



GUIDE FOR BUILDING AND CLASSING

SUBSEA PIPELINE SYSTEMS

MAY 2006 (Updated February 2014 – see next page)

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

**Copyright © 2006
American Bureau of Shipping
ABS Plaza
16855 Northchase Drive
Houston, TX 77060 USA**

Updates

February 2014 consolidation includes:

- March 2008 version plus Corrigenda/Editorials

March 2008 consolidation includes:

- November 2007 version plus Notice No. 2, Corrigenda/Editorials

November 2007 consolidation includes:

- May 2007 version plus Notice No. 1

Foreword

This Guide applies to classification of design, construction and installation of offshore pipelines made of metallic materials, as well as the periodic surveys required for maintenance of classification. Serviceability of pipelines is also addressed, but only to the extent that proper functioning of the pipe and its components affects safety. This Guide may also be used for certification or verification of design, construction and installation of pipelines. ABS will certify or verify design, construction and installation of offshore pipelines when requested by the Owner or mandated by government regulations to verify compliance with this Guide, a set of specific requirements, national standards or other applicable industry standards. If ABS certification or verification is in accordance with this Guide and covers design, construction and installation, then the pipeline is also eligible for ABS classification.

This Guide has been written for worldwide application, and as such, the satisfaction of individual requirements may require comprehensive data, analyses and plans to demonstrate adequacy. This especially applies for pipelines located in frontier areas, such as those characterized by relatively great water depth or areas with little or no previous operating experience. Conversely, many provisions of this Guide often can be satisfied merely on a comparative basis of local conditions or past successful practices. ABS acknowledges that a wide latitude exists as to the extent and type of documentation which is required for submission to satisfy this Guide. It is not the intention of this Guide to impose requirements or practices in addition to those that have previously proven satisfactory in similar situations.

Where available, design requirements in this Guide have been posed in terms of existing methodologies and their attendant safety factors, load factors or permissible stresses that are deemed to provide an adequate level of safety. Primarily, ABS's use of such methods and limits in this Guide reflects what is considered to be the current state of practice in offshore pipeline design. At the same time, it is acknowledged that methods of design, construction and installation are constantly evolving. In recognition of these facts, the Guide specifically allows for such innovations and the Appendices are intended to reflect this. The application of this Guide by ABS will not seek to inhibit the use of any technological approach that can be shown to produce an acceptable level of safety.

This ABS Guide is effective 1 May 2006 and supersedes the edition published in May 2005.

Changes to Conditions of Classification (1 January 2008)

For the 2008 edition, Chapter 1, "Scope and Conditions of Classification" was consolidated into a generic booklet, entitled *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* for all units, installations, vessels or systems in offshore service. The purpose of this consolidation was to emphasize the common applicability of the classification requirements in "Chapter 1" to ABS-classed offshore units, pipelines, risers, and other offshore structures, and thereby make "Conditions of Classification" more readily a common Rule of the various ABS Rules and Guides, as appropriate.

Thus, Chapter 1 of this Guide specifies only the unique requirements applicable to subsea pipeline systems. These supplemental requirements are always to be used with the aforementioned *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

GUIDE FOR BUILDING AND CLASSING SUBSEA PIPELINE SYSTEMS

CONTENTS

CHAPTER 1	Scope and Conditions of Classification (Supplement to the ABS Rules for Conditions of Classification – Offshore Units and Structures)	1
Section 1	Applicability	3
Section 2	Classification Symbols and Notations.....	4
Section 3	Rules for Classification	5
Section 4	Documents to be Submitted	6
Section 5	Survey, Inspection and Testing	11
Section 6	Definitions	17
<i>[See also separately published booklet ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)]</i>		
CHAPTER 2	Materials and Welding.....	19
Section 1	Metallic Pipe.....	21
Section 2	Piping Components and Pipe Coating.....	24
Section 3	Welding of Pipes Piping Components	28
Section 4	Corrosion Control.....	29
CHAPTER 3	Design	31
Section 1	Design Requirements and Loads	35
Section 2	Geotechnical Conditions.....	44
Section 3	Environmental Effects	45
Section 4	Flow Assurance Analysis	51
Section 5	Strength and Stability Criteria	53
Section 6	Pipeline Rectification and Intervention Design	59
Section 7	Routing, Installation and Construction.....	65
Section 8	Special Considerations for Pipe-in-Pipe Design.....	71
Section 9	Special Considerations for Pipeline Bundle Design	72
CHAPTER 4	Testing, Inspection and Maintenance	75
Section 1	Testing, Drying and Commissioning	77
Section 2	Inspection, Maintenance and Repair	83
Section 3	Extension of Use.....	86

APPENDIX 1	Limit State Design Criteria	88
Section 1	Limit State Design Principles	90
Section 2	Classes for Containment, Location, Material Quality and Safety	91
Section 3	Limit State for Bursting.....	94
Section 4	Limit State for Local Buckling	95
Section 5	Limit State for Fracture of Girth Weld Crack-like Defects	98
Section 6	Limit State for Fatigue.....	100
Section 7	Limit State for Ratcheting/Out-of-roundness	102
Section 8	Finite Element Analysis of Local Strength	103
APPENDIX 2	Assessment of Corrosion, Dent and Crack-like Defects	105
Section 1	Corrosion Defect Assessment	106
Section 2	Maximum Allowable Operating Pressure for Dented Pipes	112
APPENDIX 3	Design Recommendations for Subsea LNG Pipelines.....	115
APPENDIX 4	References by Organization.....	119

This Page Intentionally Left Blank

CHAPTER 1 **Scope and Conditions of Classification**

(Supplement to the ABS Rules for Conditions of Classification – Offshore Units and Structures)

CONTENTS

SECTION 1	Applicability	3
1	Classification	3
SECTION 2	Classification Symbols and Notations	4
1	Pipelines Built under Survey	4
3	Pipelines not Built under Survey	4
5	Classification Data	4
SECTION 3	Rules for Classification	5
1	Application	5
3	Risk Evaluations for Alternative Arrangements and Novel Features	5
SECTION 4	Documents to be Submitted.....	6
1	General	6
3	Plans and Specifications.....	6
5	Information Memorandum.....	6
7	Site-specific Conditions.....	7
9	Material Specifications	7
11	Design Data and Calculations	7
11.1	Structural Strength and On-bottom Stability Analysis	8
11.3	Installation Analysis	8
11.5	Safety Devices	8
13	Installation Manual	8
15	Pressure Test Report.....	9
17	Operations Manual.....	9
19	Maintenance Manual.....	10
21	As-built Documents.....	10
SECTION 5	Survey, Inspection and Testing	11
1	General	11
1.1	Scope	11
1.3	Quality Control and Assurance Program	11
1.5	Access and Notification	12
1.7	Identification of Materials	12

3	Inspection and Testing in Fabrication Phase.....	12
3.1	Material Quality.....	12
3.3	Manufacturing Procedure Specification and Qualification.....	12
3.5	Welder Qualification and Records	12
3.7	Pre-Welding Inspection.....	12
3.9	Welding Procedure Specifications and Qualifications.....	13
3.11	Weld Inspection	13
3.13	Tolerances and Alignments	13
3.15	Corrosion Control Systems	13
3.17	Concrete Weight Coatings.....	14
3.19	Nondestructive Testing	14
3.21	Fabrication Records.....	14
5	Inspection and Testing during Installation	15
5.1	Specifications and Drawings for Installation	15
5.3	Installation Manual	15
5.5	Inspection and Survey During Pipe Laying	15
5.7	Final Inspection and Pressure Testing.....	15
5.9	Inspection for Special Cases	15
5.11	Notification	15
7	In-service Inspection and Survey.....	15
9	Inspection for Extension of Use	16
SECTION 6	Definitions	17
1	Classification	17
3	Constructor or Contractor	17
5	Extension of Use.....	17
7	Maximum Allowable Operating Pressure.....	17
9	Offshore	17
11	Operator	17
13	Owner.....	17
15	Pipeline	17
17	Pipeline System	17
19	Recurrence Period or Return Period	18



CHAPTER 1 Scope and Conditions of Classification

SECTION 1 Applicability (1 January 2008)

The intention of this Guide is to serve as technical documentation for design, fabrication, installation and maintenance of offshore production, transfer and export pipelines made of metallic materials. The principal objectives are to specify the minimum requirements for classing, continuance of classing, certification and verification by ABS.

In addition to the requirements of this Guide, the design of a marine system requires consideration of all relevant factors related to its functional requirements and long term integrity, such as:

- Compliance with local Laws, Acts and Regulations
- Functional requirements
- Physical site information
- Operational requirements

1 Classification (1 January 2008)

The requirements for conditions of classification are contained in the separate, generic *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part I)*.

Additional requirements specific to subsea pipeline systems are contained in the following Sections.

CHAPTER 1 Scope and Conditions of Classification

SECTION 2 Classification Symbols and Notations (1 January 2008)

A listing of Classification Symbols and Notations available to the Owners of vessels, offshore drilling and production units and other marine structures and systems, “List of ABS Notations and Symbols” is available from the ABS website “<http://www.eagle.org/absdownloads/index.cfm>”.

The following notations are specific to subsea pipeline systems.

1 Pipelines Built under Survey

Pipelines which have been built, installed, tested and commissioned to the satisfaction of the ABS Surveyors to the full requirements of this Guide or to its equivalent, where approved by the Committee, will be classed and distinguished in the *Record* by:

✕ A1 Offshore Installation – Offshore Pipelines

3 Pipelines not Built under Survey

Pipelines which have not been built, installed, tested and commissioned under ABS survey, but which are submitted for classification, will be subjected to a special classification survey. Where found satisfactory, and thereafter approved by the Committee, they will be classed and distinguished in the *Record* in the manner as described in 1-2/1, but the mark ✕ signifying survey during construction will be omitted.

5 Classification Data

Data on the pipeline will be published in the *Record* as to the latitude and longitude of its location, type, dimensions and depth of water at the site.

CHAPTER 1 Scope and Conditions of Classification

SECTION 3 Rules for Classification (1 January 2008)

1 Application

These requirements are applicable to those features that are permanent in nature and can be verified by plan review, calculation, physical survey or other appropriate means. Any statement in the Guide regarding other features is to be considered as guidance to the designer, builder, Owner, et al.

3 Risk Evaluations for Alternative Arrangements and Novel Features

Risk assessment techniques may be used to demonstrate that alternatives and novel features provide acceptable levels of safety in line with current offshore and marine industry practice. The *ABS Guide for Risk Evaluations for the Classification of Marine-Related Facilities* provides guidance on how to prepare a risk evaluation to demonstrate equivalency or acceptability for a proposed design.

Risk evaluations for the justification of alternative arrangements or novel features may be applicable either to the installation as a whole, or to individual systems, subsystems or components. ABS will consider the application of risk evaluations for alternative arrangements and novel features for subsea pipeline systems.

Portions of the subsea pipeline system or any of its components thereof not explicitly included in the risk evaluation submitted to ABS are to comply with any applicable part of the ABS Rules and Guides. If any proposed alternative arrangement or novel feature affects any applicable requirements of Flag and Coastal State, it is the responsibility of the Owner to discuss with the applicable authorities the acceptance of alternatives based on risk evaluations.

For new or novel concepts, i.e. applications or processes that have no previous experience in the environment being proposed, the guidance encompassed in the class Rules may not be directly applicable to them. The *ABS Guidance Notes on Review and Approval of Novel Concepts* offer ABS clients a methodology for requesting classification of a novel concept. The process described in this guidance document draws upon engineering, testing and risk assessments in order to determine if the concept provides acceptable levels of safety in line with current industry practices.

CHAPTER 1 Scope and Conditions of Classification

SECTION 4 Documents to be Submitted

1 General

For classing pipelines according to this Guide, the documentation submitted to ABS is to include reports, calculations, drawings and other documentation necessary to demonstrate the adequacy of the design of the pipelines. Specifically, required documentation is to include the items listed in this Chapter.

3 Plans and Specifications

Plans and specifications depicting or describing the arrangements and details of the major items of pipelines are to be submitted for review or approval in a timely manner. These include:

- Site plan indicating bathymetric features along the proposed route, the location of obstructions to be removed, the location of permanent man-made structures, the portions of the pipe to be buried and other important features related to the characteristics of the sea floor
- Structural plans and specifications for pipelines, their supports and coating
- Schedules of nondestructive testing and quality control procedures
- Flow diagram indicating temperature and pressure profiles
- Specifications and plans for instrumentation and control systems and safety devices

When requested by the Owner, the Owner and ABS may jointly establish a schedule for information submittal and plan approval. This schedule, to which ABS will adhere as far as reasonably possible, is to reflect the fabrication and construction schedule and the complexity of the pipeline systems as they affect the time required for review of the submitted data.

5 Information Memorandum

An information memorandum on pipelines is to be prepared and submitted to ABS. ABS will review the contents of the memorandum to establish consistency with other data submitted for the purpose of obtaining classification or certification.

An information memorandum is to contain, as appropriate to the pipelines, the following:

- A site plan indicating the general features at the site and the field location of the pipelines
- Environmental design criteria, including the recurrence interval used to assess environmental phenomena
- Plans showing the general arrangement of the pipelines
- Description of the safety and protective systems provided
- Listing of governmental authorities having authority over the pipelines
- Brief description of any monitoring proposed for use on the pipelines
- Description of manufacturing, transportation and installation procedures

7 Site-specific Conditions

An environmental condition report is to be submitted, describing anticipated environmental conditions during pipe laying, as well as environmental conditions associated with normal operating conditions and the design environmental condition. Items to be assessed are to include, as appropriate, waves, current, temperature, tide, marine growth, chemical components of air and water, ice conditions, earthquakes and other pertinent phenomena.

A route investigation report is to be submitted, addressing with respect to the proposed route of the pipeline system the topics of seafloor topography and geotechnical properties. In the bathymetric survey, the width of the survey along the proposed pipeline route is to be based on consideration of the expected variation in the final route in comparison with its planned position, and the accuracy of positioning devices used on the vessels employed in the survey and in the pipe laying operation. The survey is to identify, in addition to bottom slopes, the presence of any rocks or other obstructions that might require removal, gullies, ledges, unstable slopes and permanent obstructions, such as existing man-made structures. The geotechnical properties of the soil are to be established to determine the adequacy of its bearing capacity and stability along the route. The methods of determining the necessary properties are to include a suitable combination of in-situ testing, seismic survey, and boring and sampling techniques. As appropriate, soil testing procedures are to adequately assess sea floor instability, scour or erosion and the possibility that soil properties may be altered due to the presence of the pipe, including reductions in soil strength induced by cyclic soil loading or liquefaction. The feasibility of performing various operations relative to the burial and covering of the pipe is to be assessed with respect to the established soil properties.

Where appropriate, data established for a previous installation in the vicinity of the pipeline proposed for classification may be utilized, if acceptable to ABS.

9 Material Specifications

Documentation for all materials of the major components of pipelines is to indicate that the materials satisfy the requirements of the pertinent specification.

For linepipes, specifications are to identify the standard with which the product is in complete compliance, the size and weight designations, material grade and class, process of manufacture, heat number and joint number. Where applicable, procedures for storage and transportation of the linepipes from the fabrication and coating yards to the offshore destination are to be given.

Material tests, if required, are to be performed to the satisfaction of ABS.

11 Design Data and Calculations

Information is to be submitted for the pipelines that describe the material data, models and variability, long-term degradation data and models, methods of material system selection, analysis and design that were employed in establishing the design. The estimated design life of the pipelines is to be stated. Where model testing is used as the basis for a design, the applicability of the test results will depend on the demonstration of the adequacy of the methods employed, including enumeration of possible sources of error, limits of applicability and methods of extrapolation to full scale data. It is preferable that the procedures be reviewed and agreed upon before material and component model testing is performed.

Calculations are to be submitted to demonstrate the adequacy of the proposed design and are to be presented in a logical and well-referenced fashion, employing a consistent system of units. Where suitable, at least the following calculations are to be performed:

11.1 Structural Strength and On-bottom Stability Analysis

Calculations are to be performed to demonstrate that, with respect to the established loads and other influences, the pipelines, support structures and surrounding soil possess sufficient strength and on-bottom stability with regard to failure due to the following:

- Excessive stresses and deflections
- Fracture
- Fatigue
- Buckling
- Collapse
- Foundation movements

Additional calculations may be required to demonstrate the adequacy of the proposed design. Such calculations are to include those performed for unusual conditions and arrangements, as well as for the corrosion protection system.

11.3 Installation Analysis

With regard to the installation procedures, installation analyses, including trenching effects, are to be submitted for review. These calculations demonstrate that the anticipated loading from the selected installation procedures does not jeopardize the strength and integrity of the pipelines.

11.5 Safety Devices

An analysis of the pipeline safety system is to be submitted to demonstrate compliance with API RP 14G. As a recommended minimum, the following safety devices are to be part of the pipelines:

- For departing pipelines, a high-low pressure sensor is required on the floater or platform to shut down the wells, and a check valve is required to avoid backflow.
- For incoming pipelines an automatic shutdown valve is to be connected to the floater or platform's emergency shutdown system, and a check valve is required to avoid backflow.
- For bi-directional pipelines, a high-low pressure sensor is required on the floater or platform to shut down the wells, and an automatic shutdown valve is to be connected to the floater or platform's emergency shutdown system.

Shortly after the pipelines are installed, all safety systems are to be checked in order to verify that each device has been properly installed and calibrated and is operational and performing as prescribed.

In the post-installation phase, the safety devices are to be tested at specified regular intervals and periodically operated so that they do not become fixed by remaining in the same position for extended periods of time.

13 Installation Manual

A manual is to be submitted describing procedures to be employed during the installation of pipelines and is as a minimum to include:

- List of the tolerable limits of the environmental conditions under which pipe laying may proceed
- Procedures and methods to evaluate impact and installation damage tolerance
- Procedures to be followed should abandonment and retrieval be necessary
- Repair procedures to be followed should any component of pipelines be damaged during installation
- Contingency plan

An installation manual is to be prepared to demonstrate that the methods and equipment used by the contractor meet the specified requirements. As a minimum, the qualification of the installation manual is to include procedures related to:

- Quality assurance plan and procedures
- Welding procedures and standards
- Welder qualification
- Nondestructive testing procedures
- Repair procedures for field joints, internal and external coating repair, as well as repair of weld defects, including precautions to be taken during repairs to prevent overstressing the repair joints
- Qualification of pipe-lay facilities, such as tensioner and winch
- Start and finish procedure
- Laying and tensioning procedures
- Abandonment and retrieval procedures
- Subsea tie-in procedures
- Intervention procedures for crossing design, specification and construction, bagging, permanent and temporary support design, specification and construction, etc.
- Trenching procedures
- Burying procedures
- Field joint coating and testing procedures
- Drying procedures
- System pressure test procedures and acceptance criteria

Full details of the lay vessel, including all cranes, abandonment and recovery winches, stinger capacities and angles, welding and nondestructive testing gear, firing line layout and capacity and vessel motion data are to be provided, together with general arrangement drawings showing plans, elevations and diagrams of the pipeline assembly, welding, nondestructive testing, joint coating and lay operations. Full details of any trenching and burying equipment is to be provided.

15 Pressure Test Report

A report including procedures for and records of the testing of each pipeline system is to be submitted. The test records are, as a minimum, to include an accurate description of the facility being tested, the pressure gauge readings, the recording gauge charts, the dead weight pressure data and the reasons for and disposition of any failures during a test. A profile of the pipeline that shows the elevation and test sites over the entire length of the test section is to be included. Records of pressure tests are also to contain the names of the Owner and the test contractor, the date, time and test duration, the test medium and its temperature, the weather conditions and sea water and air temperatures during the test period. Plans for the disposal of test medium together with discharge permits may be required to be submitted to ABS.

17 Operations Manual

An operations manual is to be prepared to provide a detailed description of the operating procedures to be followed for expected conditions. The operations manual is to include procedures to be followed during start-up, operations, shutdown conditions and anticipated emergency conditions. This manual is to be submitted to ABS for record and file.

19 Maintenance Manual

A maintenance manual providing detailed procedures for how to ensure the continued operating suitability of the pipeline system is to be submitted to ABS for approval.

The manual is, as a minimum, to include provisions for the performance of the following items:

- Visual inspection of non-buried parts of pipelines to verify that no damage has occurred to the systems and that the systems are not being corroded
- Evaluation of the cathodic protection system performance by potential measurements
- Detection of dents and buckles by caliper pigging
- Inspection and testing of safety and control devices

Additionally, ABS may require gauging of pipe thickness should it be ascertained that pipelines are undergoing erosion or corrosion.

Complete records of inspections, maintenance and repairs of pipelines are to be provided for ABS.

21 As-built Documents

The results of surveys and inspections of the pipelines are to be given in a report which, as a minimum, is to include the following details:

- Plot of the final pipeline position, superimposed on the proposed route including pipeline spans and crossings
- Description and location of any major damage to the pipelines alongside information regarding how such damage was repaired
- Description of the effectiveness of burial operations (if applicable for pipelines)

As appropriate, results of additional inspections, which may include those for the proper operation of corrosion control systems, fiber-optic and/or damage sensors, buckle detection by caliper pig or other suitable means and the testing of alarms, instrumentation and safety and emergency shutdown systems, are to be included.

CHAPTER 1 Scope and Conditions of Classification

SECTION 5 Survey, Inspection and Testing (1 January 2008)

1 General

1.1 Scope

This Section pertains to inspection and survey of pipelines at different phases, including:

- Fabrication
- Installation
- Testing after installation

The phases of fabrication and construction covered by this Section include pipe and coating manufacture, fabrication, assembly and linepipe pressure test. The phases of installation include route survey of the pipelines, preparation, transportation, field installation, construction, system pressure test and survey of the as-built installation. The post-installation phase includes survey for continuance of classification, accounting for damage, failure and repair.

1.3 Quality Control and Assurance Program

A quality control and assurance program compatible with the type, size and intended functions of pipelines is to be developed and submitted to ABS for review. ABS will review, approve and, as necessary, request modification of this program. The Contractor is to work with ABS to establish the required hold points on the quality control program to form the basis for all future inspections at the fabrication yard and surveys of the pipeline. As a minimum, the items enumerated in the various applicable Subsections below are to be covered by the quality control program. If required, Surveyors may be assigned to monitor the fabrication of pipelines and assure that competent personnel are carrying out all tests and inspections specified in the quality control program. It is to be noted that the monitoring provided by ABS is a supplement to and not a replacement for inspections to be carried out by the Constructor or Operator.

The quality control program, as appropriate, is to include the following items:

- Material quality and test requirements
- Linepipe manufacturing procedure specification and qualification
- Welder qualification and records
- Pre-welding inspection
- Welding procedure specifications and qualifications
- Weld inspection
- Tolerances and alignments
- Corrosion control systems
- Concrete weight coating
- Nondestructive testing

- Inspection and survey during pipe laying
- Final inspection and system pressure testing
- Pigging operations and tests
- Final as-built condition survey and acceptance

1.5 Access and Notification

During fabrication and construction, ABS representatives are to have access to pipelines at all reasonable times. ABS is to be notified as to when and where linepipe, pipeline and pipeline components may be examined. If ABS finds occasion to recommend repairs or further inspection, notice will be made to the Contractor or his representatives.

1.7 Identification of Materials

The Contractor is to maintain a data system of material for linepipe, pipeline components, joints, anodes and coatings. Data concerning place of origin and results of relevant material tests are to be retained and made readily available during all stages of construction.

3 Inspection and Testing in Fabrication Phase

Specifications for quality control programs of inspection during fabrication of linepipe and pipeline components are given in this Subsection. Qualification tests are to be conducted to document that the requirements of the specifications are satisfied.

3.1 Material Quality

The physical properties of the linepipe material and welding are to be consistent with the specific application and operational requirements of pipelines. Suitable allowances are to be added for possible degradation of the physical properties in the subsequent installation and operation activities. Verification of the material quality is to be done by the Surveyor at the manufacturing plant, in accordance with Chapter 2 of this Guide. Alternatively, materials manufactured to the recognized standards or proprietary specifications may be accepted by ABS, provided such standards give acceptable equivalence with the requirements of this Guide.

3.3 Manufacturing Procedure Specification and Qualification

A manufacturing specification and qualification procedure is to be submitted for acceptance before production start. The manufacturing procedure specification is to state the type and extent of testing, the applicable acceptance criteria for verifying the properties of the materials and the extent and type of documentation, record and certificate. All main manufacturing steps from control of received raw material to shipment of finished linepipe, including all examination and checkpoints, are to be described. ABS will survey formed linepipe, pipeline, pipeline components such as bends, tees, valves, etc., for their compliance with the dimensional tolerances, chemical composition and mechanical properties required by the design.

3.5 Welder Qualification and Records

Welders who are to work on pipelines are to be qualified in accordance with the welder qualification tests specified in a recognized code, such as API STD 1104 and Section IX of the ASME "Boiler and Pressure Vessel Code". Certificates of qualification are to be prepared to record evidence of the qualification of each welder qualified by an approved standard/code. In the event that welders have been previously qualified, in accordance with the requirements of a recognized code, and provided that the period of effectiveness of previous testing has not lapsed, these welder qualification tests may be accepted.

3.7 Pre-Welding Inspection

Prior to welding, each pipe is to be inspected for dimensional tolerance, physical damage, coating integrity, interior cleanliness, metallurgical flaws and proper fit-up and edge preparation.

3.9 Welding Procedure Specifications and Qualifications

Welding procedures are to conform to the provisions of a recognized code, such as API STD 1104, or Owner's specifications. A written description of all procedures previously qualified may be employed in the construction, provided it is included in the quality control program and made available to ABS. When it is necessary to qualify a welding procedure, this is to be accomplished by employing the methods specified in the recognized code. All welding is to be based on welding consumables and welding techniques proven to be suitable for the types of material, pipe and fabrication in question. As a minimum, the welding procedure specification is to contain the following items:

- Base metal and thickness range
- Types of electrodes
- Joint design
- Weld consumable and welding process
- Welding parameters and technique
- Welding position
- Preheating
- Interpass temperatures and post weld heat treatment

For underwater welding, additional information is to be specified, if applicable, including water depth, pressure and temperature, product composition inside the chamber and the welding umbilical and equipment.

3.11 Weld Inspection

As part of the quality control program, a detailed plan for the inspection and testing of welds is to be prepared.

The physical conditions under which welding is to proceed, such as weather conditions, protection and the condition of welding surfaces are to be noted. Alterations in the physical conditions may be required should it be determined that satisfactory welding cannot be obtained.

Where weld defects exceed the acceptability criteria, they are to be completely removed and repaired. Defect acceptance criteria may be project-specific, as dictated by welding process, nondestructive testing resolution and results of fatigue crack growth analysis. The repaired weld is to be reexamined using acceptable nondestructive methods.

3.13 Tolerances and Alignments

The dimensional tolerance criteria are to be specified in developing the linepipe manufacturing specification. Inspections and examinations are to be carried out to ensure that the dimensional tolerance criteria are being met. Particular attention is to be paid to the out-of-roundness of pipes for which buckling is an anticipated failure mode. Structural alignment and fit-up prior to welding are to be monitored to ensure the consistent production of quality welds.

3.15 Corrosion Control Systems

The details of any corrosion control system employed for pipelines are to be submitted for review. Installation and testing of the corrosion control systems are to be carried out in accordance with the approved plans and procedures.

Where employed, the application and resultant quality of corrosion control coatings (external and internal) are to be inspected to ensure that specified methods of application are followed and that the finished coating meets specified values for thickness, lack of holidays (small parts of the structural surfaces unintentionally left without coating), hardness, etc. Visual inspection, micrometer measurement, electric holiday detection or other suitable means are to be employed in the inspection.

3.17 Concrete Weight Coatings

Weight coatings applied when onshore or, if applicable, when on the lay vessel are to be inspected for compliance with the specified requirements for bonding, strength and hardness, weight control and any necessary special design features. Production tests are to be carried out at regular intervals to prove compliance with the specifications.

3.19 Nondestructive Testing

A system of nondestructive testing is to be included in the fabrication and construction specification of pipelines. The minimum extent of nondestructive testing is to be in accordance with this Guide or a recognized design Code. All nondestructive testing records are to be reviewed and approved by ABS. Additional nondestructive testing may be requested if the quality of fabrication or construction is not in accordance with industry standards.

3.21 Fabrication Records

A data book of the record of fabrication activities is to be developed and maintained so as to compile as complete a record as is practicable. The pertinent records are to be adequately prepared and indexed in order to assure their usefulness, and they are to be stored in a manner that is easily recoverable.

As a minimum, the fabrication record is to include, as applicable, the following:

- Manufacturing specification and qualification procedures records
- Material trace records (including mill certificates)
- Welding procedure specification and qualification records
- Welder qualification
- Nondestructive testing procedures and operator's certificates
- Weld and nondestructive testing maps
- Shop welding practices
- Welding inspection records
- Fabrication specifications
- Structural dimension check records
- Nondestructive testing records
- Records of completion of items identified in the quality control program
- Assembly records
- Pressure testing records
- Coating material records
- Batch No., etc.
- Concrete weight coating mix details, cube test, etc.

The compilation of these records is a condition of certifying pipelines.

After fabrication and assembly, these records are to be retained by the Operator or Fabricator for future reference. The minimum time for record retention is not to be less than the greatest of the following:

- Warranty period
- Time specified in fabrication and construction agreements
- Time required by statute or governmental regulations

5 Inspection and Testing during Installation

This Subsection gives the specifications and requirements for the installation phase, covering route survey of pipelines prior to installation, installation manual, installation procedures, contingency procedures, as-laid survey, system pressure test, final testing and preparation for operation.

5.1 Specifications and Drawings for Installation

The specifications and drawings for installation are to be detailed and prepared giving the descriptions of and requirements for the installation procedures to be employed. The requirements are to be available in the design premise, covering the final design, verification and acceptance criteria for installation and system pressure test, records and integrity of pipelines. The drawings are to be detailed enough to demonstrate the installation procedures step-by-step. The final installation results are to be included in the drawings.

5.3 Installation Manual

Qualification of installation manual is specified in [1-4/13](#) of this Guide.

5.5 Inspection and Survey During Pipe Laying

Representatives from ABS are to witness the installation of pipelines to ensure that it proceeds according to approved procedures.

5.7 Final Inspection and Pressure Testing

A final inspection of the installed pipeline is to be completed to verify that it satisfies the approved specifications used in its fabrication and the requirements of this Guide. If the pipeline is to be buried, inspection will normally be required both before and after burial operations. As appropriate, additional inspections, which may include those for the proper operation of corrosion control systems, buckle detection by caliper pig or other suitable means, the testing of alarms, instrumentation, safety systems and emergency shutdown systems, are to be performed.

5.9 Inspection for Special Cases

Areas of pipelines may require inspection after one of the following occurrences:

- Environmental events of major significance
- Significant contact from surface or underwater craft, dropped objects or floating debris
- Any evidence of unexpected movement
- Any other conditions which might adversely affect the stability, structural integrity or safety of pipelines

Damage that affects or may affect the integrity of pipelines is to be reported at the first opportunity by the Operator for examination by ABS. All repairs deemed necessary by ABS are to be carried out to their satisfaction.

5.11 Notification

The Operator is to notify ABS on all occasions when parts of pipelines not ordinarily accessible are to be examined. If at any visit a Surveyor should find occasion to recommend repairs or further examination, this is to be made known to the Operator immediately in order that appropriate action may be taken.

7 In-service Inspection and Survey

The phases of operation include operation preparation, inspection, survey, maintenance and repair. During the operation condition, in-service inspections and surveys are to be conducted for pipelines. In-service inspections and surveys are to be planned to identify the actual conditions of pipelines for the purpose of integrity assessment. In-service inspection can be planned based on the following:

- At each Annual Survey, the records of maintenance are to be reviewed for compliance with the approved maintenance plan. The function of the safety protective devices is to be proven in order.
- Any subsea maintenance inspection carried out internally or externally of the pipeline is to be verified and reported by an ABS attending Surveyor.
- At each five (5) year interval, the complete maintenance records are to be reviewed and any major inspections, in accordance with the approved maintenance plans, are to be witnessed and reported by an ABS attending Surveyor.

9 Inspection for Extension of Use

Existing pipelines to be used at the same location for an extended period of time beyond the original design life are to be subject to additional structural inspection in order to identify the actual condition of the pipelines. The extent of the inspection will depend on the completeness of the existing inspection documents. Any alterations, repairs, replacements or installation of equipment since installation are to be included in the records.

The inspection schedule of the pipelines can be planned based on the requalification or reassessment of the systems applying, e.g., structural reliability methodology and incorporating past inspection records.

CHAPTER 1 Scope and Conditions of Classification

SECTION 6 Definitions

1 Classification

The term *Classification*, as used herein, indicates that an offshore installation has been designed, constructed, installed and surveyed in compliance with accepted Rules and Guides.

3 Constructor or Contractor

A *Constructor* or *Contractor* is any person or organization having the responsibility to perform any or all of the following: analysis, design, fabrication, inspection, testing, load-out, transportation and installation.

5 Extension of Use

An existing pipeline used at the same location beyond its original design life.

7 Maximum Allowable Operating Pressure

The *Maximum Allowable Operating Pressure* is defined as the design pressure less the positive tolerance of the pressure regulation system.

9 Offshore

Offshore is the area seaward of the established coastline that is in direct contact with the open sea.

11 Operator

An *Operator* is any person or organization empowered to conduct commissioning and operations on behalf of the Owners of pipelines.

13 Owner

An *Owner* is any person or organization who owns pipelines.

15 Pipeline

A *Pipeline* is a primarily horizontal pipe lying on, near or beneath the seabed, normally used for the transportation of hydrocarbon products between offshore production facilities or between a platform and a shore facility.

17 Pipeline System

A *Pipeline System* is an integrated set of subsea pipelines and flowlines, including pertinent instrumentation, foundations, coatings, anchors, etc.

19 Recurrence Period or Return Period

The *Recurrence Period* or *Return Period* is a specified period of time that is used to establish extreme values of random parameters, such as wave height, for design of pipelines.

CHAPTER 2 Materials and Welding

CONTENTS

SECTION 1	Metallic Pipe	21
1	General	21
3	Selection of Materials.....	21
5	Steel Linepipe	21
5.1	Chemical Composition	21
5.3	Weldability	22
5.5	Pipe Manufacturing Procedure	22
5.7	Fabrication Tolerance.....	22
5.9	Fracture Arrest Toughness.....	23
5.11	Mill Pressure Test.....	23
7	Linepipe Materials for Special Applications	23
7.1	Sour Service.....	23
7.3	Stainless, Duplex and Super Duplex Stainless Steel Pipes.....	23
7.5	Clad Pipe.....	23
7.7	Titanium Pipe	23
9	Marking, Documentation and Transportation.....	23
SECTION 2	Pipe Components and Pipe Coating.....	24
1	General	24
3	Piping Components.....	24
3.1	Flanges.....	24
3.3	Pipe Fittings.....	24
3.5	Gaskets	24
3.7	Bolting	24
3.9	Valves.....	24
3.11	Subsea Tees	25
3.13	Y-pieces	25
3.15	Bends	25
3.17	Piping Supports and Foundations	25
5	Pipe Coating	25
5.1	Corrosion Protection Coating	25
5.3	Weight Coating	26
5.5	Insulation Coating.....	26
5.7	Field Joint Coating.....	27
SECTION 3	Welding of Pipes and Piping Components	28

SECTION 4	Corrosion Control.....	29
1	General	29
3	Corrosion Control.....	29
3.1	External Corrosion Control	29
3.3	Internal Corrosion Control.....	29
3.5	Corrosion Allowance.....	30
3.7	Monitoring and Maintenance of Corrosion Control Systems.....	30

CHAPTER 2 Materials and Welding

SECTION 1 Metallic Pipe

1 General

This Chapter specifies the linepipe material requirements, including steel pipes and other special metallic pipes used for pipeline applications. Material and dimensional standards for metallic pipe are to be in accordance with this Guide with respect to chemical composition, material manufacture, tolerances, strength and testing requirements. A specification is to be prepared stating the requirements for materials and for manufacture, fabrication and testing of linepipes, including their mechanical properties.

3 Selection of Materials

The linepipe materials used under this Guide are to be carbon steels, alloy steels or other special materials, such as titanium, manufactured according to a recognized standard. The materials are to be able to maintain the structural integrity of pipelines for hydrocarbon transportation under the effects of service temperature and anticipated loading conditions. Materials in near vicinity are to be qualified in accordance with applicable specifications for chemical compatibility.

The following aspects are to be considered in the selection of material grades:

- Mechanical properties
- Internal fluid properties and service temperature
- Resistance to corrosion effects
- Environmental and loading conditions
- Installation methods and procedure
- Weight requirement
- Weldability
- Fatigue and fracture resistance

Documentation for items such as formability, welding procedure, hardness, toughness, fatigue, fracture and corrosion characteristics is to be submitted for ABS review to substantiate the applicability of the proposed materials.

5 Steel Linepipe

The material, dimensional standards and manufacturing process of steel pipe are to be in accordance with API SPEC 5L, ISO 3183-1~3 or other recognized standards. Approval by ABS is required for the intended application with respect to chemical composition, material manufacture, tolerances, strength and testing requirements.

5.1 Chemical Composition

The chemical composition of linepipes, as determined by heat analysis, is to conform to the applicable requirements of the grade and type of steel material. However, the requirements of chemical composition may be agreed upon between the Operator and the linepipe manufacturer.

5.3 Weldability

The carbon equivalent (C_{eq}) and the cold cracking susceptibility (P_{cm}) for evaluating the weldability of steel pipes may be calculated from the ladle analysis, in accordance with the following equations (percentage of weight):

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn + Cu + Cr}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

Selection of C_{eq} and P_{cm} , as well as their maximum values, is to be agreed between the Operator and the steel mill when the steel is ordered to ensure weldability. When low carbon content is used for sour service, the value of the cold cracking susceptibility (P_{cm}) is to be limited. However, the behavior of steel pipe during and after welding is dependent on the steel, the filler metals used and the conditions of the welding process. Unless it can be documented otherwise, a testing program is to be performed to qualify candidate linepipe materials and filler metals.

5.5 Pipe Manufacturing Procedure

During the initial stages of manufacture of each item (after this called “first day production”), certain supplementary tests and qualification of manufacturing and testing facilities will be required in addition to the testing and inspection required during production of pipe. This testing and qualification is also to be done if there are any alterations in the manufacturing, testing or inspection procedures that might result in a detrimental change in pipe quality. No pipe will be accepted until first day production tools and qualifications are accepted.

The fabrication procedures are to comply with an approved standard pertinent to the type of pipe being manufactured. All nondestructive testing operations referred to in this Chapter are to be conducted by nondestructive testing personnel qualified and certified in accordance with standards such as ASNT SNT-TC-1A, ISO 9712 or other applicable codes.

The manufacturer is to prepare a manufacturing procedure specification for review by ABS. The manufacturing procedure specification is to document the forming techniques and procedures, welding procedures and welding testing, material identification, mill pressure testing, dimensional tolerances, surface conditions and properties to be achieved and verified. Pipes are to be selected from initial production for manufacturing procedure qualification through mechanical, corrosion and nondestructive testing.

Deepwater service requires the manufacture, inspection, testing and shipping of linepipes with minimum requirements as follows:

- The steel is to be fully killed and fine-grain.
- Plate is to be manufactured to a well-known and documented practice. All heat-treating facilities are to be equipped with instrumentation such that all temperatures can be controlled and recorded.
- All production welding is to be automatic.
- Pipe may be either non-expanded or cold expanded. Cold expanded pipe is not to exceed 2.0 percent maximum expansion, nor is it to exceed the amount of expansion used during first day production tests by more than 0.2 percent.
- Pipe may be cold compressed. Cold compressed pipe is not to exceed 2.0 percent maximum compression, nor is it to exceed the amount of compression used during first day production tests.
- The plates and/or pipe from each heat are to remain segregated during the entire manufacturing, testing, inspection and shipping process, as is practical.

5.7 Fabrication Tolerance

The fabrication tolerance may be agreed upon between the operator and the linepipe manufacturer, but is to be consistent with the design requirements. The pipes may be sized to their final dimensions by expansion and straightening. The pipes are to be delivered to the dimensions specified in the manufacturing procedure.

5.9 Fracture Arrest Toughness

Fracture toughness values for crack arrest given in ISO codes and API RP are adequate for design factors up to 72% and are given mainly for land-based pipelines. The acceptance criteria for fracture arrest toughness of offshore pipelines are to be agreed upon between the operator and linepipe manufacturer.

5.11 Mill Pressure Test

The mill test pressure and duration may be agreed upon between the Operator and the linepipe manufacturer, but it is to be consistent with the design requirements. The mill pressure test is to be conducted after final pipe expansion and straightening.

7 Linepipe Materials for Special Applications

This Subsection defines the minimum requirements for linepipe materials such as carbon steel, stainless steel, duplex, clad carbon steel and titanium alloy for extreme temperatures, sour service or other special applications.

7.1 Sour Service

Linepipe materials for sour (H_2S -containing) service are to satisfy the criteria of NACE MR0175 for resistance to sulfide stress cracking (SSC) and hydrogen-induced cracking (HIC) failures. Materials that are not listed in NACE MR0175 are to be tested according to procedures NACE TM0177 and NACE TM0284 for both materials and welds. The acceptance criteria are to be agreed upon between the Operator and the linepipe manufacturer based on the intended service condition

7.3 Stainless, Duplex and Super Duplex Stainless Steel Pipes

The chemical composition and the manufacturing of stainless steel pipes are to follow standards such as ASTM A790. The manufacturer is to establish the manufacturing procedure for the pipes, which is to contain relevant information about steel manufacturing, pipe manufacturing, welding and control methods which are to follow recognized standards such as API SPEC 5LC. Mechanical tests are to be performed after heat treatment, expansion and final shaping. Specific tests may be required to meet project requirements.

7.5 Clad Pipe

Clad pipes are to be compatible with the functional requirements and service conditions as specified for the project. Material dimensional standards and manufacturing process of clad steel pipe are to be in accordance with API SPEC 5LD or equivalent recognized standards.

7.7 Titanium Pipe

Specific compositional limits and tensile property minimums for titanium alloy tubular products may be produced in accordance with ASTM B861 and ASTM B862 specifications. Titanium alloys are highly corrosion-resistant to produced well fluid, including all hydrocarbons, acidic gases (CO_2 and H_2S), elemental sulfur and sweet and sour chloride brines at elevated temperatures. Titanium alloys are also generally resistant to well, drilling and completion fluids.

9 Marking, Documentation and Transportation

Pipes are to be properly marked for identification by the manufacturer. The marks are to identify the standard with which the product is in complete compliance, the size and weight designations, material grade and class, process of manufacture, heat number and joint number.

Pipe storage arrangements are to preclude possible damage, such as indentations of the surface and edges of pipes. Materials are to be adequately protected from deleterious influences during storage. The temperature and humidity conditions for storing weld filler material and coating are to be in compliance with those specified in their controlling material specification or manufacturer-supplied information.

Documentation for all materials of the major components of pipelines is to indicate that the materials satisfy the requirements of the pertinent specification. Material tests are to be performed to the satisfaction of ABS. Procedure for the transportation of the linepipes from the fabrication and coating yards to the offshore destination is to be established. Transportation of the pipes is to follow the guidelines of API RP 5L1 and API RP 5LW.

CHAPTER 2 Materials and Welding

SECTION 2 Pipe Components and Pipe Coating

1 General

The design of the pipeline includes various piping components. Specifications for each piping component and coating material used on a pipeline system are to be identified. The specifications are to be submitted to ABS for approval if the components have special service conditions or deviate from the standards indicated in this Guide or other comparable codes.

For valves, fittings, connectors and joints, if the wall thickness and yield strength between the adjoining ends are different, the joint design for welding is to be made in accordance with ASME B31.4, Figure 434.8.6(a)-(2), for liquid pipelines, or ASME B31.8, Appendix I, Figure I5, for gas pipelines.

The internal diameter of pipeline components is to be equal to that of the connecting pipeline sections. Consideration is to be given to effects of erosion at locations where the flow changes direction.

Seal design for valves, fittings and connectors is to take into account external hydrostatic pressure.

3 Piping Components

The piping components are to be suitable for the pipeline design conditions and be compatible with the linepipes in material, corrosion and welding.

3.1 Flanges

Pipe flanges used for offshore pipelines vary depending on the connection requirement subsea and at the surface to the platforms. Typical flange materials and dimensions are to follow ASME B16.5, API SPEC 17D, and MSS SP-44, where applicable. The flange design may be determined by calculations in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.

3.3 Pipe Fittings

Pipe fittings are to match the design of the linepipes and flanges. Typical materials and dimensions are to follow ASME B16.9, B16.11, B16.25, MSS SP-75, and API SPEC 17D, where applicable.

3.5 Gaskets

Gaskets are to match the design of the flanges. Typical materials and dimensions are to follow ASME B16.20 and API SPEC 6A, where applicable.

3.7 Bolting

The bolting is to match the design of the flanges. Typical materials, dimensions and bolting torque are to follow ASME B16.5 and API SPEC 6A, where applicable.

3.9 Valves

The valves are to match the linepipes and flanges. Typical materials and dimensions are to follow ASME B16.34, API STD 600 and API SPEC 6D, ISO 14313 or equivalent codes or standards.

3.11 Subsea Tees

Subsea tees are to be of the extruded outlet, integral reinforcement type. The design is to be in accordance with ASME B 31.4, ASME B31.8 or equivalent codes or standards.

3.13 Y-pieces

Y-pieces and tees where the axis of the outlet is not perpendicular to the axis of the run are to be designed by finite element analysis.

3.15 Bends

Mitered bends are not permitted in offshore liquid and gas pipeline systems. Pipe that has been cold-worked solely for the purpose of increasing the yield strength to meet specified minimum yield strength is not allowed in offshore pipeline systems. Bends are to be made in such a manner as to preserve the cross-sectional shape of the pipe, and are to be free from buckling, cracks or other evidence of mechanical damage. The pipe diameter is not to be reduced at any point by more than 2.5% of the nominal diameter, and the completed bend is to be able to pass the specified sizing pig.

3.17 Piping Supports and Foundations

Piping support and foundation design is to follow the appropriate criteria of ASME B31.4 and API RP 2A-WSD.

Supporting elements, such as supports, braces and anchors for pipelines are to be designed in accordance with ASME B31.4 for liquid pipelines and ASME B31.8 for gas pipelines. No supporting elements are allowed to be welded directly to the pipeline except clamps, which are to fully encircle the pipe and be welded to the pipe by a full encirclement weld.

5 Pipe Coating

Specifications for corrosion protection coatings and concrete weight coating are to be submitted to ABS for approval if special service conditions exist. The weight coating specification is as a minimum to include:

- Chemical composition
- Physical and strength properties
- Quality control procedures and verifying tests for manufacturing or production

5.1 Corrosion Protection Coating

Corrosion protection coating materials are to be suitable for the intended use and consideration is to be given to:

- Corrosion protective properties
- Temperature resistance
- Adhesion and disbonding properties in conjunction with cathodic protection
- Mechanical properties
- Impact resistance
- Durability
- Shear strength
- Tensile strength
- Sea water resistance
- Water absorption
- Dielectric resistance

- Compatibility with cathodic protection system
- Resistance to chemical, biological and microbiological effects
- Aging, brittleness and cracking
- Variation of properties with temperature and time
- Health and safety information and instruction according to national regulations

The coating procedure is to be in compliance with appropriate standards and is to include the details of the pipe surface preparation, production parameters, material specifications, application and testing methods, including acceptance criteria, and details of cutback lengths and coating termination.

Before and after the coating application, inspection and testing are to be conducted by means of holiday detection to identify discontinuities or other defects that may impair its performance.

5.3 Weight Coating

Weight coating is, when applicable, to be applied to ensure vertical and horizontal on-bottom stability by providing negative buoyancy to the pipeline. The weight coating specification is to include:

- Mechanical properties, including strength, density, durability, etc.
- Cement materials or equivalent
- Reinforcement, including type, amount and grade
- Concrete coating method to achieve homogeneous and adequately consolidated coating
- Curing method compatible with coating application
- Repairs of uncured or hardened defective concrete coatings
- Storage, handling and transportation of coated pipe

Inspection and testing are to be carried out at regular intervals during weight coating application, and consideration is to be given to:

- Mix proportions and water-cement ratio
- Concrete density and compressive strength
- Weight before and after concrete application
- Outer diameter of coated pipe
- Water absorption
- Compatibility with corrosion protection coating

Stress concentration in the pipeline due to the weight coating is to be examined to avoid local damage in the form of buckling or fracture during handling and laying operations.

5.5 Insulation Coating

Thermal insulation coatings may be required for pipelines, spools, pipe-in-pipe systems and pipeline bundle systems to ensure flow assurance, in which case, a design and qualification program is to be submitted to ABS for review.

The thermal insulation design is to consider the coating material properties, including:

- Thermal conductivity
- Density
- Adhesion to base material
- Abrasion resistance

- Service pressure and temperature
- Impact resistance
- Creep
- Durability against chemical, physical or biological effects
- Water absorption
- Degradation during service

Inspection is to be conducted both during surface preparation and after coating application.

5.7 Field Joint Coating

Field joint coating is to be placed on the pipe joint after completion of the welding and weld testing. Installation, inspection and testing procedures for the field joint are to be developed and submitted to ABS.

CHAPTER 2 Materials and Welding

SECTION 3 Welding of Pipes and Piping Components

The welding of metallic pipes is to be performed in accordance with approved welding procedures that have been qualified to produce sound, ductile welds of adequate strength and toughness. Welding standards comparable to API STD 1104 and Section IX of the ASME Boiler and Pressure Vessel Code are to be employed in association with this Guide. For special pipe materials, the applicability of the API STD 1104 is to be examined and verified at all stages of welding, and any alternative methods are to be submitted for review.

Welders are to be tested in accordance with the welder qualification tests specified in recognized national codes, such as API STD 1104. Certificates of qualification are to be prepared to cover each welder when they are qualified by standards other than those of ABS, and such certificates are to be available for the reference of the Surveyors.

Before construction begins, details of the welding procedures and sequences are to be submitted for review. The details are to include:

- Base metal and thickness range
- Types of electrodes
- Edge preparation
- Electrical characteristics
- Welding technique
- Proposed position and speed
- Preheating and post-weld heat treatment practices

Welding procedures conforming to the provisions of an acceptable code may be qualified in the presence of the Surveyor, in accordance with the pertinent code. A written description of all pre-qualified procedures employed in the pipeline's construction is to be prepared and made available to the Surveyors.

When it is necessary to qualify a welding procedure, this is to be accomplished by employing the methods specified in an acceptable code, and in the presence of the Surveyor.

CHAPTER 2 Materials and Welding

SECTION 4 Corrosion Control

1 General

A corrosion control system analysis is to be performed to determine necessary protection measures and to provide in-service performance criteria and procedure for maintaining the system. The analysis is to be submitted to ABS for review and approval.

This Section recommends guidelines for the establishment of corrosion mitigation procedures for offshore pipelines. The following publications are incorporated by reference for the detection and mitigation of external and internal corrosion:

- ASME B31.4, Chapter VIII
- ASME B31.8, Chapter VI

3 Corrosion Control

3.1 External Corrosion Control

Adequate anti-corrosion coating and cathodic protection are to be provided for protection against external corrosion and may include a galvanic anode system, an impressed current system or both. Design considerations are to be given to:

- Pipe surface area
- Environmental conditions
- Suitability of galvanic anode systems under given marine environment
- Design life of galvanic anode systems
- How to minimize potential damage to the cathodic protection system during the lifecycle
- Interference of electrical currents from nearby structures
- Necessity of insulating joints for electrical isolation of portions of the system
- Inspection requirements for rectifiers or other impressed current sources

3.3 Internal Corrosion Control

Adequate measures are to be taken against internal corrosion. Proper selection of pipe material, internal coating, injection of a corrosion inhibitor or a combination of such options are to be considered.

When necessary, internal corrosion may be mitigated by the following:

- Running scrapers
- Dehydration
- Injection of corrosion inhibitors

- Use of bactericides
- Use of oxygen scavengers
- Use of internal coating compatible to the contents
- Use of corrosion resistant alloys

3.5 Corrosion Allowance

The selected pipe wall thickness is to include a corrosion allowance to account for internal and external corrosion during the service life of the pipe. Determination of the amounts of corrosion allowances is to take into account corrosion protection methods applied, corrosion-resistant properties of the linepipe material, the fluid corrosivity inside the pipe, chemical compositions of seawater, location of the pipeline, etc. The values of the allowances are to be submitted and agreed upon between the Designer/Owner and ABS. Guidance for estimating corrosion rates and allowances is given in Appendix 2.

The net thickness, which means that the thickness of the corrosion allowance is deducted from the nominal wall thickness ($t_{nominal} = t_{net} + \text{Corrosion Allowance}$), is to be used for the checks of hoop stress and hydrostatic collapse, as specified in Chapter 3, Section 5. For all other load cases involving longitudinal and radial stresses, the nominal wall thickness is to be used.

3.7 Monitoring and Maintenance of Corrosion Control Systems

Corrosion rate and the effect of anti-corrosion systems are to be evaluated by applying a monitoring program. Remedial actions are to be taken based on the evaluation results.

CHAPTER 3 Design

CONTENTS

SECTION 1	Design Requirements and Loads	35
1	General	35
1.1	Regulations, Codes and Standards	36
1.3	Mechanical Design	36
1.5	Load Case Definition	36
1.7	Wall Thickness Selection	37
1.9	Expansion Analysis	37
1.11	Buckle Analysis	37
1.13	Buckle Arrestor Design	38
1.15	Fracture Analysis	38
1.17	On-Bottom Stability	38
1.19	Free Span Analysis	39
1.21	Vortex-Induced Vibration and Fatigue	40
1.23	External Corrosion Protection Design	40
3	Design Basis	40
5	Definitions of Design Loads	42
5.1	Environmental Loads	42
5.3	Functional Loads	42
5.5	Accidental Loads	42
TABLE 1	Design Information for Pipelines	41
TABLE 2	Internal Fluid Parameters	41
TABLE 3	Environment Parameters	42
TABLE 4	Categorization of Design Loads for Pipelines	43
FIGURE 1	Pipeline Design Flowchart	35
SECTION 2	Geotechnical Conditions	44
1	General	44
3	Pipe Penetration in Soil	44
5	Soil Friction	44
7	Breakout Force	44
9	Soil Surveys	44

SECTION 3	Environmental Effects	45
1	General	45
3	Current	45
5	Waves	46
7	Combinations of Current and Waves	46
9	Tides	47
11	Marine Growth	47
13	Subsidence	48
15	Scours	48
17	Seafloor Instability	48
19	Seismic	48
21	Sea Ice	49
23	Environmental Design Conditions	49
23.1	Normal Operating Condition with Pipeline in the Normal Intact Status	49
23.3	Temporary Condition	49
23.5	Abnormal/Accidental Operating Condition	50
23.7	Fatigue	50
SECTION 4	Flow Assurance Analysis	51
1	General	51
3	Pipeline Sizing/Steady State Analysis	51
5	Fluid Phase Definition	51
7	Pressure and Temperature Profile	51
9	Transient Analysis	51
11	Surge Analysis	52
13	Heat Transfer/Insulation Design	52
15	Hydrate Mitigation	52
17	Wax Deposition	52
SECTION 5	Strength and Stability Criteria	53
1	General	53
3	Stress Criteria for Metallic Gas Transportation Pipelines	53
3.1	Hoop Stress Criteria	53
3.3	Longitudinal Stress	54
3.5	Von Mises Combined Stress	54
5	Stress Criteria for Metallic Liquid Transportation Pipelines	54
5.1	Hoop Stress Criteria	54
5.3	Longitudinal Stress	55
5.5	Von Mises Combined Stress	55
7	Global Buckling	55
9	Local Buckling/Collapse for Metallic Pipelines	56
9.1	Collapse Under External Pressure	56
9.3	Local Buckling/Collapse under External Pressure and Bending	56

11	Propagating Buckles	57
13	Fatigue for Metallic Pipelines	57
15	Out-of-roundness	58
17	Allowable Stresses for Supports and Restraints	58
19	Installation	58
SECTION 6	Pipeline Rectification and Intervention Design	59
1	General	59
3	In-place Analysis	59
3.1	Parameters and Procedures for In-place Analysis	59
3.3	Modal Analysis	59
3.5	Location Fixity	60
3.7	High Pressure/High Temperature	60
5	On-bottom Stability	60
5.1	Static Stability Criteria	60
5.3	Dynamic Stability Analysis	61
7	Free Spanning Pipeline	61
7.1	General	61
7.3	Evaluation of Free Spanning Pipelines	62
7.5	Span Correction	63
9	Upheaval and Lateral Buckling	63
9.1	Upheaval Buckling	64
9.3	Lateral Buckling	64
11	Design for Impact Loads	64
11.1	Fishing Gear Loads	64
11.3	Dropped Objects	64
11.5	Anchoring	64
SECTION 7	Routing, Installation and Construction	65
1	Route Selection	65
1.1	Route Survey	66
1.3	In-Field Pipelines	67
3	Installation Analysis	67
3.1	S-Lay Installation	67
3.3	J-Lay Installation	68
3.5	Reel Lay Installation	68
3.7	Installation by Towing	68
5	Construction	68
5.1	Construction Procedures	68
5.3	Buckle Detection	68
5.5	Weld Repair	69
5.7	Trenching	69
5.9	Gravel Dumping	69
5.11	Pipeline Cover	69
5.13	Pipeline Crossings	69
5.15	Protection of Valves and Manifolds	69