



Bureau Veritas

NON-BONDED FLEXIBLE STEEL PIPES USED AS FLOW-LINES

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MARINE BRANCH GENERAL CONDITIONS

ARTICLE I

1.1. — BUREAU VERITAS is a Society, the purpose of whose Marine Branch is the classification of vessels, sea and river units and craft of all kinds.

The Society develops Rules, Guidance Notes and other Documents, publishes Registers and issues Certificates, Attestations and Reports which are the confirmation of its interventions.

1.2. — BUREAU VERITAS also participates in the application of National or International Regulations or Standards, in particular by delegation from different Governments.

1.3. — BUREAU VERITAS can also carry out Technical Assistance missions, to which Particular Conditions apply.

ARTICLE II

2.1. — Classification is the expression of confidence given by the Society to a vessel, sea or river unit or craft, for a particular use or service, during a certain period and with reference to its Rules, Guidance Notes or other Documents. This opinion expresses only the strict personal view of the Society. It is represented by a class published in the Register.

2.2. — The documents issued further to surveys carried out by the Society's surveyors, according to modalities mentioned in Article IV, reflect the condition of the vessel, sea or river unit or craft, at the time of survey. It is the responsibility of the owner, or of his agents, to maintain that condition until the next survey required by the Rules.

ARTICLE III

3.1. — The Rules, Guidance Notes and other Documents are developed by the Society, taking into consideration theoretical and practical research as well as the experience acquired on the vessels, units or craft classed by the Society.

Committees, consisting of personalities from the International Maritime Industry, contribute in the development of these documents.

3.2. — BUREAU VERITAS alone is qualified to apply and to interpret the documents mentioned above in paragraph 3.1. Any reference to them is without value if it does not involve the intervention of BUREAU VERITAS.

ARTICLE IV

4.1. — In accordance with Classification Societies' standards of practice, BUREAU VERITAS uses the services of qualified surveyors for carrying out its activities.

4.2. — BUREAU VERITAS undertakes to exercise due care and skill based on the state of art and technique prevailing at that time, in the elaboration and application of its rules, guidance notes and other documents as well as the preparation and issuance of its reports and certificates.

ARTICLE V

5.1. — BUREAU VERITAS is neither Underwriter, Consulting Engineer, Naval Architect, Shipbuilder, nor Shipowner, and cannot assume the obligations inherent to such functions, even though its experience enables it to answer enquiries concerning matters not covered by its Rules, Guidance Notes or other Documents.

5.2. — BUREAU VERITAS cannot substitute for Designers, Shipbuilders, Manufacturers or Shipowners who, notwithstanding the interventions of the Society, are not released from any obligation whatever its nature.

In particular, BUREAU VERITAS does not declare the acceptance of a vessel, a sea or river unit or craft, of an installation, material or equipment, such acceptance being declared by the Owner.

ARTICLE VI

6.1. — The Rules, Guidance Notes and other Documents as well as the Reports and Certificates developed or issued by BUREAU VERITAS cannot be considered, under any circumstances, as implying any guarantee whatsoever from BUREAU VERITAS, as to the characteristics, performances or safety of sea and river units and craft of all kinds which they pertain to.

6.2. — Except where gross negligence has been shown, BUREAU VERITAS cannot be held responsible for the results of its activities which are carried out according to its Rules, Guidance Notes or other pertinent Documents, and its opinions such as expressed through the classification or the Certificates, Attestations, Reports and other Documents issued by it.

6.3. — In the event BUREAU VERITAS is held liable pursuant to paragraph 6.2, the extent of liability shall, in no circumstance, whatever the nature and magnitude of the damages for which a claim has been filed, exceed a total aggregate sum equal to five times the amount of the fees paid in respect of the specific services rendered which gave rise to such claim.

6.4. — Although BUREAU VERITAS exercises due care and skill in the preparation of its Publications, Certificates, Attestations, Reports and other Documents, it disclaims all responsibility for any material omission or error that might be found in any such Document.

ARTICLE VII

When BUREAU VERITAS acts by delegation of Governments, as mentioned in Article I § 1.2, its responsibility is delimited within the framework of International Conventions and National Regulations which govern these interventions.

ARTICLE VIII

Requests for interventions shall, in principle, be submitted in writing. They entail the acceptance without reservation, of the present General Conditions and of Particular Conditions which may be attached thereto.

ARTICLE IX

Any intervention of BUREAU VERITAS, whatever its nature, whether completed or interrupted for any cause whatsoever, shall entail the payment of fees upon receipt of the invoice and the reimbursement of the expenses incurred. Interest may be demanded in case of late payment.

ARTICLE X

Should a technical disagreement arise between the requesting party and the BUREAU VERITAS surveyor, the Society may, at the request of that party, designate another of its surveyors.

ARTICLE XI

Any dispute shall be submitted to the court of Nanterre (France), even in case of third party claims "intervention forcée" or in case of multi-party claims.

CONTENTS

1 - GENERAL

1.1. Scope

1.2. Certification Scheme

1.2.1. Regulatory Frame

1.2.2. Independent Review Certificate

1.2.3. Certificate of Conformity

1.3. Applicable Codes and Standards

2 - DEFINITIONS AND SYSTEM DESCRIPTION

2.1. Definitions

2.2. Flexible Steel Pipe

2.2.1. Scope

2.2.2. Construction Types

2.2.3. Application

2.3. End-fittings

2.4. Secondary Devices and Appurtenances

2.4.1. Bend Limiters

2.4.2. Bend Stiffeners

3 - OPERATIONAL REQUIREMENTS AND DESIGN CONSIDERATIONS

3.1. General

3.2. Mechanical Considerations

3.2.1. Dimensions

3.2.2. Internal Pressure

3.2.2.1. Operating Pressure

3.2.2.2. Surge Pressures

3.2.2.3. Design Pressure

3.2.2.4. Provision for Surge Over Pressure

3.2.2.5. Test Pressures

3.2.2.6. Bursting Pressure

3.2.3. Collapse

3.2.3.1. Design Hydrostatic Pressure

3.2.3.2. Collapse Pressure

3.2.3.3. Crush Resistance

3.2.4. Tensile Load

3.2.5. Flexibility

3.2.6. Minimum Bend Radius

3.2.7. Weight and Buoyancy

3.2.8. Torsion

3.2.9. Rapid Decompression

3.3. Transported Fluid Considerations

3.3.1. Temperature Limits

3.3.2. Fluid Properties

3.3.2.1. H₂S Service

3.3.2.2. CO₂ Service

3.3.2.3. Chloride Service

3.3.3. Fluid Velocity

3.4. Environmental Considerations

3.5. Other Considerations

3.5.1. Thermal Insulation

3.5.2. On-bottom Stability

3.5.3. Trenching

3.5.4. Pigging/TFL Requirements

3.5.5. Service Life

3.5.6. End-fittings

3.5.7. Bend Limiters/Stiffeners

3.5.8. Permeability

3.5.9. Electrical Continuity

4 - DESIGN ANALYSIS

4.1. Scope

4.2. Analysis Objectives and Procedures

4.2.1. Analysis Objectives

4.2.2. Analysis Procedures

4.3. Environmental and Design Conditions

4.3.1. General

4.3.2. Loading Conditions

4.3.3. Operational Loads

4.3.4. Environmental Loads

4.3.5. Accidental Loads

4.4. Design Criteria

4.4.1. General

4.4.2. Bursting

4.4.2.1. Maximum Allowable Stress

4.4.2.2. Comparison Bursting Stress

4.4.2.3. Stress Coefficient

4.4.2.4. Bursting Pressure

4.4.3. Operating Conditions

4.4.3.1. Maximum Allowable Stress

4.4.3.2. Comparison Design Stress

4.4.4. Collapse

4.4.5. Tension

4.4.5.1. Maximum Allowable Stress

4.4.5.2. Comparison Tensile Stress

4.4.5.3. Damaging Tensile Load

4.4.6. End-fittings

4.5. On-bottom Stability

5 - MATERIALS

5.1. General

5.2. Structural Elements Categories

5.3. Scope and Conditions of Inspection

5.3.1. Inspection and Tests

5.3.2. Scope

5.3.3. Conditions

5.3.4. Manufacturer Attestation

5.4. Plastics

5.4.1. General

5.4.2. Physico-mechanical Properties

5.4.3. Permeability

5.4.4. Ageing Resistance

5.5. Steel Materials

5.5.1. General

5.5.2. Steel Wires

5.5.3. End-fitting Materials

5.5.3.1. Test Series - Sampling for Mechanical Tests

5.5.3.2. Mechanical Characteristics

5.5.3.3. Non-destructive Testing

5.5.3.4. Additional Tests

5.5.4. Welding

5.5.4.1. General

5.5.4.2. Welding Qualifications

6 - FABRICATION AND INSPECTION

6.1. General

6.2. Materials

6.3. Manufacturing

6.3.1. Welding

6.3.2. Defect Repair

6.3.3. Pipe Identification

6.4. Quality Assurance

6.4.1. Documentation

6.4.2. Acceptance Tests

6.4.3. Test Certificates

6.5. Testing

6.5.1. General

6.5.2. Performance Tests

6.5.2.1. Scope

6.5.2.2. Bursting Test

6.5.2.3. Tension Test

6.5.2.4. Hydrostatic Collapse Test

6.5.2.5. Bending Test

6.5.2.6. Torsion Test

6.5.3. Acceptance Tests

6.5.3.1. Scope

6.5.3.2. Hydrostatic Test

6.5.3.3. Drift Test

6.5.4. Special Tests

6.5.4.1. Scope

6.5.4.2. Sand Slurry Test

6.5.4.3. Hydrogen Sulphide Test

6.5.4.4. Through Flowline (TFL) Test

6.5.4.5. Arctic Condition Test

6.5.4.6. Weathering Test

6.5.4.7. Fire Test

6.5.4.8. Crush Resistance Test

7 - STORAGE, HANDLING, TRANSPORTATION AND INSTALLATION

7.1. Scope

7.2. Storage

7.2.1. Reels and Baskets

7.2.2. Crates and Pallets

7.2.3. Storage Recommendations

7.3. Handling and Transportation

7.4. Installation

7.4.1. Installation Loads

7.4.1.1. Tension

7.4.1.2. Crushing

7.4.1.3. Collapse

7.4.2. Trenching

7.5. Re-use of Flexible Steel Pipe

8 - OPERATION AND MAINTENANCE

8.1. General

8.2. Operation and Maintenance

8.3. Survey Program

8.4. Repairs

8.4.1. General

8.4.2. Repairs

APPENDICES

A. Environmental

- A.1. Scope
- A.2. Waves and Current Forces
 - A.2.1. Drag Force
 - A.2.2. Inertia Force
 - A.2.3. Lift Force
 - A.2.4. Resulting Force on the Pipe
- A.3. Wave Theory
- A.4. Recommended Values for Hydrodynamic Coefficients
 - A.4.1. General
 - A.4.2. Drag Coefficient
 - A.4.3. Added Water Mass Coefficient
 - A.4.4. Lift Coefficient

B. Documents to be Submitted for a Non-bonded Flexible Steel Pipe Certification

- B.1. General
- B.2. Documents for Information
- B.3. Documents for Issuance of the Certificate of Design Approval
- B.4. Documents for Issuance of the Certificates of Independent Review
- B.5. Documents for Issuance of the Certificate of Type Approval
- B.6. Documents for Issuance of the Independent Review Certificate
- B.7. Documents for Issuance of the Certificate of Conformity

C. Quality Assurance Procedure

- C.1. General
- C.2. General Concepts
- C.3. Objectives
- C.4. Quality System
- C.5. Quality Assurance
 - C.5.1. Design
 - C.5.2. Raw Materials
 - C.5.3. Fabrication
 - C.5.4. Non-conformity
 - C.5.5. Corrective Actions
 - C.5.6. Documentation

D. Welding

- D.1. Scope
- D.2. Butt Welding of Carcass
 - D.2.1. General
 - D.2.2. Conditions of Welding - Welding Procedure Specification (WPS)
 - D.2.3. Welding Procedure Qualification Record (WPQR)
 - D.2.3.1. Scope
 - D.2.3.2. Welding Procedure Qualification Tests
 - D.2.3.3. Acceptance Criteria
 - D.2.3.4. Certificate of Qualification
 - D.2.3.5. Validity of the Qualification

- D.2.4. Qualification of the Welders/Operators
 - D.2.4.1. Procedure
 - D.2.4.2. Certificate of Qualification
 - D.2.4.3. Validity of the Qualification
- D.2.5. Welds Inspection
- D.3. Butt Welding of the Steel Wires
 - D.3.1. General
 - D.3.2. Conditions of Welding - Welding Procedure Specification (WPS)
 - D.3.3. Welding Procedure Qualification Record (WPQR)
 - D.3.3.1. Scope
 - D.3.3.2. Welding Procedure Qualification Tests
 - D.3.3.3. Acceptance Criteria
 - D.3.3.4. Certificate of Qualification
 - D.3.3.5. Validity of the Qualification
 - D.3.4. Qualification of the Welders/Operators
 - D.3.4.1. Procedure
 - D.3.4.2. Certificate of Qualification
 - D.3.4.3. Validity of the Qualification
 - D.3.5. Welds Inspection
- D.4. Welding of End-fittings
 - D.4.1. General
 - D.4.1.1. Documents
 - D.4.1.2. Electrodes and Fillers materials
 - D.4.1.3. Weld Preparation
 - D.4.1.4. Welding Operations
 - D.4.2. Welding Qualifications
 - D.4.2.1. General
 - D.4.2.2. Welding Procedure Specification (WPS)
 - D.4.2.3. Welding Procedure Qualification (WPQ)
 - D.4.2.4. Qualification and Testing of Welding Procedures
 - D.4.3. Testing of Butt-joints for Welding Procedure Qualification
 - D.4.3.1. General
 - D.4.3.2. Qualification Testings
 - D.4.3.3. Acceptance Criteria
 - D.4.3.4. Qualification Documentation
 - D.4.3.5. Certificate of Qualification
 - D.4.3.6. Validity of the Qualification
 - D.4.4. Testing of Fillet Welds for Welding Procedure Qualification
 - D.4.4.1. General
 - D.4.4.2. Qualification Testings
 - D.4.4.3. Acceptance Criteria
 - D.4.4.4. Qualification Documentation
 - D.4.4.5. Certificate of Qualification
 - D.4.4.6. Validity of the Qualification
 - D.4.5. Surfacing by Welding with Stainless Steel Procedure Qualification
 - D.4.5.1. General
 - D.4.5.2. Qualification Testings
 - D.4.5.3. Acceptance Criteria
 - D.4.5.4. Qualification Documentation
 - D.4.5.5. Certificate of Qualification
 - D.4.5.6. Validity of the Qualification
- D.5. Qualification of Welders and Welding Operators
 - D.5.1. Procedure
 - D.5.2. Certificate of Qualification
 - D.5.3. Validity of the Qualification
- D.6. Production Welds
- D.7. Inspection of Welds

Table D.1. : Welding Procedure Details (from BS4515)

Table D.2. : Changes Affecting Approval (from BS4515)

E. Type Approval Procedure

- E.1. Scope
- E.2. Description and Identification
- E.3. Design Rules
- E.4. Raw Materials
- E.5. Fabrication and Inspection
- E.6. Quality Assurance System
- E.7. Certificates

Procedure for Type Approval

1 - GENERAL

1.1. SCOPE

These Guidelines apply to non-bonded flexible steel pipes, the definition of which is given in section 2.2., with a design pressure greater than 1.6 MPa (225 psi) used as flow-lines.

The scope of these Guidelines is to outline the basic considerations for the design analysis, quality assurance, storage, handling, transportation, installation and maintenance of flexible steel pipes.

Due to the variety of possible designs and methods of analysis, some topics are presented in general terms to provide guidance to the operator while still leaving the door open to alternative approaches.

Low pressure (design pressure not greater than 1.6 MPa (225 psi)) hoses, flexible choke and kill lines are beyond the scope of these guidelines.

This document is not intended to offer a comprehensive treatment of flexible steel pipe. It will be revised as new information become available.

1.2. CERTIFICATION SCHEME

1.2.1. Regulatory Frame

National and Coastal State regulations requiring certification of pipelines may be satisfied by the issuance of BUREAU VERITAS "Certificate of Type Approval", "Independent Review Certificate", and "Certificate of Conformity".

During the Type Approval process, some intermediate Certificates such as "Certificate of Design Approval" or "Certificate of Independent Review" may be issued by BUREAU VERITAS. The procedure to be followed for Type Approval certification is as indicated in appendix E.

1.2.2. Independent Review Certificate

The flexible steel pipe for which an Independent Review Certificate is requested belongs to a family for which a Certificate of Type Approval has been issued.

Upon satisfactory completion of BUREAU VERITAS verification of the design calculations, taking into account the design specifications, and the choice of the materials, taking into account the service conditions, an Independent Review Certificate will be issued. The Certificate will refer to the relevant Certificate of Type Approval and design specifications.

1.2.3. Certificate of Conformity

The flexible steel pipe for which a Certificate of Conformity to the present Guidance Note is requested belongs to a family for which a Certificate of Type Approval has been issued, and is covered by an Independent Review Certificate.

Upon satisfactory completion of BUREAU VERITAS checking of the attestations related to material inspection, acceptance tests, and special tests if necessary, a Certificate of Conformity to the present Guidance Note will be issued for each flexible steel pipe. The Certificate will refer to the relevant Certificate of Type Approval and Independent Review Certificate, and will list the performed tests.

1.3. APPLICABLE CODES AND STANDARDS

The following standards are referenced in part, or in whole, in these Guidelines. It is recognized that additional standards have been developed by other bodies. Therefore this listing is representative and should not be considered as either all inclusive, or exclusive, of other standards relating to topics covered in these Guidelines.

BUREAU VERITAS

RULES AND REGULATIONS FOR THE CLASSIFICATION OF STEEL SHIPS AND OFFSHORE UNITS - MATERIALS.

ASSOCIATION FRANCAISE DE NORMALISATION (AFNOR)

NF A 35-051 : IRON AND STEEL - NON ALLOY STEEL WIRE ROD FOR WIRE DRAWING AND COLD ROLLING GRADES

NF X 50-101 : SUPPLIER - USER RELATIONSHIPS - GENERAL DRAFTING PRINCIPLES OF TECHNICAL HANDBOOKS CONCERNING APPLIANCES FOR INDUSTRIAL USE

NF X 50-103 : SUPPLIERS, USERS - GENERAL METHODS FOR INSPECTION AND ACCEPTANCE (SUB- CONTRACTING)

NF X 50-104 : SUPPLIERS, USERS - PROGRAMME OF ADVANCED QUALITY ASSURANCE

NF X 50-105 : SUPPLIERS, USERS - PROGRAMME OF ADVANCED QUALITY ASSURANCE FOR PERFORMANCE MATERIALS AND SMALL SERIES

NF X 50-106 : SUPPLIERS, USERS - QUALITY AUDIT.

AMERICAN PETROLEUM INSTITUTE (API)

RP 2Q : DESIGN AND OPERATION OF MARINE DRILLING RISER SYSTEMS

SPEC 6 A : SPECIFICATION FOR WELLHEAD AND CHRISTMAS TREE EQUIPMENT

SPEC 6 FA : SPECIFICATION FOR FIRE TEST FOR VALVES

RP 6 G : THROUGH FLOW-LINE (TFL) PUMP-DOWN SYSTEM

SPEC 14 A : SPECIFICATION FOR SUBSURFACE SAFETY VALVE EQUIPMENT

SPEC 16 A : DRILL THROUGH EQUIPMENT

RP 17 A : DESIGN AND OPERATION OF SUBSEA PRODUCTION SYSTEMS

RP 17 B : FLEXIBLE PIPE

RP 1110 : PRESSURE TESTING OF LIQUID PETROLEUM PIPELINES

RP 1111 : DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF OFFSHORE HYDROCARBON PIPELINES.

LLOYD'S REGISTER OF SHIPPING

ICE/FIRE, OSC 1000/499 : FLEXIBLE HOSES ON OFFSHORE INSTALLATION (FIRE TESTS)

NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE)

MR-01-75 : SULFIDE STRESS CRACKING RESISTANT METALLIC MATERIALS FOR OIL FIELD EQUIPMENT

RP-01-75 : CONTROL OF INTERNAL CORROSION IN STEEL PIPELINES AND PIPING SYSTEMS

TM-01-77-86 : TESTING OF MATERIALS FOR RESISTANCE TO SULFIDE STRESS CRACKING AT AMBIENT TEMPERATURE

OIL COMPANIES INTERNATIONAL MARINE FORUM (OCIMF)

SPECIFICATION FOR RUBBER, REINFORCED, SMOOTH BORE, OIL SUCTION AND DISCHARGE HOSES FOR OFFSHORE MOORINGS.

GUIDE FOR THE HANDLING, STORAGE, INSPECTION AND TESTING OF HOSES IN FIELD.

2 - DEFINITIONS AND SYSTEMS DESCRIPTION

2.1. DEFINITIONS

ACID LINES - Flexible steel pipes used for the transportation of acid or batch treatment chemicals to be used in production well stimulation.

BEND LIMITER - A mechanical device that limits the local radius of curvature of the flexible steel pipe to a minimum value.

BEND STIFFENER - Flexible steel pipe construction aimed at increasing the bending stiffness in a particular area to reduce maximum stresses.

CARCASS - An interlocked metallic construction that can be used as one of the flexible steel pipe layers.

CONNECTOR - A device used to provide a leak-free structural connection at the end of a length of flexible steel pipe.

END-FITTING - The flexible steel pipe end construction including the termination of the different flexible steel pipe layers and the connector.

FLEXIBLE STEEL PIPE - A composite of different layers including steel and resins that can perform functions similar to rigid pipe and can also withstand large curvature without adverse effects.

H₂S SERVICE - H₂S Service is defined as fluid service conditions containing above 0.04 MPa (0.05 Psi) partial pressure of hydrogen sulfide calculated at operating pressure.

LAY ANGLE - This is the angle between the axis of an armour wire and a line parallel to the flexible steel pipe axis.

MINIMUM BEND RADIUS (MBR) - The minimum radius, measured from the pipe centre line, to which it may be bent without damage.

PERMEABILITY - The characteristic of a material to allow a fluid to pass through it.

QUALITY ASSURANCE - Those planned, systematic and preventive actions which are required to ensure that materials, products, or services will meet specified requirements.

QUALITY CONTROL - Inspection, test or examination to ensure that materials, products, or services comply with specified requirements.

QUALITY PROGRAM - An established documented system to ensure quality.

TERMINATION - A part of the end-fitting which forms the transition between regular flexible steel pipe construction and the connector.

2.2. FLEXIBLE STEEL PIPE

2.2.1. Scope

This section describes the main construction types and the different possible applications of flexible steel pipes.

2.2.2. Construction Types

Flexible steel pipes may be divided into two types depending on the construction, non bonded layer and bonded layer. Flexible steel pipe mainly relies on steel to provide mechanical strength, and on thermoplastic resins to ensure leak-tightness. The number and angle of the steel armours, the thicknesses and materials choice of layers and the arrangement of layers is governed by service and installation requirements.

Non-bonded flexible steel pipe consists of several and separate layers having no adhesion between them. Each succeeding layer is wrapped or extruded on the previous layer in a continuous process along the entire length.

Bonded flexible steel pipe consists of several layers wrapped or extruded individually and then bonded together through the use of adhesive or by applying heat and/or pressure (such as vulcanizing) to fuse the layers into a single construction. This kind of structure is out of the scope of the present Guidance Note.

2.2.3. Application

In static application, flexible steel pipes are mainly used as pipelines. The choice of flexible steel pipe is based on facility of storage and installation.

2.3. END-FITTINGS

The end-fitting, which is located at each end of a length of flexible steel pipe, consists of a termination and a connector. Its purpose is as follows :

- 1/ The termination should be able to transmit the axial and radial loads, bending moments, instead of the strength elements of the flexible steel pipe, without adversely affecting the fluid-containing layers.
- 2/ The connector should provide a pressure tight transition between the pipe body and the connection point.

Connectors may be an integral part of, or welded to, the termination to complete the end-fitting. The choice of the connector depends on operational and service requirements.

2.4. SECONDARY DEVICES AND APPURTENANCES

2.4.1. Bend Limiters

Bend limiters are designed either to restrict mechanically the flexible steel pipe from bending beyond its MBR or to meet operational requirements.

2.4.2. Bend Stiffeners

Bend stiffeners are used to increase the pipe's bending stiffness in some areas. The increased stiffness reduces stresses in pipe layers subjected to anticipated bending moments that could otherwise be unacceptable.

3 - OPERATIONAL REQUIREMENTS AND DESIGN CONSIDERATIONS

3.1. GENERAL

The scope of this section is to provide guidelines for the operator when defining flexible steel pipe for a given application and set of operational requirements. This section also provides information concerning the effect of varying criteria, conditions of service, and loading conditions on the design and construction of flexible steel pipe.

Operational requirements consist of functional requirements and performance characteristics. Functional requirements are criteria to be specified by the operator that the pipe must meet in a given application. Performance characteristics are properties that characterize the performance of a given flexible steel pipe as determined by the design, based on the functional requirements specified by the operator.

Because of its composite construction, the choice of design criteria for certain functional requirements may adversely affect the performance characteristics of flexible steel pipe in other areas of the design.

All pipe materials, the choice of which should be carefully considered, must be selected with regard to the physical and chemical conditions to which the pipe will be exposed.

3.2. MECHANICAL CONSIDERATIONS

3.2.1. Dimensions

The following dimensions are required to define a flexible pipe : inside diameter (I.D), and length.

Given a design pressure, the choice of the I.D. conditions the structure of the flexible steel pipe (strength, materials, layer dimensions, additional layers).

The operator should notify the manufacturer if there is any restriction to the outside diameter or end-fitting dimensions for the application considered.

Tolerances for these dimensions should be agreed between the operator and the manufacturer. Particular attention should be given to the elongation of the flexible steel pipe resulting from the action of internal pressure.

3.2.2. Internal Pressure

3.2.2.1. Operating Pressure

The operating pressure, also called working pressure, is the pressure needed to maintain the required mass flow rate through the pipe, taking into account any elevation differences and terminal pressure requirements.

3.2.2.2. Surge Pressures

Surge pressures are produced by a change in velocity of the moving stream and are greatest when there is a stoppage, such as would be caused by the closing of a valve or by shutting down a pump station.

3.2.2.3. Design Pressure

The design pressure is the maximum internal pressure to which the pipe is supposed to be subjected during its life. It includes operating pressure and allowances for surges or factors affecting internal pressure. The pipe should be able to withstand the internal design pressure with atmospheric external pressure. The design pressure, which is to be defined by the operator, is to be warranted by the manufacturer.

3.2.2.4. Provision for Surge Over Pressure

The maximum actual pressure which arises, in service, as the result of the operating conditions plus surge pressure should in no case exceed 110 % of the internal design pressure.

3.2.2.5. Test Pressures

Pressure testing includes tests to be performed either after fabrication or after installation, as indicated in section 6.

The test pressure, resulting from pressure test after fabrication, should be at least 1.5 times the design pressure.

The installed test pressure should be at least 1.1 times the design pressure, but generally it should not exceed 1.25 times the design pressure.

3.2.2.6. Bursting Pressure

The bursting pressure for a flexible steel pipe is a performance characteristic. It should be at least 2 times the design pressure.

3.2.3. Collapse

The collapse of a flexible steel pipe, which results in a permanent damage, involves a flattening of the cross section, and prevents the pipe from performing its function.

Collapse may be caused by one of the following loading conditions acting separately or in combination :

- 1/ Excessive external pressure
- 2/ Excessive axial or lateral compressive loads
- 3/ Accidental external impact loads
- 4/ Excessive tensile load
- 5/ Bending of the pipe to a radius smaller than its minimum bend radius.

Operator should be aware that tension in a flexible steel pipe can induce internally-generated collapse loads.

3.2.3.1. Design Hydrostatic Pressure

The design hydrostatic pressure is the external pressure acting on the pipe, filled with air at atmospheric pressure, resulting from the action of the sea water at the pipe service depth.

3.2.3.2. Collapse Pressure

The collapse pressure is defined as being the external pressure for which the collapse of the flexible steel pipe, with internal atmospheric pressure, will occur. It should be at least 1.5 times the design hydrostatic pressure.

3.2.3.3. Crush Resistance

The crush resistance of a flexible steel pipe is also a design consideration.

It should be noted that excessive local loading through external concentrated loads caused by foreign objects can cause failure and leads to provide external protection to the pipe.

3.2.4. Tensile Load

The design tensile load is the maximum tension to which the flexible steel pipe will be subjected during storage, installation and in service phases.

The damaging tensile load is the minimum tension for which collapse or other damage will occur in the pipe. It should be at least 2 times the design tensile load.

During the installation phase, the ratio of the damaging tensile load to the design tensile load can be reduced to a value, not less than 1.5, provided a full analysis, including dynamic aspects, is carried out and submitted to the Society.

The most severe combination of pressure (internal and external) and tensile load on the pipe should be considered for the design.

3.2.5. Flexibility

Flexibility is a performance characteristic of the flexible steel pipe. The operator should advise if there is a specific flexibility requirement.

3.2.6. Minimum Bend Radius

Minimum bend radius is a performance characteristic of the flexible steel pipe. As such it is to be specified by the manufacturer to prevent damage to the pipe during storage, installation and operation.

In certain circumstances, the operator may need to specify a required value for the minimum bend radius. In these cases, a distinction may be made between storage, installation and operation.

3.2.7. Weight and Buoyancy

Weight and buoyancy are performance characteristics of the flexible steel pipe. As such they have to be specified by the manufacturer.

3.2.8. Torsion

Torsional characteristic is a performance characteristic of the flexible steel pipe. If special requirement is asked by the operator, it should be indicated to the manufacturer.

3.2.9. Rapid Decompression

In case of rapid decompression possibility, which can lead to structural damage of the flexible steel pipe, the operator should advise the manufacturer who has to take into account the possibility in its design.

3.3. TRANSPORTED FLUID CONSIDERATIONS

3.3.1. Temperature Limits

The operator should specify the maximum and the minimum temperatures of the transported fluid by the flexible steel pipe during service.

Special care should be exercised to ensure that the polymers used in the flexible steel pipe will not be damaged by the transported fluid in such a way they will not be able to provide a satisfactory service life.

3.3.2. Fluid Properties

Flexible steel pipe materials should be selected with regard to the chemical conditions to which the pipe will be exposed during its life. These chemical conditions have to be specified by the operator. It is important that any adverse substances found in produced fluid be identified as they may affect the service life of the pipe, by accelerating, for example, the ageing of the polymers.

Example of adverse elements are H₂S, CO₂, sand, water and chloride.

3.3.2.1. H₂S Service

All pipe materials used in H₂S service should be capable of resisting degradation over the life of the pipe. Many polymers are susceptible to degradation and blistering in presence of H₂S. They may become brittle and fail in flexure. Many metals are subject to sulfide stress cracking.

3.3.2.2. CO₂ Service

CO₂ is highly corrosive in presence of water. If CO₂ and water are present in sufficient quantities to be detrimental, the materials should resist to such corrosion. Some polymers may also be chemically degraded under the acidic condition of wet CO₂.

3.3.2.3. Chloride Service

When the fluid is anticipated to contain chloride, care should be taken in the selection of materials to avoid the possibility of chloride stress corrosion cracking. Polymers used in flexible steel pipe are generally not affected by contact with chlorides, except in presence of a second reactive component.

Some methods of controlling internal corrosion are discussed in NACE-RP-01-75.

3.3.3. Fluid Velocity

The operator should advise the manufacturer of fluid velocity, particularly when abrasive materials are in the fluid. In this case, use of a wear-resistant inner layer is recommended.

3.4. ENVIRONMENTAL CONSIDERATIONS

All environmental phenomena which may impair the proper function of the flexible steel pipe or cause a reduction of its reliability are to be considered.

Data, supplied by recognized consultants, must describe the characteristic parameters which are relevant in the evaluation of the effect on the flexible steel pipe. These parameters can be measured or estimated with reasonable accuracy by currently available methods.

The followings are examples of environmental information that may be required :

- 1/ Water depth
- 2/ Soil conditions and bottom topography
- 3/ Waves and current
- 4/ Tide and storm surge
- 5/ Air and sea temperatures
- 6/ Marine growth
- 7/ Presence of ice

3.5. OTHER CONSIDERATIONS

3.5.1. Thermal Insulation

Thermal insulation, which is necessary when the fluid temperature must be maintained at a given level, can be incorporated into the pipe structure.

3.5.2. On-bottom Stability

The flexible steel pipe, when laid down on the seabed, is subjected to hydrodynamic forces. Its susceptibility to motion should be evaluated. Excessive motion which might damage the pipe should be prevented.

3.5.3. Trenching

Trenching of the flexible steel pipe may be required. The operator should be aware that under internal pressure, flexible steel pipe is normally subjected to elongation which may result in the buckling of the pipe in the plane of the trench. It is therefore necessary for the operator to indicate to the manufacturer that the pipe will be trenched.

3.5.4. Pigging/TFL Requirement

The operator should specify any pigs or tools to be passed through the flexible steel pipe during service.

Flexible steel pipe intended for TFL service should comply with API RP 6G Section 3 for design, fabrication and testing, and with appendix A of the same RP for internal diameter and drift testing.

3.5.5. Service Life

Required service life is to be specified by the operator.

3.5.6. End-fittings

End-fittings have to be designed in order to withstand the loads (tension, pressure, and bending moment) resulting from the flexible steel pipe service. The interface between the end-fitting and the flexible steel pipe should be designed in such a way that the pipe, in no case, will be divorced from the end-fitting.

The resins used in the termination have to be chosen in order to behave adequately over the service life of the pipe. Special care is to be taken to the possible degradation of the resins due to elevated temperatures.

The type of connector should be specified by the operator. The connectors have to be designed according to a recognized standard such as Section C6 of CODAP 80, API SP 6A, ASME Section VIII Div. A or ANSI-B-5-1981.

3.5.7. Bend Limiter/Stiffener

When flexure close to the end-fitting may result in damage to the pipe, bend limiter/stiffener use is required.

3.5.8. Permeability

Permeability is a performance characteristic of the flexible steel pipe for a given application.

All polymers are to some extent permeable to gases. The amount of permeating depends on the kind of gas and the kind of polymer.

The flexible steel pipe should be designed to prevent any problem caused by permeated gas, such as collapse of the liner.

3.5.9. Electrical Continuity

The operator should specify any requirements concerning electrical continuity of the pipe structure.

4 - DESIGN ANALYSIS

4.1. SCOPE

This section defines the general principles that have to be followed in the design of flexible steel pipe. Analysis objectives, general procedures and requirements are also reviewed.

Methodologies suitable for flexible steel pipe analysis are discussed in the literature.

4.2. ANALYSIS OBJECTIVES AND PROCEDURES

4.2.1. Analysis Objectives

The objective of analysis is to help ensure that flexible steel pipe systems are designed, installed and operated in safe conditions. The results of the analysis have to be used in the design phase for checking the pipe design, for determining the proper installation procedures and the safe operating limits.

4.2.2. Analysis Procedures

Techniques for the analysis of flexible steel pipe systems are not as widely published as are techniques for the analysis of rigid pipe systems. Different techniques are usually required for flexible steel pipes because of fundamental differences between the two systems.

Static analysis is used to evaluate flexible pipe systems. Loads that are typically considered in a static analysis include gravity loads, buoyancy, pressure, current and wave loads.

Considering the disjunction of functions between the different layers of a non-bonded flexible steel pipe, local stresses may be computed as they are in rigid lines.

Two sources of damage have to be considered for the service life analysis which are material wear and chemical deterioration.

Material wear is mainly caused by the transported fluid. For this reason, the erosion of the inner liner by the transported fluid should be estimated. Test data should be relied upon to estimate the severity of pipe erosion for a given application.

Chemical deterioration results from a reaction of pipe material with the environment. Special attention should be given to this problem during the design of the flexible steel pipe.

4.3. ENVIRONMENTAL AND DESIGN CONDITIONS

4.3.1. General

All environmental phenomena which may impair the proper function of the flexible steel pipe, or cause a reduction of its reliability are to be considered. Such phenomena include wind, waves, current, tide, ice, temperature, etc.

Data, which are supplied by recognized consultants, have to describe the characteristic parameters which are relevant in the evaluation of the effect on the pipe. These parameters can be measured, or estimated, with reasonable accuracy by currently available methods.

4.3.2. Loading Conditions

Any part of the flexible steel pipe system is to be designed for the most unfavourable of the following conditions:

- 1/ Flexible steel pipe in place under operational loads acting alone.
- 2/ Flexible steel pipe in place under operational and environmental loads.
- 3/ Flexible steel pipe during hydrostatic test.
- 4/ Flexible steel pipe during installation.
- 5/ Flexible steel pipe under accidental loads.

Operational loads, environmental loads and accidental loads are defined in Sections 4.3.3., 4.3.4. and 4.3.5.

4.3.3. Operational Loads

Operational loads are resulting from the use of the system, when no environmental load is acting.

The operational loads are normally those due to :

- 1/ Weight
- 2/ Internal and/or external pressure
- 3/ Temperature.

Weight is to include :

- 1/ Weight of the pipe and all attachments
- 2/ Weight of transported fluid
- 3/ Buoyancy.

4.3.4. Environmental Loads

Environmental loads are due to wind, waves and current, and other environmental phenomena.

The maximum environmental loads during normal operation are to be taken not less than the most probable severe load in a time period of 100 years. Other environmental conditions (1 year period) may be used for installation.

The loads, resulting from the environmental phenomena, may be determined in accordance with the methods given in Appendix A.

4.3.5. Accidental Loads

Accidental loads are loads resulting from exceptional phenomena. Once the pipe has been subjected to such loads, it has to be submitted to special investigations in order to check its integrity. Such phenomena include unexpected high temperature in combination with high pressure, impact etc.