INTERNATIONAL STANDARD

ISO 3482

First edition
2022-05

Ships and marine technology — Technical guidelines for active source exploration with ocean bottom seismometers (OBS)

Navires et technologie maritime — Lignes directrices techniques relatives à l'exploration des sources actives avec des sismomètres de fond de mer (OBS)

Reference number
ISO 3482:2022(E)

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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Foreword

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This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 13, *Marine technology*.

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.

Introduction

Exploration for the structures and movement of deep earth on the seafloor is one of the important approaches for human beings to recognize earth system evolution, predict seabed resources formation, and understand natural disaster mechanisms. Unlike the multi-channel seismic method which only obtains primary waves by hydrophone streamers on the ocean surface, the ocean bottom seismometer (OBS) is directly placed on the seabed and can receive both primary and shear waves, even Rayleigh and Love waves from earth interior. Such a new seismic method gives an opportunity to better image the structures, movement and rheology for the deep targets in solid earth beneath ocean which cover up to ≈71 % of the earth's surface. This method has been widely used in research on not only global continental margins, subduction zones, mid-ocean ridges, but also regional oil and gas fields, marine engineering constructions.

The signals received in OBS exploration can be either natural earthquakes or artificial excited seismic sources. Accordingly, OBS exploration is divided into passive and active source methods. Passive source exploration with OBS is a method by which OBSs just receive global natural earthquakes and obtain deeper and wider information from the earth interior. Active source exploration with OBS is usually used in a target region to reveal the structures, tectonics and composition of underground geological bodies or crust and upper mantle by a special designed array of OBSs and sources. Because of its strong pertinence, this active source method gradually becomes the main tool for regional deep earth exploration, and is widely used by industry and academia.

OBS is a mature technical product and widely used in various deep earth imaging. However, there is a lack of such a standard about active source exploration with OBS, which will seriously affect the testing, identifying, evaluating of the performance requirements and data quality of such products. It should therefore be necessary to standardize its technical requirements and basic procedures to promote healthy development of this industry of seabed OBS exploration. In view of the above, this document establishes the technical guidelines covering the main content of active source exploration with OBS from OBS instruments, seismic sources and fieldwork processes, to data services.

Ships and marine technology — Technical guidelines for active source exploration with ocean bottom seismometers (OBS)

1 Scope

This document specifies the technical requirements for system makeup, ocean bottom seismometer (OBS) instruments, active sources, field design, exploration operation, data processing for active source exploration with OBS, and their relative terms.

This document is applicable to active source exploration with OBS, but also a useful reference to the passive source exploration with OBS. It can be used in seabed resource exploration, geological disaster surveillance and submarine geoscience research.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

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

3.1
ocean bottom seismometer
OBS
seismic observation system with a seismic sensor placed on the seabed to record ground motions and an acoustic sensor to record signals in the water column

Note 1 to entry: The main components include *seismic sensing system* (3.3) and *acoustic sensing system* (3.4), *recording and storage unit* (3.5), *release unit* (3.8), *acoustic communication unit* (3.7), compass, internal clock, power supply, lighting system, cargo compartment and protective cover etc.

Note 2 to entry: There are mainly two types of OBS, broadband and short period. The short period OBS, with the lower corner of its frequency band not less than 2 Hz, usually used for active seismic source exploration.

3.2
active source exploration
exploration method in which sound wave signals are emitted in the water by ship-borne seismic sources such as air gun, propagated downward through the crust and upper mantle, finally return to the seabed and recorded by *ocean bottom seismometers* (3.1)

Note 1 to entry: The crust and upper mantle information carried by ocean bottom seismometers is in the form of elastic wave.

Note 2 to entry: Active source is artificially excited at sea by physical or/and chemical means. Air gun sources are used in arrays.

Note 3 to entry: Multiple sources of same or different volume are towed at designed offsets and field at defined time delay to shape the resulting pressure wave used as seismic source.

3.3
seismic sensing system
system of earthquake sensing by *ocean bottom seismometer* (3.1) composed mostly of a low gain geophone or a high gain seismometer, mostly with three components, one vertical and two perpendicular horizontal components (XYZ) or, as an alternative, three identical sensors in three directions (UVW)

3.4
acoustic sensing system
system of sound sensing by *ocean bottom seismometer* (3.1) composed of a pressure sensor, mostly a high impedance hydrophone

3.5
recording and storage unit
ocean bottom seismometer (3.1) recording unit which is used to control data acquisition, signal filtering, signal amplification, analogue-to-digital conversion and storage

Note 1 to entry: The recording unit is composed of microprocessor and circuit components, the storage unit is composed of a buffer and one or more internal or external memory devices.

3.6
breakout box
device for *ocean bottom seismometer* (3.1) to set up a cabled or wireless communication for status checking or parameter setting

3.7
acoustic communication unit
acoustic wave sensing device which communicates with the *deck control unit* (3.9) through the acoustic wave, starts the release decoupling program, and sends the position or distance to the *deck control unit* (3.9) through the acoustic wave

3.8
release unit
device for driving the *ocean bottom seismometer* (3.1) placed on the seabed to separate from the anchor which is mainly composed of a physical fixing device, a power supply and a circuit, and is matched with an acoustic wave sensing device

Note 1 to entry: There are usually two release modes, one is that the deck unit drives the acoustic wave sensing device to start the release procedure, the other is to set the release start-up time in advance, and the built-in circuit and power supply realize the timing release.

Note 2 to entry: Release is usually accomplished by mechanical or electrochemical means.

3.9
deck control unit
acoustic communication device composed of a controller, a special cable and an acoustic transducer which is used to directly communicate with the *release unit* (3.8) or a built-in *acoustic communication unit* (3.7)

3.10
auxiliary recovery device
device which help to spot the *ocean bottom seismometer* (3.1) after emerging at the sea surface especially at night or during bad weather conditions

EXAMPLE Radio beacons, flash lights, AIS systems.

3.11
anchor
concrete block or ironwork that is used to provide weight (negative buoyancy) to ensure *ocean bottom seismometer* (3.1) fall free and couple well with the seafloor

Note 1 to entry: During recovering ocean bottom seismometers (OBS), the anchor is separated from the OBS and then disposed on the seabed. Some shallow water OBS use fixed reusable anchors and pop-up buoys for recovery.

4 Requirements

4.1 General

This document analyses the system makeup, performance requirements and quality control of active source exploration with OBS. It establishes the technical needs and basic procedures including reference/positioning system, instrument calibration, field design, OBS delivery, seismic sources, OBS recovery, exploration process, data acquisition and data processing, to promote standardized development of the OBS technology and its exploration.

4.2 Standard of time and space

4.2.1 Standard of time

Coordinated Universal Time (UTC) or local time shall be adopted.

4.2.2 Coordinate system

WGS84 coordinate system shall be adopted.

4.2.3 Vertical reference

Local mean sea level shall be used.

4.2.4 Positioning system

Global Navigation Satellite System (GNSS) positioning system shall be adopted.

4.3 OBS technical indicators

4.3.1 OBS acquisition system

The OBS sensor system usually consists of a 3-component seismic sensor and an acoustic sensor, corresponding to the seismic sensing system and the acoustic sensing system, respectively. OBS acquisition system shall be in accordance with a) to e) below.

a) On the lower corner of the frequency band for velocity seismometers, the short-period OBS shall not be less than 2 Hz.

b) The sampling frequency of OBS data recorder shall not be less than 20 Hz.

c) The internal clock shall be provided with absolute time service and the linear clock drift is less than 3 000 ms/y.

d) The dynamic range shall be not less than 120 dB.

e) The pressure resistance of OBS equipment cabin and acoustic sensor shall comply with a water depth which is deeper than the actual working water depth instructed by manufacturers.

4.3.2 OBS deployment/recovery system

The OBS shall have at least one set of built-in release unit which is on-site acoustic recovery or with timing floating for special exploration and environmental protection. OBS deployment/recovery system shall be in accordance with the following.

a) The buoyancy of the OBS shall ensure a rapid rising to minimize lateral drift during ascent which maximum rising velocity depends on the type of OBS, typical ranges are 0,3 m/s to 1,5 m/s.

b) The anchor shall match the OBS weight, with a settling velocity from 0,3 m/s to 1,5 m/s.

c) The anchor shall be designed in a way to keep the OBS balanced in air as well as in water.

d) The OBS shall have an independent tracking device for day and night recovery, like flags, radar reflectors, flasher, radio beacons, AIS or satellite-based systems.

e) The attitude of OBS after reaching to the sea level shall ensure normal communication between the release auxiliary equipment (tracking devices) and the search source.

4.3.3 Power supply system

The power supply system shall provide the power for the recording unit and release unit of OBS, and shall be in accordance with the following.

a) The nominal capacity of the battery used by the OBS for recording shall be more than 1 time the capacity required for the acquisition operation.

b) The nominal capacity of the battery used by the OBS for release shall be more than 1 time the capacity required for the release operation. The power supply for the release unit shall be independent from the power supply for the recording unit. A third power supply for the time release is recommended.

4.4 Seismic sources

Seismic source is an important part of active source exploration with OBS, the most popular marine seismic sources include airguns, sparkers and boomers. The seismic sources shall:

a) choose an appropriate seismic source for different exploration targets;

b) determine seismic source parameters, such as energy capacity, air pressure, gun array assembly, dominant frequency range, towing depth and shooting interval by seismic simulation and practical tests according to the nature, structure and depth of exploration target, and also the requirements of accuracy and resolution of exploration.

4.5 Field design

The field design shall meet the following criterion.

a) Suitable seismic source and OBSs are chosen for different water depth and exploration targets of the study area.

b) The direction of the main survey line is adjusted according to different exploration targets. Normally, the main survey line is perpendicular to the tectonic strike.

c) The spatial resolution of the exploration is mainly controlled by OBS station spacing and seismic source density. The higher the resolution is needed, the smaller OBS station spacing and higher seismic source density should be designed.

d) The capacity and frequency of seismic source match with the exploration depth of the study area; the higher energy and lower frequency of seismic source is usually designed for deeper exploration targets.

e) The shooting time interval is adjusted according to the exploration target and vessel speed, and designed to avoid the signal interference from both direct water-wave arrivals and water peg-leg multiples generated by the preceding shot.

