NATIONAL IRANIAN OIL REFINING & DISTRIBUTION COMPANY
NATIONAL IRANIAN OIL ENGINEERING & CONSTRUCTION COMPANY

NIOEC SP

NIOEC SPECIFICATION
FOR
SEISMIC DESIGN OF TRANSPORTATION OIL PIPELINES

FIRST EDITION
SEPTEMBER 2008

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FOREWORD

By their very nature, technical standard specifications are continuously subject to modifications and revisions. To strengthen their merit and usefulness, continuous improvements, addendum, deletion of disparate information and consequently provision of updated revisions are to be made in order to ascertain that such standard specifications meet the current requirements, inclusive of Iranian Petroleum Standards (IPS) and the recognized and acceptable national and international standards, as well as the optimal codes and practices based on the accumulated in-house know-how and plant knowledge and experiences.

However, in reality, due to several reasons, not to mention the complexity of the matter, the ultimate goal of continuous direct embedment of the required changes on the relevant standard specifications may be far reaching. Therefore, in the interim periods between the officially issued revisions, the required changes will appear in other documents related to the engineering and design work of the ongoing projects.

In response to the initiative of the Design Division of the Engineering and Construction Directorate, and considering that the task of the execution of several important and mega projects for the realization of the new oil refineries, pipelines and oil terminals as well as improvements of the existing facilities, has been assigned to NIOEC, it was decided to update the NIOEC Specifications and to issue new official revisions.

The Design Division of the Engineering and Construction Directorate was itself entrusted to carry out this important task, and as such by forming several special technical committees, working in close co-operation and cohesion and sharing their expertise and knowledge, the updated and revised NIOEC Specifications were successfully prepared and complied.

These Specifications are intended to be used for Oil Refineries, Distribution Depots, Oil Terminals, Pipelines and Pump Stations within NIOEC's projects, and have been proven to be of high value for such purposes. It must however be appreciated that these Specifications represent the minimum requirements and should in no way be interpreted as a restriction on the use of better procedures, engineering and design practices or materials.

We encourage and highly appreciate the users and other clear sighted and experts to send their comments on the Specifications to the Design Deputy of the Engineering Department of NIOEC for evaluation and consideration.
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## NOTES:

1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.

2) REMARKS RELATED TO EACH REVISION SHOW A BRIEF DESCRIPTION. THESE REMARKS SHALL BE INTERPRETED IN CONJUNCTION WITH THE REVISED TEXT MARKED BY REVISION NUMBERS.

3) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.

4) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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1. SCOPE

NIOEC Specifications cover the general requirements for detailed engineering, of refinery/oil plant, distribution depots, pump stations and pipelines. The series of NIOEC Specifications as outlined through NIOEC-SP-01-01 to NIOEC-SP-01-28 define the method of calculation and minimum design criteria for seismic and retrofit design of all civil works for new and existing oil facilities. This NIOEC specification covers:
Seismic Design of Transportation Oil Pipelines.

2. REFERENCES

Throughout this Specification the following dated and undated standards/codes are referred to these referenced documents shall, to the extent specified here form a part of this Specification. For undated references, the latest edition of the referenced document (including any supplements and amendments) applies. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date, shall mutually be agreed upon by NIOEC and Vendor / Contractor.
The main part of this specification is extracted from new Seismic Design Code of Oil Facility. Therefore, for further details, references shall be made to NIOEC-SP-01-01.
Other references are as below.

NIOEC-SP(NIOEC-SPECIFICATIONS)

NIOEC-SP-00-10 "NIOEC Specification for Units"
NIOEC-SP-00-01 "NIOEC Specification for Civil Design Criteria"
NIOEC-SP-01-01 "Seismic Design Methods volume 3"
ASCE1984 "American Society of Civil Engineers"
JGA1974, 1982, 2000-1 "Japan Gas Association"
API5L "American Petroleum Institute"
ASME B31.4 "American Society of Mechanical Engineers"
JRA V "Japan Road Association"
JWWA1987 "Japan sewage work association"
WSP064 "Water Steel Pipe association"
KHK "(High Pressure Gas Safety Institute of Japan) 2000" Guideline of Anti Earthquake Design of High-Pressure Gas Manufacturing Facilities in Japan"
ALA2005 "Architectural Institute of Japan"
Iran2800 "Iranian Code of Practice for Seismic Resistant Design of Buildings"
3. UNITS

International system of units (SI) shall be used in accordance with NIOEC-SP-00-10, unless otherwise specified.

Numbers of Table, Figure and Equation in this Specification are corresponding to those of the detailed guideline.

4. TARGET COMPONENTS

Transmission pipeline is classified into several groups from installation conditions;
(1) Surface pipelines
(2) Buried pipelines
(3) Governor and pumping station

5. SEISMIC DESIGN FLOW BASED ON PERFORMANCE-BASED-CONCEPT

The seismic design of transmission pipeline should be based on the intended operational performance level the system must achieve in a post-earthquake disaster situation. This requires seismic performance objectives to be selected for the system.

*Damage limitation state* requires that pipeline can operate immediately after a MOE.
For this purpose, pipeline system should be designed to respond nearly elastically to a MOE.

*Ultimate limit state* requires that pipeline can re-start as soon as possible after repair and restoration works.
For this purpose, pipeline system should be designed not to rupture during a MCE.

6. EFFECTS BY EARTHQUAKES

The seismic design flowchart for buried pipelines is prepared for the seismic wave effects of MOE and MCE, while the seismic design flowchart for liquefaction, fault crossing and landslide must be provided for permanent ground displacements (PGD).

7. MATERIALS AND ALLOWABLE LEVELS

(1) Line pipe for transmission pipelines shall comply with last edition* of API specifications 5L.
   Refer NIOEC-SP-50-50(0)-6.4.1
(2) Construction materials shall comply with the relevant ASME code B31.4.
   Refer NIOEC-SP-50-50-(0)-6.3.1
(3) Materials for use in the pipeline system shall have the mechanical properties, such as strength and toughness, necessary to comply with the design requirements, and be suitable for the intended fabrication and/or construction methods.

1) Chemical component
   Ferritic steel materials intended for welding and for which a product standard is not available should have a maximum carbon equivalent (CE), while ferritic steel materials intended for welding and for which a product standard is available shall have a CE not exceeding the above values or the values quoted in the product standard, whichever is the lowest.
2) Brittle fracture toughness
   Materials in pipeline systems shall be selected and applied in such a way that brittle fracture is prevented.

(4) Allowable stress, strain and elastic stability shall comply with the relevant codes as shown in the main codes.
8. CALCULATION PROCEDURES (MODELING AND FORMULATION) AND SAFETY CRITERIA

For surface pipelines and stations, the structural responses shall be analyzed based on the seismic ground acceleration excitations with a dynamic response analysis technique. For buried pipelines, however, the structural response shall be calculated with an equivalent static analysis technique to estimate the structural strains induced by wave effects of MOE and MCE, and also by PGD.

9. SURFACE PIPELINE

Surface pipelines with their own support system shall be designed for seismic ground excitations and permanent ground displacement (PGD). The appropriate analytical methods from a simplified static estimate to non-linear finite element analysis should be selected based on the quality of seismic design level to be adopted.

(1) Pipeline with support system
(2) Pipeline bridge

10. PIPELINE WITH SUPPORT SYSTEM

The structural responses of surface pipeline with support system shall be analyzed in terms of relative displacement between neighboring anchors when a pipeline is excited by wave effects of MOE and MCE, while a pipeline crossing a fault line shall be designed to consume the PGD caused by a fault movement.

11. BASIC PRINCIPLES FOR SEISMIC DESIGN OF PIPELINE BRIDGE

(1) The seismic design of a bridge shall secure the seismic performance required depending on the importance of the bridges. Bridges shall be classified into two groups of importance; bridges of standard importance (Class B) and bridges of high importance (Class A).

(2) The seismic design shall be performed according to the seismic coefficient method and the ductility design method.

(3) The bridge structure must be designed not to lose its integrity during seismic motion to keep the oil transportation services through the pipeline.
12. LOAD COMBINATION

(1) In seismic design, the following inertia loads shall be taken into account:
   1) Primary loads
      The primary loads are
      a. Dead load (DH)
      b. pre-stress force (PS)
      c. Effect of creep of concrete (CR)
      d. Effect of drying shrinkage of concrete (SH)
      e. Earth pressure (Ep)
      f. Hydraulic pressure (HP)
      g. Buoyancy or uplift (U)
   2) Secondary loads
      Effects of earthquake (EQ)

(2) Combinations of loads shall be as follows:
   1) Superstructure
      Primary loads shown in (1) + effects of earthquake (EQ)
   2) Substructure
      Primary loads shown in (1) + effects of earthquake (EQ)

(3) Loads shall be assumed to act to cause the most disadvantageous stress, displacement and other effects.
13. FORCES BY EARTHQUAKES

As effects of earthquakes, the following shall be taken into account. However, when seismic design is carried out according to the ductility design method, it is generally not necessary to take (2) and (3) into account.

(1) Inertia force caused by the weight of the structure
   The inertial force shall be obtained by multiplying the weight of the structure by a design seismic coefficient.
(2) Earth pressure during an earthquake
(3) Hydraulic pressure during an earthquake
(4) Effects of liquefaction and lateral spreading

14. STRUCTURAL ANALYSIS

The structural analysis is carried out for the following 3 cases:

(1) when any seismic load is not applied.
(2) when a seismic load in the axial direction (x direction in Fig.4-3-5-1-2-3(1)) is applied.
(3) when a seismic load in the transverse direction (y direction) is applied.

(WSP064)

![Diagram](Fig.4-3-5-1-2-3(1) Model of bridge carrying a pipeline)

15. BEARING SUPPORT STRUCTURES

(1) The part of the bearing supports shall generally be capable of securely conveying the inertial force of the superstructures corresponding to the equivalent horizontal seismic coefficients.
(2) The bearing supports must be able to withstand the inertial force corresponding to the equivalent seismic force coefficients alone on a self-supporting basis.
(3) The bearing support shall be made of steel fabrications.
(4) Seismic forces to bearing support systems shall be calculated by the codes.
(5) Seat length and unseating structures shall be taken into consideration.

16. BURIED PIPELINE
Potential earthquake hazards to buried pipelines include transitory strains caused by differential ground displacement arising from ground shaking and permanent ground displacement (PGD) from surface faulting, lateral spread displacement, triggered landslide displacement, and settlement from compaction or liquefaction.

Seismic responses of buried pipelines must be analyzed by a conventional approach for a simple stretch of pipeline or by a finite element approach for more complex piping configuration.

1. For a simple stretch of pipeline which includes a straight pipeline and a single bending portion, a static analysis method is used to evaluate the structural responses of buried pipelines for wave-effects and permanent ground displacement (PGD).
2. For more complex piping configuration which includes 3-dimensional piping combination in buried ground, a finite element method can be applied to evaluate the structural responses of buried pipelines for wave effects and permanent ground displacement (PGD).
3. Straight and Bend portion pipelines shall be designed by the codes.
4. Wave propagation, Surface faulting, Liquefaction and Land slide shall be taken into consideration based on the codes.

Numbers shown in this book mean the number of Chapter, Section and Item written in the main codes.