangements are rigid, torsionally rigid, flexible, torsionally flexible or through a clutch.

9.5.3 Assembly arrangements

The assembly between the RIC engine and the electrical generator may be with or without the use of a flange housing.

9.6 Additional installation features — Weather effects

9.6.1 Inside installation

In this type of installation, the generating set is installed in a closed environment where it is not exposed to the direct effects of the weather. Careful consideration shall be given to the maximum and minimum temperatures expected in the operating environment.

9.6.2 Outside installation with protection from weather

In this type of installation, the generating set is installed in an environment where it can be partially exposed to the direct effects of the weather. The generating set may be installed in a closed, but not permanent, protective enclosure or under a protective roof.

9.6.3 Open-air installation

In this type of installation, the generating set is installed in an environment which is fully exposed to the direct effects of the weather.

10 Emissions

An operating generating set produces various emissions including noise, vibration, heat, gas and electromagnetic disturbance.

Protection of the environment and health and safety of personnel operating or maintaining the generating set shall be taken into account by the manufacturer and customer at the time of agreeing to the performance specification.

11 Standard reference conditions

For the purpose of determining the rated power output of the generating set, the following standard reference conditions shall be used:

— total barometric pressure: p_r = 100 kPa;

— air ambient temperature: T_r = 298 K (t_r = 25 °C);

— relative humidity: $Ø_r$ = 30 %.

12 Site conditions

12.1 General

The site conditions under which a generating set is required to operate can affect certain characteristics and shall be taken into account by the customer and manufacturer when agreeing to the contract.

The prevailing site conditions shall be clearly specified by the customer and any particular hazardous conditions (e.g. explosive atmospheres or flammable gases) shall be described. Such characteristics can include but are not limited to those indicated in 12.2 to 12.10.

12.2 Ambient temperature

The customer shall inform the manufacturer of the upper and the lower ambient temperature limits at the site where the generating set will be installed and operated.

12.3 Altitude

The customer shall inform the manufacturer of the altitude above sea level of the site where the generating set will be installed and operated. However, it is preferable to provide the typical upper and lower limits of the barometric pressure experienced on site.

12.4 Humidity

The customer shall inform the manufacturer of the typical upper and lower values of humidity related to the temperature and pressure experienced on site (see 12.2 and 12.3).

12.5 Air quality

The customer shall inform the manufacturer if the generating set is required to operate in a polluted atmosphere (e.g. sand or dust). It can be necessary to apply special requirements in order to obtain satisfactory generating set performance and operation. Any increased maintenance requirements necessary to ensure trouble-free generating set operation due to these conditions should be noted by the customer.

12.6 Marine environment

Special consideration is necessary when generating sets are required to operate in a marine environment. This can also apply to generating sets on land but installed and operated at a coastal site. The ambient environment of the generating set installation area shall be clearly defined by the customer.

12.7 Shock and imposed vibration

It shall be clearly stated by the customer if the generating set is required to operate under conditions where external shock and/or vibration can occur (e.g. in an earthquake area or where externally imposed vibration from an adjacent source is possible).

12.8 Chemical pollution

If the generating set is required to operate under conditions where chemical pollution exists, the nature and extent of the pollution shall be clearly stated by the customer.

12.9 Radiation

Various kinds of radiation can affect components of the generating set. As a result, it is possible that some components/assemblies need special protection and/or a special maintenance programme in order to ensure trouble-free operation. The nature and extent of the radiation shall be clearly stated by the customer.

12.10 Cooling water/liquid

If the generating set has water/liquid cooled heat exchangers, the customer shall state the minimum and maximum temperatures (and, where necessary, the chemical composition and quantity) of the secondary (external) transfer liquid provided.

13 Power adjustment for operating conditions

To determine the appropriate generating set power ratings, the customer shall specify the operating conditions prevailing at the site as follows:

a) the barometric pressure (highest and lowest readings available or, if no pressure data are available, the altitude above sea level);

b) the monthly mean, minimum and maximum air temperatures during the hottest and coldest months of the year;

c) the highest and lowest ambient air temperatures around the engine;

d) the relative humidity (or alternatively the water vapour pressure or the wet and dry bulb temperature) ruling at the maximum temperature conditions;

e) the maximum and minimum temperatures of the cooling water available.

Where the site operating conditions differ from the standard reference conditions given in Clause 11, any necessary adjustment to the generating set power shall be made in order to determine the site rated power of the generating set. For generating sets that are to be installed on board ships and intended for unrestricted service, the rated power shall be based on the nominal ambient conditions as specified in ISO 3046-1.

NOTE The International Association of Classification Societies (IACS) provides information on generating sets that are to be installed on board ships and intended for unrestricted service.

14 Power rating definitions

14.1 General

The power of the generating set is the power output available for consumer loads at the generating set terminals excluding the electrical power absorbed by the essential independent auxiliaries (see ISO 8528-2:2005, 5.1 and ISO 8528-3:2005, Clause 5).

14.2 Power ratings

Generating set power ratings shall be expressed in kilo Volt Ampere (kVA) at its rated frequency or frequency range and a power factor (cos φ) of 0,8 lagging unless otherwise stated.

Generating set power rating categories are necessary for inclusion in the manufacturer's declaration of the power which the generating set will deliver under the agreed installation and operating conditions.

The power rating categories declared by the generating set manufacturer shall be used. No other category shall be used unless agreed between the customer and manufacturer.

14.3 Power rating categories

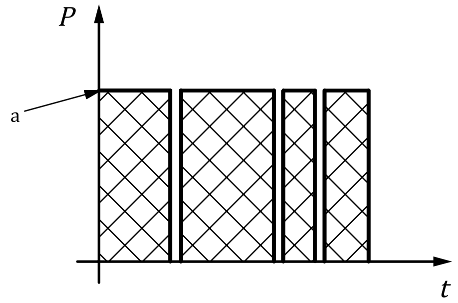
14.3.1 General

The generating set manufacturer shall be responsible for determining the power output in accordance with the requirements of 14.3.2 to 14.3.7 (see Figures 1 to 4) and recognizing the maintenance schedules and service procedures specified by the engine, a.c. generator and controlgear and switchgear manufacturers.

The user should be made aware that if any of the conditions regarding power output are not fulfilled, the generating set life will be reduced.

14.3.2 Continuous power (COP)

Continuous power is defined as being the maximum power which the generating set is capable of delivering continuously while supplying a constant electrical load when operated for an unlimited number of hours per year under the agreed operating conditions with the maintenance intervals and procedures being carried out as prescribed by the manufacturer (see Figure 1).



Key

t time

P power

a Continuous power (100 %).

Figure 1 — Illustration of COP

14.3.3 Prime power (PRP)

Prime power is defined as being the maximum power which a generating set is capable of delivering continuously while supplying a variable electrical load when operated for an unlimited number of hours per year under the agreed operating conditions with the maintenance intervals and procedures being carried out as prescribed by the manufacturer (see Figure 2).

The permissible average power output, P_{pp}, over 24 h of operation shall not exceed 70 % of the PRP unless otherwise agreed by the RIC engine manufacturer.

It can be necessary to provide additional electrical power for transient load conditions and suddenly applied load. This additional power is usually 10 % of the rated power of the generating set.

Unless otherwise stated, and taking into account the site operating conditions (refer to the manufacturer data sheet), a 10 % overload power is permitted for a period of one hour with or without interruptions, within 12 hours of operation.

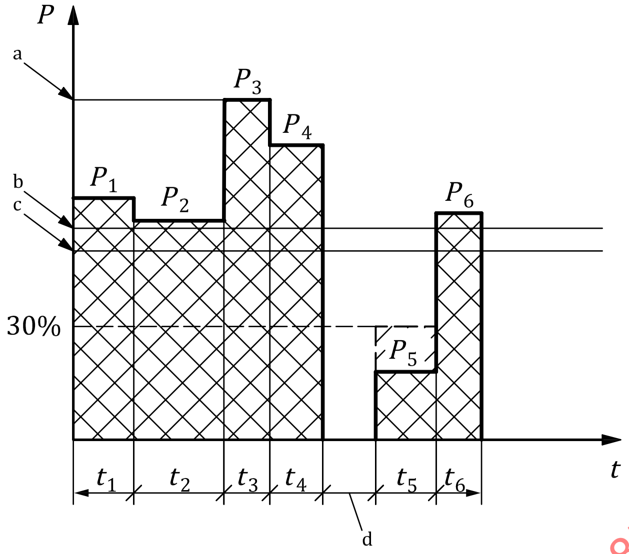
For applications requiring a permissible P_{pp} higher than stated, a continuous power COP rating should be used.

When determining the actual average power output, P_{pa}, (see Figure 2) of a variable power sequence, powers of less than 30 % of the PRP shall be taken as 30 % and time at standstill shall not be counted.

The actual average power, P_{pa}, is calculated as shown in Formula (1):

$$P_{pa} = \frac{P_1 t_1 + P_2 t_2 + P_3 t_3 + \ldots + P_n t_n}{t_1 + t_2 + t_3 + \ldots + t_n} = \frac{\sum_{i=1}^{n} P_i t_i}{\sum_{i=1}^{n} t_i} \quad (1)$$

where P_1, P_2 ... P_i is the power at time t_1, t_2 ... t_i.



Key

t time

P power

a Prime power (100 %).

b Permissible average power during a 24 h period (P_{pp}).

c Actual average power over a 24 h period (P_{pa}).

d Stop.

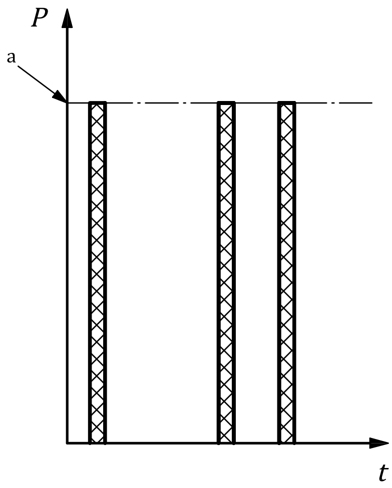
NOTE $t_1 + t_2 + t_3 + \ldots \ldots \ldots + t_n = 24$ h.

Figure 2 — Illustration of PRP

14.3.4 Limited-time running power (LTP)

Limited-time running power is defined as the maximum power available, under the agreed operating conditions, for which the generating set is capable of delivering for up to 500 h of operation per year with the maintenance intervals and procedures being carried out as prescribed by the manufacturers (see Figure 3).

NOTE Limited time running power at 100 % is limited to a maximum of 500 h per year.



Key

t time

P power

a Limited time running power (100 %).

Figure 3 — Illustration of LTP

14.3.5 Emergency standby power (ESP)

Emergency standby power is defined as the maximum power available during a variable electrical power sequence, under the stated operating conditions, for which a generating set is capable of delivering in the event of a utility power outage or under test conditions for up to 200 h of operation per year with the maintenance intervals and procedures being carried out as prescribed by the manufacturers (see Figure 4).

The permissible average power output, P_{pp}, (see Figure 4) over 24 h of operation shall not exceed 70 % of the ESP unless otherwise agreed by the RIC engine manufacturer.

The actual average power output, P_{pa}, shall be below or equal to the permissible average power output, P_{pp}, defined for ESP.

When determining the actual average power output, P_{pa}, of a variable power sequence, powers of less than 30 % of the ESP shall be taken as 30 % and time at standstill shall not be counted.

The actual average power, P_{pa}, is calculated as shown in Formula (2):

$$P_{pa} = \frac{P_1 t_1 + P_2 t_2 + P_3 t_3 + ... + P_n t_n}{t_1 + t_2 + t_3 + ... + t_n} = \frac{\sum_{i=1}^{n} P_i t_i}{\sum_{i=1}^{n} t_i} \quad (2)$$

where P_1, P_2 ... P_i is the power at time t_1, t_2 ... t_i.

