Seismic Design Procedures and Criteria for Offshore Structures

ANSI/API RECOMMENDED PRACTICE 2EQ
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ISO 19901-2:2004 (Modified), Petroleum and natural gas industries—Specific requirements for offshore structures—Part 2: Seismic design procedures and criteria

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Addendum 1

Annex B: The first paragraph shall read:

The maps shown in Figures B.1 to B.26 of this annex give generic 5 % damped spectral accelerations, expressed in g, for bedrock outcrop for a 0.2 s oscillator period and for a 1.0 s oscillator period, respectively, for determining the site seismic zone (see 6.4) of an area and for use in the simplified seismic action procedure (see Clause 7). See Table B.1 for maps by region.

Annex B: The following table shall be added:

Table 1—List of Ground-Motion Maps by Region

Region	Figure
Canada—British Columbia	B.1
Canada—Arctic	B.2
Canada—Atlantic Seaboard	B.3
United States—Pacific Coast (35° N–49° N)	B.4
United States—Southern California	B.5
United States—Gulf of Mexico	B.6
United States—Atlantic Seaboard	B.7
United States—Alaska Arctic	B.8
United States—Alaska Aleutians	B.9
United States—Alaska Panhandle	B.10
Mexico	B.11
Central America and Caribbean	B.12
South America	B.13
Europe—North Atlantic, North Sea, and Baltic Sea	B.14
Eastern Mediterranean Sea and Black Sea	B.15
Western Mediterranean Sea, France, Portugal, and Spain	B.16
Africa—Atlantic Ocean and Indian Ocean	B.17
Middle East	B.18
Asia—Pakistan and India	B.19
Asia—Russian Arctic	B.20
Asia—Russia, China, Korea, and Japan	B.21
Asia—Southeast (to 120° E)	B.22
Asia—Southeast (east of 118° E)	B.23
Australia—NW Shelf Region and East Indonesia Island Arc (to ~130° E)	B.24
Australia—Other than NW Shelf Region	B.25
New Zealand	B.26

Annex B: All of the figures in this annex are new as of this addendum. Figure titles are as follows:

Figure B.1a—5 % damped spectral response acceleration (g) at 0.2 sec period, for British Columbia, Canada	Figure B.14a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Europe Atlantic, and North and Baltic Seas.
Figure B.1b—5 % damped spectral response acceleration (g) at 1.0 sec period, for British Columbia, Canada	Figure B.14b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Europe Atlantic, and North and Baltic Seas.
Figure B.2a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Canada Arctic	Figure B.15a—5 % damped spectral response acceleration (g) at 0.2 sec period, for the East Mediterranean and Black Seas.
Figure B.2b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Canada Arctic	Figure B.15b—5 % damped spectral response acceleration (g) at 1.0 sec period, for the East Mediterranean and Black Seas.
Figure B.3a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Atlantic Seaboard Canada.	Figure B.16a—5 % damped spectral response acceleration (g) at 0.2 sec period, for the West Mediterranean.
Figure B.3b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Atlantic Seaboard Canada	Figure B.16b—5 % damped spectral response acceleration (g) at 1.0 sec period, for the West Mediterranean.
Figure B.4a—5 % damped spectral response acceleration (g) at 0.2 sec period, for United States Pacific Coast (35°N - 49°N).	Figure B.17a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Africa Atlantic and Indian Ocean.
Figure B.4b—5 % damped spectral response acceleration (g) at 1.0 sec period, for United States Pacific Coast (35°N - 49°N).	Figure B.17b—5 % damped spectral response acceleration (g) at 1.0 sec period, . for Africa Atlantic and Indian Oceans.
Figure B.5a—5% damped spectral response acceleration (g) at 0.2 sec period, for Southern California, United States.	Figure B.18a. 5 % damped spectral response acceleration (g) at 0.2 sec period, for the Middle East.
Figure B.5b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Southern California, United States.	Figure B.18b—5 % damped spectral response acceleration (g) at 1.0 sec period, for the Middle East.
Figure B.6a—5 % damped spectral response acceleration (g) at 0.2 sec period, for United States Gulf of Mexico.	Figure B.19a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Asia, Pakistan, India.
Figure B.6b—5 % damped spectral response acceleration (g) at 1.0 sec period, for United States Gulf of Mexico.	Figure B.19b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Asia, Pakistan, India.
Figure B.7a—5 % damped spectral response acceleration (g) at 0.2 sec period, for United States Atlantic Seaboard.	Figure B.20a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Asia Russian Arctic.
Figure B.7b—5 % damped spectral response acceleration (g) at 1.0 sec period, for United States Atlantic Seaboard.	Figure B.20b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Asia Russian Arctic.
Figure B.8a—5 % damped spectral response acceleration (g) at 0.2 sec period for United States Alaska Arctic.	Figure B.21a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Asia Far East (Russia, China, Korea and Japan).
Figure B.8b—5 % damped spectral response acceleration (g) at 1.0 sec period, for United States Alaska Arctic.	Figure B.21b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Asia Far East (Russia, China, Korea and Japan).
Figure B.9a—5 % damped spectral response acceleration (g) at 0.2 sec period, for United States Alaska Aleutian Islands.	Figure B.22a—5 % damped spectral response acceleration (g) at 0.2 sec period, for SE Asia (to 120° E).
Figure B.9b—5 % damped spectral response acceleration (g) at 1.0 sec period, for United States Alaska Aleutian Islands.	Figure B.22b—5 % damped spectral response acceleration (g) at 1.0 sec period, for SE Asia (to 120° E).
Figure B.10a—5 % damped spectral response acceleration (g) at 0.2 sec period, for United States Alaska Panhandle.	Figure B.23a—5 % damped spectral response acceleration (g) at 0.2 sec period, for SE Asia (east of 120° E).
Figure B.10b—5 % damped spectral response acceleration (g) at 1.0 sec period, for United States Alaska Panhandle.	Figure B.23b—5 % damped spectral response acceleration (g) at 1.0 sec period, for SE Asia (east of 120° E).
Figure B.11a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Mexico.	Figure B.24a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Northwest Australia and East Indonesia.
Figure B.11b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Mexico.	Figure B.24b—5 % damped spectral response acceleration at 1.0 sec period, for Northwest Australia and East Indonesia.
Figure B.12a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Central America and the Caribbean.	Figure B.25a—5 % damped spectral response acceleration (g) at 0.2 sec period, for Australia (other than NW).
Figure B.12b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Central America and the Caribbean.	Figure B.25b—5 % damped spectral response acceleration (g) at 1.0 sec period, for Australia (other than NW).
Figure B.13a—5 % damped spectral response acceleration (g) at 0.2 sec period, for South America.	Figure B.26a—5 % damped spectral response acceleration (g) at 0.2 sec period, for New Zealand.
Figure B.13b—5 % damped spectral response acceleration (g) at 1.0 sec period, for South America.	Figure B.26b—5 % damped spectral response acceleration (g) at 1.0 sec period, for New Zealand.

Annex C.2, the following rows shall be added at the end of the table:

Annex B Regional Information	Replace Figures B.1 to B.11 with new/updated Figure B.1 to B.26.
Explanation: The new maps are larger scale and focus on sub-regions where digital ground-motion data exist for onshore and offshore areas. These areas contain many acceleration contours to provide better spatial definition of the variability of the ground motion.	

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The verbal forms used to express the provisions in this specification are as follows:

— the term "shall" denotes a minimum requirement in order to conform to the specification;

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Standards referenced herein may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

This standard is under the jurisdiction of the API Subcommittee on Offshore Structures. This is standard modified from the English version of ISO 19901-2:2004. ISO 19901-2 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*.

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Foreword

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19901-2 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee 7, *Offshore structures*.

ISO 19901 consists of the following parts, under the general title *Petroleum and natural gas industries—Specific requirements for offshore structures*:

— Part 1: *Metocean design and operating considerations*,

— Part 2: *Seismic design procedures and criteria*,

— Part 3: *Topsides structure*,

— Part 4: *Geotechnical and foundation design considerations*,

— Part 5: *Weight control during engineering and construction*,

— Part 6: *Marine operations*,

— Part 7: *Stationkeeping systems for floating offshore structures and mobile offshore units*.

ISO 19901 is one of a series of standards for offshore structures. The full series consists of the following international standards.

— ISO 19900, *Petroleum and natural gas industries—General requirements for offshore structures*;

— ISO 19901 (all parts), *Petroleum and natural gas industries—Specific requirements for offshore structures*;

— ISO 19902, *Petroleum and natural gas industries—Fixed steel offshore structures*;

— ISO 19903, *Petroleum and natural gas industries—Fixed concrete offshore structures*;

— ISO 19904-1, *Petroleum and natural gas industries—Floating offshore structures—Part 1: Monohulls, semi-submersibles and spars*;

— ISO 19905-1, *Petroleum and natural gas industries—Site-specific assessment of mobile offshore units—Part 1: Jack-ups*;

— ISO/TR 19905-2, *Petroleum and natural gas industries—Site-specific assessment of mobile offshore units—Part 2: Jack-ups commentary*;

ISO 19906, *Petroleum and natural gas industries—Arctic offshore structures.*

Introduction

The series of standards applicable to types of offshore structures, ISO 19900 to ISO 19906, API 2A-WSD, and offshore structures used by the petroleum and natural gas industries worldwide. Through their application, the intention is to achieve reliability levels appropriate for manned and unmanned offshore structures, whatever the nature or combination of the materials used.

It is important to recognize that structural integrity is an overall concept comprising models for describing actions, structural analyses, design rules, safety elements, workmanship, quality control procedures, and national requirements, all of which are mutually dependent. The modification of one aspect of design in isolation can disturb the balance of reliability inherent in the overall concept or structural system. The implications involved in modifications, therefore, need to be considered in relation to the overall reliability of all offshore structural systems.

The series of standards applicable to types of offshore structures is intended to provide a wide latitude in the choice of structural configurations, materials, and techniques without hindering innovation. Sound engineering judgement is therefore necessary in the use of these standards.

The overall concept of structural integrity is described above. Some additional considerations apply for seismic design. These include the magnitude and probability of seismic events, the use and importance of the platform, the robustness of the structure under consideration, and the allowable damage due to seismic actions with different probabilities. All of these, and any other relevant information, need to be considered in relation to the overall reliability of the structure.

Seismic conditions vary widely around the world, and the design criteria depend primarily on observations of historical seismic events together with consideration of seismotectonics. In many cases, site-specific seismic hazard assessments will be required to complete the design or assessment of a structure.

This part of ISO 19901 is intended to provide general seismic design procedures for different types of offshore structures, and a framework for the derivation of seismic design criteria. Further requirements are contained within the general requirements standard ISO 19900 and within the structure-specific standards, ISO 19902, ISO 19903, ISO 19904, and ISO 19906. The consideration of seismic events in connection with mobile offshore units is addressed in ISO 19905.

Some background to and guidance on the use of this part of ISO 19901 is provided in informative Annex A. The clause numbering in Annex A is the same as in the normative text to facilitate cross-referencing.

Regional information on expected seismic accelerations for offshore areas is provided in informative Annex B.

Annex C provides a list and explanation of the deviations of this document to ISO 19901-2:2004.

Petroleum and natural gas industries—Specific requirements for offshore structures—Part 2: Seismic design procedures and criteria

1 Scope

This standard contains requirements for defining the seismic design procedures and criteria for offshore structures and is a modified adoption of ISO 19901-2. The intent of the modification is to map the requirements of ISO 19901-2 to the United States' offshore continental shelf (U.S. OCS). The requirements are applicable to fixed steel structures and fixed concrete structures. The effects of seismic events on floating structures and partially buoyant structures are also briefly discussed. The site-specific assessment of jack-ups in elevated condition is only covered to the extent that the requirements are applicable.

This document defines the seismic requirements for new construction of structures in accordance with API 2A-WSD, 22nd Edition and later. Earlier editions of API 2A-WSD are not applicable.

The majority of the ISO 19901-2 document is applicable to the U.S. OCS. Where necessary, this document provides guidance for aligning the ISO 19901-2 requirements and terminology with API. The key differences are as follows.

a) API 2EQ adopts the ISO 19901-2 site seismic zones in lieu of those previously used in API 2A-WSD, 21st Edition and earlier.

b) Only the maps in Figure B.2 are applicable, in lieu of those previously used in API 2A-WSD, 21st Edition and earlier.

c) ISO 19901-2 seismic design approach is also adopted here with:

   — a two-level seismic design in which the structure is designed to the ultimate limit state (ULS) for strength and stiffness and then checked to the abnormal or accidental limit state (ALS) to ensure that it meets reserve strength and energy dissipation requirements;

   — the seismic ULS design event is the extreme level earthquake (ELE) [this is consistent with, but not exactly the same as the strength level earthquake (SLE) in API 2A-WSD, 21st Edition and earlier];

   — the seismic ALS design event is the abnormal level earthquake (ALE) [this is consistent with, but not exactly the same as the ductility level earthquake (DLE) in API 2A-WSD, 21st Edition and earlier].

Only earthquake-induced ground motions are addressed in detail. Other geologically induced hazards such as liquefaction, slope instability, faults, tsunamis, mud volcanoes, and shock waves are mentioned and briefly discussed.

The requirements are intended to reduce risks to persons, the environment, and assets to the lowest levels that are reasonably practicable. This intent is achieved by using:

— seismic design procedures which are dependent on the platform's exposure level and the expected intensity of seismic events;

— a two-level seismic design check in which the structure is designed to the ultimate limit state (ULS) for strength and stiffness and then checked to abnormal environmental events or the accidental limit state (ALS) to ensure that it meets reserve strength and energy dissipation requirements.

For high seismic areas and/or high exposure level fixed structures, a site-specific seismic hazard assessment is required; for such cases, the procedures and requirements for a site-specific probabilistic seismic hazard analysis (PSHA) are addressed. However, a thorough explanation of PSHA procedures is not included.