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Reciprocating internal combustion engine driven alternating current generating sets —

Part 12: Emergency power supply to safety services

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

Partie 12: Alimentation électrique de secours de services de sécurité

Reference number
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Foreword

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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).

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

This second edition cancels and replaces the first edition (ISO 8528-12:1997), of which it constitutes a minor revision. The changes are as follows:

— structure updated according to the current ISO template;

— normative references updated;

— previous Clause 4 deleted – the symbols used in ISO 8528-5 now apply;

— Clause 7 split into subclauses;

— hanging paragraphs removed from Clauses 8 and 9;

— values in Table 3 modified based on the values in ISO 8528-5:2022, Table 4;

— minor editorial changes.

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

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Reciprocating internal combustion engine driven alternating current generating sets —

Part 12: Emergency power supply to safety services

1 Scope

This document applies to generating sets driven by reciprocating internal combustion (RIC) engines for emergency power supply to safety services.

This document applies, for example, to safety equipment in hospitals, high-rise buildings and public gathering places. It establishes the special requirements for the performance, design and maintenance of generating sets used in these applications referred to previously and takes into account the provisions of ISO 8528-1 to ISO 8528-6 and ISO 8528-10[1)].

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 8528-1:2018, *Reciprocating internal combustion engine driven alternating current generating sets — Part 1: Application, ratings and performance*

ISO 8528-2:2018, *Reciprocating internal combustion engine driven alternating current generating sets — Part 2: Engines*

ISO 8528-3, *Reciprocating internal combustion engine driven alternating current generating sets — Part 3: Alternating current generators for generating sets*

ISO 8528-4:2005, *Reciprocating internal combustion engine driven alternating current generating sets — Part 4: Controlgear and switchgear*

ISO 8528-5:2022, *Reciprocating internal combustion engine driven alternating current generating sets — Part 5: Generating sets*

ISO 8528-6:2005, *Reciprocating internal combustion engine driven alternating current generating sets — Part 6: Test methods*

IEC 60364-7-710, *Low-voltage electrical installations — Part 7-710: Requirements for special installations and locations — Medical locations*

IEC 60622, *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Sealed nickel-cadmium prismatic rechargeable single cells*

IEC 60623, *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Vented nickel-cadmium prismatic rechargeable single cells*

IEC 60896-11, *Stationary lead-acid batteries — Part 11: Vented types — General requirements and methods of tests*

IEC 60896-21, *Stationary lead-acid batteries — Part 21: Valve regulated types — Methods of test*

1) Under preparation. Stage at the time of publication: ISO/FDIS 8528-10:2022.

IEC 61951-1, *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Secondary sealed cells and batteries for portable applications — Part 1: Nickel-Cadmium*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8528-1 to ISO 8528-6 and the following apply.

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

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

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

3.1
changeover time
time interval from the appearance of a malfunction of the normal electrical power supply system until the safety services are again connected to the emergency power supply

Note 1 to entry: This connection to the safety services may be applied in several load steps.

3.2
bridging time
minimum time for which the generating station supplies the consumers with electrical power under predetermined operating conditions

Note 1 to entry: The bridging time corresponds with the rated operating time as defined in IEC 60601-1.

3.3
safety services
equipment for the safety of persons which is installed and kept prepared in case of failure of the usual electrical power supply system

3.4
consumer power demand
total of all intended demands of the connected consumers, taking into consideration the actual load steps

3.5
power demand for safety services
required power demand to fulfil the safety service requirements

4 Additional regulations and requirements

If special requirements or additional regulations are to be observed, they shall be stated by the customer and agreed upon between manufacturer and customer.

5 Classification designation

5.1 General

Classification of generating sets for safety services is based on performance class G2 as defined in ISO 8528-1 and the required changeover time, t_{co}, according to IEC 60364-5-56 and Table 1.

Table 1 — Classification by changeover time

Generating sets	No break	Short break	Long break	
Changeover time	0	< 0,5 s	< 15 s	> 15 s
Classification	1	2	3	4

5.2 Typical examples of classification

Typical examples of classification as defined in Table 1 are given in Table 2.

Table 2 — Examples

Classification	Typical examples
1	The mains voltage drops below the rated voltage by more than 10 %. After a changeover time of 0 s the power for the consumer power demand for safety services shall be available. The design of the no-break generating sets depends on the required frequency and voltage deviations.
2	The mains voltage drops below the rated voltage by more than 10 %. After a changeover time of 0,5 s the power for the consumer power demand for safety services shall be available. The design of the short-break generation set depends on the required frequency and voltage deviations.
3	The mains voltage drops below the rated voltage by more than 10 % for a period longer than 0,5 s. After a changeover time of maximum 15 s, power for 100 % of the consumer power demand for safety services shall be available in steps.
4	The mains voltage drops below the rated voltage by more than 10 % for a period longer than 0,5 s. After a changeover time of maximum 15 s, power for 80 % of the consumer power demand for safety services shall be available in two steps, and the power for 100 % of the consumer demand shall be available after an additional 5 s has passed.

6 Generating set design

6.1 Criteria for determining the required power

To ensure a reliable supply of electrical power by the generating set, the generating set manufacturer shall be informed of the power requirements of the installations to be supplied.

The power requirements shall include short load peaks when switching in electrical installations (e.g. lifts, pumps, fans, lighting equipment and nonlinear electrical installations). Where applicable, for example for reasons of redundancy, the use of several generating sets operating in parallel will possibly be required.

Since many modern RIC engines are turbocharged, it will be necessary to arrange load acceptance in several steps.

For load acceptance, the definitions and values laid down in ISO 8528-5:2022, 8.4, Figure 5 and Figure 6 apply, where the load acceptance capability of the generating set is shown to be dependent on the brake mean effective pressure of the RIC engine.

If larger steps are used than those recommended in ISO 8528-5:2022, Figure 5 and Figure 6, either suitable additional measures shall be taken or the generating set power rating and, where applicable, the rotating mass of the flywheel shall be increased.

The information provided by the checklist in Clause 13 is recommended for designing the generating set.

Essential equipment of emergency generating sets, such as a cooling system, a fuel system including storage tank and a lubrication system, shall be provided to ensure the operation of the generating set for the required period.

The cooling system of the RIC engine shall be self-contained.

6.2 Power determination

ISO 8528-1:2018, Clauses 13 and 14 apply for determining the power requirement.

6.3 Operating limit values

The operating limits shall at least meet the requirements of performance class G2 in ISO 8528-5:2022.

Special requirements for the limit values are given in ISO 8528-5:2022, Table 4.

The transient operating limits given in ISO 8528-5:2022, Table 4 generally apply.

Classifications given in Table 2 are listed in Table 3.

Table 3 — Special requirements for examples given in Table 2

Parameter	Symbol	Unit	Reference	Classification			
				1	2	3	4
Frequency droop	δf_{st}	%	ISO 8528-5:2022, 3.1.26	AMC[a]	AMC	≤ 5	≤ 4
Steady-state frequency band	β_f	%	ISO 8528-5:2022, 3.1.23	AMC	AMC	≤ 1,5	≤ 0,5
Transient frequency deviation from rated frequency	δf_{dyn}^{-}	%	ISO 8528-5:2022, 3.2	AMC	AMC	−10	−10
Steady-state voltage deviation	ΔU_{st}	%	ISO 8528-5:2022, 3.1.28	AMC	AMC	≤ ± 2,5	≤ ± 1
Transient voltage deviation	ΔU_{dyn}^{+} ΔU_{dyn}^{-}	% %	ISO 8528-5:2022, 3.2	AMC	AMC	+20 −15	+10 −10
Voltage recovery time	$t_{u,de}$ $t_{u,in}$	s s	ISO 8528-5:2022, 3.2 ISO 8528-5:2022, 3.2	AMC	AMC	4	4
Unbalanced load current ratio	I_2 / I_N [b]	1	IEC 60034-1:2017, 7.2.3	33[c] 15[d]	33[c] 15[d]	33[c] 15[b,d]	33[c] 15[d]

NOTE All other values are given in ISO 8528-5.

[a] AMC agreement between AC generating set manufacturer and customer.

[b] See also definition in IEC 60034-1:2017, 7.2.3.

[c] For generating sets with ratings above 300 kVA.

[d] For generating sets with ratings below 300 kVA.

[e] This applies also to the voltage between conductors and the neutral conductor under linear and symmetrical loading.

Table 3 *(continued)*

Parameter	Symbol	Unit	Reference	Classification			
				1	2	3	4
Total voltage harmonic distortion	k_u	%	IEC 60034-1:2017, 9.11	AMC	AMC	–	5[e]

NOTE All other values are given in ISO 8528-5.

[a] AMC agreement between AC generating set manufacturer and customer.

[b] See also definition in IEC 60034-1:2017, 7.2.3.

[c] For generating sets with ratings above 300 kVA.

[d] For generating sets with ratings below 300 kVA.

[e] This applies also to the voltage between conductors and the neutral conductor under linear and symmetrical loading.

7 Additional requirements

7.1 Characteristics of batteries and battery charger for auxiliaries and starter

A continuous power supply for monitoring and controlling voltages shall be backed up by batteries. Batteries for this application shall conform to the requirements of either IEC 60622, IEC 60623, IEC 60896-11, IEC 60896-21 or IEC 61951-1.

Such batteries, if suitable, may also be used for starting the engine. Partial voltages shall not be tapped. The battery shall not be used for any other purpose than starting the engine and as a power supply for the monitoring or controlling voltages.

The battery (or battery bank) is to be of such a capacity that it provides enough current to start, monitor and control the generating set at an ambient temperature of 10 °C under float-charged conditions, enabling three starts of 10 s duration each with a 5 s break between starts. The voltage drops each time the starter is operated shall not negatively influence the control system.

For each battery (or battery bank), charging equipment of a controlled type with limited constant current and limited constant voltage characteristics (I-U curve), changing to a float charge characteristic at the end of the charging period, shall be provided. The battery charger shall be capable of automatically recharging a discharged battery (or battery bank) to 80 % of its rated capacity (in Ah) as follows:

— for classification 4, generating sets in within 6 h;

— for classification 3, generating sets in within 10 h.

In addition to charging the battery (or battery bank), the charging equipment shall supply adequate energy for continuous operation of the monitoring and control equipment.

Equipment which continuously monitors the battery voltage and health and includes a malfunction alarm shall be provided. The circuit for this alarm shall fail in the alarm mode. This alarm shall sound at or be repeated to a permanently manned monitoring station. Voltage drops of short duration, for example during the start event or while charging, shall not initiate an alarm.

Malfunctions of the battery charger (e.g. loss of AC supply voltage for more than 3 min or tripping of AC or DC miniature circuit breaker) shall also initiate an alarm.

The design of the battery charger and its associated system shall be such that the voltage appearing at the output terminals shall not exceed the maximum rated voltage of permanently connected control and actuating equipment.

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

If separate batteries are used for controlling the generating set and for starting the generating set, each battery (or battery bank) shall be provided with an individual battery charger in accordance with the requirements of this subclause.

7.2 Compressed air starter

For RIC engines which are started using compressed air, the size and number of air bottles shall be such that the RIC engine can be run at five times the firing speed in both hot and cold conditions. An automatic compressor system shall be provided to recharge the air bottles. The charging system shall be able to fill the air bottles to the operating pressure within 45 minutes of starting. The pressure in the air bottles shall be indicated at all times.

If the required air pressure is not maintained, an alarm shall be initiated.

An automatic and manual water drain shall be provided on each air bottle.

7.3 Fuel capacity

The bridging time during which a generating set driven by an RIC engine can supply consumers with electrical power depends primarily on the amount of fuel supplied.

The amount of fuel available for classification 3 generating sets shall be adequate for at least eight hours of operation; for classification 4 generating sets, this shall be for at least 24 h of operation at the rated power, including the fuel required for test operation.

The amount of fuel available can be increased based on an agreement between customer and manufacturer for special services when the generating set is operated for longer time periods in the case of disasters such as earthquakes.

The fuel service tank capacity for liquid fuelled engines shall be large enough for at least two hours of operation at rated power. It shall be placed close to the engine. To ensure reliable starting the bottom edge of the service tank shall be at least 0,5 m above the injection pump of the RIC engine, unless otherwise specified by the engine manufacturer. The service tank shall have bleed and venting equipment. To avoid overfilling and to detect leakages, appropriate protection measures shall be provided.

Other requirements for duration of operation and fuel storage shall be by agreement between customer and manufacturer.

The tanks shall be provided with level indicators or dipsticks as well as an indication of their capacity.

7.4 Ventilation louvers

Movable ventilation louvers, where fitted, shall be opened automatically by the emergency power supply.

These ventilation louvers shall also be manually operable.

7.5 Electric power supply

Malfunctions of the normal electrical power supply systems of less than 0,5 s shall not initiate engine start, except for no-break and short-break generating sets.

7.6 Robustness against vibrations

If necessary, effective measures shall additionally be provided against vibrations due to earthquakes. A daily maintenance of the emergency generating set is recommended by checking, for example, fuel oil level, filter clogging condition and battery charging level.

NOTE 1 Damage due to earthquakes to any single component of the emergency generating set, including piping and cabling, can stop the generating set from supplying power to safety services.

NOTE 2 If safety services and/or cables to them are damaged due to an earthquake, supplying power from emergency generating sets can cause a secondary disaster.

NOTE 3 If the disaster happens over a wide area, emergency generating sets can be expected to supply power to safety services for a long time before the normal electrical power supply system is repaired. It took 153 h to repair – in some cases temporarily – the normal electric power supply system to all consumers after the disaster in the Kobe area of Japan in January 1995. A few emergency generating sets were unable to start after the disaster due to poor daily maintenance.

8 Controlgear and switchgear

8.1 General

The automatic equipment of generating sets may be combined into a single unit with the mains switchgear.

8.2 Protection, measurement, monitoring and control equipment for the AC generator

8.2.1 AC generator protection equipment

ISO 8528-4:2005, 5.5 specifies the criteria for the protection equipment for the AC generator.

8.2.2 AC generator measurement and monitoring equipment

ISO 8528-4:2005, 7.2 and 7.3 specify the criteria for the measurement and monitoring equipment for the AC generator.

The maximum currents shall be indicated or recorded.

The following shall also be monitored:

— excessive AC generator current;

— “Mains ON” and “AC Generator ON” modes.

Refer also to ISO 8528-4:2005, Clause 7.

8.3 Engine measurement and monitoring equipment

ISO 8528-4:2005, 7.4 and 7.5 specify the criteria for the measurement and monitoring equipment for the engine.

8.4 Generating set measurement and monitoring equipment

ISO 8528-4:2005, Clause 7 specifies the criteria for the measurement and monitoring equipment for the generating set.

8.5 Remote signals

The following operating messages and malfunction alarms shall be provided for remote-controlled long-break generating sets:

— generating set “READY” (selector at “AUTOMATIC” mode);

— generating set “OPERATING” – consumers are provided with electric power by the long-break generating set;

— generating set “OPERATING” – consumers are provided with electric power by the mains;

— generating set “MALFUNCTION”.

9 Test mode

9.1 Test operation with synchronization to the mains supply

9.1.1 General

To test classification 3 and 4 generating sets which are usually supplied with electric power from the mains, pickup of the installation power with synchronization to the mains and without interruption can be accomplished as follows.

9.1.2 Gradual power application without switching

The generating set shall be brought to the frequency and voltage of the mains either manually or automatically.

After operating the generating set circuit breaker in the synchronized state, adjustment of the desired speed is taken over by the speed governor of the RIC engine as a function of the amount of power required by the installation. Test operation takes place with the generating set in parallel with the mains.

Upon completion of the test, the generating set load is shed by reducing the desired speed setting of the speed governor. When less than 10 % of the rated power is reached, the generating set circuit breaker is opened.

For this purpose, suitable AC generator protection equipment as well as switching and control equipment are necessary and are to be provided (see ISO 8528-4:2005, 5.5 and 7.3).

Coordination with the electric power utility is necessary to determine the protection required for the mains and to recognize mains failure.

9.1.3 Gradual power application with switching

The generating set shall be brought to the frequency and voltage of the mains either manually or automatically.

After operation of the generating set circuit breaker in the synchronized state, the generating set power output shall be increased by raising the setting of the RIC engine’s governor. When approximately 10 % of the generating set’s rated power is supplied from the mains, the mains circuit breaker shall be opened.

Upon conclusion of the test, the switching sequence described shall be reversed to disconnect the installations from the generating set and reconnect them to the mains without interruption.

For this purpose, suitable AC generator protection equipment as well as switching and control equipment are necessary and are to be provided (see ISO 8528-4:2005, 5.5 and 7.3).

Coordination with the electric power utility is necessary to determine the protection for the mains and to recognize mains failure.

9.1.4 Sudden power application with short time parallel operation

The generating set shall be brought to the frequency and voltage of the mains either manually or automatically.

When it is synchronous with the mains, the generating set circuit breaker shall be closed and, with a maximum overlap duration of 100 ms, the mains circuit breaker shall be opened. The power consumption of the installations shall be immediately taken over by the generating set.

To prevent overloading and subsequent failure of the generating set, it shall be ensured that at the moment of load acceptance the installations do not draw more than the power recommended for the first stage as described in ISO 8528-5:2022, 8.4. The frequency and voltage will not be the same as those of the mains.

Upon conclusion of the test, the switching sequence described shall be reversed to disconnect the installations from the generating set and reconnect them to the mains without interruption.

A prerequisite for this changeover is that the electric power utility grants permission to switch the total consumer load back on to the mains at a particular time.

For this purpose, suitable AC generator protection equipment as well as switching and control equipment are necessary and are to be provided (see ISO 8528-4:2005, 6.12)

Coordination with the electric power utility is necessary to determine the protection for the mains and to recognize mains failure.

9.2 Without mains synchronization

For a test operation simulating malfunction of the mains supply, the mains circuit breaker shall be opened. This causes an interruption of electric power to the installations, with the switching time corresponding to that given in Clause 5. Starting of the generating set and acceptance of the installation power requirement is to follow the sequence in Clause 5.

Generally, testing follows the description:

— for classification 3 generating sets as described in 9.1.1 and 9.1.2;

— for classification 4 generating sets as described in 9.1.3.

10 Testing

10.1 General

Testing is classified according to installation or periodic tests.

The acceptance test is given in ISO 8528-6:2005, Clause 6.

10.2 Installation tests

The tests listed under items a) to f) are to provide information on the correct dimensioning and working order of the generating set. The tests shall be performed before initial operation as well as after any modification or repair before putting the generating set back into operation.

a) Testing the operation of the emergency power supply by interrupting the mains supply at the distribution point to the installations.

b) Examination of the room in which the generating set is located with respect to, for example, fire protection, flooding, ventilation or exhaust ducting.

c) The size of the generating set under consideration, static floor loading and possible starting currents (e.g. for motors driving fans, pumps and lifts) shall be taken into account.

d) Testing of the generating set protection equipment, particularly the selectivity matching.

e) Operational testing of the emergency power supply with RIC engines, including the testing of start and run-up behaviour, operation of the auxiliary equipment, switchgear and control equipment, performance of a power test with possible rated power and testing of operational behaviour as one generating set. Particular attention shall be paid to the dynamic deviations in voltage and speed.

f) Verification of compliance with local fire protection requirements.

10.3 Periodic tests

Generating sets in electrical plants shall be tested at periodic intervals in accordance with IEC 60364-7-710.

The tests listed in 10.2 a) to f) are in addition to the following:

a) Monthly operating test of supply to security equipment, documenting:

— mains voltage monitoring;

— start and run-up behaviour;

— specified load acceptance;

— behaviour of switchgear, controlgear and auxiliary equipment.

b) Load behaviour operating test of the emergency generating set shall be carried out monthly with at least 50 % of the rated power for 60 minutes for emergency power sources driven by RIC engines, unless agreed otherwise between customer and manufacturer.

This operating test may be deleted for emergency power supplies operating continuously.

c) Monthly test of switchgear operation.

d) Annual verification of whether the power of the emergency power supply still meets the necessary power requirement of the installations.

Logbooks shall be maintained for those tests to be performed at recurring intervals to enable monitoring over a period of at least two years.

11 Rating plate

In addition to the marking specified in ISO 8528-5:2022, Clause 13, the generating set rating plate shall indicate the classification according to Table 1.

12 Required documentation

Instruction manuals providing sufficient information for operation, maintenance and safety shall be provided for the system components and auxiliaries.

13 Checklist

Table 4 provides information for the correct design of generating sets.

Table 4 — Design considerations for generating sets

Designation	Reference	Remarks	Information		
			a	b	c
Start-up time	ISO 8528-1:2018, 7.5 ISO 8528-5:2022, Clause 10	Information on the required switching time; this determines whether to install a long-break, a short-break or a no-break generating set	×		
Performance classes	ISO 8528-1:2018, Clause 8 ISO 8528-5:2022, Clause 15	Information on the installations, concerning load application and type of load; which installations are to be connected in the respective steps; the greatest load change to be expected during operation	×		
Single and parallel operation	ISO 8528-1:2018, 7.3	Due to the variety of synchronization and operation possibilities, purpose and conditions for parallel operation are to be agreed upon	×	×	
Modes of start-up and control	ISO 8528-1:2018, 7.4	Starting, monitoring, switching	×	×	×
Prime movers	ISO 8528-1:2018, 6.1.2	Diesel, gas engine	×	×	×
Electrical generators	ISO 8528-1:2018, 6.1.3	Synchronous or asynchronous	×	×	×
Generating set configuration	ISO 8528-1:2018, 9.3	Determination of shape	×	×	×
Site conditions	ISO 8528-1:2018, Clause 12	Location and ambient conditions affecting generating set	×		
Emissions	ISO 8528-1:2018, Clause 10	Influences affecting the environment	×	×	
Power characteristics	ISO 8528-2:2018, 5.1	Determine rated power, load peaks, short-circuit behaviour	×	×	
Switchgear and controlgear	ISO 8528-4:2005	Short-circuit stability, tolerances, rated and control voltages, neutral-line load ability, type of protection	×	×	×
Mounting types	ISO 8528-1:2018, 9.4	Selection of rigid or resilient mounting depending on specification of structure-borne-noise attenuation and permissible foundation vibration loading	×	×	×
Central supply to several buildings	IEC 60601-1 IEC 60364-7-710	Details and number of main distributors	×	×	

[a] Items to be supplied by the customer to the manufacturer.

[b] Items which are to be agreed upon between the customer and manufacturer.

[c] Items to be supplied by the manufacturer to the customer.

Bibliography

[1] ISO 8528-10,[2)] *Reciprocating internal combustion engine driven alternating current generating sets — Part 10: Measurement of airborne noise by the enveloping surface method*

[2] IEC 60034-1:2017, *Rotating electrical machines — Part 1: Rating and performance*

[3] IEC 60364-5-56, *Low-voltage electrical installations — Part 5-56: Selection and erection of electrical equipment — Safety services*

[4] IEC 60601-1, *Medical electrical equipment — Part 1: General requirements for basic safety and essential performance*

2) Under preparation. Stage at the time of publication: ISO/FDIS 8528-10:2022.

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