

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Static transfer systems (STS) –
Part 3: Method for specifying performance and test requirements**

**Systèmes de transfert statique (STS) –
Partie 3: Méthode de spécification des performances et exigences d'essai**



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STATIC TRANSFER SYSTEMS (STS) –

Part 3: Method for specifying performance and test requirements

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International Standard IEC 62310-3 has been prepared by subcommittee 22H: Uninterruptible power systems (UPS), of IEC technical committee 22: Power electronic systems and equipment.

The text of this standard is based on the following documents:

FDIS	Report on voting
22H/105/FDIS	22H/107/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62310 series, under the general title: *Static transfer systems (STS)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

STATIC TRANSFER SYSTEMS (STS) –

Part 3: Method for specifying performance and test requirements

1 Scope

The IEC 62310 series of three standards applies to stand-alone operating a.c. static transfer systems (STS) intended to ensure the continuity of load supply through controlled transfer, with or without interruption of power, from two or more independent a.c. sources.

This series of standards includes information for the overall integration of the STS and its accessories into the a.c. power network and includes requirements for the switching elements, their control and protective elements, where applicable.

Part 1 of the series concerns general and safety requirements.

Part 2 of the series concerns electromagnetic compatibility (EMC) requirements.

This Part 3 of the series concerns methods for specifying performance and test requirements including applicable safety tests referenced in standard IEC 62310-1 for general and safety requirements.

This standard applies for single-phase, phase-phase and three-phase static transfers in a. c. systems up to 1 000 V. It takes precedence over all aspects of generic performance standards, and no additional performance testing is necessary.

The requirements have been selected so as to be consistent with compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems (see IEC 61000-2-2) as well as to ensure an adequate level of performance when the STS is applied in diverse critical load situations. The requirements take into account the differing test conditions necessary to encompass the range of physical sizes and power ratings of STS. This standard applies to STS as a stand-alone product, whether presented as a unit or an assembly of units. This standard does not apply to:

- devices for d.c. source switching;
- single source systems;
- transfer systems using only electromechanical switching devices with interruption of the supply to the load during transfer and intended to be used in emergency power systems or covered by IEC 60947-6-1;
- automatic switching devices integrated into UPS covered by the IEC 62040 series of UPS product standards.

NOTE Additional or different requirements may apply to STS intended for use on board of vehicles including ships and aircrafts, in emergency power systems subject to a particular regulation e.g. health care facilities, fire fighting or emergency rescue, in tropical countries or where elevations are greater than 1 000 m.

2 Normative references

The following referenced documents are indispensable for the application 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.

IEC 60068 (all parts), *Environmental testing*

IEC 60146-1-1, *Semiconductor convertors – General requirements and line commutated convertors – Part 1-1: Specifications of basic requirements*

IEC 60439-1, *Low-voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60947-6-1, *Low-voltage switchgear and controlgear – Part 6-1: Multiple function equipment – Transfer switching equipment*

IEC 60950-1, *Information technology equipment – Safety – Part 1: General requirements*

IEC 61000-2-2, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

IEC 62040-3, *Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements*

IEC 62310-1, *Static Transfer Systems (STS) – Part 1: General and safety requirements*

IEC 62310-2, *Static Transfer Systems (STS) – Part 2: Electromagnetic Compatibility (EMC) requirements*

ISO 7779, *Measurement of airborne noise emitted by information technology and telecommunications equipment*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 General definitions

3.1.1

static transfer system (STS)

system that transfers a load, by static means, between a preferred source and an alternate source

NOTE 1 The transfer may be automatic and/or manual.

NOTE 2 The transfer may be with or without interruption.

3.1.2

power pole or electronic power switch

in the context of this standard, an operative unit for electronic power switching comprising at least one controlled electronic valve device

[IEV 551-13-01, modified]

3.1.3

primary circuit

internal circuit which is directly connected to the external supply source which supplies the electric power to the load. It includes the primary windings of transformers, motors, other loading devices and the means of connection to the supply source.

3.1.4

input power

power derived either from the preferred or from the alternate source or from both and supplied to the STS (and maintenance bypass if any)

3.1.5

SELV circuit

secondary circuit which is so designed and protected that under normal operating conditions and single fault conditions, its voltages do not exceed a safe value

NOTE 1 The limit values of voltages under normal operating conditions and single fault conditions are specified in 2.2 of IEC 60950-1, see also Table 1A of IEC 60950-1.

NOTE 2 This definition of an SELV CIRCUIT differs from the term “SELV system” as used in IEC 61140.

3.1.6

preferred source

source used as normal power supply to the load, usually set by the operator

3.1.7

alternate source

source used as alternate power supply to the load when the preferred source fails or is out of tolerance or is switched off for maintenance

3.1.8

normal mode of STS operation

condition where the load is supplied via the electronic (power) switches by either the preferred source or by the alternate source

3.1.9

maintenance bypass

power path designed to allow isolation of an appropriate section or sections of an STS for safety during maintenance and/or to maintain continuity of load power

3.1.10

transfer

act of altering the supply path to the load from one source to another

3.1.11

automatic transfer

transfer without human intervention as a result of the supplying source being outside specified conditions

3.1.12

automatic retransfer

transfer without human intervention from an alternate to the preferred source once the preferred source has returned to specified conditions

3.1.13

manual transfer

transfer that occurs as a result of local or remote operator intervention

3.1.14

normal transfer

transfer of load power between two sources while their voltage phase angle difference is within a tolerance band as declared by the manufacturer

3.1.15

synchronous (or synchronised) transfer

transfer within a limited voltage phase angle difference specified by the user

3.1.16**asynchronous (or non-synchronised) transfer**

transfer of load power between two sources while their voltage phase angle difference, when transfer occurs, is out of a tolerance band as declared by the manufacturer

3.1.17**transfer time**

time interval between initiation of transfer and the instant when the output quantities have been transferred

3.1.18**cross-current**

current due to conduction from a phase of one source through electronic power switches to the corresponding phase of another source

3.1.19**objectionable current**

load current that, during normal operation and/or transfers, flows in paths other than those intended and that contributes to any of the following:

- interference with the proper sensing and operation of ground-fault residual current devices (RCDs)
- arcing of sufficient energy to ignite flammable materials
- electromagnetic emission in excess of levels prescribed in IEC 62310-2 for STSs

3.1.20**linear load**

load where the current drawn from the supply is defined by the relationship:

$$I = U/Z$$

where

I is the load current;

U is the supply voltage;

Z is a constant impedance

3.1.21**non-linear load**

load where the parameter Z (load impedance) is no longer a constant but is a variable dependent on other parameters, such as voltage or time

3.1.22**active power**

under periodic conditions, mean value, taken over one period T , of the instantaneous power p :

$$P = \frac{1}{T} \cdot \int_0^T p \cdot dt$$

[IEV 131-11-42]

NOTE 1 Under sinusoidal conditions, the active power is the real part of the complex power.

NOTE 2 The SI unit for active power is the watt.

NOTE 3 DC, fundamental and harmonic voltages contribute directly to the magnitude of the active power. Where applicable, instruments used to measure active power should therefore present sufficient bandwidth and be capable of measuring any significant non-symmetrical and harmonic power components.

3.1.23**power factor, (λ)**

ratio of the active power to the apparent power

$$\lambda = \frac{P}{S}$$

[IEV 131-11-46, modified]

NOTE For the purpose of this standard, the load power factor is determined assuming an ideal sinusoidal supply voltage, where the load is non-linear; the load power factor includes harmonic power components.

3.1.24**apparent power, (S)**

product of the r.m.s. values of voltage and current at a port

[IEV 133-11-41, modified]

$$S = UxI$$

3.1.25**ambient temperature**

temperature of the air or other medium where the equipment is to be used

[IEV 826-01-04]

3.2 Specified values**3.2.1****rated value**

quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment

[IEV 151-16-08, modified]

3.2.2**rating**

set of rated values and operating conditions of a machine or a device or equipment

[IEV 151-16-11]

3.2.3**tolerance (band)**

range of values of a quantity within specified limits

3.2.4**deviation**

difference between the desired value and the actual value of a variable at a given instant

[IEV 351-12-15, modified]

3.2.5**transient**

behaviour of a variable during transition between two steady states

[IEV 351-14-04]

3.2.6**rated voltage**

input or output voltage (for three-phase supply, the phase-to-phase and phase-to-neutral voltage when the STS supports neutral connection) as declared by the manufacturer

3.2.7**voltage variation**

difference between the r.m.s. voltage and the corresponding previously undisturbed r.m.s. voltage

NOTE For the purposes of this standard, the term "variation" has the following meaning: the difference of the value of a quantity before and after a change of an influence quantity.

3.2.8**rated current**

r.m.s. input or output phase current of the equipment as declared by the manufacturer

3.2.9**rated frequency**

operating frequency as declared by the manufacturer

3.2.10**total harmonic distortion (THD)**

ratio in percent of the r.m.s. value of the harmonic content to the r.m.s. value of the fundamental component of the alternating quantity

3.2.11**harmonic components**

components of the harmonic content as expressed in terms of the order and r.m.s. values of the Fourier series terms describing the periodic function

3.2.12**harmonic content**

quantity obtained by subtracting from an alternating quantity its fundamental component

NOTE The harmonic content may be given as a time-function or as an r.m.s. value.

3.2.13**crest or peak factor**

ratio of peak value to the r.m.s. value of a periodic quantity

NOTE The terms «crest factor» and «peak factor» have the same meaning.

3.3 Input values**3.3.1****input voltage tolerance**

maximum variation of steady-state input voltage acceptable by the STS to function

3.3.2**input frequency tolerance**

maximum variation of steady-state input frequency acceptable by the STS to function

3.4 Output values**3.4.1****critical load voltage protection limits**

maximum variation of steady-state and of transient output voltage of the STS

3.4.2**conditional short-circuit current**

prospective current that a STS can withstand when protected by a specified protective device

3.4.3

output voltage tolerance

maximum variation of steady-state output voltage of the STS, generally adjusted to ensure compliance with the critical load protection limits

3.4.4

overload capability

output current capability of the STS in excess of its stated continuous current over a given time, with the output voltage remaining within its rated range

3.4.5

short time withstand current

current that a circuit or a switching device in a closed position can carry during a specified short time and under prescribed conditions of use and behaviour

3.4.6

step load

instantaneous addition or removal of electrical loads to a power source

4 Performance requirements

4.1 Declared electrical characteristics

4.1.1 Performance classification

The manufacturer shall classify STSs complying with this standard in accordance with the following coding.

XX	YY	B	ST
-----------	-----------	----------	-----------

where

XX characterises the management of fault current:

CB: STS capable of making and of breaking specified short-circuit currents and containing integral overcurrent protection.

PC: STS capable of making and of withstanding specified short-circuit currents but not intended for breaking short-circuit currents.

YY characterises the management of input neutrals:

00 – Neutral not supported

NC – Neutral common

NS – Neutral separation by switching

NI – Neutral separation by galvanic isolation

NOTE Galvanic neutral isolation can be achieved through the use of an isolation transformer.

B characterises the nature of the transfer:

B - Break before make (open transition) – no transient cross-conduction during transfer

M - Make before break (closed transition) – possible transient cross-conduction during transfer

ST characterises the sensing and transfer features:

"S" - sensing tolerance prior to automatic transfer being initiated

Voltage in the conducting source, when beyond the specified sensing tolerance, shall cause the STS to initiate an automatic transfer. Figures B.1, B.2, B.3 and B.4 of Annex B define the over and undervoltage limits corresponding to sensing tolerances 1, 2, 3 and 4 respectively. The sensing tolerance (S) shall be agreed on between the manufacturer and the purchaser in accordance with voltage limits deemed acceptable for the critical load - see Annex E – Purchaser specification guidelines

“T” - duration of any power interruption to the load once an automatic transfer is initiated (see Table 1)

Table 1 – Transfer interruption classification “T”

T	Interruption ms
1	$\leq 0,1$
2	≤ 1
3	≤ 10
4	≤ 20
5	(reserved)

NOTE Transfer classification T = 5 is reserved for particular transfer characteristics if required and agreed upon between the manufacturer/supplier and the purchaser.

Compliance with the STS sensing and transfer features is required when at least one input source is within tolerance under conditions agreed between the purchaser and the manufacturer. For guidance, refer to “Maximum voltage phase difference between sources to enable synchronous transfer” in Table E.1. In the event of all preferred and alternate source(s) being out of tolerance, the manufacturer shall specify the performance.

NOTE Phase to neutral voltage sensing is required in STS where a neutral connection is available to the load.

Example of STS performance classification: “PC NC B 23” characterises a STS that

- can make and withstand specified short-circuit currents but that is not intended for breaking of short-circuit currents,
- presents a common input neutral terminal for all sources
- is break before make (open transition), causing no transient cross-conduction during a transfer
- initiates a transfer automatically when the voltage of the conducting source is beyond the limits for source tolerance classification 2 (see Annex B)
- may interrupt supply to the load for up to 10 ms during the transfer

4.1.2 Main electrical characteristics

The STS manufacturer shall specify the following characteristics in the application documentation pertaining to a STS that complies with this standard.

4.1.2.1 Current

- Rated (phase r.m.s. value)

4.1.2.2 Voltage

- rated (phase-phase / phase–neutral as applicable, r.m.s. value)
- input tolerance (refer to 4.2a)
- input unbalance tolerance (for 3-phase STS, refer to 4.2.c)

4.1.2.3 Frequency

- rated
- tolerance (refer to 4.2.b)

4.1.2.4 Input / output wiring

- number of phases (1, 2 or 3) + N (if applicable)

- pluggable or fixed wiring

4.1.2.5 Input sources

- number of input sources (2 or more)
- reference compatibility (common or separately derived, common or separately grounded)
- distribution compatibility (TNC, TNS, TT or IT, refer to annex V IEC 60950-1)

4.1.2.6 Power poles

- number of poles switched (1, 2, 3 or 4)
- switching sequence (open or closed transition – refer to 4.1.1)
- rated neutral current (percentage of rated phase current)
- state if the neutral is switched (refer to 4.1.1)

4.1.2.7 Overload

- declared (% of rated current and duration)
- load fault clearing capability (% of rated phase current and duration, refer to 5.2.7.2)

4.1.2.8 Fault (short-circuit) current

- management (PC or CB – refer 4.1.1)
- withstand capability, rated (kA and duration – refer to 5.2.7.3)
- breaking capability, rated - CB management only (kA – refer to 5.2.7.3)

4.1.2.9 Operating losses at rated load (refer to 5.2.8)

4.2 Normal service conditions

Except where otherwise specified in this paragraph , the STS shall be compatible with

- levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems as described in IEC 61000-2-2;
- linear loads;
- non-linear loads as specified in Clause A.5.

The STS shall be capable of operation when at least one source meets the following limits:

- a) voltage variation ± 10 % of nominal rated voltage, minimum;
- b) frequency variation ± 5 % of nominal rated frequency;
- c) voltage unbalance of 5% for three-phase systems (see 2.5 of IEC 60146-1-1).

NOTE The conditions above represent compatibility requirements for proper operation of the STS and its control circuits (as opposed to representing the actual operating limits required by the load – see Annex B).

4.3 Transfer characteristics

4.3.1 Load voltage

Transfers and retransfers in STS conforming to this standard, whether manual or automatic, shall not contribute to an output voltage deviation in excess of the critical load voltage protection limits as declared by the manufacturer in 4.1.1. Refer to 5.2.5.1 and 5.2.1.2 for test guidance.

The manufacturer shall declare the maximum voltage phase difference permitted between sources to comply with the STS transfer classification declared (see 4.1.1).

4.3.2 Cross-current

Static transfer equipment shall not permit cross-current flow between input sources under any normal operating condition except for inherent transient currents that may arise during synchronised transfers through STS declared “closed transfer” or “make before break”. Design of STS shall guard against current flow between sources arising as a result of a single fault condition. Static transfer equipment declared by the manufacturer to be “closed transfer” or “make before break” shall tolerate any inherent transient currents that may arise during synchronised transfers without malfunctioning.

Refer to 5.2.5.3 for test guidance.

4.4 Neutral management

4.4.1 Common neutral

No neutral switching or particular management of the neutral reference is required where a.c. input sources share a common neutral grounding point. Refer to Annex C for guidance.

4.4.2 Separately derived neutrals

A neutral management technique is required when separately derived a.c. input sources are independently grounded and connected to a STS. Refer to Annex C for guidance.

4.4.3 Neutral current

The current carrying capacity of STS shall support the neutral current arising from any rated combination of balanced and unbalanced linear load and of non-linear load as described in Clause A.5.

4.4.4 Protective earth current

The STS shall not contribute to objectionable load current flow in the protective earth conductor.

NOTE Current may flow in the protective earth conductor during transfers. This is permissible as long as the current does not become objectionable (objectionable current is defined in 3.1).

Figure 1 is an example of a complying STS application wherein objectionable load current cannot flow in the protective earth conductor because one a.c. source is referred to the grounding potential of the other. The installer should verify the continuous effectiveness of the neutral grounding path as applicable. In TN systems, this may impose additional conditions on the upstream use of manual or automatic circuit-breakers that open the neutral.

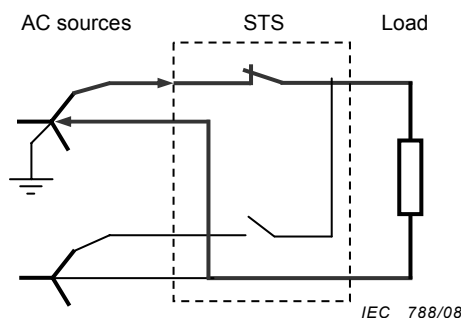


**Figure 1 – Complying load current flow –
Common grounding of a.c. input sources – Common STS neutral**

Figure 2 is an example of a non-complying STS application wherein objectionable load current can flow in the protective earth because both a.c. sources are independently grounded.

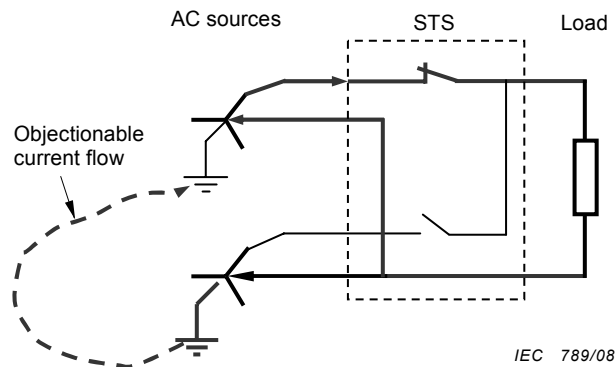


Figure 2 – Objectionable load current flow – Independent grounding of a.c. input sources – Common STS neutral

Compliance is checked by circuit analysis of the STS in the context of a.c. input power distribution system classification (TN, TT, IT), the number of phases and of wires as presented in Annex V of 60950-1.

4.5 Performance requirements to be identified by the purchaser

When applicable, and subject to an agreement between the manufacturer and the purchaser, the purchaser shall identify alternative application related performance requirements and deviation limits not specified in this Clause. Refer to Annex E for guidance.

5 STS tests

5.1 General

5.1.1 Type tests

Type tests are performed on a STS that represents a series of substantially identical products. Type tests are intended to ensure that such identical products become compliant with their full specification when produced under relevant quality standards and after having passed the routine tests detailed in this Clause.

5.1.2 Routine tests

Routine and any optional tests are generally performed in the factory.

5.1.3 Site tests

Site tests are subject to an agreement between the purchaser and the manufacturer. If routine tests are conducted on site, such tests shall use the available site load that shall not exceed the rated continuous load of the complete STS site configuration.

5.1.4 Testing schedule

Tests shall be performed in accordance with Table 2.

Table 2 – Tests for STS performance characteristics

Test description	Routine test	Type test	Subclause
Insulation (to ground)	x	x	5.2.1a
Insulation (input to input and input to output) ^{a)}		x	5.2.1.b, c
Light load	x	x	5.2.2
Functional and Interconnection cable check	x	x	5.2.2
Control device(s)	x	x	5.2.2.a
Protective device(s)	x	x	5.2.2.b
Auxiliary device(s)	x	x	5.2.2.c
Supervisory, measuring, signalling device(s)	x	x	5.2.2.d
Automatic transfer	x	x	5.2.2e
Manual transfer	x	x	5.2.2.f
No load	x	x	5.2.3
Rated load	x	x	5.2.4
Automatic transfer		x	5.2.5.1
Manual transfer		x	5.2.5.2
Cross-current		x	5.2.5.3
Source tolerance (voltage and frequency)		x	5.2.6
Overload		x	5.2.7.1
Overcurrent clearing capability		x	5.2.7.2
Short-circuit withstand current		x	5.2.7.3
Operating losses		x	5.2.8
Backfeed		x	5.2.9
Abnormal operating conditions		x	5.2.10
Transportation and environment		x	5.3.1
Impact and shock		x	5.3.2
Free fall		x	5.3.3
Storage		x	5.3.4
Temperature and humidity		x	5.3.5
Acoustic noise		x	5.3.6
Safety		x	See IEC 62310-1
Electromagnetic compatibility		x	See IEC 62310-2

a) The routine test exemption for input to input and input to output insulation applies only when:

- manufacturing is subjected to a quality control programme that includes sample testing to ensure reproducibility of the type-tested STS

NOTE Annex R of IEC 60950-1 provides examples of requirements for quality control programmes.

- appropriate isolation devices are installed either inside or external to STS – see 5.2.9.

5.2 Electrical tests

5.2.1 Insulation and dielectric

A STS shall be capable of withstanding for 1 min without breakdown the application of a 50 Hz or 60 Hz sinusoidal potential voltage as described below, between:

- a) all primary circuit terminals together and the ground: $2U + 1\,000\text{ V}$;
- b) all terminals of preferred source together and all terminals of alternate source together:
 - $2 \times 2,4 \times (U/1,73)$ or $1\,200\text{ V}$ for 3-phase systems whichever is greater;
 - $2 \times 2,4 \times U$ or $1\,200\text{ V}$ for single-phase systems whichever is greater.

The output terminals shall be connected together and left floating

NOTE 1 Any neutral, if common, should be connected together with the preferred source terminals only.

- c) All terminals of preferred and alternate sources together and all output terminals together:
 - $1,2 \times U \times (1+1/1,73)$ or 600 V for 3-phase systems whichever is greater;
 - $2,4 \times U$ or 600 V for single-phase systems whichever is greater.

NOTE 2 Any neutral, if common, should be connected together with the source terminals only.

NOTE 3 This withstand voltage requirement takes into account the effect of a single fault to ground occurring in an impedance grounded IT system.

Certain devices bridging the insulation under test may be disconnected from one of the test potentials and/or be tested by alternative methods. Examples are devices providing a d.c. path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors, voltage limiting devices or surge suppressors. Subclause 5.2.2 of IEC 60950-1, where applicable, provides further guidance.

U = nominal r.m.s. voltage from phase to phase (in 3-phase systems) or from phase to neutral (in single phase systems). Valid for TN and impedance grounded IT systems. Due consideration applies when other systems are used.

To determine whether a STS complies with the requirements of this test, the device is to be tested by means of a 500 VA or larger capacity transformer, the output voltage of which is capable of being varied. The waveform of the voltage is to simulate a sine wave. The applied potential is to be increased gradually from zero to the required test value, and is to be held at that value for 1 min. The increase in the applied potential is to be at a uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter in the output circuit of the test transformer.

NOTE 4 A d.c. test source in lieu of an a.c. source may be used. The applied d.c. test voltage should be the value of the a.c. r.m.s. test voltage multiplied by 1,414.

Compliance is verified by observing that no arcing occurs during the voltage application and that the STS is functional following the test without the need to replace any component.

NOTE 5 The STS functionality is generally verified while performing the light load tests (see 5.2.2).

5.2.2 Light load and functional test

The light load test is a functional test carried out in accordance with 4.2.2 of IEC 60146-1-1 to verify that the STS is correctly connected and that all functions operate properly. The load applied is limited, for practical and cost reasons, to a percentage of the rated value, for example 10 %. Correct operation of the following shall be verified:

- a) all control switches and other means to activate STS operation;
- b) protective devices (refer 4.2.10 of IEC 60146-1-1);
- c) auxiliary devices, such as contactors, fans, outlets annunciators and communication devices;

- d) supervisory and measuring devices and remote signalling circuits (if any);
- e) automatic transfer test – performed under initially normal conditions by failing and subsequently restoring the preferred input source voltage and by repeating the test on the alternate source;
- f) manual transfer test – performed under normal conditions by altering the preferred source status to alternate in both transfer directions.

Compliance is verified by observation that the devices and functions intended to control, protect, supervise, measure and signal STS activities perform as expected and that the load voltage remains within specified values during the manual and automatic transfers.

5.2.3 No load

The STS output voltage shall remain within the specified values when the STS operates at nominal input voltage and frequency and with no load connected at the output.

5.2.4 Rated load

The STS output voltage shall remain within the specified values when the STS operates at nominal input voltage and frequency and with a linear load simulating 100 % of the rated output current connected at the output.

5.2.5 Transfer

5.2.5.1 Automatic transfer

a) Source fail

While operating at nominal input voltage on both sources and supplying rated (linear) load, the input supply voltage of the preferred source shall be interrupted.

Once the voltage of the preferred source is returned to normal, the STS shall be capable of transferring back (automatically or manually as specified by the manufacturer).

The test shall be repeated for the alternate input source.

b) Undervoltage

While initially operating at nominal input voltage on both sources and supplying light (linear) load, the input supply voltage of the preferred source shall slowly be decreased until automatic transfer occurs.

Once the voltage of the preferred source is returned to normal, the STS shall be capable of transferring back (automatically or manually as specified by the manufacturer).

The test shall be repeated for the alternate input source.

c) Overvoltage

While initially operating at nominal input voltage on both sources and supplying light (linear) load, the input supply voltage of the preferred source shall slowly be increased until automatic transfer occurs.

Once the voltage of the preferred source is returned to normal, the STS shall be capable of transferring back (automatically or manually as specified by the manufacturer).

The test shall be repeated for the alternate input source.

Compliance is verified by recording the transient deviation of the STS output voltage waveform prior to and during the transfer or retransfer as applicable. The STS output voltage waveform shall remain within the critical load voltage protection limits declared by the manufacturer – see 4.1.1.

5.2.5.2 Manual transfer

While operating at nominal input voltage on both sources and supplying rated (linear) load, a manual transfer command shall be initiated.

Where applicable, additional electrical transfers shall be carried out to verify the functionality of any manual tie or bypass switches.

Compliance is verified by recording the transient deviation of the STS output voltage waveform prior to and during the transfer. The STS output voltage waveform shall remain within the critical load voltage protection limits declared by the manufacturer – see 4.1.1.

5.2.5.3 Cross-current

A STS shall be tested to verify that no cross-currents flow between corresponding phases of the input sources during normal operation except for inherent transient currents that may arise during synchronised transfers through STS declared “closed transfer” or “make before break”.

A STS declared to be an “open-transfer” or “break before make” shall be tested to verify that no cross-currents flow between corresponding phases of the input sources during normal operation including during transfer.

Compliance is verified for both synchronous and asynchronous automatic transfers due to over-voltage, under-voltage and loss of phase. All phases shall be tested by checking that the instantaneous currents i_1 , i_2 , i_L , (see Figure 3) are related as:

$$|i_1| + |i_2| = |i_L|$$

NOTE 1 Inherent protective and snubber current excepted.

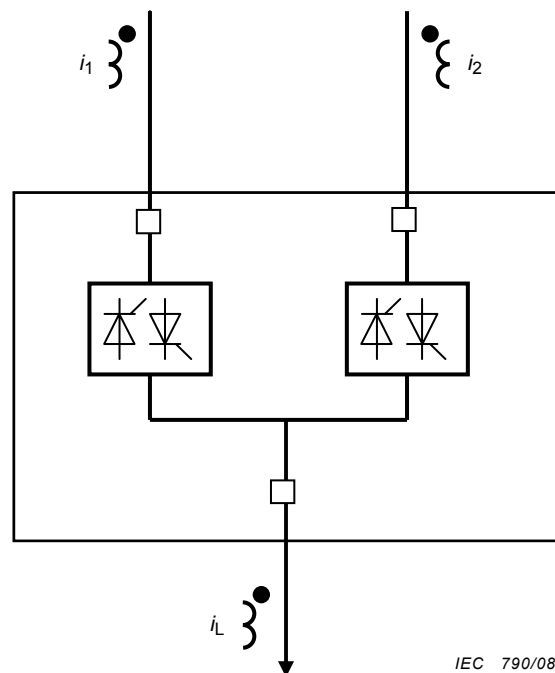


Figure 3 – STS cross-current test

NOTE 2 The test may be performed with the use of summing input and output current transformers (with appropriate polarity).

NOTE 3 The voltage across the three secondaries may be observed on an oscilloscope. Instantaneous cross-current is measured by a deviation from the zero current baselines.

NOTE 4 The thyristor/SCR symbol shown is for illustration purposes and does not preclude the use of other electronic power switching devices.

5.2.6 Source tolerance

The STS output shall be loaded at rated output current.

The input supply shall be from a variable frequency/voltage generator whose output impedance shall be capable of maintaining the voltage wave shape within the limits of IEC 61000-2-2. Alternative test methods in the absence of a variable frequency/voltage generator are permitted.

5.2.6.1 Steady-state voltage

With the alternate source not supplied, the preferred source input frequency set at nominal frequency, and a light load connected to the output of the STS, the input voltage of the preferred source shall be adjusted to the minimum and maximum values of the input voltage tolerance range declared by the manufacturer (see 4.1.2.b). This test shall be performed at all inputs.

Compliance is verified by observing that the STS continuously supplies the load during the test.

NOTE 1 The conditions above represent compatibility requirements for proper operation of the STS and its control circuits.

NOTE 2 Clean load shut-down is acceptable if the source voltage goes beyond the operating limits specified for the load (see 4.1.1 "S").

5.2.6.2 Frequency

The test of 5.2.5.1 shall be repeated with the input frequency adjusted to the limits specified by the manufacturer (see 4.2 b).

Compliance is verified by test, or alternatively by circuit analysis if the STS is not frequency sensitive.

5.2.7 Overload and fault current

5.2.7.1 Overload test

With the STS operating under the test conditions of 4.2, a resistive load shall be applied to simulate the STS overloading declared by the manufacturer (see 4.1). The STS shall continue to operate as declared by the manufacturer within the specified conditions and shall not be damaged. The components of the STS shall not exceed their respective temperature limits.

Compliance is verified by observation that:

- *the STS supplies the load during and after the test,*
- *the temperature of components does not exceed applicable limits and is as specified by the technical data sheets.*

5.2.7.2 Overcurrent clearing capability

The manufacturer shall verify the short time overcurrent capability declared for the purpose of clearing downstream protection devices without adversely affecting the STS performance. This information shall be presented as a percentage of the rated current for 100 ms e.g. "xxx % for 100 ms".

Compliance may be demonstrated through analysis that the over current will be supplied for a minimum of 100 ms without damaging the STS. Alternatively, compliance may be verified by test as follows:

- *connect the STS to a stiff AC source that is capable of maintaining the voltage within the applicable source tolerance classification "S" (see Annex B);*
- *apply the specified overcurrent to the output of the STS;*
- *observe that the STS supplies the load without damage to the STS during and after the test;*
- *observe that the STS does not transfer the load to the alternate source.*

5.2.7.3 Short-circuit test

With the STS operating under the test conditions of 4.2, a light load may be applied if desired. A prospective short time current as specified in Table 3 shall then be applied to the STS output.

If the STS is rated for operation at multiple voltages, a short circuit test shall be performed at the highest nominal rated voltage. Additional rated voltages and short-circuit currents may be tested at the manufacturer's option.

NOTE Annex F provides guidance to the test and to the selection of protective devices.

Table 3 – Short time withstand current

Rated STS current I_e (r.m.s.) A	Prospective test current (r.m.s.) A	Initial asymmetric peak current ratio (A peak / A r.m.s)	Minimum duration of prospective test current cycles (50/60 Hz)
$I_e \leq 16$	3 000	1,42	1,5
$16 < I_e \leq 75$	6 000	1,53	1,5
$75 < I_e \leq 400$	10 000	1,70	1,5
$400 < I_e \leq 500$	10 000	1,70	3,0
$500 \leq I_e$	20 I_e or 50 kA whichever is the lower	$(0,5 I_e + 3 150) / 2 000$ or 2,2 whichever is the lower	3,0

For PC type STS, the manufacturer may declare a conditional short circuit rating in lieu of the short time withstand current rating and, in such a case, shall specify an external protective device, e.g. a circuit breaker or fuse. The prospective test current listed in Table 3 shall then be applied until interrupted by the external protective device.

For CB type STS, the prospective test current listed in Table 3 shall be applied until interrupted by the protective device internal to the STS.

NOTE Depending on the characteristics of the protective device supplied for CB type STS, or specified for conditional withstand current rating of PC type STS, the actual values observed during the test may be lower than those listed in Table 3.

For PC and for CB type of STS, the manufacturer may declare and test at a higher prospective short-circuit current. Refer to Table F.1 for additional guidance.

Compliance is verified at the conclusion of each test by the following criteria:

- a) *no flames, molten metal or burning particles shall be emitted from the STS;*

- b) the STS shall be fully functional with the exception that power switching components are permitted to fail;*
- c) there shall have been no arcing from live parts to the STS chassis or enclosure; NOTE The use of an enclosure test fuse as described in Annex F provides a positive method of verification (fuse opening indicates failure of the test);*
- d) there shall be no damage to the STS to the extent that the integrity of the mounting of live parts is impaired;*
- e) the enclosure door shall not be blown open prevented only by its latch;*
- f) no conductor shall have pulled out of its terminal connector and there shall be no damage to the conductor or conductor insulation;*
- g) the test unit shall successfully pass the dielectric tests as specified in 5.2.1.*

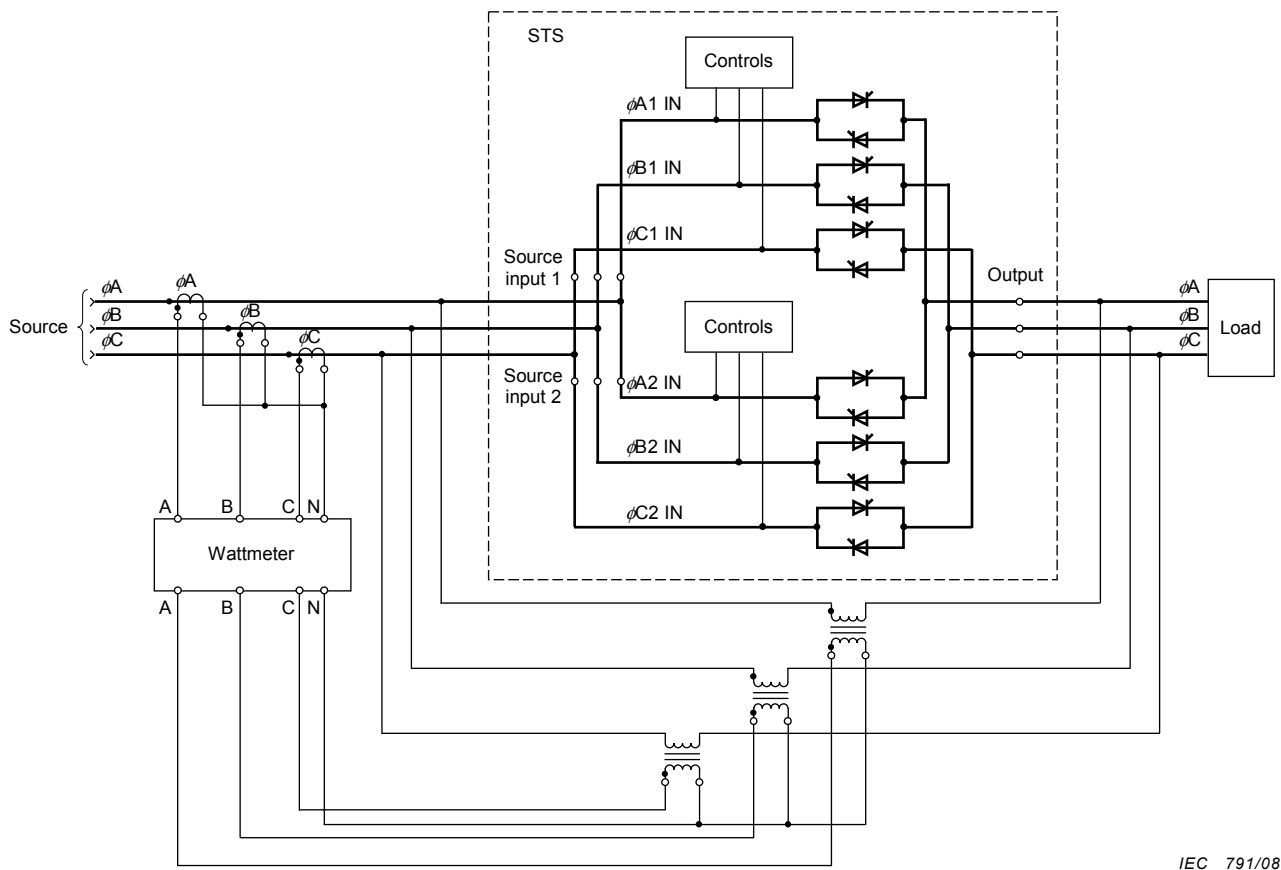
5.2.8 Operating losses

Operating losses are determined while operating the STS at rated (resistive) load within the normal service conditions of 4.2. The active power delivered to the resistive load shall be subtracted from the sum of all active power supplied to the STS from all sources.

$$\text{operating losses (W)} = \text{sum input source (W)} - \text{load (W)}$$

Compliance is verified when the operating losses remain within the limits declared by the manufacturer.

For purpose of testing three-phase STS without neutral switching, a test circuit may be connected as illustrated in Figure 4. Additional requirements apply for three-phase STS with neutral switching. See Clause D.3.



IEC 791/08

Figure 4 – Typical circuit for measuring conduction losses

NOTE 1 The measuring instruments should be true r.m.s. measuring meters and should have full scale accuracy of 1 % or better. Instrument transformers, if used, should have an accuracy of 1 % at rated range.

NOTE 2 The voltage range of the wattmeter used should be 10 V or less. If the voltage range of the wattmeter is greater than 10 V, the accuracy of measurements may be improved by use of typical potential transformers, as shown.

NOTE 3 This test should be conducted at ambient temperature between 20 °C and 30 °C.

NOTE 4 The STS should be operated in the normal mode at rated voltage, current and frequency. For STS rated at multiple voltages, the STS should be operated at the highest rated nominal voltage. The load current should be within 10 % of the rated load current and may have any power factor between unity and 0,10 leading or lagging.

NOTE 5 The measured losses should be adjusted to rated operating losses by the equation:

$$\text{Operating losses (W)} = [\text{Measured losses (W)}] \times \left\{ \left[\frac{I_{\text{rated (A)}}}{I_{\text{Measured (A)}}} \right]^2 \right\}$$

5.2.9 Backfeed

Backfeed protection shall be provided in compliance with 4.2.1.4 of IEC 62310-1.

The backfeed protection control scheme shall reduce the possibility of inadvertent permanent interconnection of the preferred and alternate sources and shall provide, in the event of shorting of one or more of the solid-state switching devices, an action to prevent permanent interconnection of the preferred and alternate sources. The detection circuitry of the control scheme shall be factory-connected and located entirely within the transfer device enclosure.

The backfeed protection shall continue to operate in the intended manner at the conclusion of the performance tests. In addition, all wiring connections shall be examined to determine that

there has been no adverse effect – for example, connections shall not become loose, parts shall not rotate and the like.

Compliance is checked by inspection of the equipment and relevant circuit diagram, and by simulating fault conditions in accordance with Annex G of this standard.

NOTE The backfeed protection prescribed by this standard does not cover the additional system protection required in applications where an energy generating device is connected to the STS output or where a co-generating device is involved for transfer of energy between sources, e.g. as described in IEC 61400-1.

5.2.10 Abnormal operating conditions

5.2.10.1 Unsynchronised transfer

The STS shall supply rated (resistive) load through the preferred source and both preferred and alternate sources shall be at nominal voltage except that the alternate source shall be phase-shifted between 120 electrical degrees and 180 electrical degrees from the preferred source. The input supply voltage of the preferred source shall then be interrupted and the load shall be automatically transferred to the alternate source.

Once the voltage of the preferred source is returned to normal, the STS shall be capable of transferring back (automatically or manually as specified by the manufacturer).

The test shall be repeated for the alternate input source.

Compliance is verified by recording the transient deviation of the STS output voltage waveform prior to and during the transfer or retransfer as applicable. The STS output voltage waveform shall remain within the transient voltage limits declared by the manufacturer for unsynchronised transfers (for guidance, see Annex E).

NOTE 1 The manufacturer may offer a particular unsynchronised transfer management that avoids the high inrush currents and / or back emf normally arising from the transfer of an inductive load, e.g. a transformer, between unsynchronised sources.

NOTE 2 In particular cases, a special load can be used if agreed upon between supplier and purchaser.

5.2.10.2 Forced ventilation test

For the purpose of this test, a STS having forced ventilation shall be operated in the normal mode at rated voltage, current and frequency. For STS rated at multiple frequencies, the blower motors or fans shall be operated at the lowest rated nominal frequency.

At the end of test, the STS shall not reach a temperature at any point high enough to

- a) cause risk of fire,
- b) damage any material used,
- c) exceed specified temperature limits of the components, or
- d) cause a protective device other than over temperature device to operate.

5.2.10.2.1 With the rotor of a blower motor or fan locked, the temperature rise test shall be conducted till the temperatures are stable or the STS is shut down by operation of an over temperature device. For a STS having more than one blower motor or fan, the test shall be conducted with the rotor of each blower motor or fan locked, one at a time.

Exception: If agreeable to all concerned, for a STS having more than one blower motor or fan, the test may be conducted with all blower or fan motors in a unit locked simultaneously.

5.2.10.2.2 A STS having filters over ventilation openings shall be operated with the openings blocked to represent clogged filters. The test shall be conducted initially with the ventilation

openings blocked approximately 50 %, and then shall be repeated under fully blocked condition.

Exception: A single blower or fan with a filter need not be tested under the filter fully blocked condition.

5.2.10.3 Open switching device

If a switching device is detected in open circuit, all switches connected to the corresponding source shall be disabled.

NOTE 1 This requirement prevents applying d.c. voltage to the load or causing phase failure ("single phasing") in multi-phase systems.

NOTE 2 An automatic transfer may be initiated.

Compliance is verified by demonstration.

5.2.10.4 Shorted switching device

If a switching device is detected as shorted, cross-current and backfeed shall be prevented (see 5.2.5.3 and 5.2.9).

Compliance is verified by demonstration.

5.3 Transportation and environment

5.3.1 General

The following test sequences assess the construction of the STS in the shipping container for its resistance to damage by normal handling operations and by environmental changes during transportation. Where practicable, and where the manufacturer selects to carry out transportation type testing, the STS shall meet all the applicable requirements of this subclause.

5.3.2 Impact and shock

The test shall be performed only on STSs with a mass of 50 kg or less excluding container and packing material.

- a) Initial measurements: Check the electrical characteristics of the STS (as described in 5.2.2) before packing it into its shipping state for transportation.
- b) Mode of operation: The STS is non-operational and packed in its normal shipping state for transportation.
- c) Test: The packaged specimen shall be subjected to two 15 g half-sine wave shock pulses, each with a duration of 11 ms. The specimen shall be tested in all three planes; see IEC 60068-2-27 for test methods.
- d) Measurements during testing: No measurements are taken during the test.
- e) Final requirements: After the tests, the STS shall be unpacked and checked for signs of physical damage or distortion to component parts and shall continue to function according to this standard.
- f) Final measurements: Same as initial measurements.

NOTE Initial and final measurements may be combined with the electrical tests of 5.2.

5.3.3 Free fall

The free fall test shall be performed as follows:

- a) Initial measurements: check the electrical characteristics of the STS (as described in 5.2.2).
- b) Mode of operation: The STS is non-operational during the test and packed in its normal shipping state for transportation.
- c) Test: The specimen shall be allowed to fall freely from a point of suspension onto a solid surface; the surface of the package that is caused to touch the solid surface through the fall is the surface on which the package normally rests. The method of test shall be as in IEC 60068-2-32. The following are the minimum requirements.
 - 1) The test shall be carried out twice.
 - 2) The test shall be made with the specimen in its integral transport case or shipping state for transportation.
 - 3) The height of fall shall be according to Table 4.
 - 4) The height of fall shall be measured from the part of the specimen nearest to the test surface.

Table 4 – Free fall testing

Mass of unpacked specimen kg	Height of fall mm
$M \leq 10$	250
$10 < M \leq 50$	100
$50 < M \leq 100$	50
$100 < M$	25

- d) Measurements during testing: No measurement is taken during the test.
- e) Final requirements: After the test, the STS shall be unpacked and inspected for physical damage to component parts, and meet the constructional safety requirements.
- f) Final measurements: Same as initial measurements.

NOTE Initial and final measurements may be combined with the electrical tests of 5.2.

5.3.4 Storage

The storage test shall be performed as follows:

- a) Initial measurements: check the electrical characteristics of the STS (as described in 5.2.2).
- b) Mode of operation: The STS is not operational, but packed in its normal shipping state for transportation and storage with controls set in shipping state.
- c) Tests:
 - 1) Dry heat as per the normal environmental conditions: $+ 55\text{ °C} \pm 2\text{ °C}$ for a duration of 16 h using the test method B6 of IEC 60068-2-2.
 - 2) Damp heat as per the normal environmental conditions: $+ 40\text{ °C} \pm 2\text{ °C}$ at a humidity of 90 % to 95 % for a duration of 96 h using the test method Cb of IEC 60068-2-56.
 - 3) Cold as per the normal environmental conditions: $-25\text{ °C} \pm 3\text{ °C}$ for a duration of 16 h where practicable using test method Ab of IEC 60068-2-1.
 - 4) Damp heat repeated.
- d) Measurements during test: No measurement is taken during the tests.
- e) Final requirements: After the tests, the STS shall be unpacked and inspected for signs of damage to components or corrosion of metallic parts. The STS shall meet the constructional safety requirements.
- f) Final measurements: Allow unit to return to normal ambient temperature and pressure. After tests, the STS shall perform in accordance with the initial characteristics.

5.3.5 Temperature and humidity

The temperature and humidity test shall be performed as follows:

- a) Initial measurements: Check the electrical characteristics of the STS (as described in 5.2.2).
- b) Mode of operation: The STS works in normal mode of operation at rated input voltage and rated output apparent power.
- c) Test: Tests shall be done in the following sequence.
 - 1) Dry heat as per the normal environmental conditions or as per the manufacturer's stated maximum value for a duration of 16 h using test method Bd of IEC 60068-2-2.
 - 2) Damp heat as per the normal environmental conditions: $+ 30\text{ °C} \pm 2\text{ °C}$ at a humidity of 82 % to 88 % for a duration of 96 h using test method Cb of IEC 60068-2-56.
 - 3) Cold as per the normal environmental conditions or as per the manufacturer's stated minimum temperature for a duration of 2 h using test method Ad of IEC 60068-2-1.
 - 4) Damp heat repeated.
- d) Measurements during testing: Measurements are taken during the tests in order to check that the STS continues to function according to this standard in the modes of operation described in 5.2.2 under stabilized temperature conditions.
- e) Final measurements: Same as initial measurements.
- f) Final requirements: After the tests, the STS shall work in accordance with the initial characteristics described in 5.2.2 and meet the constructional safety requirements.

5.3.6 Acoustic noise

The manufacturer shall state in the technical documentation the acoustic noise level of the STS. The measurements shall be made in normal mode of operation, and the values shall be stated in dB curve A at 1 m. The sound measurement shall be made at the normal input voltage and rated linear load in steady-state. Where automatically switched fans are used, these shall be switched on. Audible alarms are excluded from the measurement. The method of measurement shall be as specified in ISO 7779 and shall be governed by the normal positioning expected in use (for example, table-top, wall-mounted or free-standing).

Annex A (normative)

Reference load

A.1 General

Except where otherwise declared by the STS manufacturer, and in this case subject to an agreement between the manufacturer and the purchaser, a STS shall be suitable for the supply of both linear and non-linear loads as described in this annex.

The load is characterised by the following symbols:

S = output apparent power in VA

P = output active power in W

λ = power factor = P/S

U = output voltage in V

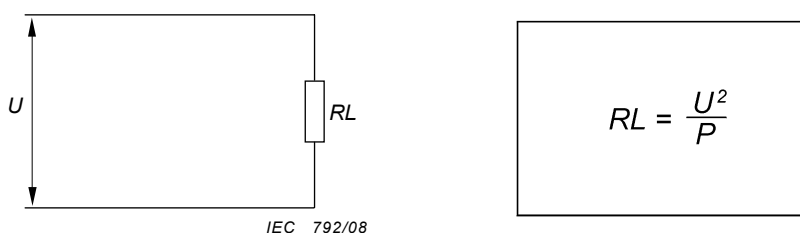
f = frequency in Hz

NOTE 1 A linear load presents a current waveform with a shape similar and proportional to the supply voltage. When a sinusoidal voltage is supplied to a linear load, the resulting current will be sinusoidal also. Common linear loads are either resistive, inductive-resistive or capacitive-resistive.

NOTE 2 A non-linear load presents a current waveform with a shape that differs from that of the supply voltage. When a sinusoidal voltage is supplied to a non-linear load, the resulting current will be non-sinusoidal. Such non-sinusoidal current can however be understood as being the sum of several sinusoidal currents of different frequencies (namely the fundamental and the harmonic frequencies). Common non-linear loads are rectified capacitive (e.g. switch mode power supplies) or phase controlled (e.g. variable speed drives). In the low power range < 3 kVA, the rectifier in bridge connection with capacitive load is the most common.

A.2 Reference resistive load (linear)

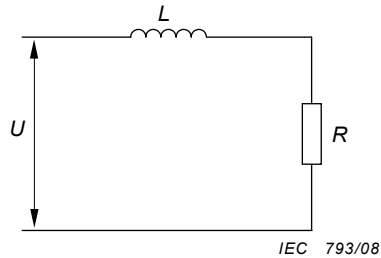
For resistive loads, the STS is loaded with a resistor up to nominal power.



A.3 Reference inductive-resistive load (linear)

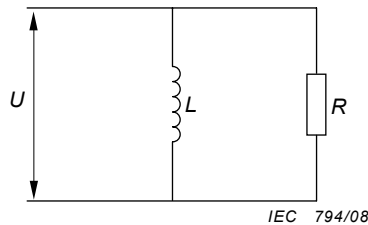
For inductive-resistive loads, an inductance is connected in series or in parallel with a resistor. The resistor (R) and inductance (L) are given by the following formulae:

a) series connection



$R = \frac{U^2}{S} \lambda$	(Ω)
$L = \frac{U^2 \sqrt{1 - \lambda^2}}{2 \pi f S}$	(H)

b) parallel connection

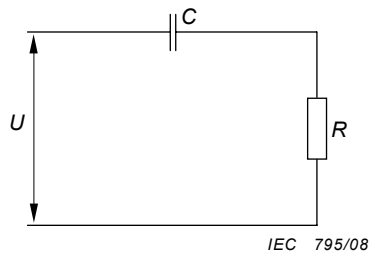


$R = \frac{U^2}{S \lambda}$	(Ω)
$L = \frac{U^2}{2 \pi f S \sqrt{1 - \lambda^2}}$	(H)

A.4 Reference capacitive-resistive loads (linear)

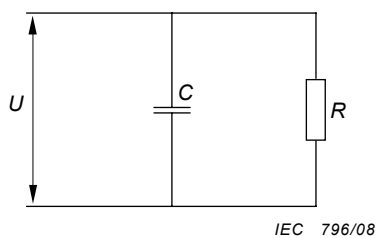
For capacitive-resistive loads, a capacitance and a resistor are connected either in series or in parallel. The resistor (R) and capacitance (C) are given by the following formulae:

a) series connection



$R = \frac{U^2 \lambda}{S}$	(Ω)
$C = \frac{S}{2 \pi f U^2 \sqrt{1 - \lambda^2}}$	(F)

b) parallel connection



$R = \frac{U^2}{S \lambda}$	(Ω)
$C = \frac{S \sqrt{1 - \lambda^2}}{2 \pi f U^2}$	(F)

A.5 Reference non-linear load

To simulate a single-phase steady state rectifier-capacitive load, the STS is loaded with a diode-rectifier bridge which has a capacitor and a resistor in parallel on its output.