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Petroleum and natural gas industries — Specific requirements for offshore structures —

Part 10: Marine geophysical investigations

Industries du pétrole et du gaz naturel — Exigences spécifiques relatives aux structures en mer —

Partie 10: Enquêtes géophysiques marines

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 7, *Offshore structures*.

A list of all parts in the ISO 19901 series can be found on the ISO website.

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

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Introduction

The general objective of a marine site investigation is to provide information about the seafloor, the sub-seafloor and geological processes affecting both, geohazards, and human-made objects at or below the seafloor. Marine site investigations can encompass both marine soil investigations and marine geophysical investigations, as shown in Figure 1. This document provides requirements for marine geophysical investigations to support oil and gas developments offshore, is complementary to ISO 19901-8 on marine soil investigations, and provides guidance on the integration of both types of investigations.

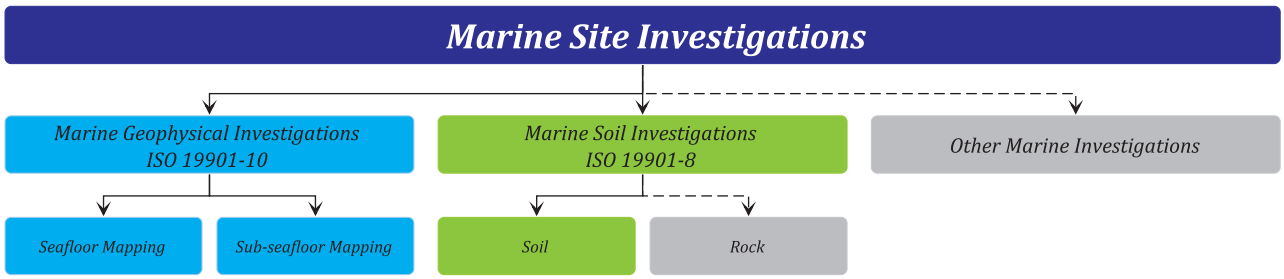


Figure 1 — Marine geophysical investigations as part of marine site investigations.

NOTE Subjects denoted in grey boxes in Figure 1 are neither covered in ISO 19901-8 nor in this document. However, marine geophysical investigations can provide information about soils and rocks, whereas rocks are only covered by ISO 19910-8 to the extent that ordinary marine soil investigation tools can be used, e.g. for chalk.

Marine site investigations for a specific project can comprise both geophysical and geotechnical investigations, depending on project scale and complexity. It is common practice to conduct first a marine geophysical investigation, sometimes in combination with a limited marine soil investigation consisting of shallow soil sampling and/or in situ testing. A more extensive marine soil investigation is often conducted at a later stage. In some cases, a marine site investigation can consist solely of a stand-alone geophysical survey that has a specific and limited purpose. A marine site investigation can also consist solely of a stand-alone marine soil investigation, for which details on soil investigation equipment and procedures are provided in ISO 19901-8.

Particular objectives of a marine geophysical investigation should be addressed in project specifications, which should specify desired investigation depths, desired resolutions (horizontal and vertical), and whether the objective is to illuminate the seafloor and/or the sub-seafloor. Caution is necessary in the selection of the type of equipment to be used, and operational parameters for that equipment, in order to meet those desired depths, resolutions, and illumination targets, particularly because local site conditions can affect the abilities of certain equipment to meet those objectives. This document includes discussion of the selection and operation of appropriate geophysical equipment.

Marine geophysical investigations and marine soil investigations can be (and often are) carried out as separate exercises, the results of which can be integrated into a ground model. This document applies to critical stages in the development of a ground model, from the initial conception stage through successive stages of increased detail.

In this document, the following verbal forms are used:

— “shall” indicates a requirement;

— “should” indicates a recommendation;

— “can” indicates a possibility or a capability;

— “may” indicates a permission.

Annex A provides additional information intended to assist the understanding or use of this document.

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Petroleum and natural gas industries — Specific requirements for offshore structures —

Part 10: Marine geophysical investigations

1 Scope

This document provides requirements and guidelines for marine geophysical investigations. It is applicable to operators/end users, contractors and public and regulatory authorities concerned with marine site investigations for offshore structures for petroleum and natural gas industries.

This document provides requirements, specifications, and guidance for:

a) objectives, planning, and quality management;

b) positioning;

c) seafloor mapping, including instrumentation and acquisition parameters, acquisition methods, and deliverables;

d) sub-seafloor mapping, including seismic instrumentation and acquisition parameters, and non-seismic-reflection methods;

e) reporting;

f) data integration, interpretation, and investigation of geohazards.

This document is applicable to investigation of the seafloor and the sub-seafloor, from shallow coastal waters to water depths of 3 000 m and more. It provides guidance for the integration of the results from marine soil investigations and marine geophysical investigations with other relevant datasets.

NOTE 1 The depth of interest for sub-seafloor mapping depends on the objectives of the investigation. For offshore construction, the depths of investigation are typically in the range 1 m below seafloor to 200 m below seafloor. Some methods for sub-seafloor mapping can also achieve much greater investigation depths, for example for assessing geohazards for hydrocarbon well drilling.

There is a fundamental difference between seafloor mapping and sub-seafloor mapping: seafloor signal resolution can be specified, while sub-seafloor signal resolution and penetration cannot. This document therefore contains requirements for the use of certain techniques for certain types of seafloor mapping and sub-seafloor mapping (similarly, requirements are given for certain aspects of data processing). If other techniques can be shown to obtain the same information, with the same or better resolution and accuracy, then those techniques may be used.

Mapping of pre-drilling well-site geohazards beneath the seafloor is part of the scope of this document.

NOTE 2 This implies depths of investigation that are typically 200 m below the first pressure-containment casing string or 1 000 m below the seafloor, whichever is greatest. Mapping of pre-drilling well-site geohazards is therefore the deepest type of investigation covered by this document.

In this document, positioning information relates only to the positioning of survey platforms, sources and receivers. The processes used to determine positions of seafloor and sub-seafloor data points are not covered in this document.

Guidance only is given in this document for the use of marine shear waves (A.8.3.3), marine surface waves (A.8.3.4), electrical resistivity imaging (A.8.3.5) and electromagnetic imaging (A.8.3.6).

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19901-8, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 8: Marine soil investigations*

3 Terms and definitions

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

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

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

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

3.1
abyssal water
water depths greater than 3 000 m

3.2
acoustic impedance
seismic velocity multiplied by density

Note 1 to entry: Compressional-wave impedance uses compressional-wave velocity, and shear-wave impedance uses shear-wave velocity.

3.3
acoustic noise
unwanted acoustic signal

3.4
active tail buoy
buoy fitted with a global navigation satellite system transponder attached to the end of a streamer

3.5
airgun
seismic source that injects a bubble of highly compressed air into the water

Note 1 to entry: Whereas single airguns can be used, it is common practise to deploy and fire several airguns in arrays to produce an acoustic pulse that has certain temporal and spatial characteristics.

3.6
aliasing
effect that causes signals to be misrepresented in recorded data as a result of undersampling

Note 1 to entry: Undersampling can be in time or spatial domain.

3.7
anisotropy
dependence of velocity on direction or upon angle of wave propagation

3.8
array
system of linked hydrophones or seismic sources arranged in a geometric pattern to increase sensitivity and/or directionality and/or in the case of a seismic source, the pulse characteristics

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3.9
attenuation
reduction in amplitude or energy

Note 1 to entry: Attenuation in seismic data is related in part to soil conditions.

3.10
attribute
characteristic of a given object, structure or feature

Note 1 to entry: A seismic attribute is a quantity or property derived or extracted from seismic data that provides specific information contained within the data as an aid in interpretation.

3.11
backscatter
amplitude of echo sounder energy reflected by the seafloor that can be processed into information about seafloor features and texture

3.12
bandwidth
range of frequencies in an acoustic signal between the two half power points

Note 1 to entry: This corresponds with the frequencies at which the power drops to half the peak power (3 dB).

3.13
boomer
seismic source that operates by the rapid movement of a restricted metal plate

3.14
chirp
type of sub-bottom profiler that emits a frequency-modulated pulse of acoustic energy over a specified range of frequencies

3.15
common depth point
CDP
common reflection point at depth on a reflector, or the halfway point when a wave travels from a source to a reflector to a receiver

Note 1 to entry: In the case of flat layers, the common depth point is vertically below the common mid-point.

3.16
common mid-point
CMP
in multichannel seismic acquisition, the point on the surface halfway between the source and receiver that is shared by a number of source-receiver pairs

Note 1 to entry: CMP gather refers to the set of traces that have a common mid-point.

3.17
common reference point
datum point on a vessel to which all positioning systems are referenced in three dimensions

3.18
cone penetration test
CPT
CPTU
in situ soil strength testing device that makes direct measurements of cone resistance, sleeve friction and pore pressure response as it is pushed into the sub-seafloor

Note 1 to entry: See ISO 19901-8.

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3.19
contractor
party or person responsible for an assigned scope of work described in project specifications

3.20
coordinate reference system
coordinate system that is related to an object by a datum

Note 1 to entry: Geodetic and vertical datums are referred to as reference frames.

Note 2 to entry: For geodetic and vertical reference frames, the object will be the Earth. In planetary applications, geodetic and vertical reference frames can be applied to other celestial bodies.

[SOURCE: ISO 19111:2019, 3.1.9]

3.21
deconvolution
filtering process that undoes the effect of another filter

Note 1 to entry: There are many applications in seismic data processing. One example is removing the filtering effect of the sub-seafloor.

3.22
deep water
water depths between 750 and 1 800 m

3.23
demultiple
seismic processing application that attenuates multiple energy

3.24
designature
filtering process to compensate for the non-minimum phase characteristics of a seismic source

3.25
digital terrain model
DTM
digital representation of a mapped surface usually defined by xyz values for defined cells

3.26
dip move-out
DMO
difference in the arrival times or travel times of a reflected wave, measured by receivers at two different offset locations, that is produced from dipping reflectors

Note 1 to entry: Dip move-out can be compensated for in processing.

3.27
direct arrival
recorded seismic energy that has travelled directly from source to receiver and has neither been reflected nor refracted

3.28
doppler velocity log
DVL
instrument to measure the speed of a survey platform by measuring the frequency shift of acoustic pulses reflected from the seafloor

3.29
dynamic range
ratio of the largest recoverable signal to the smallest recoverable signal

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3.30
exploration seismic data
seismic data containing frequencies between 0 Hz and 100 Hz, typically acquired for the purpose of exploring for oil and gas rather than site investigation

Note 1 to entry: In this document, "exploration seismic data" also includes data acquired for the purposes of hydrocarbon reservoir management (assessment, development, and monitoring).

3.31
far-field source signature
characteristic wave shape of a particular seismic source recorded at a remote distance, so that the wave front is close to a straight line

Note 1 to entry: In practice this is difficult to achieve, and a mid-field source signature is more common.

3.32
feather angle
angle between the line connecting the near and far receivers of a streamer and course made good of the nearest receiver

Note 1 to entry: Differences are caused by a cross current.

3.33
feature
item observed in seafloor mapping data or sub-seafloor mapping data that characterizes the site or renders it unique

Note 1 to entry: A featureless seafloor is completely smooth and flat, for example.

3.34
first break
first recorded signal attributable to seismic-wave travel from a known source

3.35
first pressure containment string
first casing installed in a well that will enable the pressure inside the well to be controlled

3.36
frequency spectrum
function of power versus frequency that illustrates the frequency content of a wavelet or signal

Note 1 to entry: A frequency spectrum is produced by a Fourier transform.

3.37
Fresnel zone
generally circular area on a reflecting interface from which all reflections contribute to the recorded signal

Note 1 to entry: The Fresnel zone is dependent on the period of the wave and determines lateral resolution.

3.38
geohazard
geological condition that has the potential to have adverse effects on persons, operations, infrastructure or the environment

3.39
geological model
explanation of geological conditions

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3.40
ghost
spurious seismic reflection that occurs when energy is reflected between sources and/or receivers and the sea surface

3.41
global navigation satellite system
GNSS
satellite based navigation system that provides autonomous global positioning of a receiving device

Note 1 to entry: Global positioning system (GPS), and global navigation satellite system (Glonass), Galileo and BeiDo are typical examples of global navigation satellite systems.

3.42
ground model
2- or 3-dimensional representation of the seafloor (bathymetry) and, where applicable, the sub-seafloor conditions, at a given time, that is specific to the offshore structure(s) considered

3.43
ground-truthing
integration of seafloor or sub-seafloor geophysical data with data acquired by marine soil investigation and other dataNote 1 to entry: See, for example, ISO 19901-8 for marine soil investigation data.

3.44
high-resolution seismic
HR seismic
seismic reflection method that acquires seismic data containing frequencies between 75 Hz and 300 Hz

3.45
horizon
seismic reflector associated with the surface separating two strata

3.46
hydrophone
sensor that detects variations in pressure

3.47
inertial navigation system
navigation aid that uses accelerometers and gyroscopes to continuously calculate position, orientation and velocity by dead reckoning without external input

3.48
interval velocity
seismic velocity measured over a depth interval

3.49
isochore
line drawn on a map through points of equal vertical thickness of a soil unit, bed, formation or group of these

3.50
isochron
line drawn on a map through points at which a characteristic reflection time or interval has the same value

3.51
isopach
line drawn on a map through points of equal stratigraphic thickness of a sub-seafloor stratum or a group of these

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3.52
magnetic gradiometer
system which measures magnetic gradient using two or more closely spaced magnetometers

3.53
magnetometer
instrument used to measure the strength and/or direction of a magnetic field

3.54
marine geophysical investigation
type of marine site investigation of seafloor or sub-seafloor that uses non-destructive methods involving marine deployment of geophysical tools

3.55
marker horizon
seismic reflector that maintains its characteristics over an area or distance so that it can be used as an interpretation reference

3.56
metadata
metacontent
information describing the content and context of the data within the given file or format

3.57
migration
seismic data processing step in which seismic events are geometrically re-located to the true location at which the event occurs in the sub-seafloor rather than the location at which it was recorded at the surface

Note 1 to entry: A more accurate image of the sub-seafloor will be created by applying migration.

3.58
motion reference unit
MRU
instrument for measuring pitch, roll, yaw, surge, sway and heave

Note 1 to entry: The primary use is to provide observations needed to correctly determine the position of geophysical sensors and in the processing of the sensor data.

3.59
multiple energy
noise on seismic records caused by reverberations between strong reflecting interfaces, such as the seafloor and the sea surface

3.60
mute
removal of certain components of traces prior to common mid-point stacking

3.61
near-field signature
pulse shape measured within the near-field range of a seismic source, generally less than 1 wavelength

3.62
noise
unwanted signal

3.63
normal moveout
NMO
variation in reflection arrival time caused by variation in seismic source to receiver (offset) distance

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3.64
offset
horizontal distance from the seismic source to the seismic receiver

3.65
offset well
existing well from which information is available to tie back to and assist with making predictions about conditions at another well location

3.66
penetration
greatest depth below seafloor from which geophysical signals (such as seismic reflections) can be recognized with reasonable certainty

3.67
pinger
transducer or array of transducers using piezo-electric effects used as seismic source in sub-bottom profiling profilers

3.68
pitch
up-and-down motion of the bow or stern of a survey platform about the horizontal axis that passes across it from port to starboard through its centre of gravity

3.69
positioning
process to derive a three-dimensional coordinate, which uniquely defines a location within the project coordinate reference system, that should include the time of the observations used to derive the coordinate

3.70
pre-stack depth migration
PSDM
migration applied to seismic data in depth domain, calculated from seismic data in time coordinates, and applied before the data is stacked

3.71
pre-stack time migration
PSTM
migration applied to seismic data in time domain before it is stacked

3.72
project specification
scope of work for marine site investigation assigned by the client to a contractor

3.73
P-wave
primary wave
elastic body wave in which the particle motion is in the direction of propagation

3.74
reflection
energy or wave from a seismic source which has been reflected or returned from an acoustic impedance contrast

3.75
refraction
change in the direction of travel of a wavefront, or the bending of a ray, as it passes from one medium to another, expressed mathematically by Snell's law

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3.76
resolution
distance between separate points or objects, such as sedimentary sequences in a seismic section, that can be distinguished

3.77
roll
up-and-down motion of the sides of a survey platform about the horizontal axis that passes along it through the bow and stern, and through its centre of gravity

3.78
sample interval
time interval between successive samples of a recorded signal

3.79
seafloor
interface at the bottom of the water column between the sea and soil or rock

Note 1 to entry: Equivalent terms "water bottom" or “mudline” are commonly used in seismic acquisition and processing.

3.80
SEG-D
SEG-Y
society of exploration geophysicists standard formats commonly used to record and/or exchange seismic data

3.81
seismic method
use of sound waves to image the earth’s subsurface

Note 1 to entry: This term should not be confused with the one used in ISO 19901-2, which defines seismic as being related to strong ground motions (earthquake-related). These ground motions are addressed during the design of structures, so that the structures are not vulnerable to the motions.

3.82
seismic data processing
applying geometrical corrections and signal processing techniques to improve the signal to noise ratio and facilitate the interpretation of seismic data

3.83
seismic source
source of controlled acoustic energy that is used in seismic reflection and seismic refraction marine geophysical investigation

3.84
shallow water
water depths less than 25 m

3.85
shallow water flow
flow of pore water into a hydrocarbon well from an overpressured formation causing difficulties in well control and effective cementing of casing

3.86
side scan sonar
SSS
instrument for imaging the seafloor to either side of a survey track line using acoustic pulses

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3.87
site
defined investigation space, including seafloor and sub-seafloor, that can also include the water column

3.88
soil province
3D unit in which soil or ground conditions demonstrate a particular characteristic or fall within a defined range

3.89
source signature
output wavelet, or waveshape, of a particular seismic source from which frequency, output power and phase can be determined

3.90
sparker
seismic source that operates by producing an electric discharge in water

3.91
spherical divergence
decrease in acoustic signal strength with distance as a result of geometric spreading of acoustic energy

3.92
stack
process of making a composite record by combining traces from different records

Note 1 to entry: Most common application is common mid-point stacking.

3.93
statics
corrections applied to seismic data to eliminate the effects of variations in elevation and near-seafloor velocities

3.94
streamer
set of seismic receivers contained in a linear, normally neutrally buoyant, cable that is deployed aft of a seismic acquisition vessel

Note 1 to entry: Streamers can contain hydrophones, accelerometers, and geophones.

3.95
streamer bird
depth control or heading measurement device fitted to a streamer

3.96
sub-bottom profiler
SBP
seismic reflection instrument for investigating the upper few tens of metres of the sub-seafloor with a high vertical resolution

3.97
sub-seafloor
soil or rock existing beneath the seafloor/base of the water column

Note 1 to entry: Referred to as "seabed" in ISO 19901-8. "Sub-seafloor" should not be confused with "seafloor". Other commonly used terms are subsurface, sub-bottom and shallow section.

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3.98
survey platform
vehicle on which survey sensors and/or sources for marine geophysical investigations are mounted

EXAMPLE Towfish, autonomous underwater vehicle, remotely operated underwater vehicle, hydrophone streamer and surface vessel.

3.99
survey track line
line through coordinates of a sensor and/or sources used during seafloor mapping or sub-seafloor mapping

3.100
multi-beam echo sounder
swathe bathymetry system
instrument for measuring water depths within a defined swathe either side of a survey track line

Note 1 to entry: Two technologies exist. Beam forming multi beam echo sounders and interferometric or phase differencing bathymetric systems.

3.101
shear wave
S-wave
body wave in which the particle motion is perpendicular to the direction of propagation

3.102
tail buoy
buoy fitted to the end of a streamer

3.103
time slice
horizontal section through 3D seismic data that displays information at the same two-way reflection time

3.104
time-to-depth conversion
application of the appropriate seismic velocity to a measured reflection time in order to derive distance through the earth or the water column

3.105
trace
record of one seismic channel

3.106
trace header
identification information and parameters that precede data in a file of recorded traces

3.107
transponder
transducer that produces an acoustic response when it receives an acoustic signal from another transducer

Note 1 to entry: The other transducer can be mounted on a surface or subsea survey platform.

3.108
ultradeep water
Note 1 to entry: water depths from 1 800 m to 3 000 m

3.109
ultra-high-resolution seismic
UHR seismic
seismic reflection method that acquires seismic data containing frequencies between 250 Hz and 800 Hz

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3.110
ultra-short baseline system
USBL
sub-sea acoustic positioning system used to determine the position of towed or deployed sensors in the water column

Note 1 to entry: A transponder or responder is mounted on the sensor to be positioned and interrogated from a transducer of known position.

3.111
ultra-ultra-high resolution seismic
UUHR seismic
seismic reflection method that acquires seismic data containing frequencies between 750 Hz and 2 000 Hz

3.112
velocity analysis
process of calculating acoustic velocity from measurements of normal moveout

3.113
velocity model
model of discrete geological units or reflection time intervals with different acoustic velocities

3.114
vertical datum
vertical reference frame
reference frame describing the relation of gravity-related heights or depths to the Earth

Note 1 to entry: In most cases, the vertical reference frame will be related to mean sea level. Vertical datums include sounding datums (used for hydrographic purposes), in which case the heights may be negative heights or depths.

Note 2 to entry: Ellipsoidal heights are related to a three-dimensional ellipsoidal coordinate system referenced to a geodetic reference frame.

[SOURCE: ISO 19111:2019, 3.1.72]

3.115
wavelet
seismic pulse usually consisting of one-and-a-half to two cycles

3.116
yaw
sideways movement of the bow and stern of a survey platform about the vertical axis that passes through the centre of gravity

4 Symbols and abbreviated terms

4.1 Symbols

R_p	ping rate
S_r	slant range
σ	standard deviation

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