



# Piping Engineering Specification

*Prepared exclusively for*

*Kearns Technical Solutions Ltd (KTS)*

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## 1. Scope

This specification defines the scope, responsibilities, deliverables, and digital integration protocols for the piping discipline within [Project Name]. It is authored exclusively by Kearns Technical Solutions Ltd (KTS) and reflects proprietary standards for team structure, authorship, and document control.

The specification applies to all piping activities from concept design through detailed engineering and construction support. It formalizes discipline boundaries, interface expectations, and the integration of AI-enabled roles within the engineering team.

## 2. Applicable Codes and Standards

All piping design and engineering shall comply with the following standards unless otherwise approved by the Engineering Manager:

- ASME B31.3 – Process Piping
- ASME B16 series – Pipe Fittings and Flanges
- ISO 9001 – Quality Management Systems
- Project-specific standards as defined in the Basis of Design
- Client specifications where contractually binding

Where conflicts arise, project-specific standards shall take precedence unless otherwise approved by the Engineering Manager. Deviations must be documented and approved via formal change control.

## 3. Piping team Structure and Responsibilities

The piping discipline shall be organized to ensure clarity of roles, accountability, and efficient collaboration across interfaces. KTS defines the following core roles:

- Lead Piping Engineer – Discipline oversight, technical authority, interface coordination
- Piping Designer – Layouts, isometrics, GA drawings, model development
- Stress Analyst – Flexibility analysis, support design, stress reports
- Materials Engineer – Specification compliance, valve, and material selection
- AI Coordinator – Digital QA/QC, spec generation, smart tagging, clash detection
- Document Controller – Document control, revision tracking, metadata management

Each role is defined in the RRM-001 matrix, including responsibilities, reporting lines, interface disciplines, and digital tools used.

### 3.1 Piping Discipline Roles and Reporting Structure

The piping discipline shall operate under the leadership of the Lead Piping Engineer, who reports to the Engineering Manager. All roles within the discipline are defined in the Roles and Responsibilities Matrix (RRM-001) and shall be documented in the project org chart.

Core Roles Reporting to the Lead Piping Engineer

Role	Primary Responsibilities
Piping Design Engineer(s)	Routing, layout, model coordination, clash resolution, and drawing production
Stress Analyst	Pipe stress analysis, support design, and flexibility studies
Materials Engineer	Material selection, MSD development, MTO/MR preparation, and vendor coordination
QA/QC Engineer	Weld mapping, NDT coordination, inspection records, and test pack validation
Field Engineer	Site coordination, spool fit-up, support installation, and punch list resolution
Doc Controller	Digital tool management, smart tagging, clash detection, dashboard generation, and traceability oversight

Each role shall be assigned a named individual with documented responsibilities, reporting lines, and tool access. The AI Coordinator supports all roles by maintaining digital workflows, metadata compliance, and version control across deliverables

## 4. Design Requirements

This section defines the design protocols, ownership boundaries, and digital workflows for piping design activities. It incorporates AI-enabled tools to support optimization, traceability, and coordination across disciplines.

### 4.1 General Design Basis

Piping design shall comply with ASME B31.3 and project-specific specifications. Design conditions are derived from process data sheets and line class specifications. Routing decisions shall prioritize safety, maintainability, and constructability.

### 4.2 Line List Ownership and Creation

The Process Engineering team owns the line list. The Piping discipline is responsible for validating constructability, layout feasibility, and tie-in logic.

AI tools assist with:

- Extraction from P&IDs and datasheets
- Cross-referencing with MSDs and 3D model
- Anomaly detection and flagging

### 4.3 Critical Line List

A subset of lines requiring enhanced scrutiny shall be maintained. Criteria include:

- High pressure or temperature
- Toxic or hazardous contents
- Stress analysis requirements
- QA/QC or inspection needs

Reviewed jointly by Process, Piping, and QA/QC.

AI tools assist in:

- Flagging based on metadata
- Prioritization dashboards
- Predictive risk scoring

### 4.4 Routing and Layout Integration

The validated line list feeds into 3D routing tools. Routing shall consider:

- Equipment layout and access
- Structural constraints
- Safety zones and escape routes
- Maintenance envelopes

AI-enhanced auto-routing may be used to:

- Optimize paths
- Reduce congestion
- Flag potential clashes

### 4.5 Model Review Milestones

Formal model reviews shall be held at:

- 30% – Initial layout and tie-in logic
- 60% – Routing maturity and clash resolution
- 90% – Final model and deliverable readiness

AI tools support:

- Review dashboards
- Comment tracking
- Readiness scoring
- Discipline-specific punch list generation

#### 4.6 Material Take-Off (MTO)

The Lead Piping Engineer owns the MTO. It shall be developed from:

- Line list
- 3D model
- Isometric drawings
- MSD overlays

AI tools assist with:

- Quantity extraction
- Revision tracking
- Validation against MSDs and specs

#### 4.7 Material Requisitions (MRs)

MRs are prepared by the Materials Engineer in coordination with Procurement. Each MR includes:

- Bill of Materials (BOM)
- Datasheets and specifications
- Inspection and test requirements
- Delivery schedule and lead times

AI tools assist with:

- Template population
- Consistency checks
- Long-lead item flagging
- Registration via Document Control

### 5. Materials

This section defines the philosophy, selection criteria, and documentation protocols for piping materials. It integrates AI-enabled tools to support lifecycle optimization, traceability, and digital twin readiness.

#### 5.1 General Requirements

All piping materials shall conform to applicable standards including ASME, ASTM, and API. Selection shall be based on:

- Process conditions
- Corrosion resistance
- Mechanical integrity
- Lifecycle cost and maintainability

Materials shall be traceable to line classes and validated against project specifications.

## 5.2 Material Selection Philosophy (MSP)

KTS adopts a digitally enabled MSP that is:

- Process-driven – aligned with fluid properties and operating conditions
- Corrosion-aware – responsive to degradation mechanisms and inspection intervals
- Lifecycle-focused – optimized for long-term performance and maintainability
- Digitally integrated – supported by AI tools for validation and traceability

The MSP shall be reviewed and approved by the Lead Piping Engineer and Materials Engineer.

## 5.3 Material Selection Diagrams (MSDs)

MSDs are visual overlays showing material boundaries and line class assignments across the plant layout. They shall be:

- Developed from P&IDs, line list, and process data
- Validated against the MSP and project specs
- Maintained as live documents during design evolution

AI tools may assist in:

- Generating MSDs from tagged data
- Flagging inconsistencies
- Embedding metadata for searchability

## 5.4 Relationship to P&IDs

P&IDs are the primary source for line identification and material boundaries. AI tools shall be used to:

- Extract line data
- Cross-reference with MSDs and line list
- Validate consistency across disciplines

Any discrepancies shall be flagged by the AI Coordinator and resolved by the Lead Piping Engineer.

## 5.5 Material Classes

The following material classes are defined for piping systems:

- Carbon Steel – General service, non-corrosive fluids
- Stainless Steel – Corrosive or hygienic service
- Alloy Steel – High temperature or pressure
- Duplex/Super Duplex – High strength, corrosion-resistant applications

Each line shall be assigned a material class based on process conditions and validated against the MSP. Assignments shall be traceable via MSD overlays and embedded metadata.

## 6. Fabrication and Installation

This section defines the requirements for shop fabrication, field installation, and support systems for piping. It incorporates AI-enabled tools to enhance constructability, reduce rework, and support digital traceability.

### 6.1 Welding and Assembly

All welding shall comply with ASME Section IX and project-specific welding procedures. Welders shall be qualified, and weld maps maintained digitally.

AI tools support:

- Smart welding tools that capture heat input, travel speed, and filler material usage
- Automated linking of weld data to QA records and isometric drawings
- Real-time alerts for deviations from qualified procedures

Weld logs shall be version-controlled and traceable to line numbers and weld IDs.

### 6.2 Field Fit and Adjustment

Field fit-up shall be minimized through accurate spool planning and model coordination. Spools shall be prefabricated based on the 3D model and verified against site conditions.

AI tools assist with:

- Predictive fit-up risk analysis based on model tolerances and site survey data
- Suggesting pre-adjustment zones or flexible connections
- Tracking field modifications and updating as-built models

All field adjustments shall be documented and approved by the Lead Piping Engineer.

### 6.3 Support Installation

Pipe supports shall be installed in accordance with the stress analysis output and support index. Support types include:

- Standard hangers and guides
- Spring supports and snubbers
- Custom structural frames

AI tools assist with:

- Tagging support locations in the 3D model
- Verifying load paths and anchor points
- Generating support schedules and installation sequences

Support installation shall be coordinated with structural and civil disciplines. Deviations from the support index must be reviewed and approved by the Stress Analyst and Lead Piping Engineer.

## 7. Inspection and Testing

This section defines the protocols for pressure testing, non-destructive testing (NDT), and smart monitoring of piping systems. It integrates AI-enabled tools to enhance QA/QC, traceability, and predictive maintenance.

### 7.1 Pressure Testing

All pressure testing shall comply with ASME B31.3 and project-specific requirements.

- Hydrostatic testing is the default method
- Pneumatic testing shall only be used with written approval from the Engineering Manager and HSE Lead
- Test boundaries shall be clearly defined on isometric drawings
- Test pressures shall be calculated based on design pressure and code factors

AI tools assist with:

- Generating test packs from line list and isometrics
- Flagging incomplete test boundaries
- Tracking test status and linking results to line numbers

All test records shall be version-controlled and submitted to Document Control.

### 7.2 NDT and QA/QC

Non-destructive testing shall be performed in accordance with project specifications and applicable codes. Techniques include:

- Radiographic Testing (RT)
- Ultrasonic Testing (UT)
- Penetrant Testing (PT)
- Magnetic Particle Testing (MT)

NDT scope is defined by line class, service criticality, and weld type. Weld maps shall be maintained digitally and linked to QA records.

AI tools support:

- Scheduling of NDT activities based on construction progress
- Generating weld traceability dashboards
- Flagging overdue inspections or missing documentation

All NDT results shall be reviewed by the QA/QC Lead and uploaded to the Document Management System (DMS).

### 7.3 Smart Monitoring and Predictive Maintenance

For critical lines, smart sensors may be installed to monitor:

- Pressure and temperature fluctuations
- Vibration and acoustic signatures
- Corrosion rates and wall thinning

AI models shall be used to:

- Predict failure modes
- Recommend inspection intervals
- Trigger alerts for abnormal conditions

Smart monitoring data shall be integrated into the digital twin and reviewed periodically by the Piping and Integrity teams.

## 8. Documentation and Handover

This section defines the documentation requirements for project closeout, including deliverables, AI-generated outputs, and digital twin integration. All documents shall be version-controlled, metadata-tagged, and traceable to their source discipline.

### 8.1 Deliverables

The piping discipline shall submit the following as part of project handover:

- Smart P&IDs (with embedded metadata)
- 3D model files (native and IFC formats)
- Isometric drawings (with weld maps and test boundaries)
- Line list and valve list
- Material Take-Off (MTO) and Material Requisition (MR) registers
- Weld logs and NDT records
- Pressure test packs and certificates
- Punch lists and closeout reports

All deliverables shall be submitted in accordance with the Document Control Plan and stored in the Document Management System (DMS).

### 8.2 AI-Generated Outputs

AI-generated documents and dashboards may include:

- Auto-tagged line lists and MSD overlays
- Clash detection reports
- Weld traceability dashboards
- Predictive maintenance summaries
- Interface registers and coordination logs

These outputs shall be reviewed and approved by the relevant discipline leads before formal issue.

The AI Coordinator is responsible for ensuring:

- Version control and traceability
- Metadata compliance
- Integration with formal deliverables

AI outputs are considered supplementary unless explicitly accepted as contractual deliverables.

### 8.3 Digital Twin Integration

All piping documentation shall be structured to support digital twin development and lifecycle asset management. This includes:

- Consistent use of smart tags and metadata
- Linking of documents to 3D model objects and asset IDs
- Inclusion of inspection, testing, and maintenance history
- Compatibility with client-specified digital twin platforms

The AI Coordinator shall ensure that all digital handover files meet the required format, structure, and metadata standards for integration into the owner's digital ecosystem.

## 9. Health, Safety, and Environment (HSE)

This section outlines the HSE requirements applicable to piping design, fabrication, installation, and testing. All activities shall comply with project-specific HSE standards, regulatory requirements, and KTS's commitment to safe, sustainable engineering.

### 9.1 Design Safety Principles

Piping design shall incorporate the following safety principles:

- Minimize personnel exposure to hazardous fluids and high-temperature zones
- Ensure accessibility for maintenance and emergency isolation
- Avoid routing through congested or high-risk areas
- Include provisions for pressure relief, drainage, and venting
- Comply with escape route and fire zone requirements

AI tools may assist in:

- Simulating risk scenarios based on layout and fluid properties
- Flagging non-compliant routing or access constraints
- Generating safety overlays for model reviews

## 9.2 Environmental Considerations

Design and material selection shall consider environmental impact, including:

- Corrosion mitigation and containment
- Lifecycle emissions and energy usage
- Waste minimization during fabrication and installation
- Compatibility with environmental monitoring systems

AI tools support:

- Lifecycle impact assessments
- Material selection optimization
- Integration with environmental dashboards

## 9.3 Construction and Testing Safety

All site activities shall follow approved method statements and risk assessments. This includes:

- Safe handling and lifting of spools and supports
- Controlled execution of pressure tests
- Compliance with confined space and hot work protocols
- Use of PPE and safety signage

AI tools may assist in:

- Predicting high-risk activities based on schedule and layout
- Flagging overdue safety reviews or missing permits
- Tracking safety observations and incident trends

## 10. Glossary and Definitions

For clarity and consistency, the following terms are defined as used in this specification. These definitions reflect KTS's proprietary workflows, digital integration strategy, and discipline-specific terminology.

Term	Definition
AI Coordinator	A designated role responsible for managing digital workflows, QA/QC, smart tagging, and clash detection within the piping discipline.
Clash Detection	Automated identification of spatial conflicts between piping and other disciplines using digital tools.
Digital Twin	A structured digital representation of the physical piping system, including metadata, inspection history, and lifecycle traceability.
DMS	Document Management System used for version control, metadata tracking, and controlled document issuance.
Doc Tracker	A digital tool used to monitor document status, revision history, and metadata compliance across deliverables.
Interface Register	A live document tracking coordination points between disciplines, including status, responsible parties, and resolution history.
MSD	Material Selection Diagram—visual overlays showing material boundaries and line class assignments across the plant layout.
MSP	Material Selection Philosophy—KTS's approach to selecting piping materials based on process, corrosion, lifecycle, and digital traceability.
RRM-001	Roles and Responsibilities Matrix defining team structure, reporting lines, and tool usage.
Smart Tagging	The use of AI tools to embed searchable metadata in drawings and documents, enabling traceability and automated indexing.
Spec Generator	AI-enabled tool used to produce discipline specifications based on predefined templates and project inputs.

We can now move to Appendix A: Roles and Responsibilities Matrix (RRM-001) or prep a revision history table and drawing register.

## APPENDIX 1 – RRM-001

The following matrix defines the core roles within the piping discipline, including responsibilities, reporting lines, interface points, and digital tools. This structure reflects KTS's commitment to clarity, accountability, and digital integration.

Role	Responsibilities	Reporting Line	Interfaces	Digital Tools
Lead Piping Engineer	Discipline oversight, design review	Engineering Manager	Process, Mechanical, Civil	3D Model, Spec Generator
Piping Designer	Layouts, isometrics, GA drawings	Lead Piping Engineer	Stress, Instrumentation	CAD, Smart Tagging
Stress Analyst	Flexibility, support checks, stress reports	Lead Piping Engineer	Structural, Civil	Stress Tool, Clash Check
Materials Engineer	Spec compliance, valve/material selection	Lead Piping Engineer	Procurement, QA/QC	Spec Generator
AI Coordinator	QA/QC, spec generation, digital workflows	Lead Piping Engineer	All disciplines	AI Assistant, Doc Tracker
Doc Controller	Document control, revision tracking	Project Controls	All disciplines	DMS, Metadata Manager