SVENSK STANDARD
SS-ISO 8727:2018

Fastställd/Approved: 2018-09-11
Utgåva/Edition: 1
Språk/Language: engelska/English
ICS: 13.160

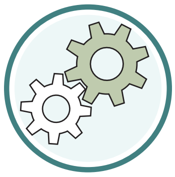
-

Mechanical vibration and shock – Human exposure – Biodynamic coordinate systems (ISO 8727:1997, IDT)

Standarder får världen att fungera

SIS (Swedish Standards Institute) är en fristående ideell förening med medlemmar från både privat och offentlig sektor. Vi är en del av det europeiska och globala nätverk som utarbetar internationella standarder. Standarder är dokumenterad kunskap utvecklad av framstående aktörer inom industri, näringsliv och samhälle och befrämjar handel över gränser, bidrar till att processer och produkter blir säkrare samt effektiviserar din verksamhet.

Delta och påverka
Som medlem i SIS har du möjlighet att påverka framtida standarder inom ditt område på nationell, europeisk och global nivå. Du får samtidigt tillgång till tidig information om utvecklingen inom din bransch.



Ta del av det färdiga arbetet
Vi erbjuder våra kunder allt som rör standarder och deras tillämpning. Hos oss kan du köpa alla publikationer du behöver – allt från enskilda standarder, tekniska rapporter och standard-paket till handböcker och onlinetjänster. Genom vår webbtjänst e-nav får du tillgång till ett lättnavigerat bibliotek där alla standarder som är aktuella för ditt företag finns tillgängliga. Standarder och handböcker är källor till kunskap. Vi säljer dem.

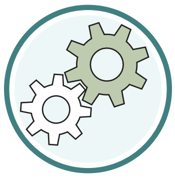
Utveckla din kompetens och lyckas bättre i ditt arbete
Hos SIS kan du gå öppna eller företagsinterna utbildningar kring innehåll och tillämpning av standarder. Genom vår närhet till den internationella utvecklingen och ISO får du rätt kunskap i rätt tid, direkt från källan. Med vår kunskap om standarders möjligheter hjälper vi våra kunder att skapa verklig nytta och lönsamhet i sina verksamheter.

Vill du veta mer om SIS eller hur standarder kan effektivisera din verksamhet är du välkommen in på www.sis.se eller ta kontakt med oss på tel 08-555 523 00.

Standards make the world go round

SIS (Swedish Standards Institute) is an independent non-profit organisation with members from both the private and public sectors. We are part of the European and global network that draws up international standards. Standards consist of documented knowledge developed by prominent actors within the industry, business world and society. They promote cross-border trade, they help to make processes and products safer and they streamline your organisation.

Take part and have influence
As a member of SIS you will have the possibility to participate in standardization activities on national, European and global level. The membership in SIS will give you the opportunity to influence future standards and gain access to early stage information about developments within your field.



Get to know the finished work
We offer our customers everything in connection with standards and their application. You can purchase all the publications you need from us - everything from individual standards, technical reports and standard packages through to manuals and online services. Our web service e-nav gives you access to an easy-to-navigate library where all standards that are relevant to your company are available. Standards and manuals are sources of knowledge. We sell them.

Increase understanding and improve perception
With SIS you can undergo either shared or in-house training in the content and application of standards. Thanks to our proximity to international development and ISO you receive the right knowledge at the right time, direct from the source. With our knowledge about the potential of standards, we assist our customers in creating tangible benefit and profitability in their organisations.

If you want to know more about SIS, or how standards can streamline your organisation, please visit www.sis.se or contact us on phone +46 (0)8-555 523 00

Den internationella standarden ISO 8727:1997 gäller som svensk standard. Detta dokument innehåller den officiella engelska versionen av ISO 8727:1997.

The International Standard ISO 8727:1997 has the status of a Swedish Standard. This document contains the official English version of ISO 8727:1997.

Upplysningar om sakinnehållet i standarden lämnas av SIS, Swedish Standards Institute, telefon 08-555 520 00. Standarder kan beställas hos SIS som även lämnar allmänna upplysningar om svensk och utländsk standard.

Information about the content of the standard is available from the Swedish Standards Institute (SIS), telephone +46 8 555 520 00. Standards may be ordered from SIS, who can also provide general information about Swedish and foreign standards.

Denna standard är framtagen av kommittén för Människans påverkan av vibrationer, SIS/TK 111/AG 01.

Har du synpunkter på innehållet i den här standarden, vill du delta i ett kommande revideringsarbete eller vara med och ta fram andra standarder inom området? Gå in på www.sis.se - där hittar du mer information.

Contents

Foreword

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

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

International Standard ISO 8727 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock,* Subcommittee SC 4, *Human exposure to mechanical vibration and shock.*

Annexes A to C of this International Standard are for information only.

Introduction

For many purposes in biodynamics and in human vibration engineering practice, it is necessary to define the point of origin, magnitude, and direction of a mechanical input or response (force or motion) with respect to a specific orthogonal coordinate system. Biodynamic coordinate systems require a defined point of origin within the human body or within an external frame of reference to which an anatomical coordinate system may be related. Applications include the evaluation of human exposure to vibration and shock, the precise definition of the functional location and orientation of biodynamic instrumentation systems, the biodynamic modelling of force and motion inputs to the human body and its parts or segments, and inter-subject or inter-species comparisons of biodynamic data.

For the purpose of data comparison between individuals (or between repeated measurements in the same individual), between persons and human analogues, or between measured data and a standard prescribing boundaries of acceptable mechanical inputs to the human body or its segments, it is imperative that any anatomical coordinate system used originates in and is oriented with respect to recognized, firm, and radiographically or stereotactically determinable (hence, skeletal) anatomical landmarks. This International Standard embodies that fundamental principle: it specifically deprecates using systems loosely defined as centred in the heart or other soft and mobile structures. Precise definition of anatomical coordinate systems is fundamental to biodynamical science, because all biodynamic measurements must ultimately be related to the bony anatomy of the human body.

Mechanical vibration and shock — Human exposure — Biodynamic coordinate systems

1 Scope

This International Standard specifies anatomical and basicentric coordinate systems for biodynamical measurements, for reference purposes in cognate standards development, and for precisely describing human exposure to mechanical vibration and shock. The segmental anatomical coordinate systems defined in this International Standard are for the head, root of the neck (driving-point for the head and neck system), pelvis, and hand. General principles are stated for the establishment of corresponding anatomical coordinate systems for other skeletal body segments. The biodynamic coordinate systems defined in this International Standard can serve as frames of reference for the description and measurement of both translational and rotational vibration and shock motion affecting humans.

NOTES 1 Although defined for human subjects, these anatomical coordinate systems are adaptable, using a knowledge of comparative anatomy, to non-human primates or to other animal species whose skeletal anatomy is recognizably comparable, radiographically, with the relevant anatomy of humans.

2 When the need arises for other segmental anatomical coordinate systems (e.g. for the arm, wrist, leg or foot), these should be defined according to corresponding principles of anatomy and of standardization, and may be proposed for inclusion in subsequent revisions of this International Standard.

3 This International Standard recognizes no difference between male and female skeletal anatomy bearing upon the definition and use of biodynamic coordinate systems. Moreover, the same principles apply when defining anatomical coordinate systems for children, and for non-human mammalian species used in ethical biodynamics research, development, testing and evaluation.

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 subjected 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 1503:1977, *Geometrical orientation and directions of movements.*

ISO 5805:1997, *Mechanical vibration and shock — Human exposure — Vocabulary.*

3 Biodynamic coordinate systems

Standard biodynamic coordinate systems shall be used, if practicable, whenever collecting, transforming, analysing, reporting, describing, comparing, or evaluating human mechanical vibration and shock input data and consequent human body structural and system responses.

NOTES 1 A biodynamic coordinate system may be oriented with respect to a hierarchy of coordinate systems within inertial space (see figures A.1 and A.2). Such inertial reference systems may be geocentric, in which the principal or normal axis lies in the direction of earth's gravity, or basicentric, originating in the contacting surface (or some fully orientatable structure connected rigidly thereto) through which the force or motion of interest is transmitted to the body. Basicentric coordinate systems may, for example, be defined with respect to the structure of a vehicle, a workplace, or a laboratory, to an immediate source of vibration or shock affecting persons, such as a vibrating tool or appliance, or to a research vibration machine, motion simulator or impact device. For research and evaluation purposes, a biodynamic coordinate system may itself provide the external frame of reference for an instrumentation coordinate system, used to define inertial measurements made upon or within the human body.

2 Geometrically speaking, the human body may, for any given posture, be treated as a fully-oriented object (see figure A.3).

3 The use of coordinate systems originating in amorphous or flexible soft-tissue or surface anatomical features which are deformable or freely mobile within the body (e.g. coordinate systems loosely defined as centred in the heart or the buttocks) precludes the precise acquisition or comparison of biodynamic data, and is accordingly deprecated. The anatomical systems defined in this International Standard all originate in, and are oriented with respect to, radiographically or stereotactically determinable (including palpable) bony landmarks. Moreover, these systems are adaptable, for the purpose of comparative biodynamics, to mammalian species other than humans, and to mechanical analogue models (dummies or manikins) of humans.

4 A radiographically determinable landmark means one that, for research or reference purposes, can be visualized, and its position measured, by methods of X-ray or ultrasonic radiographical anthropometry. It may also be (but not necessarily is) determinable stereotactically, if it is palpable (or reliably related to structures that are palpable) in the surface anatomy. It is of course recognized that in many areas and applications it may be impossible or impractical to define the relevant bony anatomy by radiographical methods. Nevertheless, the applicable anatomical coordinate system or systems should be identified when inertial measurements are made on humans, and the measurements related to the standard anatomical coordinate system(s) to the extent practicable.

3.1 Direction

All orthogonal coordinate systems adopted in biodynamics shall be defined as right-handed (see figure A.4). Definitions of *x*-, *y*- and *z*-axes for anatomical coordinate systems shall be in accordance with ISO 5805 (see figures A.5 and A.6 for examples of these axes). Definitions of orientations and axes for basicentric systems (e.g. in vehicles) shall be in accordance with the principles of ISO 1503.

NOTE — An exception to the rule regarding right-handedness of the coordinate system may be made in the case of the anatomical coordinate system (hand) adopted specifically for measurements in the left hand (see 3.4.1).

3.2 Biodynamic coordinate systems for the whole body

3.2.1 Whole-body anatomical coordinate system

For most purposes (for example, when considering force or motion inputs to the whole body from a contact or supporting surface upon which the person is standing, sitting or lying), the anatomical coordinate system of choice shall be that defined for the pelvis (see 3.3.4).

NOTES 1 When practical considerations clearly dictate that it is more appropriate to do so, whole-body inputs may be defined with reference to an alternative system within the torso, which, together with the posture and the orientation of the body with respect to the source of the vibration or shock, should be defined unambiguously when reporting data referenced to this alternative coordinate system. For example, whole-body inputs applied mainly to a person's back, as from a vibrating seat-back or a motorized backpack appliance, may be related to the upper torso anatomical coordinate system. Unless otherwise specified, whole-body vibration or shock shall be deemed to be applied to persons in the (conventional) "normal" anatomical position, that is, with the *z*-axis of the principal axial segmental (i.e. head and trunk) anatomical coordinate systems approximately parallel, the limbs aligned, and the palms facing forward. When a particular posture is adopted (e.g. sitting) during human vibration measurements, as precise an attempt as possible should be made to specify the relative orientation of segmental coordinate systems relevant to the measurement. This may be done by quantifying the extent of rotation of the principal axes of each segmental anatomical coordinate system (and, if appropriate, displacement of the system's origin) with respect to its normal anatomical position.

2 Bilateral (left-right) skeletal symmetry of the human body is an assumption implicit in the adoption of the anatomical coordinate systems recommended in this International Standard.

3.2.2 Basicentric coordinate systems for the whole body

3.2.2.1 Basicentric coordinate system for standing persons

Origin: The midpoint of a line in the plane of a contact surface (e.g. a ship's deck or the floor of a vehicle containing standing crew or passengers) supporting the standing person, passing beneath the lowermost points of the heel bones (calcanei).

NOTE — The orientation of this line in the plane of the contact surface can be defined with respect to the coplanar orientation of that surface as a practical matter, when there is a habitual stance upon it (e.g. of a human operator at a workstation).

Orientation: The *y*-axis is the line defined above, with the positive direction lying to the subject's left. The *x*-axis passes through the origin, lies in the plane of the contact surface, and is perpendicular to the *y*-axis. The *z*-axis is mutually perpendicular to the other two axes (hence, normal to the contact surface).

NOTE — The orientations of a basicentric coordinate system with respect to the direction of gravity (or to a geocentric coordinate system) varies with the orientation of a vehicle and with the relative orientation of a vehicle and with the orientation of supporting surfaces within the vehicle. It may from time to time happen that the *z*-axes of the major anatomical (head, pelvis), basicentric and geocentric coordinate systems are all approximately aligned, as when a person stands on a ship's deck in a calm sea and gazes ahead at the horizon. However, non-alignment is more frequently the rule (for example, when a person reclines in a car seat while the vehicle is climbing a hill, see 3.2.2.2).

3.2.2.2 Basicentric coordinate system for seated persons

Origin: The midpoint of a line in the plane of a contact surface (e.g. a vehicle seat) supporting a seated person, passing through the pressure area of the buttocks and beneath the lowermost points of the ischial tuberosities.

NOTE — The orientation of this line in the plane of the contact surface can be defined with respect to the coplanar orientation of that surface as a practical matter, when there is a habitual sitting position and seat alignment (e.g. of a human operator at a workstation).

Orientation: Defined with respect to the origin and the plane of the contact surface in a manner similar to that in which a basicentric system for standing persons is defined above. The direction of the *y*-axis is positive to the subject's left.

NOTES 1 In a normal sitting posture, the orientation of the principal axis of the basicentric coordinate system for persons seated on a flat seat may be assumed to approximate to that of the corresponding axis of the anatomical coordinate system (pelvis).

2 For some applications, a basicentric coordinate system for a vehicle driver (or a mechanical human analogue) originating at the seat index point, SIP, (see ISO 5353) is used as a frame of reference, for example, in ergonomic or human factors engineering evaluations of tractor seats and the like. Its use presupposes that the seat is normally positioned and centred in its ranges of adjustment with respect to the vehicle frame, and relates measurements to the geometry of the vehicle. Reference to the H-point (equivalent to the SIP for a normal adjustment of a tractor operator's seat) is sometimes used for human engineering purposes in the automotive industry. This practice, which has not been generally accepted internationally, is generally not used in the context of biodynamical evaluations of human exposure to vehicle vibration and shock motion.

3 When whole-body vibration measurements are taken from a suitable formed instrumentation-mount interposed at the interface between a rider and his seat (see ISO 10326-1), the mount serves as the contact surface in which the origin and orientation of the basicentric coordinate system for the seated person may be defined, that in turn provides the frame of reference for the related instrumentation coordinate system.

4 When analysing, comparing and reporting biodynamical data or interpreting human vibration and shock standards applying to seated subjects, due allowance should be made for any significant angle that may stand between the seat and the geocentric (or vehicular) and instrumentation coordinate systems.

3.3 Segmental anatomical coordinate systems

NOTE — An assumption implicit in the definition and adoption of the following anatomical coordinate systems is that the respective body segment for which each system is established obeys to a sufficient approximation the laws of rigid-body mechanics. (This has been demonstrated for certain biodynamically important skeletal segments, namely, the head and the pelvis.) For examples, see figures A.1 to A.6.

3.3.1 Anatomical coordinate system: head

Origin: The midpoint of a line connecting the superior margins of the right and left external auditory meatus of the skull.

NOTE — In classical anatomy, that line is the base of a triangle defining the transverse plane of the human skull (the apex, i.e. the third point defining that plane, is conventionally the left infraorbital notch).

Orientation: The *x*-axis of this system passes posteroanteriorly through the origin and lies in the transverse plane of the head. The *y*-axis passes through the origin, is directed positively to the left, lies in the same plane, and is perpendicular to the *x*-axis. The *z*-axis is mutually perpendicular to the other two axes and is directed approximately through the vertex of the skull.

3.3.2 Anatomical coordinate system: root of neck

Origin: The anterior superior border of the body of the first thoracic vertebra (T1) in the midplane of that vertebra.

Orientation: The *x*-axis of this system passes through the origin and, posteroanteriorly, through the midpoint of a line in the midplane of T1 connecting the posterosuperior and posteroinferior points of the posterior spinous process of T1. The *y*-axis passes through the origin and is mutually perpendicular to the *x*- and *z*-axes. The *z*-axis passes through the origin, lies in the midplane of T1, and is perpendicular to the *x*-axis.

NOTE — The axes of this system are not necessarily exactly parallel with the corresponding axes of the major axial segmental anatomical coordinate systems (head, pelvis) in the normal anatomical position, and there will in any case be divergences with changes in posture. However, for the purposes of describing force and motion inputs to the upper torso and the root of the neck in the normal anatomical position, a sufficient approximation may be presumed to exist between the orientation for the midplane of T1 and the midsagittal plane of the trunk. A precise description of the postural relationships between body segments is needed to define the orientation of these systems in inertial space.

3.3.3 Anatomical coordinate system: upper torso

Origin: The anterior superior border of the fourth thoracic vertebra (T4) in the midsagittal plane.

Orientation: Defined in the corresponding manner as for T1 above.

NOTE — Note in 3.3.2 applies equally to this system.

3.3.4 Anatomical coordinate system: pelvis

Origin: The midpoint of a line connecting the right and left anterior superior iliac spines. That imaginary line forms the base of an inverted triangle connecting the anterior superior iliac spines with the most superior anterior point of the symphysis pubis (which accordingly forms the apex of the triangle).

Orientation: The *x*-axis of this system projects anteriorly from the origin, it is perpendicular to the plane of the triangle defined above. The *y*-axis is the line passing from right to left that connects the anterior superior iliac spines. The *z*-axis of the system passes through the origin and is mutually perpendicular to the other two axes, it lies in the plane of the triangle and bisects it.

NOTES 1 The *z*-axis of the anatomical coordinate system (pelvis) is approximately vertical in humans standing upright on a horizontal surface or sitting erect on a horizontal flat seat.

2 The pelvic anatomical reference points defining the basic triangle used to establish this coordinate system, although they are normally palpable in the living human subject and in the cadaver (and are identifiable radiographically), cannot yet be defined with complete precision, for they are irregularly rounded bony prominences. They may in due course be superseded by more exactly determinable pelvic reference points if such can be established by anatomists. Moreover, biodynamical applications of this coordinate system assume approximate bilateral symmetry of the pelvis.

3 In biodynamical measurements in which the motion of the pelvis is assumed to generate the mechanical input to the lumbar spine, it is necessary in any final analysis to define the location and orientation of the interface between the sacrum and the body of the fifth lumbar vertebra (L5).

4 Although in reclining and recumbent postures, substantial fractions of the weight of the person may be distributed through the upper body and the limbs, impressed vibration or shock may nevertheless be deemed to act through the pelvis or the body's approximate centre of mass for the purposes of evaluating human exposure to whole-body vibration or shock. Significant exceptions to this general rule should be reported.

3.4 Biodynamic coordinate systems for the hand

3.4.1 Anatomical coordinate system: hand

Origin: The centre of the head of the third metacarpal bone (middle knuckle) of either hand.

Orientation: This system is oriented to the bony anatomy of the hand by the *z*-axis, the *z*-axis passes proximally through the origin and is the long axis of the third metacarpal bone. The *x*-axis of the system is approximately normal to the palm of the hand, projecting anteriorly from the origin when the hand lies open in the normal anatomical position, i.e. palms facing forward (see figure A.3). The *y*-axis passes through the origin, approximately from the root of the first to that of the little finger, and is mutually perpendicular to the *x*- and *z*-axes.

NOTES 1 As part of a right-handed orthogonal coordinate system, the *y*-axis of the anatomical coordinate system (hand) is defined as running from right to left (i.e. from the root of the forefinger towards the root of the little finger of the right hand in the normal anatomical position). The mirror image of this system may be applied specifically to measurements in the left hand, but such usage should be unambiguously identified when used as the basis for reporting hand-transmitted vibration data (see ISO 5349). Use of a left-handed anatomical coordinate system, while reasonable for application to symmetrical parts on the left side of the body, can lead to anomalies in vector algebra if resulting data are compared directly with those derived using a right-handed system (e.g. incorrect sign of vector cross-products).

2 The absolute orientation of the anatomical coordinate system (hand) necessarily varies with the position and posture of the hand, wrist and upper limb. Accordingly, it is rarely parallel with the correspondingly designated coordinate systems of the axial body segments (head, thorax, pelvis). The posture of the arm and hand should be defined as precisely as practicable when reference is made to the anatomical coordinate system (hand). The orientation of the system may for many practical purposes be independently defined with reference to an appropriate basicentric coordinate system originating, for example, in a vibrating appliance, a workpiece, or a handle or control device held by the hand in question. Such a basicentric system may simultaneously serve as the frame of reference for the instrumentation coordinate system when instrumentation is fixed to the object grasped, for the purpose of measuring vibration transmitted to the same hand.

3 When, as is commonly done in handling vibrating tools or hand-held appliances, the hand is used to grasp a cylindrical or approximately cylindrical handle, the *y*-axis of the anatomical coordinate system (hand) may not necessarily be assumed to lie parallel with the axis of the handle, although such an assumption may be a sufficient approximation for some measurement purposes. It should be noted that the orientation of the anatomical coordinate system (hand), being defined by the orientation of the third metacarpal bone, is, over a wide range of movement, essentially independent of flexion or extension of the fingers (see figure A.6).