INTERNATIONAL STANDARD

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Reciprocating internal combustion engine driven alternating current generating sets —

Part 4:
Controlgear and switchgear

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

Partie 4: Appareillage de commande et de coupure

Reference number
ISO 8528-4:1993(E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8528-4 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Sub-Committee SC 2, *Performance and tests*.

ISO 8528 consists of the following parts, under the general title *Reciprocating internal combustion engine driven alternating current generating sets*:

— *Part 1: Application, ratings and performance*

— *Part 2: Engines*

— *Part 3: Alternating current generators for generating sets*

— *Part 4: Controlgear and switchgear*

— *Part 5: Generating sets*

— *Part 6: Test methods*

— *Part 7: Technical declarations for specification and design*

— *Part 8: Low-power general-purpose generating sets*

— *Part 9: Measurement and evaluation of mechanical vibration*

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— *Part 10: Measurement of airborne noise — Enveloping surface method*

— *Part 11: Security generating sets with uninterruptible power systems*

Parts 7, 8, 9 and 10 are in course of preparation. Part 11 is at an early stage of preparation and may be split into two parts.

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Reciprocating internal combustion engine driven alternating current generating sets —

Part 4:
Controlgear and switchgear

1 Scope

This part of ISO 8528 specifies criteria for controlgear and switchgear for generating sets with reciprocating internal combustion engines.

It applies to alternating current (a.c.) generating sets driven by reciprocating internal combustion (RIC) engines for land and marine use, excluding generating sets used on aircraft or to propel land vehicles and locomotives.

For some specific applications (for example, essential hospital supplies, high-rise buildings, etc.) supplementary requirements may be necessary. The provisions of this part of ISO 8528 should be regarded as a basis.

For generating sets driven by other prime movers (e.g. sewage gas engines, steam engines) this part of ISO 8528 should be applied as a basis.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 8528. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8528 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6826:1982, *Reciprocating internal combustion engines — Fire protection.*

ISO 8528-5:1993, *Reciprocating internal combustion engine driven alternating current generating sets — Part 5: Generating sets.*

IEC 34-1:1983, *Rotating electrical machines — Part 1: Rating and performance.*

IEC 298:1990, *A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV.*

IEC 439-1:1985, *Low-voltage switchgear and controlgear assemblies — Part 1: Requirements for type-tested and partially type-tested assemblies.*

IEC 947-1:1988, *Low-voltage switchgear and controlgear — Part 1: General rules.*

3 Other regulations and additional requirements

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

For a.c. generating sets operating in non-classed equipment, such additional requirements are in each case subject to agreement between the manufacturer and customer.

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

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

4 General requirements for the equipment

4.1 Mounting

Switchgear, controlgear and monitoring equipment may be mounted on or off the generator set and in one or more cubicles.

4.2 Construction

The equipment shall be constructed in accordance with IEC 439-1 for rated low voltages up to 1 kV, and in accordance with IEC 298 for rated voltages from 1 kV to 52 kV.

4.3 Operating voltage

The definition of operating voltage is given in IEC 439-1 and IEC 298.

4.4 Rated frequency

The operational frequency of the switchgear and controlgear shall be the same as the rated frequency of the generating set.

The frequency shall lie within the limits specified in the relevant IEC standards for the incorporated components. Unless otherwise stated, the acceptable operating limit values shall be assumed to comply with ISO 8528-5:1993, clause 16.

4.5 Rated current

The rated current of the switchgear assembly shall be stated, taking into account the ratings of all components of electrical equipment in the main circuit within the assembly, their disposition and application.

This current shall be carried without the temperature rise of any of its parts exceeding the limits specified in IEC 439-1 and IEC 298.

If the switchgear assembly consists of multiple main circuits, derating shall be carried out, taking into account the maximum sum of the actual currents at any one time.

The voltage variations during operation of the generator shall be taken into account when determining the rated current of the equipment (see voltage variations during operation in IEC 34-1:1983, 12.3).

4.6 Control circuit voltage

A voltage of less than 250 V should be used. The following voltages are recommended:

— for alternating current: 48 V, 110 V, 230 V, (250 V)[1];
— for direct current: 12 V, 24 V, 36 V, 48 V, 110 V, 125 V.

NOTE 1 Limits of control supply variation should be taken into account to ensure correct operation of control circuit devices.

4.7 Starter battery systems

4.7.1 If the engine is to be started electrically, heavy-duty starter batteries of adequate capacity for the duty considered shall be used and allowance made for the ambient temperature at which they are expected to operate.

Partial voltages shall not be taken from the battery unless the battery will be equalized.

If the control circuitry is also connected to the starter battery, then the battery shall have sufficient capacity for reliable operation of the control equipment under all conditions, even when cranking the engine (see 4.6).

4.7.2 For batteries which are always connected in parallel to the consumers, and which are discharged only in case of power failure or peak current demand, a static charger adapted for consumer feeding shall be used.

Such a charging device shall have sufficient output to provide the control system standing load current in addition to the necessary charging current for recharging the battery within an adequate time.

4.7.3 When the RIC engine is equipped with a mechanically driven battery-charging generator, recharging of the battery shall be executed within a reasonable engine running time. When such a battery-charging generator is provided, the static charger may supply the control system with only a standing load current and provide an adequate float charge current.

4.7.4 The charging equipment shall be selected so that no damage is caused to control relays and solenoids connected across the battery by occasional over-voltage during charging.

4.7.5 Starter motor cables shall be dimensioned for a total cable voltage drop, while cranking the engine, not exceeding 8 % of the nominal battery voltage.

1) Value not specified in IEC 38:1983, *IEC standard voltages*.

4.8 Environmental conditions

Normal service conditions are specified in IEC 439-1 and IEC 298.

Where there are deviations from the normal service conditions, the applicable particular requirements shall be complied with or special agreements shall be made between manufacturer and customer.

The customer shall inform the manufacturer if such exceptional service conditions exist.

In order to establish the ambient air temperature, the heat dissipation of other equipment installed in the same room shall be considered.

4.9 Enclosure and degree of protection

The enclosure shall be determined and may be selected from requirements specified in IEC 947-1. Degrees of protection of persons against hazardous approach to live parts should be selected from IEC 298.

5 Generating set switchgear

Generating set switchgear includes all main circuit equipment of the generator incoming unit. If required, it may be extended by the mains incoming unit and the associated distribution.

Typical generating set switchgear schemes are shown in figure 1.

All components incorporated in the switchgear shall be adequately rated to suit the generator set operation specified. They shall also be suitable, if required, for mains operation.

5.1 Load-switching devices

Current rating of load-switching devices shall be selected for compatibility with the continuous rating of the generator, taking into account the corresponding utilization (service) category demanded (usually AC-1)[2].

NOTE 2 If the AC-1 rating is likely to be exceeded in service, the manufacturer's specified making and/or breaking capacity for the load-switching device should be considered.

Where the ratings of the mains supply and generating set supply are dissimilar, then the change-over switching device shall be matched to the respective load requirements.

The customer shall specify the number of poles required according to the requirements of the local supply authority.

5.2 Fault current ratings

Switchgear and cables shall be capable of withstanding during a specified short time the prospective fault current of the circuit in which they are located.

For a mains incoming unit incorporated in the switchgear, the customer shall give information about the short-circuit conditions at the point of installation. (See also IEC 439-1.)

Short-circuit protection by a current-limiting switching device (HRC-fuse back-up or current-limiting breaker, for example) is permissible where appropriate. When such a current-limiting protection is used, all components and interconnections downstream need only be selected for the rated conditional short-circuit current.

5.3 Cables and interconnections

The temperature rise of cables and interconnections shall not exceed the maximum temperature limits of their insulation material. Cables shall not be situated in such a way that transmitted heat dissipation would have a detrimental effect on connected equipment, or on component parts in close proximity.

The voltage drop in interconnections shall meet the requirements for proper functioning for the intended use of the installation.

Terminals shall be so designed that conductors and cables corresponding to the appropriate rated currents can be connected.

Cables and busbars shall be adequately mechanically supported.

5.4 Generator protection

As far as possible, a standard protection arrangement should be used (see table 1 and 7.2).

Consideration shall be given to the operational requirements of the generator when selecting the generator-protection equipment. (See IEC 34-1.)

The following information shall be given by the generator manufacturer:

a) the generator sustained short-circuit current (if any) with the corresponding time limit;

b) the sub-transient and transient reactances, together with the appropriate time constants;

2) See IEC 158-1:1970, *Low-voltage controlgear — Part 1: Contactors.*

c) the transient voltage performance resulting from any specified step load change.

6 Modes of control

Modes of control are defined by the methods used for initiating the control sequence.

Table 1 gives guidelines on generating set protective and control devices.

6.1 Hand start/hand stop

The control of all functions is hand operated. This is used mainly on generating sets rated up to 20 kW and usually does not include protective control.

6.2 Local electric start/hand stop

This is an extension of 6.1 (hand start/hand stop) incorporating an electric start instead of a hand start. This design of set is often supplied without protective control.

6.3 Local electric start/electric stop

This is an extension of 6.2 (local electric start/hand stop) incorporating an electric stop. An electric stop is added primarily to facilitate the inclusion of automatic protective control.

6.4 Remote start/electric stop

This is essentially a local electric start/electric stop (6.3) but arranged so that the manually initiated start and stop control is not located on or adjacent to the generating set.

In cases where the manually derived signals are initiated from a location where the set is inaudible or signal feed-back is not practical, an automatic protective control shall be used.

6.5 Automatic start/automatic stop

Start or stop is initiated by independently derived signals without manual intervention.

Typical applications include mains-failure control, load-level control, time-clock control, liquid-level control, thermostatic control, etc.

Precautions should be included to ensure adequately different switch-point values at ascending and descending levels, temperatures, etc., to minimize too frequent generating set operation.

6.6 Start on demand

This is usually applied to domestic installation where the generating set is the only source of power supply.

When the agreed minimum load is switched on, the generating set starts automatically and continues to run until the connected load is switched off.

6.7 Standby-to-mains control

Mains failure detection starts the generating set automatically in the event of a complete mains failure or a voltage deviation outside defined limits. The system is similarly designed to stop the set and restore mains supply to the load after restoration of the mains to within defined voltage and frequency limits.

In order to achieve this, the following standard facilities shall be incorporated as a minimum:

— mains-failure detection;
— engine start/stop sequential control;
— protection hold-off timer;
— change-over switching device control;
— duty selection switch, MANUAL/AUTO.

The following additional facilities may be incorporated:

— start delay;
— engine start repeater;
— engine warm-up timer;
— switch closure delay timer;
— mains restoration timer;
— engine stop delay at no-load speed;
— battery-charger failure detection;
— starter pinion repeater;
— preheating system;
— hours-run counter;
— monitoring equipment for special characteristics of the connected network.

6.8 Dual mutual standby control

This is the automatic duty cycling of two generating sets, one of which is the duty set, the other the standby to it. Duty change-over is controlled by a time clock or similar initiation, or failure of the duty set itself.

The dual mutual standby arrangement is typically used for continuously unattended operation.

6.9 Triple mutual standby control

Three generating sets operate in a similar mode to dual mutual standby control (6.8), and the sequence of standby is usually selectable.

6.10 Dual mutual standby-to-mains control

This is the same as dual mutual standby control, except that the load is normally supplied by the mains and the sequence described in 6.8 takes place in the event of a mains failure.

At satisfactory restoration of the mains supply, the load is normally, but not necessarily, returned to the mains and the selected standby sequence restored.

A variation of this arrangement is possible: the generating sets are used in sequence as the prime power supply in a dual mutual standby mode with the mains supply acting as standby.

6.11 Parallel operation

This is a multi-set installation, possibly in conjunction with a mains incomer that implies parallel operation (see ISO 8528-1:1993, 6.3.2).

Paralleling requires that the incoming generating set be synchronized; this may be executed either manually or automatically. The process of synchronizing involves voltage and frequency adjustment to bring the incoming machine into synchronism and phase with the existing system.

6.11.1 Manual operation

The following controls and instrumentation are essential for manual synchronizing and parallel operation:

- generating set circuit breaker, contactor or load switch;
- short-circuit protection;
- voltage-adjusting device, if applicable;
- frequency-adjusting device;
- synchronizing lamps[3], zero voltmeter[4] or synchroscope to indicate grade of frequency slip and phase location;
- reverse-power protection;
- active-power meter;
- ammeter;
- voltmeter.

The following controls and instrumentation are recommended:

- double frequency meter (incoming set and bus);
- double voltmeter (incoming set and bus);
- active load-sharing control;
- check synchronizing facility;
- reactive-power meter;
- reactive load-sharing control.

6.11.2 Automatic operation

The following controls and instrumentation are essential for automatic synchronizing and parallel operation:

- remote-operated generating set circuit breaker or load switch having a corresponding short closing time;
- short-circuit protection;
- voltage-adjusting device, if applicable (for reactive load level correction);
- frequency-adjusting device (for active load level correction);
- automatic active load-sharing control;
- reverse-power protection;
- automatic synchronizer;
- synchronizing mode selection switch, MANUAL/AUTO[5];
- ammeter;
- voltmeter;
- active-power meter.

The following controls and instrumentation are recommended:

- double frequency meter (incoming set and bus);
- double voltmeter (incoming set and bus);
- synchronizing lamps[3], zero voltmeter[4] or synchroscope to indicate grade of frequency slip and phase location;
- over-current protection with short-circuit discrimination;
- reactive power meter;
- automatic reactive load-sharing control;
- automatic power factor control[6].

6.12 Means of stopping

When a stop system is required, it is necessary to provide a device which, when operated, will interrupt the supply of fuel into the engine combustion chamber. Any such device shall be arranged so as to remain in the "stop" position until the engine has completely ceased to rotate.

NOTE 3 In addition, an air shut-off valve may be required in the event of overspeed.

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3) Switching-in has to be carried out so accurately that the "brightness" of lamp is not a sufficiently sensitive guide. Synchronizing lamps should only be an additional equipment.

If synchronizing lamps are used, a multiple lamp combination should be connected so as to produce rotary light showing the state of synchronization.

4) When using a zero voltmeter, the voltage has to be matched before the frequency.

5) The use of a synchronizing mode selection switch necessitates the equipment listed in 6.11.1.

6) Only needed for parallel operation with a commercial power system.