

Recommended Practice for Steel Pipeline Construction Quality Management Systems

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Background

This document is a framework for a quality management system (QMS) for onshore pipeline construction. While this document may be used for facility and station construction, that is not the focus of the document. The QMS developed for onshore pipeline projects shall include and document the following, which are discussed in more detail throughout this recommended practice:

- defined project quality objectives and personnel accountability;
- processes to establish and maintain the appropriate project organizational structure;
- processes to establish and maintain the appropriate training and qualification of internal and contracted personnel;
- processes to facilitate and verify quality throughout project design, contracting, procurement, manufacturing, fabrication, and construction;
- processes to prevent, detect, mitigate, and eliminate potential and actual nonconformance with project procedures, specifications, and referenced standards, or noncompliance with regulations, as well as verification and documentation of actions taken and the outcome;
- assessment of the achievement of quality objectives throughout the construction project; and
- methods to measure each process's effectiveness and enact continuous improvement of the QMS.

This framework can be used to develop a stand-alone QMS or to integrate quality management into an organization's existing corporate management system. In this document, "organization" is defined as the entity using this document to develop its own QMS for pipeline construction.

The organization may be the owner company, operating company, engineering and/or construction contractor, supplier, or other stakeholder in pipeline construction that has its own QMS. Typically, the owner/operating company will utilize contractors and suppliers on a pipeline construction project, which have their own QMS in alignment with this document. When the QMS is developed, the term "organization" should be replaced with the responsible entities, such as operating company, owner-company, contractor, or supplier. Elements of this RP can be met in aggregate by the organizations constructing the pipeline.

Additionally, some processes covered in this framework may already be implemented by an organization; for example, change management. Existing processes may be modified to address the quality concerns identified in this framework.

To be applicable to the wide range of organizations within the pipeline industry, the RP was developed to be flexible and scalable. The RP was developed for use by organizations of varying size and scope. While the QMS elements will apply to each organization, the application of these elements are to be appropriate for the size of the organization, the scope of the project, and the risk to the public and environment.

Each pipeline construction project is unique. While typical pipeline construction activities are included in this document, they may not be all-inclusive. Other construction activities may be relevant and should be addressed on a project-by-project basis, utilizing the principles of this RP. Likewise, it is recognized that the identified construction activities may not be applicable to every pipeline construction project. It is the organization's responsibility to consider unique quality issues applicable to their projects and address them accordingly through their organization-specific QMS.

Much of the input to this document is based on information provided in the PHMSA/DNV GL OAPUS314MJRU (PP087506), Rev. 3, report, *Improving Quality Management Systems (QMS) for Pipeline Construction Activities*, dated September 2, 2015.

The management system principles are applied in a recurring manner to achieve continuous improvement. The Plan–Do–Check–Act (PDCA) cycle is a four-step model for carrying out these efforts (Figure 1).

This cycle can be applied to the management system as a whole, to individual construction projects, and to individual elements and processes within the system. Continuous improvement is at the core of many management systems, and its principal aim is to encourage creating strategies and plans, executing those strategies and plans in line with guidelines, evaluating those actions for conformity, and using those results to adjust the next generation of plans. This cycle is iterative.

The components of the PDCA cycle are:

Plan: This step entails establishing the objectives and processes necessary to deliver results in accordance with the organization's policies and the expected goals. By establishing output expectations, the completeness and accuracy of the process is also a part of the targeted improvement.

Do: This step is the execution of the plan designed in the previous step.

Check: This step entails the review of the results compared with established objectives. Those results are compared to the expected goals to ascertain any differences and deviations in implementation from the plan.

Act: This step is where the organization takes actions to improve process performance. This may include corrective actions focusing on significant differences between actual and planned results.

Continuous improvement occurs when the PDCA cycle is repeated.

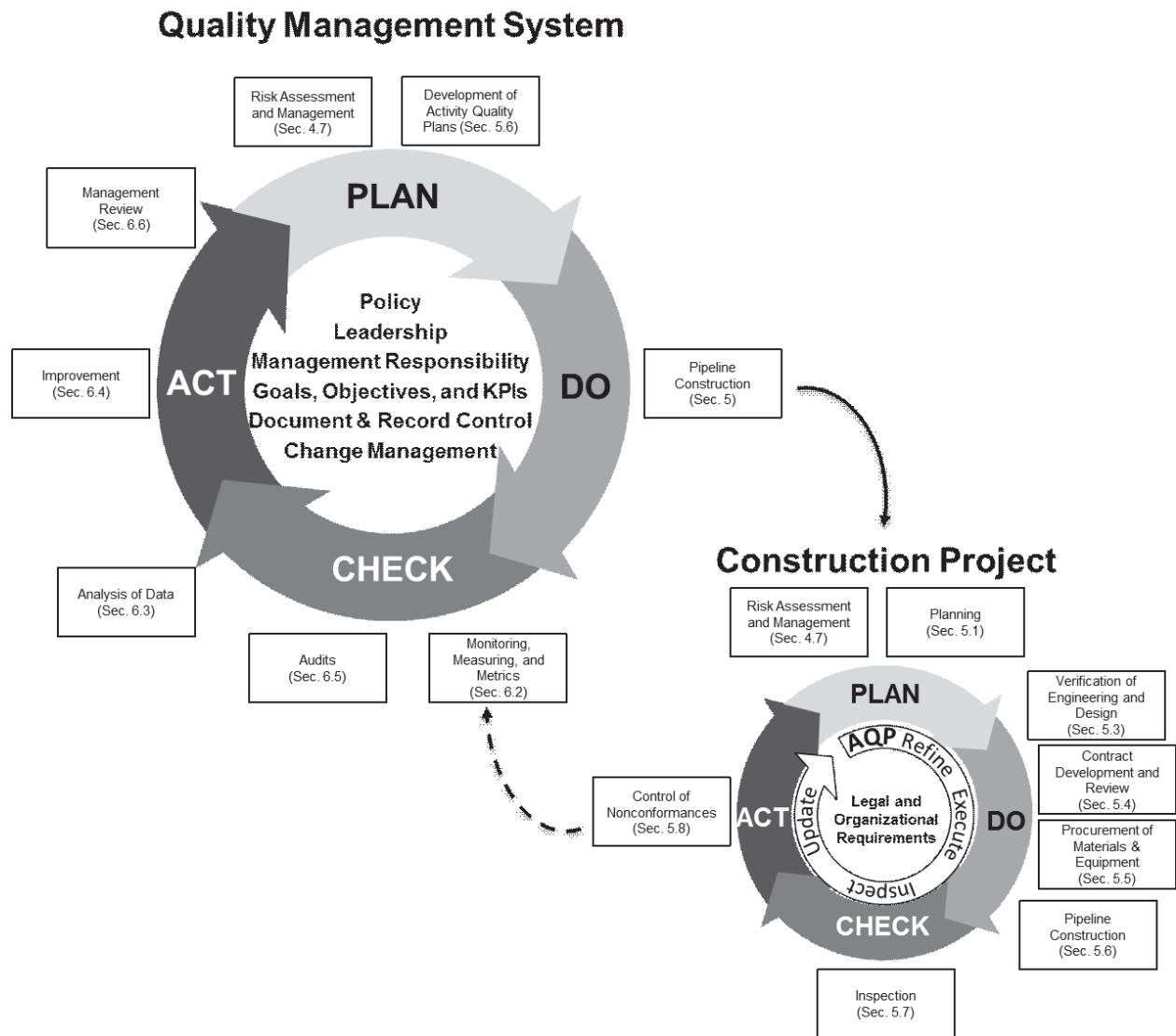


Figure 1—Continuous Improvement Cycle (PDCA)

Additional background information on QMS is contained in Annex A, Construction Quality Management Systems.

Recommended Practice for Steel Pipeline Construction Quality Management Systems

1 Scope

This recommended practice establishes minimum Quality Management System (QMS) processes for organizations that own, operate, construct, or provide construction-related services for onshore carbon and low-alloy steel pipelines used in the transportation of hazardous liquids, carbon dioxide, and gas. This recommended practice specifies the elements of a QMS to manage the construction process systematically from design verification, materials manufacturing, procurement, construction, inspection, and testing to initiation of operations.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the edition that is incorporated by reference in the code of federal regulations of the referenced document applies (including any addenda/errata).

[API Standard 1104](#), *Welding of Pipelines and Related Facilities*

3 Definitions and Abbreviations

3.1 Terms and Definitions

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

3.1.1

acceptance criteria

Specified limits of acceptability applied to process, service, or product characteristics.

3.1.2

activity quality plan

AQP

Document(s) that establishes procedures, minimum personnel qualifications, roles and responsibilities, inspection methods, and record requirements of construction activities. The intent of an AQP is to identify quality concerns and methods of control.

NOTE For pipeline construction, an activity quality plan is developed for each construction task (stringing, welding, backfilling, etc.).

3.1.3

as-built surveying

Process of collecting and documenting all of the pipeline attributes and their associated location and installation conditions along a pipeline.

3.1.4

backfilling

Replacement of the native soil in the trench surrounding the installed pipeline. Padding may be used in addition to backfilling.

3.1.5**bedding**

Method using non-native materials such as sand, or filtered or nonfiltered native materials removed while ditching (spoils) to prepare the ditch for pipeline lowering-in. Alternately, the method supports the pipeline on non-native or filtered material berms, sand bags, foam pillows, or plastic pipe support apparatuses.

3.1.6**calibration**

Comparison and adjustment to a standard of known accuracy.

3.1.7**cased crossing**

Crossing where the pipeline is installed inside of a larger diameter pipe called a casing, typically under a road, railroad, or bridge crossing.

3.1.8**collection**

Process of obtaining, assembling, and/or organizing applicable documentation with the intent of meeting the requirements for control or records.

3.1.9**compliance**

Act or process of satisfying legal or contractual requirements.

3.1.10**conformance**

Satisfying the applicable documented requirements; also referred to as “conformity.”

NOTE Documents can include procedures, standards, specifications, recommended practices, work instructions, and any other non-legal publication.

3.1.11**ditching**

Creation of a trench, or ditch, in the ground where the pipeline is to be installed and buried.

3.1.12**field bending**

Cold bending of line pipe to conform to the planned points of inflection in the pipe route and match the topography or the route/ditch.

3.1.13**final tie-in welds**

Welds made between two pressure-tested sections of pipe or piping, and that are not subjected to a pressure test. Final tie-in welds may be referred to as “golden welds.”

3.1.14**horizontal directional drilling****HDD**

A method of trenchless pipeline installation that uses steerable drilling systems.

3.1.15**in-line inspection****ILI**

Evaluation using sophisticated and sensitive tools that travel through the interior of the pipe and measure and record irregularities that may represent metal loss, cracks, laminations, deformations, or other defects.

3.1.16**inspection**

Evaluation for conformity by observation and judgment accompanied, as appropriate, by testing and/or measurement.

3.1.17**inspection and test plan****ITP**

Written description of inspection plan that may include evaluation methods, hold points, project-specific technical requirements, and resources, typically used in manufacturing.

3.1.18**key performance indicator****KPI**

Metric by which an organization measures the functioning of its processes, service, or service-related product.

3.1.19**legal requirement**

Statutory or regulatory obligation imposed on or by an organization.

3.1.20**lowering-in**

Process of lifting and moving a pipe or pipe string from alongside the ditch into the ditch.

3.1.21**management system**

A framework of policies, processes, and procedures used by an organization to ensure that it can fulfill all the tasks required to achieve its objectives

3.1.22**organization**

Entity using this document to develop its own QMS for pipeline construction. The organization may be the owner-company, operating company, engineering and/or construction contractor, supplier, or other stakeholders in pipeline construction who have their own QMS.

3.1.23**padding**

When backfilling material is unsuitable for contact with the pipe, a method using non-native materials such as sand, or filtered/screened or segregated native materials removed while ditching (spoils) to protect the pipeline prior to backfilling.

3.1.24**pipeline construction**

Activities that include design verification, contracting, procurement, planning, and construction. Design and commissioning are considered outside the scope of pipeline construction.

3.1.25**preservation**

Methods used to protect the pipeline and components from internal and external threats, including corrosion, third-party damage, etc., prior to commissioning. Preservation may also be referred to as "layup."

3.1.26**procedure**

Documented method that is followed to perform an activity or series of activities to achieve conformity to specified requirements.

3.1.27**process**

A series of interrelated or interacting activities or steps with anticipated outputs applied in the construction of a pipeline.

3.1.28**quality assurance****QA**

Proactive, process-oriented activities, independent of production, with the goal of preventing nonconformances. Examples of QA activities include checklists and the development of standards.

3.1.29**quality control****QC**

Reactive, product-oriented activities with the goal of identifying nonconformances before work is finalized. Examples of QC activities include inspection and testing.

3.1.30**risk**

Situation or circumstance that has both a likelihood of occurring and a potentially negative consequence.

3.1.31**risk assessment**

Methodology for predicting probability and consequence of nonconformance.

3.1.32**risk management**

Application of practices to prevent and mitigate risk.

3.1.33**stringing**

Placement of the line pipe and bends along the right-of-way in preparation for welding and installation.

3.1.34**tie-ins**

Welds made between two sections of installed pipe.

3.1.35**traceable**

When describing records, the ability to clearly link properties from original documentation, such as material and/or pressure test reports provided by a manufacturer, supplier, or contractor to a specific pipe, fitting, or component.

3.1.36**verifiable**

When describing records, the ability to confirm information by other complementary, but separate, documented means.

3.2 Abbreviations

For the purpose of this standard, the following abbreviated terms apply:

AC	alternating current
ACVG	alternating current voltage gradient
API	American Petroleum Institute

AQP	activity quality plan
ARO	abrasion-resistant overlay
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
BPVC	[ASME] Boiler and Pressure Vessel Code
CFR	Code of Federal Regulations
CIS	close interval surveys
CP	cathodic protection
CSA	Canadian Standards Association
DCVG	direct current voltage gradient
FBE	fusion bonded epoxy
FERC	Federal Energy Regulatory Commission
GIS	geographical information system
HCA	high-consequence area
HDD	horizontal directional drilling
ILI	in-line inspection
IMP	integrity management plan (or program)
ISO	International Organization for Standardization
ITP	inspection and test plan
KPI	key performance indicator
MPS	manufacturer procedure specification
MTR	material test report
NACE	National Association of Corrosion Engineers
NDE	nondestructive examination
PEP	project execution plan
PRCI	Pipeline Research Council International
QA	quality assurance

QC	quality control
QMS	quality management system
ROW	right of way
UT	ultrasonic testing
UV	ultraviolet
WPS	welding procedure specification

4 Quality Management System Requirements

4.1 General

4.1.1 Quality Management System

The organization shall establish, document, implement, maintain, measure the effectiveness of, and improve upon a QMS in accordance with the requirements of this document.

The organization shall ensure that legal and other applicable requirements with which the organization claims compliance are taken into account in its QMS.

The QMS should follow the continuous-improvement cycle as described in the Background section. Additional background information on QMS is contained in Annex A.

4.1.2 Quality Policy

The organization's policy for its commitment to quality shall be defined, documented, and approved by management. The organization's management shall review the quality policy for continued suitability and to ensure that it is appropriate to the organization.

4.1.3 Goals, Objectives, and Key Performance Indicators

Management shall ensure that quality goals, objectives, and key performance indicators (KPIs) required to meet requirements for pipeline construction are established. The quality goals and objectives shall be consistent with the quality policy. KPIs can be used to demonstrate attainment of goals and objectives. Refer to 6.2.1 for additional information on KPIs.

4.1.4 Planning, Development, and Maintenance

Planning and development of the QMS shall be carried out in order to meet the requirements of this document. Maintenance of the QMS should encompass periodic review.

NOTE Additionally, see 5.1 for other planning requirements on the construction project level.

4.1.5 Communication

Communication is critical to the success of a QMS.

4.1.5.1 Internal Communication

Appropriate communication processes shall be established within the organization. These should include:

- effectiveness of the QMS;

- feedback and possible solutions to issues;
- applicable communications with stakeholders; and
- lessons learned and best practices.

4.1.5.2 Project Organization Communication

The organization shall ensure appropriate communication processes are established between all organizations associated with the project to ensure requirements are fully communicated. These should include:

- appropriate lines of communication;
- execution of pipeline construction, inquiries, contracts, and procurement (see 5.4 and 5.5);
- control of pipeline construction nonconformances (see 5.8);
- sharing of organization requirements and expectations;
- learning opportunities from ongoing activities and potential or actual nonconformances;
- activity quality plans and subsequent changes (see 5.6.1); and
- sharing of best practices.

NOTE Project organization communication is considered communication among the organizations (owner/operator, supplier, contractors, subcontractors, etc.) involved in the pipeline construction project.

4.2 Management Responsibility

4.2.1 Organization Structure

Management shall ensure the availability of resources essential to establish, implement, maintain, and improve the QMS.

NOTE Resources can include human resources and specialized skills, organizational infrastructure, technology, and financial resources.

Management should provide evidence of its commitment to the implementation and continuous improvement of the QMS by:

- a) communicating to the organization the importance of meeting all applicable requirements;
- b) ensuring that quality goals and objectives are established;
- c) providing guidance for key performance indicators; and
- d) conducting appropriate management reviews (see 6.6).

4.2.2 Responsibilities and Authorities

Responsibilities and authorities that are key to QMS shall be defined, documented, assigned within, and communicated throughout the organization.

The organization should appoint a specific management representative(s) from within the organization who has defined responsibilities and authorities for:

- a) ensuring that the QMS is established, implemented, and maintained in accordance with the requirements of this document;
- b) initiating action(s) to minimize the likelihood of the occurrence of nonconformances; and
- c) reporting to management on the effectiveness of the QMS, including making recommendations for improvement.

4.2.3 Contractor and Supplier Responsibility

The organization shall define when contractors and suppliers shall have their own quality plan that is aligned with that of the organization's QMS.

Additionally, the contractors and suppliers shall be responsible for the quality of their pipeline materials and construction, including:

- compliance with legal requirements;
- conformance to industry standards; and
- conformance to applicable specifications and organization requirements.

4.3 Organization Capability

4.3.1 Provision of Resources

The organization shall determine and provide the resources required to implement, maintain, and improve the effectiveness of the QMS.

4.3.2 Human Resources

4.3.2.1 General

The organization shall maintain a procedure for identifying and defining personnel training and qualification with regards to the QMS and providing training required to conform to this document. The procedure should include provisions for ensuring the completeness of the actions taken to achieve the necessary training and qualification of personnel.

For their defined role, personnel shall have the appropriate education, training, and skills. Records of personnel training and qualification shall be maintained in accordance with 4.5. See Annex B for guidance on training, qualification, and competence.

4.3.2.2 Training

The organization shall:

- a) provide for role-specific QMS training and for job training of the personnel who affect the quality of pipeline construction or provision of pipeline construction-related products, including personnel performing QMS audits;
- b) ensure that the frequency and content of training complies with legal and other applicable requirements;
- c) document and maintain appropriate records of education, training, skills, and experience (see 4.5).

NOTE Examples of role-specific QMS training include communication processes, change management, applicable KPIs, etc.

4.3.3 Contracted Services

The organization shall develop, document, apply, and refine processes at specified intervals to audit or verify that contracted services meet or exceed the quality standards of the QMS, as applicable.

4.3.4 Infrastructure

The organization shall be responsible for identifying, providing, and maintaining the infrastructure required to support the effective implementation of the QMS.

4.3.5 Work Environment

The organization shall manage the environmental, human, organizational, safety, and security factors of the working conditions that could inhibit the ability to meet the requirements of the QMS.

4.4 Documentation Requirements

4.4.1 General

The QMS shall be documented. Documentation should include:

- a) statements of quality policy, quality goals, and objectives;
- b) scope of the QMS;
- c) description of the interaction between the processes of the QMS, including the reference to documented procedures;
- d) documents to ensure the effective planning, operation, and control of the QMS processes, and conformance to specified requirements.

Procedures required by this document and the QMS shall be established, documented, implemented, and maintained.

NOTE 1 A single document can address the requirements for one or more processes.

NOTE 2 A requirement for documented processes can be covered by more than one document.

4.4.2 Control of Documents

The organization shall maintain a procedure for the identification, distribution, and control of documents required by the QMS, including required documents of an origin external to the organization.

The procedure should define the controls required:

- a) to ensure that documents required by the QMS, including revisions, translations, and updates, are reviewed and approved for adequacy prior to issue and use;
- b) to define responsibilities for approval and re-approval of documents;
- c) to identify changes to the documents;
- d) to ensure that documents remain legible and readily identifiable; and
- e) to ensure relevant versions of applicable documents are available where the activity is being performed.

Obsolete documents shall be removed from all points of issue or use, or otherwise identified to prevent unintended use if they are retained for any purpose.

4.5 Control of Records

The organization shall maintain a procedure to define the controls and responsibilities required for the initiation, identification, collection, storage, protection, retrieval, retention time, and disposition of records.

Records, including those from outsourced activities, shall be controlled to provide evidence of conformity to requirements and of the effective operation of the QMS. Records shall remain traceable, verifiable, and complete. Records shall be retained in conformance with the organization's record-retention policies and other applicable regulatory requirements.

4.6 Change Management

4.6.1 General

The organization shall maintain a documented change-management procedure for the QMS document(s). The organization should identify potential risks associated with the change and any required approvals prior to the introduction of such changes.

4.6.2 Change Management Implementation

The organization should use the change management process for any of the following that may impact the execution of the QMS or quality of pipeline construction:

- a) changes in key or essential personnel or roles, whose absence or departure could have negative impacts;
- b) changes in critical suppliers and contractors whose absence or departure could have negative impacts;
- c) changes to the QMS documents or procedures, including temporary changes and improvements resulting from corrective and preventive actions (see 6.4); and
- d) deviations or variances or changes to the organization's design documents or specifications.

4.6.3 Change Management Evaluation, Notification, and Controls

The organization shall assess the associated risks (see 4.7) when evaluating a potential change. The organization shall notify relevant stakeholders of the change and any residual or new risks that result. The organization shall ensure that relevant documents are amended. The organization shall maintain records (see 4.5) of change-management activities.

4.7 Risk Assessment and Management

The organization shall identify the quality risks, or probability of quality events and their consequence, associated with failure to meet the quality objectives. The organization shall maintain a procedure to control quality risks throughout the execution of pipeline construction.

The procedure should include the assessment of quality risks associated with:

- a) design;
- b) execution of pipeline construction;
- c) materials and/or equipment;
- d) personnel; and
- e) security.

Records of risk assessment and actions taken shall be maintained (see 4.5). Quality risks may be addressed during pipeline design or all phases of pipeline construction. The results of risk assessment activities may be utilized as the input into the continuous improvement cycle of the QMS and construction projects.

NOTE Effective quality risk management relies upon the ability to identify potential sources of deviations or deficiencies and then develop strategies to prevent or mitigate both. Records of risk assessments may be in the form of a risk register.

5 Pipeline Construction

5.1 Planning

The organization shall identify and plan the processes and documents required for the pipeline-construction project. This is the initial step of the continuous-improvement cycle at the construction project level, as described in the Background section of this document.

In planning, the organization should address the following:

- a) scope, including organization and customer-specified requirements;
- b) schedule;
- c) legal, regulatory, permit, and other applicable requirements;
- d) project quality risk assessment and contingency planning;
- e) required resources and work environment management (see 4.3);
- f) anticipated land use, right of way (ROW), access, and temporary work space;
- g) verification of engineering and design;
- h) construction;
- i) pipeline marking, registration with utility identification services such as One Call, communication processes, and timing during construction and emergencies;
- j) identification of integrity threats and understanding of applicable prevention and mitigation methods;
- k) identification of any special environmental considerations that raise the risk associated with a failure of the pipeline or may impact frequency of access to the pipeline;
- l) inspection;
- m) anticipated testing protocols;
- n) change management (see 4.6);
- o) quality performance metrics or KPIs; and
- p) records required to provide evidence that the construction project meets requirements (see 4.5).

NOTE 1 Complex projects with various resources must have planning that considers the pipeline from “end to end” to minimize issues and allow coordination of resources at interfaces, such as intersections of spreads or facilities.

NOTE 2 Many organizations choose to use a project execution plan (PEP).

NOTE 3 Requirements for pipeline markers in the U.S. are contained in 49 CFR 195.410 and 49 CFR 192.707. [API RP 1109](#) details appropriate line markers for liquid pipelines.

5.2 Legal and Organizational Requirements

The project organization, including contractors and suppliers, shall be informed of the applicable legal requirements. The project organization is responsible for meeting all applicable requirements.

The organization may impose additional requirements necessary to ensure that the pipeline is suitable for the intended service conditions and that quality requirements are implemented. The organization shall ensure that contractors and suppliers are informed of any applicable organizational requirements and shall utilize change management (4.6) if these requirements change during the course of the project.

5.3 Verification of Engineering and Design

The organization shall maintain processes to plan and control the design of the pipeline to promote quality pipeline construction.

The processes should include:

- a) progressive checking of engineering drawings and calculations for conformance with organization and industry design standards and codes;
- b) the activities required for completion, review, and verification of design(s);
- c) the interfaces between different groups involved in design;
- d) the responsibilities and authorities for the design activities;
- e) training and awareness of personnel involved in design activities;
- f) quality assurance and quality control practices;
- g) document control procedures (4.4.2); and
- h) change management (4.6).

When engineering and design are outsourced, the organization shall have a process in place to validate that the contracted service meets the requirements of 5.1 through 5.3.

5.3.1 Design Inputs

Inputs relating to the design of the pipeline for constructability shall be determined and records maintained (see 4.5). These inputs should include:

- a) civil survey results, including utility locations, foreign pipeline crossings, surface, and subsurface conditions;

NOTE Civil surveys identify class locations, possible high-consequence areas (HCAs), environmental concerns, and geotechnical concerns such as slide areas, fault lines, and areas with possible subsidence or liquefaction, which are considered during pipeline design. For example, the geotechnical concerns are considered with regards to stress concentrations on pipeline girth welds.

- b) legal and organizational requirements (see 5.2); and
- c) other requirements, including (as applicable):
 - 1) requirements provided from an external source;

- 2) requirements for pipeline-associated products, including their functional and technical requirements;
- 3) environmental and operational conditions;
- 4) external loading (buoyancy control, subsidence, live loads, etc.);
- 5) results from risk assessments (see 4.7);
- 6) historical performance and other information derived from previous similar designs;
- 7) applicable integrity threats over the life of the pipeline; and
- 8) procurement and compatibility of pipe and components.

5.3.2 Design Outputs

The outputs of design shall be documented to allow verification against the design input requirements.

Design outputs should:

- a) meet the input requirements for design;
- b) provide information for purchasing of pipe, components, and construction-related products;
- c) provide controls for the execution of the construction, including allowable variations in the service/construction execution parameters (e.g. tie-in temperature limits, depth, etc.);
- d) include or reference acceptance criteria for the completed construction;
- e) provide mitigations or mitigation recommended practices for pipeline integrity threats and events; and
- f) be provided in a format that meets the organization requirements (for example: geographical information system (GIS) drawings, electronic models, etc.).

5.3.3 Design Review

A design review shall be conducted and documented. Records of the review shall be maintained according to the record control procedure (see 4.5).

5.3.4 Control of Design Changes

Changes in the design issued for construction shall be managed by a change-management process (see 4.6).

5.4 Contract Development and Review

5.4.1 General

The organization shall maintain a process for contracting services for pipeline construction.

5.4.2 Determination of Requirements

The organization shall determine:

- a) scope and schedule;
- b) organization-defined requirements, including the requirements for service planning, execution, evaluation, and rework; and