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Foreword

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International Standard ISO 8568 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock.*

Annexes A, B and C of this International Standard are for information only.

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Mechanical shock — Testing machines — Characteristics and performance

1 Scope

This International Standard provides guidance covering the characteristics and performance parameters of shock-testing machines. It is intended to ensure that the potential user of a particular shock machine is provided with an adequate description of the characteristics of the machine and to give guidance for the selection of such machines.

The shock-testing machines considered in this International Standard are only those used for diagnostic testing and for demonstrating or evaluating the effect of shock conditions representative of the service environment. Machines used for metal working, forming, etc., are excluded. Several techniques for generating the desired shock motion are discussed.

Machines and methods used to provide empirical service shock conditions are not covered in this International Standard.

Environmental shock test requirements frequently occur in conjunction with vibration test requirements. Vibration generators can be used when frequency, velocity change and displacement requirements for the specified shock are within the capabilities of the machine. Both simple-pulse and complex transients may be produced. The simulation of transients can be achieved by control of the test with a specified shock spectrum. Making use of test equipment and fixtures already on hand or justified for vibration testing alone has obvious economic advantages for environmental test laboratories. Characteristics of vibration-generating units are covered in ISO 5344, ISO 6070 and ISO 8626.

NOTE — Annex A gives information on pulse-shaping devices. Annex B defines the shock response spectra and pulse shape of the initial sawtooth pulse.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard 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 2041 : 1975, *Mechanical vibration and shock — Vocabulary.*

IEC 68-1 : 1982, *Basic environmental testing procedures — Part 1: General and guidance.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 2041 apply.

NOTE — For the purposes of this International Standard, the term "machine" is intended to include the physical assembly that generates the shock and applies it to the test specimen, as well as all auxiliary power, cooling, control, pulse shaping, and monitoring equipment necessary to form a complete system.

4 Shock-testing machines

Shock-testing machines are usually described according to the way in which the test is activated or the principle used, for example free-fall (gravity-activated), or accelerated shock-testing machines or gas gun, explosive gun, hydraulic and pneumatically driven shock-testing machines. Electrodynamic and servo-hydraulic test equipment for generating vibration is also used for shock testing. These machines have limited velocity and displacement capability. Since the techniques used to stay within these velocity and displacement limits are not yet standardized, these machines are treated only briefly in this International Standard.

Two types of shock test are common:

a) **Shock pulse reproduction**: The classic shock pulse shapes are generated, with additional pre-pulse and post-pulse shaping to limit velocity and displacement. The amplitude of the pre-pulse and post-pulse shapes are limited to a small fraction of the primary pulse amplitude.

b) **Shock response spectra reproduction**: A brief oscillatory transient impulse is applied to the specimen. The shock response spectrum is measured, compared with the desired shock response spectrum, and the difference used to modify the shape of the next impulse. The desired shock spectrum may be either one of the shock spectra of annex B or the shock spectrum of a field environment. Typically the input transient impulse is generated as the sum of a large number of impulse shapes, each with a zero net displacement and velocity change, but with different frequency spectra.

4.1 General

The energy needed to create a shock may be achieved by gravity (free-fall) or, if the shock has to be in a direction other than downwards or if the free-fall machine does not provide enough velocity change, the necessary potential energy may be supplied by elastic cords, springs or hydraulic and pneumatic means. The shock can also be achieved by releasing compressed gas, by explosives or by transfer of momentum from one moving mass to another.

The shock pulse — either a single-pulse or a transient vibration — is produced by a shock pulse-shaping device mounted either on the table or carriage, on the reaction mass, or on both. A wide selection of pulse shapes can be produced depending on how the kinetic energy is transferred by the pulse-shaping devices.

A shock-testing machine consists of

- a rigid table or carriage with means of attaching test specimens and shock pulse-shaping devices;
- a set of guides that control the movement of the carriage;
- a means for storing the potential energy necessary for imparting the shock, such as provisions for hoisting or preloading springs and cords attached to the carriage;
- a means for securing the carriage at a selected drop height or position, prior to initiation of the shock pulse;
- release mechanism;
- a reaction mass or base upon which the carriage impacts;
- a rebound braking system;
- auxiliary power, cooling, control, pulse-shaping, and monitoring equipment, as required.

4.1.1 Conventional shock-testing machines

The performance of the machine shall be defined and specified by the manufacturer.

The motion of the table or carriage may be specified by shock spectra and/or time-history parameters. Where applicable, data, together with tolerances, shall be given for the following items:

a) available pulse shapes;

b) the maximum velocity change;

c) the maximum displacement;

d) peak acceleration;

e) initial or pre-pulse acceleration and final or post-pulse acceleration;

f) range of shock-pulse durations;

g) maximum drop height, preload pressure or charge;

h) tare weight of table or carriage and total moving mass;

i) maximum stiffness, strength and damping of the table or carriage;

j) natural frequencies of the table or carriage;

k) natural frequencies of the machine on its foundation;

l) required pressure and volume of gas and liquids;

m) quantities and flow rates of fluid or gas for the operation of the machine;

n) type of rebound braking system and braking force;

o) size and overall dimensions of the machine and its parts, especially the table or carriage and its accessories;

p) dimensions, weight and mounting method of reaction masses and floor loading requirements;

q) maximum size and mass of test specimen;

r) mounting facilities for test specimen and transducers;

s) calibration data;

t) number of shocks (shock pulses) possible per unit time, or alternatively, minimum period between two shocks.

Installation dimensions shall include adequate working room, overhead clearances and walk-ways around the equipment.

Guns shall be located in restricted remote areas with adequate blast-proof enclosures for the protection of personnel. The maximum gas pressures external to the gun and sound pressure levels shall be specified.

The electrical power requirements shall be stated. The normal operation of the machine shall not cause any interference in the power network that might affect the test monitoring instrumentation.

The table or carriage, piston or sabot shall be securely retained and fixed when being made ready for testing. The table or carriage shall be prevented from striking the reaction mass while personnel are assembling pulse-shaping devices.

Detailed installation, operation and maintenance instruction manuals shall be provided by the manufacturer.

Instructions shall be given for periodic inspection, maintenance and lubrication of the equipment. The signs of wear of replaceable components and possible structural failure shall be described by the manufacturer.

Appropriate steps shall be proposed for reconditioning deteriorated pulse-shaping devices and repairing leaks in the pneumatic and hydraulic systems.

The application and mounting of test specimens, adaptor plates and fixtures to the table or carriage shall be thoroughly described. The effects on the test of eccentric or faulty loading of the carriage shall be explained.

A procedure shall be specified for performing a shock calibration test for periodic evaluation of system performance.

A periodic check of the test equipment characteristics shall be carried out in accordance with the specified control method or manual.

4.2 Requirements for shock-testing machines

4.2.1 General

The release or firing shall only be possible on command. The release mechanism shall be fail-safe and it shall be impossible to accidentally activate the release mechanism, for example by providing two simultaneously activated switches; one of which is lockable.

The overall machine design and installation shall provide sufficient safety and protect personnel from flying objects if the equipment or test specimen fails structurally.

Adequate seals shall be used to prevent blow-out of fluids during the test.

All sections of barrels, cylinders and piping shall be designed with an adequate safety factor. The maximum expected pressures produced throughout the worst case test shall be considered.

Gases which are likely to be compressed during testing shall not present any risk of spontaneous combustion by self-ignition. It should be considered that shock-testing machines can be used for human exposure testing and should therefore have proven reliability and safety. For such machines, the table or carriage shall be accessible immediately after the impact so that the human subject can be released quickly.

4.2.2 Table or carriage

The table or carriage (piston, sabot, spigot or tubes) and all accessories used for movement of the test specimen during the shock test shall be designed for maximum stiffness, strength and damping.

The means of attaching a test specimen and the limits of torque to be applied to the fixing screws shall be indicated.

In the case of test tables, it shall be stated whether or not they are fitted with replaceable threaded inserts and whether they are recessed or raised.

All test specimen mounting surfaces shall be geometrically flat and of minimum roughness and the applicable tolerances shall be stated. If the surface is fitted with recessed inserts, the flatness of the whole surface shall be indicated for normal reference atmospheric conditions (see IEC 68-1 : 1978, chapter 5). If replaceable raised inserts are provided the resulting co-planarity of the insert surfaces shall be given, based on the thickness tolerance of the insert flanges and the flatness of the insert mounting surface.

The maximum torque to be applied to replaceable inserts during installation shall be stated along with the types of materials being mated.

A dimensioned drawing or diagram shall be provided giving all dimensions of the table or carriage, the dimensions and positional tolerances of the inserts and the material from which they are made.

The maximum permissible torque and axial force that may be applied to the inserts shall be stated, along with the required perpendicularity of the test specimen fixing screws with respect to the mounting surface.

4.2.3 Hoisting or preloading

The free-fall and the accelerated shock-testing machines and machines that use a hammer or a pendulum shall be supplied with mechanisms for hoisting and preloading the carriage to a predetermined drop height or tension, for example by means of a built-in height- or angle-measuring scale with a residual indicator.

The precision of the drop height or preload setting shall be specified together with tolerances.

The machine shall be fitted with devices to stop the carriage automatically or to indicate to the operator when the carriage has reached a predetermined drop height or preload.

The manufacturer shall specify the maximum drop height or preload.

If the test has to be aborted, it shall be possible to disarm the machine and safely lower the table or carriage.

4.2.4 Braking

Shock-testing machines should be equipped with adequate braking systems. Braking may be achieved by mechanical, electrical, pneumatic or hydraulic devices; shock-absorbing materials or parachutes may be employed on devices that are in free trajectory and shall be recovered with minimum damage.

The design of the braking system shall ensure that minimum vibration is super-imposed on the pulse trace and that shock tests can be limited to a single pulse.

Acceleration limits for braking shall be given by the manufacturer together with information on the braking force required for controlled braking.

The magnitude of acceleration applied during braking should not exceed 25 % of that applied during the test pulse.

A shock-testing machine not equipped with a braking system should be adequately marked and by other means prevented from causing damage.

4.2.5 Reaction mass

If a reaction mass is used, it shall be a large and rigid structure by comparison with the table or carriage.

The resonance of the reaction mass shall have sufficiently high frequencies to avoid distortion of the shortest shock pulse duration for which the machine is rated.

Seismically-suspended reaction masses can be used. They can be installed where the shock has to be isolated from the surroundings and where reduced dynamic floor loading is required. They can also be used in order to control the recoil motion of the shock table or carriage by momentum transfer to the reaction mass.

The manufacturer shall provide or recommend dimensions, weights and ratio between the moving mass including the test specimen and the reaction mass, together with mounting methods.

4.2.6 Shock pulse-shaping devices

The springs, impact pads and pulse programmers or generators used for controlling the shock pulse, i.e. the pulse shape, duration and acceleration, depend on the dynamic force-deflection characteristics of the pulse-shaping device.

If two or more masses are involved in a momentum exchange, the shock motion of each mass shall be taken into consideration in the design of the shock pulse-shaping device.

Any equipment needed to form the pulse-shaping devices, for example moulds for making lead forms, shall be specified (see annex A).

Annex A
(informative)

Devices for shaping various pulse shapes

A.1 Devices for shaping half-sine and triangular pulses

The half-sine and triangular shock-pulse shapes are usually generated by various rebounding devices. The combination of the impacting mass and the pulse-shaping device then simulates the classic undamped one-degree-of-freedom spring-mass system, and the shock pulse is one-half cycle of the oscillation of this system. The shock pulse-shaping device acts as the spring. A perfectly linear or quasi-linear spring (linear force versus deflection) will generate a half-sine pulse. Progressively greater non-linear stiffening spring characteristics will generate cusp pulses approximating triangular shapes.

A.1.1 Elastomer pulse-shaping devices

Elastomers are quasi-elastic pulse-shaping devices and are normally used to generate half-sine pulses where high spring rates are required; triangles or parabolic cusps result as the material is more highly strained. Materials include rubber and rubber-like plastics and are generally reusable for many shock pulses.

A.1.2 High-strength plastics

High-strength plastic materials are quasi-elastic, pulse-shaping devices normally used to generate short-duration half-sines where a high dynamic spring rate is required. Many high-strength plastics can be used, for example polypropylene, vinylidene chloride, acetyl homopolymer resins and fibre-laminated phenolics. Normally, the pulse-shaping device is designed with a maximum stress within the elastic limits, allowing multiple reuse. Triangles can be generated when these materials are compressed in series with materials offering an appropriate linear stiffness.

A.1.3 Liquid and quasi-liquid springs

A liquid spring is a quasi-elastic, pulse-shaping device that is normally used to generate half-sine pulses. A liquid spring is a hydraulic cylinder in which a liquid (for example hydraulic oil) is compressed during pulse generation. Variation in design configuration can permit spring-rate variation for changes in pulse duration and peak acceleration. The spring can be reused without recharging. Quasi-liquid springs contain pliable elastomers that operate like a liquid spring.

A.1.4 Gas spring (variable force)

A gas spring is an elastic, pulse-shaping device that may be designed to produce some variably shaped, symmetrical pulses depending upon the initial precharge or preload pressure in the spring, the initial volume, and the change in volume during the shock. Generally, a low precharge pressure and a great decrease in volume (with respect to the initial volume) will produce a cusp pulse. Nitrogen is normally used.

A.2 Devices for shaping rectangular and trapezoidal pulses

Rectangular and trapezoidal pulses require a pulse-shaping device that exerts a constant force with time (and deflection). Such a device may behave inelastically or elastically.

A.2.1 Moulded lead forms

Lead moulded into pellet form and different types of lead blocks can be used to make crushable rectangular pulse-shaping devices. These devices are limited to shorter stroke pulses. The lead pellet or block is replaced after each test; however, the lead may be melted and remoulded.

A.2.2 Honeycomb

Honeycomb is an inelastic, pulse-shaping device that can be produced with metallic or fibrous materials made into thin-walled cells that buckle and permanently deform during loading. It can be shaped to produce controlled-rise-time, trapezoidal pulses. The honeycomb is replaced after each test.

A.2.3 Gas spring (quasi-constant force)

Gas springs are often used to generate rectangular or trapezoidal pulse shapes. The spring usually has a high precharge pressure and small volume change (with respect to initial volume) which produces a quasi-constant force during the spring deflection. When used in series with elastomers or liquid springs, this spring generates trapezoidal pulses.

Electrodynamic and servo-hydraulic test equipment for generating vibration can be used to generate rectangular pulses.

A.3 Devices for shaping peak-sawtooth pulses

The pulse-shaping device for peak sawtooth pulses shall have a linear stiffening compression spring rate. The pulse-shaping device for the final-peak sawtooth pulse shall have a non-linear stiffening compression spring rate. The force output decays rapidly to zero when it reaches its peak value. Because of their asymmetry, these pulses are always generated with non-rebounding devices.

A.3.1 Moulded lead forms

Moulded lead is a relatively inelastic deformation-type pulse-shaping device, the shape of the lead determining shock-pulse shape. For example, crushing a conical form generates a terminal-peak shock pulse approximating a sawtooth. The form may be used only once, since its shape is destroyed during the shock pulse. However, the lead may be melted and remoulded.

A.3.2 Shaped honeycomb

Different configurations of honeycomb (described in A.2.2) may be used to generate non-symmetrical pulse shapes, for example a sawtooth pulse shape is generated if the honeycomb is a triangular prism shape where the cross-sectional area of contact increases linearly with deformation.

A.3.3 Precharged differential-area gas cylinders

Precharged differential-area gas cylinders used in series with quasi-elastic materials can provide the combination of a constant or stiffening-spring-rate device and a rapid-force-decay device. The rise-time portion of the pulse is controlled by the quasi-elastic materials; the maximum amplitude, and the fall time, by the gas cylinder.

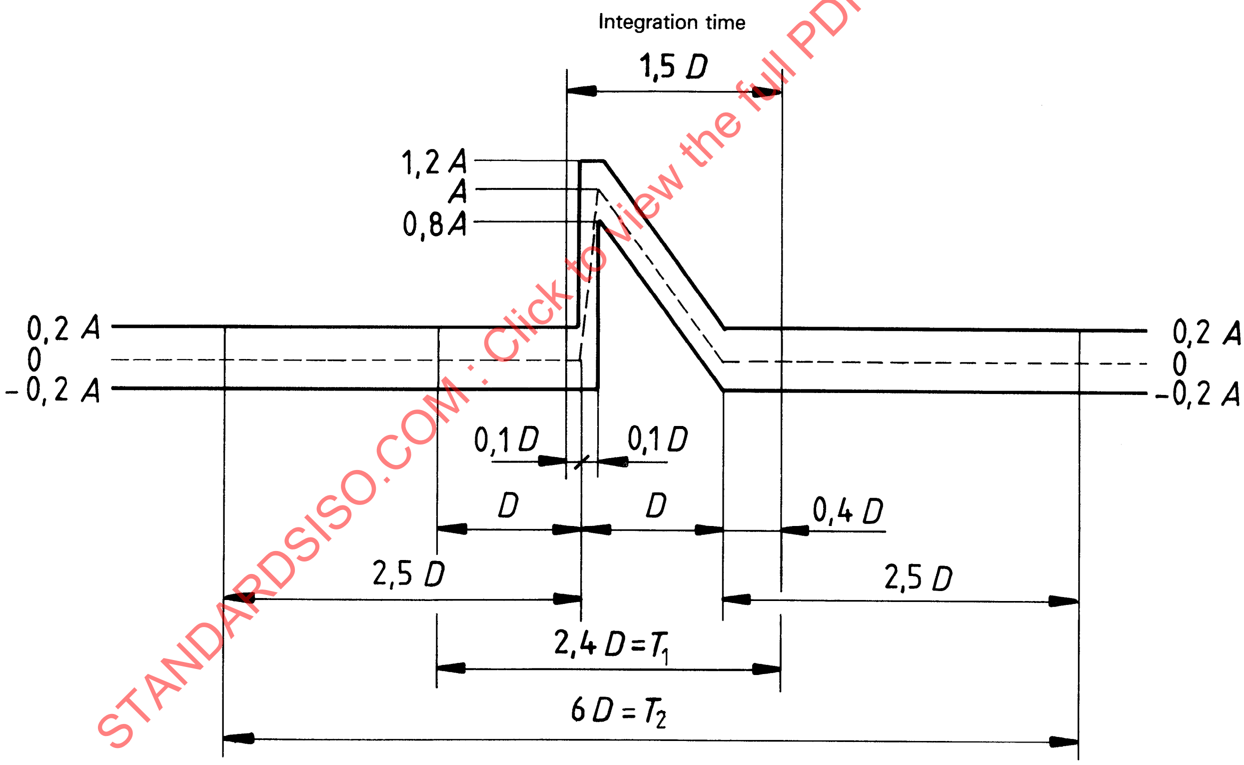
Annex B
(informative)

Shock response spectra and other characteristics of pulse shapes

B.1 Introduction

IEC 68-2-27 : 1987, *Test Ea and Guidance: Shock,* requires one of three pulse shapes, the final-peak sawtooth pulse, the half-sine pulse and the trapezoidal pulse, with a stated severity, to be applied to the specimen fixing points and does not restrict the testing to specific machines. The choice of pulse shape and severity should be made in accordance with technical considerations appropriate to the project or type of specimen.

All methods should be regarded as acceptable from the standpoint of reproducibility of the specified test condition and for reproducing the effects of actual shock environments. In order to obtain tests which are both reproducible and which can be related to practical application, certain basic concepts have been taken into consideration in producing the test procedure for the shock test. The concepts involved are given in Appendix B of IEC 68-2-27 : 1987. This annex adds the initial sawtooth pulse to the three pulses given in IEC 68-2-27 : 1987. See figures B.1 and B.2.



Key

--- nominal pulse

— limits of tolerance

D = duration of nominal pulse

A = peak acceleration of nominal pulse

T_1 = minimum time during which the pulse shall be monitored for shocks produced using a conventional shock-testing machine

T_2 = minimum time during which the pulse shall be monitored for shocks produced using a vibration generator

Figure B.1 — Initial-peak sawtooth pulse