Infrastructure Quality Standard - Core

IQI STANDARD IQC1

Second Draft Edition - Updated July 2026

Invariant Core Architecture and Requirements for Energy Infrastructure

INFRASTRUCTURE QUALITY INITIATIVE

Foreword (Informative)

Energy Infrastructure and Whole Quality

Energy infrastructure is the principal application domain of the Infrastructure Quality Initiative within Whole Quality. It includes the assets, facilities, networks, and systems-of-systems used to produce, process, convert, store, transport, transmit, distribute, and deliver energy. These objects are long-lived, interface-intensive, and often high-consequence.

This Core Standard establishes invariant requirements for determining and communicating the Infrastructure Quality State of a defined energy Infrastructure Quality Object. It is intended to make the quality of assembled infrastructure visible at asset, facility, network, subsystem, zone, program, interface, population, and system-of-systems scales.

Position Within the Whole Quality Architecture

The Whole Quality document architecture separates explanation, definition, requirements, and context-specific interpretation:

- WQI Foundational Articles explain the methodology and its development.
- WQI_VOC1 defines Root Concepts that retain the same meaning across application domains.
- IQI_VOC1 defines Applied Concepts required for energy infrastructure.
- IQC1 establishes invariant energy-infrastructure quality requirements.
- IQI Context Guides interpret IQC1 within bounded energy-infrastructure contexts.

This Standard therefore uses the authoritative definitions established in WQI_VOC1 and IQI_VOC1. It does not create competing definitions of Root or Applied Concepts.

Infrastructure Quality Object and System-Level Anchoring

Every application of this Standard begins with a declared and sufficiently described Infrastructure Quality Object. Individual components, activities, documents, tests, compliance findings, or management arrangements may provide Evidence, but they do not by themselves determine the Quality State of a broader assembled object.

Infrastructure Quality is interpreted in relation to Infrastructure Intended Functions and Infrastructure Intended Results, Boundaries and Interfaces, lifecycle and operating conditions, applicable Quality Outcome Criteria, Evidence, Uncertainty, and Critical Infrastructure Conditions.

Infrastructure Quality Object Standard, Not a Quality Management System Standard

IQC1 is an Infrastructure Quality Object and system-level Quality State standard. It does not prescribe how an organization shall structure itself, operate a quality management system, conduct audits, select technologies, or obtain certification.

Applicable laws, regulations, engineering codes, product standards, contracts, and management-system standards remain essential. They may form part of the Reference Layer, but compliance, component conformity, documentation, activity, or absence of observed failure is not by itself equivalent to demonstrated Infrastructure Quality.

Core Invariance and Context-Specific Interpretation

The Core Intended Function architecture, the 14 Core Quality Factors, and the Core Quality Indicators established in this Standard are invariant across IQI Context Guides. Context Guides

identify the Infrastructure Quality Object, Infrastructure Quality Object Description, Boundaries, Interfaces, lifecycle and operating conditions, Infrastructure Realization Pathways, Failure Modes, Context-Specific Quality Outcome Criteria, Evidence sources, Critical Infrastructure Conditions, Uncertainty, and Infrastructure Quality Claim Boundaries relevant to a defined context.

Context Guides interpret the invariant Core; they do not redefine Root or Applied Concepts, create alternative Core Quality Factors, replace Core Quality Indicators, or expand an Infrastructure Quality Claim Statement beyond its supporting Infrastructure Quality State determination.

Infrastructure Quality State Determination and Bounded Claims

The Core method proceeds from Evidence-Supported Findings to Quality Factor Interpretation, followed by Critical-Condition and Non-Compensability Review, establishment of the Infrastructure Quality State, and communication through a bounded Infrastructure Quality Claim Statement.

An Infrastructure Quality Claim Statement made under this Standard is not an IQI certification, approval, license, audit result, or endorsement. Its validity is limited by the declared Infrastructure Quality Object, Scale, Infrastructure Quality Claim Boundary, lifecycle and operating conditions, applicable Quality Outcome Criteria, Evidence basis, Assumptions, Uncertainty, Unresolved Conditions, Critical Infrastructure Conditions, and conditions of continued validity.

Intended Use

This Standard is intended for owners, operators, designers, constructors, assessors, regulators, financiers, insurers, communities, workers, and other interested parties who require a consistent and evidence-supported framework for understanding energy infrastructure quality.

How This Standard Should Be Read (Informative)

Readers new to IQI may begin with this Foreword and Sections 1 and 2. Section 3 contains the invariant normative Core Quality Factors and Core Quality Indicators. Sections 4 through 7 address Infrastructure Quality Object and Boundary definition, application, lifecycle conditions, Infrastructure Quality State determination, and Infrastructure Quality Claim Statements. Section 8 summarizes interpretive principles. The Annexes are informative and do not create additional requirements.

The term shall in this Standard applies to a required condition of the declared Infrastructure Quality Object or its Infrastructure Quality State determination. It shall not be interpreted as prescribing a quality management system, organizational structure, or certification process.

A plain-language explanation of the IQI framework and guidance on navigating the document set is provided in How to Read the Infrastructure Quality Standard - Core (IQI_RIQ1).

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1 Scope and Purpose

1.1 Scope

This Core Standard applies to defined energy Infrastructure Quality Objects, including assets, facilities, networks, subsystems, zones, lifecycle programs, interface conditions, asset populations, and energy infrastructure systems-of-systems.

The principal scope includes infrastructure for oil, natural gas, LNG, CNG, hydrogen, electric-power generation, energy conversion, transmission, distribution, storage, and related energy production, processing, transportation, and delivery.

Interfaces with water, communications, transportation, industrial, environmental-protection, and other critical systems are included where those Interfaces affect Function Realization or consequences for the energy Infrastructure Quality Object. Independent application of this edition to a non-energy infrastructure domain requires controlled vocabulary and Core architecture review.

The Standard applies across the principal IQI lifecycle sequence: Design - Construction - Commissioning - Operation - Maintenance - Repair/Modification - Decommissioning/Transition. Context-specific sub-stages may be identified without replacing this sequence.

This Standard does not prescribe engineering methods, technical solutions, organizational structures, quality management systems, staffing models, audit programs, certification schemes, or regulatory mechanisms.

1.2 Purpose

The purpose of IQC1 is to establish invariant Core requirements for determining and communicating the Infrastructure Quality State of a defined energy Infrastructure Quality Object.

Specifically, this Standard:

- establishes the invariant Core Intended Function architecture;
- establishes the 14 Core Quality Factors and their Core Quality Indicators;
- requires transparency of the Infrastructure Quality Object, Boundaries, Interfaces, Lifecycle, Evidence, Critical Conditions, and Infrastructure Quality Claim Boundaries;
- supports Infrastructure Quality State determination through Evidence-Supported Findings, Quality Factor Interpretation, and Critical-Condition and Non-Compensability Review;
- establishes the minimum structure of bounded Infrastructure Quality Claims; and
- provides a stable Core that can be interpreted by energy-infrastructure Context Guides without fragmentation.

1.3 Position Within the Whole Quality Architecture

IQC1 occupies the Core Standard layer of the Whole Quality document architecture. It follows WQI Foundational Articles, WQI_VOC1, and IQI_VOC1 and precedes IQI Context Guides and application tools.

- WQI Foundational Articles explain.
- WQI_VOC1 defines Root Concepts.
- IQI_VOC1 extends those concepts for energy infrastructure.
- IQC1 establishes invariant requirements.
- IQI Context Guides interpret those requirements within bounded contexts.

1.4 Governing Vocabulary and One Authoritative Definition

Each Whole Quality concept has one authoritative definition at the document layer appropriate to that concept. Root Concepts are defined in WQI_VOC1. Energy-infrastructure Applied Concepts are defined in IQI_VOC1.

IQC1 shall use and cross-reference those definitions. It shall not redefine them. Where a Root or Applied term appears without a separate definition in this Standard, the authoritative WQI_VOC1 or IQI_VOC1 definition governs.

For Factor-level terminology, an invariant concept needed specifically to interpret a Core Quality Factor or Core Quality Indicator may be defined in IQC1. A term shall not receive a separate IQC1 definition when its meaning is already controlled by WQI_VOC1 or IQI_VOC1, or when its meaning depends on an asset type, technology, jurisdiction, method, threshold, or other context-specific Reference Layer source.

1.5 Relationship to Context Guides

IQI Context Guides interpret IQC1 for defined energy-infrastructure contexts. They may establish context-specific Infrastructure Quality Object descriptions, Boundaries, Interfaces, lifecycle and Infrastructure Operating Conditions, Infrastructure Realization Pathways, Failure-Mode Families, Context-Specific Quality Outcome Criteria, Evidence sources, Critical Infrastructure Conditions, Uncertainty, and Infrastructure Quality Claim Boundaries.

A Context Guide shall not rename, redefine, omit, or replace the invariant Core Intended Function architecture, Core Quality Factors, or Core Quality Indicators in a manner that changes the Core architecture.

1.6 Intended Use

This Standard is intended to support consistent drafting, examination, review, interpretation, comparison, Infrastructure Quality State determination, and bounded Infrastructure Quality Claim Statements concerning energy infrastructure.

Use of this Standard does not constitute or imply IQI certification, approval, endorsement, accreditation, legal compliance, engineering acceptance, regulatory approval, or performance of a conformity assessment by IQI for any infrastructure asset, organization, project, product, service, claim, or activity.

2 Core Architecture and Document Status

2.0 Interpretive Note - Infrastructure Quality Object Standard, Not QMS

This Standard shall be interpreted as an Infrastructure Quality Object and system-level Quality State standard. Its requirements apply to the demonstrated condition and Function Realization of the declared object. They shall not be interpreted as requirements to establish, maintain, certify, or audit an organizational quality management system.

References to assessment, Evidence, documentation, competence, monitoring, conformity, or governance support interpretation of the Infrastructure Quality Object and its Quality State. They do not prescribe organizational procedures or management-system elements unless an individual Core requirement expressly makes such a relationship relevant to Function Realization.

2.1 Position and Status Within the IQI Document Set

IQC1 is the normative Core Standard within the IQI document set. Section 3 establishes the invariant Core Quality Factors and Core Quality Indicators. Sections 4 through 7 establish requirements for Infrastructure Quality Object and Boundary definition, application, lifecycle interpretation, Infrastructure Quality State determination, and Infrastructure Quality Claim Statements. Section 8 states controlling interpretive principles. The Annexes are informative.

Foundational Articles, Reader Guides, diagrams, and other explanatory materials do not replace the normative requirements of IQC1. Context Guides interpret IQC1 but do not create an alternative Core.

2.2 Governing Documents and Reference Layer

IQC1 shall be interpreted consistently with the authoritative definitions established in:

• WQI_VOC1 - Whole Quality Root Vocabulary Standard, current controlled draft edition;

• IQI_VOC1 - Infrastructure Quality Applied Vocabulary Standard, current controlled draft edition.

WQI Foundational Articles, IQI Reader Guides, diagrams, and other explanatory materials may support understanding but do not replace the normative requirements of IQC1.

IQI Context Guides are downstream interpretation documents to be updated after stabilization of this Core Standard. They do not govern the meaning of IQC1 during this controlled update.

Applicable laws, regulations, codes, technical standards, contracts, design bases, operating procedures, scientific knowledge, and professional guidance form the Reference Layer for the declared Infrastructure Quality Object and context.

Reference Layer sources support interpretation of Infrastructure Intended Functions and Infrastructure Intended Results, Quality Outcome Criteria, Evidence, responsibilities, Critical Infrastructure Conditions, and Infrastructure Quality Claim Statements. They do not alter the authoritative meanings of WQI Root Concepts or IQI Applied Concepts.

2.3 Infrastructure Quality Object and Structural Checkpoints

Every application of IQC1 shall begin with declaration and structured description of the Infrastructure Quality Object. The description shall be sufficient to identify the object Scale, composition, Infrastructure Intended Functions and Infrastructure Intended Results, relevant Infrastructure Configuration, Infrastructure Operating Medium and Infrastructure Operating Conditions, applicable Infrastructure Lifecycle Stage or transition, Boundaries, Interfaces, responsibilities, Context, and Evidence basis for the intended Infrastructure Quality State determination.

Before detailed interpretation proceeds, Structural Checkpoints shall confirm that the object and its description are sufficiently developed. A Structural Checkpoint is a completeness step; it is not a Core Quality Factor, Core Quality Indicator, Quality Outcome Criterion, technical inspection, assessment, or Infrastructure Quality State determination.

Where a Structural Checkpoint is not satisfied, the object description, scope, boundary, or proposed claim shall be refined, restricted, or qualified before interpretation continues.

2.4 Principal Core Dependency

The principal IQC1 dependency is:

Infrastructure Quality Object and Infrastructure Quality Object Description -> Structural Checkpoints -> Boundaries and Interfaces -> Infrastructure Intended Functions and Infrastructure Intended Results -> Failure-Mode Families -> Core Quality Factors -> Core Quality Indicators -> Context-Specific Quality Outcome Criteria -> Evidence-Supported Findings -> Quality Factor Interpretation -> Critical-Condition and Non-Compensability Review -> Infrastructure Quality State -> Infrastructure Quality Claim Statement

The dependency preserves traceability from every Infrastructure Quality Claim Statement back to the declared Infrastructure Quality Object, applicable Quality Outcome Criteria, Evidence, Quality Factor Interpretations, Uncertainty, Critical Infrastructure Conditions, and declared limitations.

2.5 Intended Function and the Work-Result-Outcome Relationship

The WQI Root Concepts Intended Function, Intended Result, and Function Realization apply with their authoritative WQI_VOC1 meanings. The IQI Applied Concepts Infrastructure Intended Function, Infrastructure Intended Result, Infrastructure Work, Infrastructure Result, and Infrastructure Outcome apply with their authoritative IQI_VOC1 meanings.

The invariant Core Intended Function architecture governs all IQI Context Guides. A Context Guide may identify context-specific Infrastructure subfunctions and Infrastructure Intended Results but shall not create a competing Core Intended Function.

Infrastructure Work + Infrastructure Result = Infrastructure Outcome

An Infrastructure Outcome may take the form of a product, a service, or a maintained or changed condition or capability. The relationship does not determine quality by itself.

Infrastructure Work and Infrastructure Result may require separate and combined interpretation against applicable Quality Outcome Criteria and Evidence.

2.6 Core Quality Factors, Core Quality Indicators, and Quality Outcome Criteria

The 14 Core Quality Factors and the Core Quality Indicators in Section 3 are invariant across IQI Context Guides. Together they form one integrated architecture for examining Function Realization of a declared Infrastructure Quality Object. A Core Quality Factor identifies a major dimension of Function Realization; a Core Quality Indicator identifies what is examined within that dimension.

A Core Quality Indicator does not by itself define an acceptable, required, or expected state. A Quality Outcome Criterion defines the expected condition, result, relationship, threshold, prohibited condition, tolerance, or evidence-supported state against which the Core Quality Indicator is interpreted. Evidence supports a finding against the Quality Outcome Criterion; it does not replace the Criterion.

Context Guides may define or identify Context-Specific Quality Outcome Criteria, connect them to the applicable Reference Layer, and explain relevant failure modes and evidence. They shall not replace, rename, omit, or alter the meaning of a Core Quality Factor or Core Quality Indicator.

Core Quality Factors and Core Quality Indicators shall not be averaged or treated as mutually substitutable by default. Evidence-Supported Findings are interpreted within each Factor and then reviewed across Factors, including Critical Infrastructure Conditions, Non-Compensability, Uncertainty, Boundaries, Interfaces, and Evidence limitations, before an Infrastructure Quality State is determined.

The Core does not permanently classify every Core Quality Indicator as critical or supporting for every energy-infrastructure context. A Context Guide or bounded Infrastructure Quality State determination identifies Critical Infrastructure Conditions where failure, prohibition, loss of visibility, or unresolved status would prevent a responsible positive Infrastructure Quality State determination or Infrastructure Quality Claim Statement.

2.7 Evidence-Supported Findings, Interpretation, and Infrastructure Quality State Determination

Data, records, observations, measurements, testimony, analysis, and other information become Evidence only when their relevance, credibility, Context, traceability, and relationship to the declared Infrastructure Quality Object, Core Quality Indicator, and applicable Quality Outcome Criterion are established.

The Infrastructure Quality State determination process shall distinguish Data and other information from Evidence, and shall distinguish Evidence from Evidence Sufficiency, Evidence-Supported Findings, and Quality Factor Interpretation. Evidence-Supported Findings shall be interpreted at the Core Quality Factor level before the Infrastructure Quality State is established.

Documentation, compliance, component conformity, current operation, data volume, activity completion, or absence of observed failure shall not by itself establish a positive Infrastructure Quality State.

2.8 Critical Conditions and Non-Compensability

Critical Conditions and Non-Compensability apply with their authoritative WQI_VOC1 meanings. Where the infrastructure-specific applied form is needed, IQI uses Critical Infrastructure Condition and Infrastructure Non-Substitutability as defined in IQI_VOC1.

A failed, prohibited, unresolved, or insufficiently evidenced Critical Infrastructure Condition shall prevent a responsible positive Infrastructure Quality State determination or Infrastructure Quality Claim Statement, regardless of satisfactory findings elsewhere.

2.9 Infrastructure Quality Claim Statements and Context Guides

An Infrastructure Quality Claim Statement shall be a bounded communication derived from an Infrastructure Quality State determination. It shall not exceed the supporting determination and shall identify the Infrastructure Quality Object, Scale, Infrastructure Quality Claim Boundary, lifecycle and operating conditions, applicable Quality Outcome Criteria, Evidence basis, included and excluded Interfaces, Assumptions, Uncertainty, Unresolved Conditions, Critical Infrastructure Conditions, limitations, and conditions of continued validity.

Where a Context Guide is used, the Infrastructure Quality Claim Statement shall identify the guide and the Context-Specific Interpretations on which the determination depends. Use of a Context Guide does not expand the claim beyond the declared Infrastructure Quality Object, Evidence basis, or Infrastructure Quality Claim Boundary.

3 Core Quality Factors and Core Quality Indicators (Normative Core)

3.0 Core Architecture and Interpretation Rules

The 14 Core Quality Factors and their Core Quality Indicators constitute one invariant energy-infrastructure quality architecture. They are derived from the Infrastructure Intended Functions and Infrastructure Intended Results, Boundaries, Interfaces, Infrastructure Lifecycle Stages and Infrastructure Operating Conditions, and Failure-Mode Families relevant to Function Realization. They shall be applied to the declared Infrastructure Quality Object rather than treated as a generic organizational checklist.

For architectural interpretation, the Factors perform the following connected roles:

• Factors 1–3 establish the functional, technical, and demonstrability basis for judging whether the intended infrastructure has been sufficiently defined, translated, realized, and evidenced.

• Factors 4–7 examine the integrated condition, consequence control, environmental interaction, and operational continuity of the Infrastructure Quality Object.

• Factors 8–11 examine human interaction, competence-dependent conditions, Reference Layer obligations, and effects on stakeholders and communities where these influence Function Realization.

• Factors 12–13 establish continuing visibility, interpretation, traceability, and Evidence continuity across the lifecycle.

• Factor 14 addresses controlled Adaptation, Innovation, and change without loss of alignment with Intended Functions and Intended Results, Boundaries, Interfaces, Critical Infrastructure Conditions, or Evidence requirements.

These groupings explain conceptual role only. They do not create scoring categories, permit omission of Factors, or establish priority between Factors. Each Factor shall be interpreted through its Core Quality Indicators, applicable Quality Outcome Criteria, Evidence-Supported Findings, uncertainty, and relevant Critical Infrastructure Conditions.

Where a Core Quality Indicator statement retains the words asset, infrastructure asset, or system for readability, those words shall be interpreted as referring to the declared Infrastructure Quality Object at the Scale and Boundary established for the determination.

The presence of favorable Evidence-Supported Findings under one Core Quality Factor shall not compensate for a failed or unresolved Critical Infrastructure Condition under another Factor. The Infrastructure Quality State determination shall preserve Quality Factor-level traceability and shall not rely on undocumented averaging or substitution.

Factor 1 — Functional Specification Quality

Purpose of the Factor

To ensure that the Infrastructure Intended Functions and Infrastructure Intended Results of the declared Infrastructure Quality Object are explicitly defined, complete, coherent, and traceable across the Lifecycle, forming a valid basis for technical realization, Operation, integrity interpretation, Evidence, and bounded claims.

Core architecture role: *Defines the functional reference basis from which all later technical realization, evidence, and claims shall remain traceable.*

Definitions and Governing Terms

Governing WQI and IQI terms. Intended Function, Intended Result, Function Realization, Boundary, Interface, Assumption, Uncertainty, Lifecycle, Infrastructure Intended Function, and Infrastructure Intended Result apply with their authoritative WQI_VOC1 and IQI_VOC1 meanings.

Functional Specification. A controlled statement or set of statements describing what the declared Infrastructure Quality Object is required to do and what Intended Results it is required to produce, including relevant conditions and limits of applicability.

Functional Requirement. An individual required function, result, capability, protection, or functional condition contained within a Functional Specification.

Functional Intent. The meaning expressed collectively by the Intended Functions, Intended Results, boundaries, interfaces, assumptions, and relevant context. Functional Intent does not replace the authoritative concept Intended Function.

Core Function Categories. Primary functions directly realize the principal intended purpose; supporting functions enable or sustain primary or protective functions; protective functions prevent or limit loss, harm, or unacceptable consequence; and lifecycle functions are required during a defined lifecycle stage or transition.

Operating Envelope. The bounded set or range of Infrastructure Operating Conditions within which specified Intended Functions or Intended Results are intended to be realized.

Functional Change. An addition, removal, alteration, or reinterpretation of an Intended Function, Intended Result, or governing functional condition.

Traceability. Traceability applies as defined under Factor 13.

Context-specific boundary. *Asset-specific functions, subfunctions, operating limits, acceptance conditions, and technical values are established through the applicable Context Guide or Reference Layer; they are not defined universally by this Factor.*

Core Quality Indicators

Indicator 1.1 — Completeness of Functional Requirements

Indicator Statement

The Infrastructure Intended Functions and Infrastructure Intended Results of the declared Infrastructure Quality Object shall be explicitly defined, documented, and complete for the applicable lifecycle conditions within the declared Boundary.

Intent

To prevent gaps where infrastructure is designed, built, or operated without a clear statement of what it is required to do. Incomplete functional definition is a primary source of latent design error, unsafe operating envelopes, and ungoverned change.

Scope and Boundaries

Includes primary functions, supporting functions, protective functions, and lifecycle functions (including startup, shutdown, abnormal operation, maintenance, and decommissioning). Excludes detailed technical solutions, which are addressed under Factor 2.

Lifecycle Coverage

Applies from Design through Decommissioning/Transition and shall be updated when functions are added, removed, or materially altered.

Evidence Principle

Evidence may include documented Functional Specifications, Operating Envelopes, lifecycle function statements, and records demonstrating review and maintenance of completeness.

Indicator 1.2 — Clarity and Unambiguity of Functional Intent

Indicator Statement

Functional requirements shall be stated in a manner that is clear, unambiguous, and interpretable without reliance on implicit assumptions or unstated expert knowledge.

Intent

To avoid divergent interpretations of intended function, which commonly lead to inconsistent design choices, unsafe operating practices, and disputes during verification or incident investigation.

Scope and Boundaries

Includes definitions of normal, abnormal, and foreseeable operating conditions.
Excludes numerical limits or technical tolerances, which are addressed under technical specifications.

Lifecycle Coverage

Applies at all stages where functional understanding informs decisions, including operations, maintenance, and modification.

Evidence Principle

Evidence may include structured functional statements, defined Operating Envelopes, documented Assumptions, and records showing that material ambiguity has been identified and resolved or declared as an Unresolved Condition.

Indicator 1.3 — Explicit Treatment of Functional Boundaries and Interfaces

Indicator Statement

The functional extent of the declared Infrastructure Quality Object and its relevant Interfaces shall be explicitly defined and documented within the applicable Boundary.

Intent

To prevent failures arising from boundary ambiguity, where functions are assumed to be provided by other systems or parties, resulting in unmanaged Interface Risk and system-level failure.

Scope and Boundaries

Includes physical, functional, informational, and organizational Interfaces relevant to Function Realization.
Excludes detailed Interface design, which is addressed under Factor 2 and the applicable Context Guide or Reference Layer.

Lifecycle Coverage

Applies at initial functional definition and whenever boundaries or interfaces change due to system evolution or modification.

Evidence Principle

Evidence may include boundary definitions, interface descriptions, responsibility allocations, and records demonstrating that interface assumptions are identified and addressed.

Indicator 1.4 — Identification and Documentation of Functional Assumptions and Uncertainties

Indicator Statement

Assumptions and fundamental uncertainties affecting functional requirements shall be explicitly identified, documented, and retained.

Intent

To prevent deterministic treatment of inherently uncertain conditions (such as environmental variability, demand evolution, or subsurface uncertainty), which leads to brittle designs and unsafe operation.

Scope and Boundaries

Includes natural, environmental, operational, and contextual Uncertainty that materially affects functional performance.
Excludes selection of mitigation measures, which is examined through Factors 4 through 7 and Factor 12, as applicable.

Lifecycle Coverage

Applies at all lifecycle stages and shall be revisited as knowledge improves or conditions change.

Evidence Principle

Evidence may include documented assumptions, uncertainty registers, model limitations, and traceable linkage between uncertainty and functional requirements.

Indicator 1.5 — Traceability of Functional Requirements Across the Lifecycle

Indicator Statement

Functional requirements shall be traceable across lifecycle stages, from initial Design definition through Construction, Commissioning, Operation, Repair/Modification, and Decommissioning/Transition.

Intent

To ensure that original functional intent is neither lost nor silently altered as the asset evolves, and that changes are deliberate, justified, and transparent.

Scope and Boundaries

Includes traceability between Functional Intent, subsequent specifications, realized infrastructure, and Infrastructure Operating Conditions.
Excludes verification and validation methods, which are addressed under Factor 3 and the applicable Reference Layer.

Lifecycle Coverage

Applies continuously and is especially critical during Repair/Modification and related life-extension or repurposing decisions.

Evidence Principle

Evidence may include traceability matrices, lifecycle documentation linkages, change records, and documented justification for functional changes.

Indicator 1.6 — Functional Changes

Indicator Statement

Functional changes shall be explicitly identified, evaluated, documented, and authorized before implementation.

Intent

To prevent unrecognized divergence between intended and realized function as infrastructure evolves. Implicit functional change is a recurring contributor to loss of safety margin, integrity degradation, and system failure.

Scope and Boundaries

Includes functional changes arising from operating experience, external conditions, stakeholder needs, regulatory context, Repair/Modification or repurposing of the declared Infrastructure Quality Object.
Excludes prescription of organizational procedures, roles, or management systems used to achieve this condition.

Lifecycle Coverage

Applies whenever functional change is proposed or occurs, including brownfield Repair/Modification, life extension, and Decommissioning/Transition decisions.

Evidence Principle

Evidence may include records demonstrating identification of the functional change, evaluation of implications, documented authorization, and updated functional requirements.

Factor 2 — Technical Specification Quality

Purpose of the Factor

To ensure that Technical Specifications correctly, completely, and coherently translate Functional Requirements into realizable and examinable Technical Requirements that remain valid across the Lifecycle of the declared Infrastructure Quality Object.

Core architecture role: *Examines whether functional intent has been translated into a coherent technical basis suitable for realization and lifecycle use.*

Definitions and Governing Terms

Governing terms. Functional Specification, Functional Requirement, Operating Envelope, and Infrastructure Configuration apply with the meanings established under Factor 1 or IQI_VOC1, as applicable.

Technical Specification. A controlled technical statement or set of statements translating Functional Requirements into realizable and examinable technical conditions.

Technical Requirement. An individual technical condition, characteristic, capacity, limit, relationship, or performance provision contained within a Technical Specification.

Functional-to-Technical Translation. The reasoned conversion of Functional Requirements into Technical Requirements while preserving the meaning and traceability of Functional Intent.

Technical Basis. The coherent set of Technical Requirements, assumptions, design bases, interfaces, operating conditions, and Reference Layer sources supporting technical realization of the declared Infrastructure Quality Object.

Technical Specification Change. A controlled alteration to a Technical Specification or Technical Requirement that may affect Function Realization, interfaces, Infrastructure Configuration, Evidence, or claim validity.

Context-specific boundary. *Design values, numerical limits, tolerances, safety factors, material requirements, and acceptance criteria depend on the asset, technology, lifecycle condition, and Reference Layer and therefore remain outside the universal Core definitions.*

Core Quality Indicators

Indicator 2.1 — Completeness of Technical Specifications

Indicator Statement

Technical specifications shall be complete with respect to the functional requirements they are intended to realize.

Intent

To prevent situations where functions are defined but not fully translated into technical requirements, leaving gaps that are filled implicitly during design, construction, or operation, often without adequate safety margin or traceability.

Scope and Boundaries

Includes all Technical Requirements necessary to realize defined functions, including performance, capacity, Operating Envelopes, protection, and lifecycle-related technical provisions.
Excludes methods and procedures used to procure, construct, inspect, or test infrastructure; those methods remain in the Reference Layer, while resulting conformity is examined under Factor 3.

Lifecycle Coverage

Applies from initial Design and specification through Repair/Modification and life extension, and shall be reassessed when functional requirements change.

Evidence Principle

Evidence may include documented technical specifications, coverage mappings between functional and technical requirements, and records demonstrating review for completeness.

Indicator 2.2 — Correctness and Unambiguity of Translation from Functional to Technical Requirements

Indicator Statement

Technical specifications shall correctly and explicitly translate functional requirements into clear, unambiguous technical requirements without contradiction, omission, or unintended alteration of intent.

Intent

To ensure that technical definitions faithfully realize functional intent, rather than reshaping it through convenience, legacy practice, or implicit assumptions. Demonstration of traceability alone is not sufficient; the correctness of interpretation shall be evident.

Scope and Boundaries

Includes translation of functional performance, operating conditions, protective functions, and lifecycle considerations into technical terms.
Excludes detailed design solutions, component selection, or construction methods.

Lifecycle Coverage

Applies at initial specification and whenever specifications are revised due to change, upgrade, or new information.

Evidence Principle

Evidence may include documented translation rationale, interpretive justification linking technical meaning to functional intent, and records resolving discrepancies between functional and technical definitions.

Indicator 2.3 — Internal Consistency and Coherence of Technical Specifications

Indicator Statement

Technical specifications shall be internally consistent and coherent, without conflicting requirements, incompatible assumptions, or unresolved dependencies.

Intent

To prevent latent failure modes created by contradictory or incoherent technical requirements, which often remain undetected until construction, commissioning, or abnormal operation.

Scope and Boundaries

Includes consistency across disciplines, documents, lifecycle stages, and interfacing systems. Excludes definition of functional boundaries and interfaces, which are addressed under Factor 1.

Lifecycle Coverage

Applies throughout specification development, revision, and integration into design and operation.

Evidence Principle

Evidence may include documented reviews for consistency, resolution of conflicts, and maintained alignment across technical documents.

Indicator 2.4 — Explicit Treatment of Technical Assumptions and Uncertainties

Indicator Statement

Assumptions and uncertainties underlying technical specifications shall be explicitly identified, documented, and retained.

Intent

To prevent technical requirements from being treated as deterministic when they are based on uncertain data, models, environmental conditions, degradation mechanisms, or future operating scenarios.

Scope and Boundaries

Includes assumptions related to loads, capacities, environmental conditions, degradation behavior, demand profiles, and model limitations.
Excludes selection of monitoring, mitigation, or design margin strategies.

Lifecycle Coverage

Applies at specification development and shall be revisited when conditions, knowledge, or operational context change.

Evidence Principle

Evidence may include documented assumptions, model descriptions, safety margins, and traceable linkage between uncertainty and technical requirements.

Indicator 2.5 — Alignment of Technical Specifications with Lifecycle Conditions

Indicator Statement

Technical specifications shall address the conditions required to realize functional requirements across all relevant lifecycle stages.

Intent

To prevent specifications that are valid only for initial operation but inadequate for construction, commissioning, abnormal operation, maintenance, modification, or decommissioning.

Scope and Boundaries

Includes technical provisions for installation, testing, operation, inspection, maintenance, modification, and end-of-life conditions.
Excludes procedural instructions for carrying out those activities.

Lifecycle Coverage

Applies across the full lifecycle and is especially critical for long-lived infrastructure subject to aging, degradation, and change.

Evidence Principle

Evidence may include lifecycle condition definitions within specifications, design bases covering non-steady-state conditions, and documented consideration of lifecycle transitions.

Indicator 2.6 — Traceability of Technical Specifications to Functional Requirements

Indicator Statement

Technical specifications shall be traceable to the functional requirements they are intended to realize.

Intent

To ensure that every technical requirement has a justified functional basis, and that no functional requirement is left unrealized or over-constrained.

Scope and Boundaries

Includes bidirectional traceability between functional and technical requirements.
Excludes interpretation of correctness, which is addressed under Indicator 2.2.

Lifecycle Coverage

Applies continuously and shall be maintained when specifications or functions change.

Evidence Principle

Evidence may include traceability matrices, requirement mapping records, and documented justification for technical requirements.

Indicator 2.7 — Technical Specification Changes

Indicator Statement

Changes to technical specifications shall be explicitly identified, evaluated, documented, and authorized before implementation.

Intent

To prevent uncontrolled alteration of technical requirements that can erode safety margins, invalidate assumptions, or disconnect the asset from its functional intent.

Scope and Boundaries

Includes changes driven by new information, operating experience, external conditions, regulatory context, or asset modification.
Excludes prescription of organizational procedures, roles, or management systems.

Lifecycle Coverage

Applies whenever technical specifications are modified, including brownfield Repair/Modification, upgrades, and life-extension projects.

Evidence Principle

Evidence may include records demonstrating identification of the technical change, evaluation of implications, documented authorization, and updated specifications.

Factor 3 — Conformity Assessment

Purpose of the Factor

To ensure that the condition of the declared Infrastructure Quality Object and its alignment with Functional Intent and Technical Requirements are sufficiently examined and evidenced so that Conformity Findings and Conformity Statements reflect the identified Basis for Conformity Assessment rather than Assumption or unsupported assertion.

Core architecture role: *Provides the demonstrability bridge between declared requirements and Evidence-Supported Findings about the realized Infrastructure Quality Object.*

Definitions and Governing Terms

Governing WQI and IQI terms. Evidence, Evidence Sufficiency, Evidence-Supported Finding, Unresolved Condition, Quality State Determination, Quality Claim, and Infrastructure Quality Claim Statement apply with their authoritative WQI_VOC1 and IQI_VOC1 meanings.

Conformity. The demonstrated correspondence of a specified object, result, or condition with identified requirements or criteria within a declared scope, boundary, lifecycle condition, and time.

Conformity Assessment. A structured examination of a specified object, result, or condition against identified requirements or criteria to support a Conformity Finding. It is not automatically equivalent to an audit, certification, or Quality State Determination.

Basis for Conformity Assessment. The declared object, requirements or criteria, lifecycle and operating conditions, scope, Evidence basis, assumptions, limitations, and relevant Reference Layer against which conformity is examined.

Conformity Finding. A bounded Evidence-Supported Finding concerning conformity to specified requirements or criteria.

Conformity Statement. A bounded communication of a Conformity Finding. A Conformity Statement is not an Infrastructure Quality Claim Statement unless it is incorporated into a Quality State Determination and the resulting bounded claim basis.

Non-Conformity. Demonstrated failure to satisfy an identified requirement or criterion within the declared Basis for Conformity Assessment.

Assessment Limitation. A declared restriction in scope, method, access, Evidence, competence, independence, or interpretation that bounds a Conformity Finding or Conformity Statement.

Risk-Proportionate Assessment Depth. The degree of assessment rigor and Evidence needed in relation to consequence, criticality, uncertainty, and lifecycle maturity, without prescribing a universal assurance level.

Independence and Objectivity. Properties of assessment judgment sufficient to identify and control relevant bias. They do not prescribe a particular organizational structure or require third-party certification.

Context-specific boundary. *Inspection, testing, verification, validation, sampling, assurance levels, certification, and audit methods are established by the applicable Context Guide or Reference Layer. IQC1 does not prescribe universal methods.*

Core Quality Indicators

Indicator 3.1 — Defined Basis for Conformity Assessment

Indicator Statement

The basis for conformity assessment shall be explicitly defined with respect to the functional specifications, technical specifications, and lifecycle stage of the infrastructure.

Intent

To prevent Conformity Statements that are ambiguous, incomplete, or disconnected from the approved functional and technical requirements on which infrastructure quality depends.

Scope and Boundaries

Includes definition of what is being assessed, against which requirements, and at which lifecycle stage.
Excludes prescription of specific assurance schemes or assessment methods.

Lifecycle Coverage

Applies at all lifecycle stages where conformity is claimed or relied upon.

Evidence Principle

Evidence may include documented assessment scopes, defined assessment criteria, and linkage between Conformity Statements and applicable functional and technical requirements.

Indicator 3.2 — Assessment of Conformity to Technical Specifications

Indicator Statement

Conformity of design results and realized infrastructure to applicable technical specifications shall be demonstrably established at a level appropriate to the criticality of the function and consequence of failure.

Intent

To ensure that technical requirements are not assumed to be met without adequate assessment, particularly where failure would remain latent or propagate infrastructure-level risk.

Scope and Boundaries

Includes assessment of design results, constructed, installed, configured, or operated infrastructure against technical requirements.
Excludes prescription of inspection techniques, testing methods, or acceptance criteria.

Lifecycle Coverage

Applies during Design, Construction, Commissioning, Operation, Repair/Modification, and Decommissioning/Transition, as relevant.

Evidence Principle

Evidence may include design reviews, inspection records, testing results, verification and validation activities, surveillance records, and documented assessment judgments.

Indicator 3.3 — Assessment of Continued Consistency Between Technical and Functional Specifications

Indicator Statement

The continued consistency of technical specifications with the approved functional specifications shall be assessed at appropriate lifecycle stages.

Intent

To prevent quality failures caused by technically compliant infrastructure that no longer reflects the functional intent, assumptions, or uncertainties on which it was originally based.

Scope and Boundaries

Includes assessment of whether technical requirements remain valid given evolving conditions, new knowledge, or changes to operating context.
Excludes redesign decisions or specification development activities.

Lifecycle Coverage

Applies during Design development, Commissioning, Operation, Repair/Modification, life extension, and repurposing.

Evidence Principle

Evidence may include reassessment records, review reports, and documented conclusions regarding continued adequacy of technical specifications relative to functional intent.

Indicator 3.4 — Risk-Proportionate Depth of Conformity Assessment

Indicator Statement

The level of demonstrated confidence in conformity shall be proportionate to the criticality of the function, the consequence of failure, and the stage of lifecycle realization.

Intent

To prevent both under-assessment of high-consequence infrastructure and over-reliance on superficial compliance for complex, novel, or evolving conditions.

Scope and Boundaries

Includes proportionality of assessment effort relative to infrastructure risk and maturity.
Excludes prescription of quantitative risk thresholds or predefined assurance levels.

Lifecycle Coverage

Applies whenever conformity assessment activities are planned or conducted.

Evidence Principle

Evidence may include documented justification of assessment depth and rationale linking assessment effort to risk and lifecycle stage.

Indicator 3.5 — Independence and Objectivity of Conformity Assessment

Indicator Statement

Evaluation of infrastructure condition shall be sufficiently independent to avoid bias where necessary and shall not be interpreted as a requirement for organizational structure or third-party certification.

Intent

To prevent self-confirmation, normalization of deviation, or institutional bias from masking quality failures.

Scope and Boundaries

Includes technical, organizational, or professional independence relevant to the assessment context.
Excludes specification of third-party certification or formal independence structures.

Lifecycle Coverage

Applies at all lifecycle stages where conformity assessment influences quality claims or infrastructure decisions.

Evidence Principle

Evidence may include assessor role definitions, independence declarations, peer review records, or documented independent judgment.

Indicator 3.6 — Treatment of Non-Conformity and Unresolved Conditions

Indicator Statement

Identified non-conformities and Unresolved Conditions arising from assessment shall be explicitly documented and retained, including their status and implications. Documentation of non-conformity serves to describe infrastructure condition and limitations, not to define corrective action systems.

Intent

To prevent unresolved issues from being silently accepted, normalized, or obscured by nominal Conformity Statements.

Scope and Boundaries

Includes technical non-conformities, assessment limitations, and known gaps in evidence.
Excludes prescription of corrective action processes, responsibilities, or timelines.

Lifecycle Coverage

Applies whenever conformity assessment identifies deviations, limitations, or uncertainty.

Evidence Principle

Evidence may include non-conformity records, assessment limitation statements, and documented disposition or acceptance rationales.

Indicator 3.7 — Traceability of Conformity Statements

Indicator Statement

Conformity Statements shall be traceable to the assessments performed, the requirements assessed, and the lifecycle stage to which the claim applies. Traceability supports transparency of infrastructure condition and shall not be interpreted as a reporting or certification requirement.

Intent

To ensure transparency and prevent over-generalized, misleading, or context-free quality claims.

Scope and Boundaries

Includes traceability between Conformity Statements, assessment activities, assessed requirements, and lifecycle scope.
Excludes reporting formats or publication templates.

Lifecycle Coverage

Applies whenever conformity or quality claims are made or relied upon.

Evidence Principle

Evidence may include conformity statements, assessment reports, scope definitions, and documented linkage to supporting assessments.

Nothing in this Factor establishes or implies a certification scheme, audit requirement, or approval process. Conformity remains a bounded statement about infrastructure condition within a defined scope and lifecycle stage.

Factor 4 — Structural and Functional Integrity

Purpose of the Factor

To ensure that the declared Infrastructure Quality Object preserves Structural Integrity and Functional Integrity required for realization of its Infrastructure Intended Functions and Infrastructure Intended Results, considering Degradation and Aging, damage, Interfaces, and foreseeable Abnormal Operating Conditions, Transient Conditions, and Degraded Conditions across the Lifecycle.

Core architecture role: *Examines whether the integrated object preserves the structural and functional condition needed to realize intended functions over time.*

Definitions and Governing Terms

Governing WQI and IQI terms. Infrastructure Quality Object, Infrastructure Asset, Infrastructure Configuration, Infrastructure System-of-Systems, Infrastructure Operating Condition, Degradation and Aging, Infrastructure Repair / Modification / Reconstruction, and Failure Mode apply with their authoritative WQI_VOC1 and IQI_VOC1 meanings.

Structural Integrity. Preservation of the physical condition, load-carrying or containment capability, stability, and material or structural relationships necessary for Intended Function realization.

Functional Integrity. Preservation of the capability of the declared Infrastructure Quality Object to realize its Intended Functions and Intended Results without unacceptable degradation or distortion.

Integrity-Critical Function. A function whose loss, degradation, or instability can invalidate Structural Integrity or Functional Integrity, create unacceptable consequences, or establish a Critical Infrastructure Condition.

Integrity Margin. The evidenced separation between an expected or demonstrated condition and a relevant loss-of-integrity condition. The numerical value and acceptance of a margin remain context-specific.

Damage. A change caused by an event, exposure, action, or mechanism that impairs or may impair Structural Integrity or Functional Integrity.

Abnormal Operating Condition. An Infrastructure Operating Condition outside expected normal operation but within a condition that is foreseeable or otherwise relevant to the declared object and determination.

Transient Condition. A time-dependent transition between operating states or conditions during which loads, behavior, configuration, or Function Realization may differ materially from steady operation.

Degraded Condition. A condition in which capability, integrity, performance, control, Evidence, or margin is reduced from an expected or previously established state, without necessarily constituting complete functional loss.

Context-specific boundary. *Quantitative margins, damage criteria, inspection intervals, service-life models, and mechanism-specific acceptance criteria are established by Context Guides or the Reference Layer.*

Indicator 4.1 — Definition of Integrity-Critical Functions and Failure Modes

Indicator Statement

Infrastructure Intended Functions whose loss or degradation would compromise Infrastructure Safety, Operational Reliability, Infrastructure Intended Results, or another Critical Infrastructure Condition shall be explicitly identified together with the associated integrity-critical Failure Modes.

Intent

To ensure that integrity attention is focused on functions and behaviors that matter at the infrastructure level, rather than dispersed across components without regard to consequence.

Scope and Boundaries

Includes identification of failure initiation, progression, and propagation relevant to required functions.
Excludes hazard analysis techniques or risk quantification methods.

Lifecycle Coverage

Applies from Design through Operation, Repair/Modification, life extension, and Decommissioning/Transition.

Evidence Principle

Evidence may include documented identification of Integrity-Critical Functions, Failure Modes, and their relationship to Infrastructure Intended Results and Critical Infrastructure Conditions.

Indicator 4.2 — Integrity of the Declared Infrastructure Quality Object

Indicator Statement

Structural Integrity and Functional Integrity shall be interpreted for the declared Infrastructure Quality Object as assembled and configured within its Boundary, not solely for individual Infrastructure Elements / Components or Infrastructure Subsystems.

Intent

To prevent false assurance arising from component-level adequacy where system-level behavior, interactions, or dependencies introduce unacceptable risk.

Scope and Boundaries

Includes interaction effects, load sharing, dependency chains, and combined degradation mechanisms.
Excludes component certification or product conformity.

Lifecycle Coverage

Applies at all lifecycle stages where infrastructure behavior is affected by integration or interaction.

Evidence Principle

Evidence may include system-level analyses, assessments of interaction effects, and documented conclusions regarding behavior of the declared Infrastructure Quality Object.

Indicator 4.3 — Consideration of Degradation, Damage, and Aging Mechanisms

Indicator Statement

Degradation, damage, and aging mechanisms affecting structural and functional integrity shall be explicitly identified and considered over the intended service life of the infrastructure.

Intent

To ensure that integrity is not treated as a static condition established at commissioning, but as an evolving property influenced by time, environment, and use.

Scope and Boundaries

Includes material degradation, fatigue, corrosion, wear, obsolescence, and cumulative damage mechanisms.
Excludes specification of inspection intervals or maintenance techniques.

Lifecycle Coverage

Applies from Design Assumptions through Operation, Repair/Modification, and Decommissioning/Transition decisions.

Evidence Principle

Evidence may include documented degradation assumptions, life-cycle integrity considerations, and retained records of integrity-relevant mechanisms.

Indicator 4.4 — Integrity Under Foreseeable Abnormal and Transient Conditions

Indicator Statement

Structural and functional integrity under foreseeable abnormal, transient, and degraded operating conditions shall be considered and addressed.

Intent

To prevent integrity failures that occur outside nominal operating conditions, where infrastructure is most vulnerable and consequences are often greatest.

Scope and Boundaries

Includes startup, shutdown, upset conditions, temporary overloads, degraded states, and recovery conditions.
Excludes emergency response procedures.

Lifecycle Coverage

Applies during Design, Commissioning, Operation, and Repair/Modification.

Evidence Principle

Evidence may include documented consideration of abnormal conditions, integrity margins under such conditions, and justification of acceptability.

Indicator 4.5 — Preservation of Integrity Through Change and Modification

Indicator Statement

Structural and functional integrity implications of changes and modifications shall be explicitly identified, evaluated, and documented.

Intent

To prevent incremental or localized changes from undermining infrastructure-level integrity through interaction effects or erosion of original assumptions.

Scope and Boundaries

Includes brownfield Repair/Modification, uprating, life extension, repurposing, and temporary Infrastructure Configurations.
Excludes prescription of change management processes.

Lifecycle Coverage

Applies whenever changes affect the physical configuration, operating envelope, or loading of the infrastructure.

Evidence Principle

Evidence may include documented integrity evaluations associated with changes and retained justification for integrity conclusions.

Indicator 4.6 — Integrity Margin and Tolerance to Uncertainty

Indicator Statement

Structural and functional integrity shall include tolerance to identified uncertainties and variability affecting loads, environment, materials, and operating conditions.

Intent

To ensure that integrity is robust to uncertainty rather than dependent on optimistic or deterministic assumptions.

Scope and Boundaries

Includes uncertainty arising from environmental variability, material properties, loading conditions, degradation rates, and operational behavior.
Excludes specification of safety factors or numerical margins.

Lifecycle Coverage

Applies across all lifecycle stages and shall be revisited as uncertainty evolves.

Evidence Principle

Evidence may include documented integrity assumptions, treatment of uncertainty, and justification of robustness under variable conditions.

Indicator 4.7 — Integrity-Relevant Information Retention

Indicator Statement

Information necessary to understand and evaluate structural and functional integrity over time shall be documented and retained.

Intent

To prevent loss of integrity knowledge due to personnel turnover, organizational change, or incomplete records, which can lead to unsafe decisions later in the lifecycle.

Scope and Boundaries

Includes integrity-critical assumptions, assessments, limitations, and known vulnerabilities. Excludes document management system requirements.

Lifecycle Coverage

Applies continuously across the lifecycle.

Evidence Principle

Evidence may include retained integrity assessments, design bases, modification records, and documented integrity limitations.

Factor 5 — Process Safety and Risk Mitigation

Purpose of the Factor

To ensure that Hazardous Energy, Hazardous Materials, Hazardous Processes, Loss-of-Control Scenarios, and relevant Risk are identified and interpreted so that Risk Controls and Risk Mitigation support Infrastructure Safety and prevent or limit high-consequence and Cascading Failure conditions. Applicable acceptable-Risk criteria remain context-specific Quality Outcome Criteria.

Core architecture role: *Examines prevention and control of hazardous energy, materials, processes, and high-consequence loss-of-control conditions.*

Definitions and Governing Terms

Governing WQI and IQI terms. Critical Condition, Non-Compensability, Critical Infrastructure Condition, Infrastructure Non-Substitutability, Infrastructure Operating Condition, and Infrastructure Safety apply with their authoritative WQI_VOC1 and IQI_VOC1 meanings. Abnormal Operating Condition, Transient Condition, and Degraded Condition apply as defined under Factor 4.

Hazard. A source, condition, interaction, or circumstance with the potential to prevent Function Realization or cause harm or other adverse consequences.

Hazardous Energy. Energy whose release, transfer, accumulation, or loss of control can produce harm, functional loss, or escalation.

Hazardous Material. A material whose presence, quantity, properties, release, reaction, or interaction can produce harm, functional loss, or escalation.

Hazardous Process. A process whose conditions, transformations, interactions, or loss of control can produce harm, functional loss, or escalation.

Risk. The uncertainty-informed relationship between the possibility of an adverse event or condition and its consequences for the Infrastructure Quality Object, people, the environment, or Intended Results.

Loss-of-Control Scenario. A credible sequence in which control of hazardous energy, material, process, configuration, or function is lost or materially degraded.

High-Consequence Scenario. A scenario whose credible consequences are sufficiently severe to require explicit prevention, control, or Critical-Condition treatment.

Risk Control Objective. A required prevention, limitation, isolation, detection, recovery, or consequence-control result to be achieved for an identified Risk.

Risk Control. A provision, condition, feature, or relationship intended to achieve a Risk Control Objective.

Risk Mitigation. Reduction or limitation of Risk through one or more Risk Controls. Risk Mitigation does not by itself demonstrate a positive Quality State.

Operating Mode. A distinguishable way in which the Infrastructure Quality Object is configured or operated within relevant Infrastructure Operating Conditions.

Systemic Risk. Risk arising from relationships, dependencies, common causes, interactions, or propagation across multiple elements, subsystems, interfaces, assets, or systems.

Cumulative Risk. Risk produced or increased through the combined effect of repeated, concurrent, distributed, or successive conditions and events.

Cascading Failure. A sequence in which failure, degradation, or loss of control in one part of the object contributes to further failures or adverse conditions in connected parts or systems.

Context-specific boundary. *Risk thresholds, tolerability criteria, hazard classifications, hazard-analysis methods, quantitative models, and required control performance are Context-Specific Quality Outcome Criteria supported by the applicable Reference Layer.*

Core Quality Indicators

Indicator 5.1 — Identification of Hazardous Energy, Materials, and Processes

Indicator Statement

Hazardous energy, materials, and processes associated with the infrastructure shall be explicitly identified and documented.

Intent

To ensure that process safety is grounded in explicit recognition of what can cause harm, rather than implicit assumptions based on normal operation or historical performance.

Scope and Boundaries

Includes hazardous inventories, energy sources, process conditions, and interactions capable of producing acute or systemic consequences.
Excludes prescription of hazard identification techniques or analysis methodologies.

Lifecycle Coverage

Applies from Design through Operation, Repair/Modification, and Decommissioning/Transition.

Evidence Principle

Evidence may include documented identification of hazardous energies, materials, process conditions, and their relevance to infrastructure functions.

Indicator 5.2 — Identification of High-Consequence and Loss-of-Control Scenarios

Indicator Statement

Scenarios involving loss of control, escalation, or Cascading Failure with high-consequence Infrastructure Results or Infrastructure Outcomes shall be explicitly identified and considered.

Intent

To prevent focus on frequent or minor events while neglecting rare but catastrophic scenarios that dominate infrastructure risk.

Scope and Boundaries

Includes acute accident scenarios, common-cause failures, cascading failures, and infrastructure-level escalation paths.
Excludes quantitative risk assessment or probabilistic modeling requirements.

Lifecycle Coverage

Applies during Design, Commissioning, Operation, Repair/Modification, and life-extension conditions.

Evidence Principle

Evidence may include documented scenario identification, escalation pathways, and linkage to hazardous energies and processes.

Indicator 5.3 — Definition of Risk Control Objectives

Indicator Statement

Objectives for controlling identified process safety risks shall be explicitly defined in relation to the prevention or mitigation of unacceptable consequences.

Intent

To ensure that Risk Controls are purpose-driven and tied to realization of defined Infrastructure Intended Results and prevention or limitation of identified adverse Infrastructure Results or Infrastructure Outcomes, rather than applied generically or symbolically.

Scope and Boundaries

Includes objectives related to prevention, detection, mitigation, and consequence limitation.
Excludes specification of particular safeguards, technologies, or control architectures.

Lifecycle Coverage

Applies whenever risk controls are defined, modified, or relied upon.

Evidence Principle

Evidence may include documented risk control objectives and linkage to identified hazards and scenarios.

Indicator 5.4 — Effectiveness of Risk Controls Across Operating Modes

Indicator Statement

Risk controls shall remain effective across normal, abnormal, degraded, and transitional operating conditions.

Intent

To prevent risk controls that function only under ideal or steady-state conditions, leaving the infrastructure vulnerable during upset, maintenance, startup, shutdown, or degraded operation.

Scope and Boundaries

Includes consideration of control performance under varying operational states and stress conditions.
Excludes prescription of testing or validation methods.

Lifecycle Coverage

Applies across design, operation, maintenance, modification, and abnormal conditions.

Evidence Principle

Evidence may include documented consideration of control effectiveness across operating modes and justification of adequacy.

Indicator 5.5 — Systemic and Cumulative Risk Consideration

Indicator Statement

Systemic and cumulative risks arising from interactions, degradation, organizational factors, or repeated deviations shall be explicitly considered.

Intent

To prevent gradual accumulation of risk that remains invisible when hazards are assessed only in isolation or at a single point in time.

Scope and Boundaries

Includes interaction effects, latent conditions, drift from original assumptions, and compounding vulnerabilities.
Excludes prescription of organizational safety management systems.

Lifecycle Coverage

Applies throughout the lifecycle and is particularly relevant during long-term Operation and life extension.

Evidence Principle

Evidence may include documented consideration of cumulative effects, interaction risks, and long-term risk evolution.

Indicator 5.6 — Preservation of Risk Mitigation Alignment Under Change

Indicator Statement

Risk mitigation measures shall remain aligned with the evolving operational context and infrastructure configuration.

Intent

To prevent risk controls from becoming misaligned, ineffective, or misleading as infrastructure, operating conditions, or external context change.

Scope and Boundaries

Includes changes in throughput, operating envelopes, materials, interfaces, environment, or use patterns.
Excludes prescription of management-of-change procedures.

Lifecycle Coverage

Applies whenever changes occur that affect hazard characteristics or control assumptions.

Evidence Principle

Evidence may include documented reassessment of risk mitigation alignment and retained justification for continued adequacy.

Indicator 5.7 — Risk Information Retention and Transparency

Indicator Statement

Information necessary to understand process safety risks, control objectives, limitations, and residual risk shall be documented and retained.

Intent

To prevent loss of risk knowledge that can result in unsafe decisions, false confidence, or erosion of safety margins over time.

Scope and Boundaries

Includes hazard descriptions, scenario assumptions, control objectives, known limitations, and residual risk considerations.
Excludes specification of documentation systems or formats.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include retained risk analyses, assumptions, limitation statements, and documented understanding of residual risk.

Factor 6 — Environmental Protection

Purpose of the Factor

To ensure that Environmental Protection is interpreted as an integral dimension of Infrastructure Quality, including Environmental Interactions, Exposure Pathways, emissions, discharges, Unintended Releases, Environmental Harm, and cumulative or long-term effects across the Lifecycle.

Core architecture role: *Examines whether environmental interactions and consequences remain consistent with intended function, applicable criteria, and bounded claims.*

Environmental Protection is interpreted through relevant Infrastructure Intended Results, Infrastructure Results, and Infrastructure Outcomes. The declared Infrastructure Quality Object shall prevent or limit Environmental Harm under applicable Infrastructure Operating Conditions, including foreseeable Abnormal Operating Conditions and Degraded Conditions.

Definitions and Governing Terms

Governing terms. Infrastructure Quality Object, Infrastructure Operating Condition, Evidence, Critical Condition, and the Factor 4 definitions of Abnormal Operating Condition, Transient Condition, and Degraded Condition govern their use in this Factor.

Environmental Interaction. A material, energy, physical, biological, chemical, informational, or spatial relationship through which infrastructure can affect or be affected by the environment.

Exposure Pathway. A route or mechanism through which an emission, discharge, release, disturbance, or other Environmental Interaction can reach an environmental receptor or affected area.

Environmental Harm. Adverse change to an environmental condition, function, resource, ecosystem, habitat, or protected interest within the declared Boundary and applicable Reference Layer.

Unintended Release. An unplanned or uncontrolled escape, migration, transfer, or loss of material or energy outside its intended containment or pathway.

Emission. A release or transfer of material or energy from the Infrastructure Quality Object to the surrounding environment, whether continuous, intermittent, planned, or unplanned. Regulatory classifications remain controlled by the Reference Layer.

Discharge. A directed or otherwise identifiable release of material or energy to an environmental medium or receiving system. Regulatory classifications remain controlled by the Reference Layer.

Cumulative Environmental Effect. The combined environmental effect of repeated, distributed, interacting, concurrent, or successive Environmental Interactions over time or space.

Long-Term Environmental Effect. An environmental effect whose development, persistence, recovery, or consequence extends beyond the immediate event or evaluation period.

Residual Environmental Impact. An environmental effect remaining after applicable prevention, control, limitation, response, or recovery provisions are considered.

Context-specific boundary. *Emission and discharge limits, permit conditions, receptor classifications, impact-assessment methods, remediation criteria, and environmental acceptance thresholds remain in Context Guides or the Reference Layer.*

Indicator 6.1 — Identification of Environmental Interactions and Exposure Pathways

Indicator Statement

Environmental interactions and exposure pathways arising from infrastructure behavior shall be explicitly identified and documented.

Intent

To ensure that environmental protection is grounded in explicit understanding of how infrastructure interacts with air, water, soil, ecosystems, and surrounding environments, rather than inferred solely from compliance obligations.

Scope and Boundaries

Includes emissions, discharges, releases, seepage, migration pathways, noise, thermal effects, and land or habitat interaction.
Excludes specification of emission limits or regulatory thresholds.

Lifecycle Coverage

Applies from Design through Construction, Operation, Repair/Modification, and Decommissioning/Transition.

Evidence Principle

Evidence may include documented identification of environmental interaction mechanisms and exposure pathways relevant to infrastructure behavior.

Indicator 6.2 — Prevention and Limitation of Unintended Releases and Environmental Harm

Indicator Statement

Provisions to prevent or limit unintended environmental releases and harm shall be defined and aligned with identified environmental interactions and exposure pathways.

Intent

To emphasize prevention as the primary environmental protection objective, rather than reliance on detection or remediation after harm has occurred.

Scope and Boundaries

Includes provisions addressing containment, isolation, limitation, and protection against foreseeable release mechanisms.
Excludes prescription of specific technologies or methods.

Lifecycle Coverage

Applies during Design, Operation, Repair/Modification, and Abnormal Operating Conditions.

Evidence Principle

Evidence may include documented preventive objectives, alignment between provisions and identified environmental risks, and justification of adequacy.

Indicator 6.3 — Environmental Protection Under Abnormal and Degraded Conditions

Indicator Statement

Environmental protection provisions shall remain effective under foreseeable abnormal, degraded, and transient operating conditions.

Intent

To prevent environmental harm that occurs during upsets, maintenance, startup, shutdown, or degraded states where infrastructure vulnerability is often greatest.

Scope and Boundaries

Includes abnormal operation, temporary configurations, loss-of-containment scenarios, and recovery conditions.
Excludes emergency response or cleanup procedures.

Lifecycle Coverage

Applies during Design, Commissioning, Operation, and Repair/Modification.

Evidence Principle

Evidence may include documented consideration of environmental protection performance under abnormal and degraded conditions and justification of adequacy.

Indicator 6.4 — Consideration of Cumulative and Long-Term Environmental Effects

Indicator Statement

Cumulative and long-term environmental effects arising from infrastructure operation shall be explicitly considered and documented.

Intent

To prevent gradual or distributed environmental harm that may not be evident when impacts are considered only as isolated events or short-term emissions.

Scope and Boundaries

Includes accumulation of emissions, persistent releases, habitat disturbance, long-term contamination, and interaction with existing environmental burdens.
Excludes environmental impact assessment methodologies or permitting processes.

Lifecycle Coverage

Applies throughout Operation, life extension, and Decommissioning/Transition planning.

Evidence Principle

Evidence may include documented consideration of cumulative effects, long-term interaction mechanisms, and assumptions affecting environmental outcomes.

Indicator 6.5 — Environmental Protection Alignment Under Change

Indicator Statement

Environmental protection provisions shall remain aligned with changes in infrastructure configuration, operation, external conditions, and environmental context.

Intent

To prevent erosion of environmental protection as infrastructure evolves through Repair/Modification, repurposing, or changing environmental conditions.

Scope and Boundaries

Includes changes in throughput, materials, operating envelopes, climate conditions, surrounding land use, or regulatory context.
Excludes prescription of change management processes.

Lifecycle Coverage

Applies whenever changes occur that affect environmental interactions or exposure pathways.

Evidence Principle

Evidence may include documented reassessment of environmental protection alignment and retained justification for continued adequacy.

Indicator 6.6 — Understanding and Limitation of Emissions and Discharges

Indicator Statement

Emissions and discharges arising from infrastructure behavior shall be understood and limited in relation to their environmental impact.

Intent

To ensure that emission and discharge treatment reflects understanding of environmental consequence, not merely numerical compliance.

Scope and Boundaries

Includes routine and non-routine emissions and discharges to air, water, and land.
Excludes definition of emission thresholds or compliance limits.

Lifecycle Coverage

Applies across operation, abnormal conditions, and end-of-life activities.

Evidence Principle

Evidence may include documented understanding of emission and discharge sources, limitation objectives, and the relationship between emissions/discharges and environmental effects.

Indicator 6.7 — Environmental Information Retention and Transparency

Indicator Statement

Information necessary to understand environmental risks, protection provisions, limitations, and residual impacts shall be documented and retained.

Intent

To prevent loss of environmental knowledge that can lead to unintended harm, regulatory non-conformance, or erosion of trust over time.

Scope and Boundaries

Includes environmental assumptions, known vulnerabilities, protection limitations, and residual impact considerations.
Excludes specification of reporting formats or disclosure mechanisms.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include retained environmental analyses, assumptions, limitation statements, and documented understanding of residual environmental impact.

Factor 7 — Operational Reliability

Purpose of the Factor

To ensure that the declared Infrastructure Quality Object realizes its Infrastructure Intended Functions and Infrastructure Intended Results consistently, stably, and recoverably under applicable Infrastructure Operating Conditions, including Operational Variability, Operational Disturbance, Disruption, Degradation and Aging, and change across the Lifecycle.

Core architecture role: *Examines continuity, stability, disturbance tolerance, and recovery of intended functional performance under relevant operating conditions.*

Definitions and Governing Terms

Governing IQI terms. Infrastructure Operating Condition and Degradation and Aging apply with their authoritative IQI_VOC1 meanings. Operating Envelope applies as defined under Factor 1, and the Factor 4 condition terms apply where relevant.

Operational Reliability. The evidenced capability of the declared Infrastructure Quality Object to realize required Intended Functions consistently, stably, and recoverably under relevant operating conditions over time.

Reliability-Critical Function. A function whose interruption, instability, degradation, or loss materially affects continuity, Infrastructure Intended Results, Infrastructure Safety, Environmental Protection, or another bounded Infrastructure Result or Infrastructure Outcome.

Operational Variability. Expected or foreseeable variation in demand, input, loading, environment, human interaction, or another operating condition relevant to Function Realization.

Operational Disturbance. A departure from stable or expected operation that challenges, but does not necessarily interrupt, Function Realization.

Disruption. An interruption or material loss of one or more required functions or Intended Results.

Recovery Capability. The demonstrated ability to restore required Function Realization following a disturbance, disruption, transient, or degraded condition within bounded safety and operating conditions.

Continuity, Stability, and Recoverability. Constituent attributes of Operational Reliability referring respectively to sustained Function Realization, controlled behavior without unacceptable fluctuation or loss of alignment, and the ability to restore required Function Realization after disturbance or disruption.

Context-specific boundary. Availability targets, reliability targets, redundancy levels, recovery times, service-continuity requirements, and performance thresholds are established through Context-Specific Quality Outcome Criteria and the applicable Reference Layer. The broad term resilience shall not substitute for the more precise Core term applicable to the condition being examined.

Core Quality Indicators

Indicator 7.1 — Definition of Reliability-Critical Functions

Indicator Statement

Infrastructure Intended Functions whose loss, degradation, or interruption would materially affect Infrastructure Intended Results shall be explicitly identified.

Intent

To ensure that operational reliability focuses on infrastructure functions that matter to service delivery, safety, environment, and public impact, rather than on isolated equipment performance.

Scope and Boundaries

Includes functions related to continuity of service, controllability, recoverability, and tolerance to operational disturbance.
Excludes availability targets or numerical performance levels.

Lifecycle Coverage

Applies from Design through Operation, Repair/Modification, and Decommissioning/Transition planning.

Evidence Principle

Evidence may include documented identification of Reliability-Critical Functions and their relationship to Infrastructure Intended Results, Infrastructure Results, and Critical Infrastructure Conditions.

Indicator 7.2 — Consistency of Functional Performance Under Expected Operating Conditions

Indicator Statement

Infrastructure shall demonstrate consistent performance of required functions under expected operating conditions.

Intent

To prevent chronic unreliability arising from marginal designs, degraded assumptions, or operating practices that depend on exceptional effort or favorable conditions.

Scope and Boundaries

Includes normal operating ranges, expected variability, and routine operational disturbances. Excludes Abnormal Operating Conditions, Transient Conditions, and emergency conditions, which are examined principally under Factors 4, 5, 6, and 8.

Lifecycle Coverage

Applies during operation and whenever operating conditions or assumptions change.

Evidence Principle

Evidence may include documented operating experience, performance records, and justification that observed behavior aligns with defined functional expectations.

Indicator 7.3 — Tolerance to Operational Variability and Disturbance

Indicator Statement

Infrastructure shall tolerate foreseeable operational variability and disturbance without loss of required function.

Intent

To ensure that reliability is not dependent on narrow operating envelopes or idealized conditions that are unrealistic in sustained operation.

Scope and Boundaries

Includes variability in demand, inputs, environmental conditions, and human interaction. Excludes specification of redundancy levels or design solutions.

Lifecycle Coverage

Applies from Design Assumptions through long-term Operation and life-extension decisions.

Evidence Principle

Evidence may include documented consideration of variability, resilience assumptions, and justification of tolerance to disturbance.

Indicator 7.4 — Recovery Capability Following Disruption

Indicator Statement

Infrastructure shall be capable of recovery following foreseeable operational disruption, within conditions consistent with intended function and safety.

Intent

To prevent extended loss of service or degraded operation resulting from routine disturbances, minor failures, or transient events.

Scope and Boundaries

Includes restoration of function following interruption, upset, or degraded operation.
Excludes emergency response or crisis management arrangements.

Lifecycle Coverage

Applies during Operation, Repair/Modification, and repurposing.

Evidence Principle

Evidence may include documented recovery assumptions, observed recovery behavior, and retained justification of adequacy.

Indicator 7.5 — Reliability Implications of Degradation and Aging

Indicator Statement

The effects of degradation, aging, and wear on operational reliability shall be explicitly considered and documented.

Intent

To prevent gradual erosion of reliability that remains unnoticed until service interruption becomes frequent or systemic.

Scope and Boundaries

Includes material degradation, obsolescence, and cumulative wear affecting operational performance.
Excludes inspection intervals or maintenance prescriptions.

Lifecycle Coverage

Applies across long-term Operation, life extension, and Decommissioning/Transition planning.

Evidence Principle

Evidence may include documented consideration of degradation effects on reliability and retained justification of continued functional adequacy.

Indicator 7.6 — Reliability Under Change and Modification

Indicator Statement

Operational reliability implications of changes to infrastructure configuration, operation, or context shall be explicitly identified and evaluated.

Intent

To prevent changes intended to improve performance, efficiency, or flexibility from inadvertently reducing reliability.

Scope and Boundaries

Includes brownfield Repair/Modification, uprating, repurposing, and changes in operating Context.
Excludes prescription of change processes or approval mechanisms.

Lifecycle Coverage

Applies whenever changes affect operating conditions, functional demand, or infrastructure configuration.

Evidence Principle

Evidence may include documented evaluation of reliability implications associated with changes and retained justification of acceptability.

Indicator 7.7 — Reliability-Relevant Information Retention

Indicator Statement

Information necessary to understand, assess, and evaluate operational reliability over time shall be documented and retained.

Intent

To prevent loss of operational knowledge that can lead to repeated disruptions, misinterpretation of performance, or erosion of reliability margins.

Scope and Boundaries

Includes reliability assumptions, observed performance patterns, known vulnerabilities, and limitations.
Excludes specification of data systems or reporting formats.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include retained operational records, reliability assessments, and documented understanding of performance limitations.

Factor 8 — Workplace Human Interaction and Safety

Purpose of the Factor

To ensure that Infrastructure Quality accounts for Workplace Human-Infrastructure Interaction and the ways in which Infrastructure Configuration, condition, Interfaces, operating context, Human Capabilities and Limitations, and Error-Provoking Conditions affect Infrastructure Safety and Function Realization across the Lifecycle.

Core architecture role: *Examines workplace human–infrastructure interfaces where design, condition, information, or operating context can affect safe Function Realization.*

This Factor treats humans as an integral part of the infrastructure system, focusing on how the infrastructure enables or degrades safe human interaction during work activities.

Definitions and Governing Terms

Governing WQI and IQI terms. Assumption, Infrastructure Safety, Infrastructure Operating Condition, and the Factor 4 definitions of Abnormal Operating Condition, Transient Condition, and Degraded Condition govern their use in this Factor.

Workplace Human-Infrastructure Interaction. A work-related relationship through which a person perceives, accesses, controls, monitors, maintains, tests, modifies, or is exposed to the Infrastructure Quality Object.

Workplace Human-Infrastructure Interaction Point. A location, control, display, access point, task interface, or condition where human action or understanding can affect safety or infrastructure behavior.

Human Capability. A foreseeable physical, sensory, cognitive, communicative, or temporal ability relevant to workplace interaction.

Human Limitation. A foreseeable physical, sensory, cognitive, communicative, or temporal constraint relevant to workplace interaction.

Human Performance Assumption. An Assumption concerning human perception, understanding, action, vigilance, workload, recovery, or error relevant to Function Realization.

Error-Provoking Workplace Condition. An infrastructure-related condition that increases the likelihood of Human Error, unsafe action, delayed response, or misinterpretation.

Human Error. An action, omission, timing, or interpretation differing from what is needed for the relevant function or safety condition. The term describes a condition or event and shall not be used as a blame label.

Workplace Contextual Pressure. A time, workload, environmental, production, communication, access, or other situational pressure that can affect safe interaction with infrastructure.

Workplace Safety. The workplace application of Infrastructure Safety, limited to people interacting with the Infrastructure Quality Object during work and to the infrastructure conditions affecting that interaction.

Context-specific boundary. *Training content, staffing requirements, qualification rules, ergonomic limits, personal protective provisions, and occupational-safety thresholds remain governed by the Context Guide or applicable Reference Layer. Personnel Competence is addressed under Factor 9.*

Core Quality Indicators

Indicator 8.1 — Identification of Workplace Human–Infrastructure Interaction Points

Indicator Statement

Points where human interaction with infrastructure at the workplace can influence safety or infrastructure behavior shall be explicitly identified and documented.

Intent

To ensure that safety considerations are grounded in where people actually interact with infrastructure during work, rather than treated abstractly or procedurally.

Scope and Boundaries

Includes interaction during operation, monitoring, inspection, maintenance, testing, modification, and commissioning activities performed at the workplace.
Excludes public interaction with infrastructure and off-site impacts.

Lifecycle Coverage

Applies from Design through Operation, Repair/Modification, and Decommissioning/Transition.

Evidence Principle

Evidence may include documented identification of workplace interaction points and their relevance to safety and infrastructure behavior.

Indicator 8.2 — Consideration of Human Capabilities and Limitations in Workplace Interaction

Indicator Statement

Infrastructure design and configuration shall account for foreseeable human capabilities, limitations, and variability affecting safe workplace interaction.

Intent

To prevent reliance on idealized human performance, excessive vigilance, or error-free execution as a condition for workplace safety.

Scope and Boundaries

Includes physical reach, strength, perception, cognition, workload, and fatigue as they relate to interaction with infrastructure.
Excludes training, staffing, or qualification requirements.

Lifecycle Coverage

Applies during Design, Operation, and Repair/Modification.

Evidence Principle

Evidence may include documented consideration of human performance assumptions and justification of their acceptability in workplace conditions.

Indicator 8.3 — Error-Provoking Workplace Conditions

Indicator Statement

Infrastructure-related conditions at the workplace that increase the likelihood of human error or unsafe action shall be explicitly identified and considered.

Intent

To address safety risks arising from interface complexity, poor feedback, misleading indications, time pressure, environmental stressors, or task design driven by infrastructure characteristics.

Scope and Boundaries

Includes design, layout, access, visibility, feedback, and task sequencing effects arising from infrastructure configuration.
Excludes behavioral enforcement or disciplinary measures.

Lifecycle Coverage

Applies throughout operation and during modification or change.

Evidence Principle

Evidence may include documented identification of error-provoking conditions and justification of how associated safety risks are addressed or tolerated.

Indicator 8.4 — Workplace Safety Under Abnormal and Degraded Conditions

Indicator Statement

Human interaction with infrastructure at the workplace under foreseeable abnormal, degraded, and transitional conditions shall be explicitly considered.

Intent

To prevent workplace injuries or unsafe actions that occur when infrastructure behaves differently from normal operation and human interaction becomes more error-sensitive.

Scope and Boundaries

Includes startup, shutdown, upset conditions, temporary configurations, degraded states, and recovery situations encountered by workers.
Excludes emergency response planning or procedures.

Lifecycle Coverage

Applies during Design, Commissioning, Operation, and Repair/Modification.

Evidence Principle

Evidence may include documented consideration of workplace interaction under non-normal conditions and justification of safety assumptions.

Indicator 8.5 — Alignment Between Infrastructure Design and Human Understanding

Indicator Statement

Infrastructure design shall support correct human understanding and action at the workplace under expected and stressed conditions.

Intent

To prevent infrastructure from misleading workers, obscuring hazards, or encouraging unsafe actions through ambiguous interfaces, poor feedback, or opaque system behavior.

Scope and Boundaries

Includes visibility of system state, feedback on actions, clarity of physical and functional interfaces, and avoidance of misleading cues.
Excludes specification of interface technologies, layouts, or signage.

Lifecycle Coverage

Applies during Design and Repair/Modification affecting workplace interaction.

Evidence Principle

Evidence may include documented consideration of human understanding and justification that infrastructure behavior supports safe action.

Indicator 8.6 — Workplace Contextual Pressures Affecting Safety

Indicator Statement

Workplace contextual pressures arising from infrastructure design or operating conditions that can influence safe human interaction shall be explicitly considered.

Intent

To recognize that unsafe actions often emerge from interaction between infrastructure constraints and workplace conditions, not from individual behavior alone.

Scope and Boundaries

Includes access constraints, time pressure created by infrastructure behavior, environmental exposure, and competing task demands imposed by the asset.
Excludes organizational policy, labor practices, or management directives.

Lifecycle Coverage

Applies during operation, sustained service, and change.

Evidence Principle

Evidence may include documented consideration of contextual pressures and justification of residual workplace safety risk.

Indicator 8.7 — Retention of Workplace Interaction Safety Knowledge

Indicator Statement

Information necessary to understand and evaluate workplace safety risks arising from human–infrastructure interaction shall be documented and retained.

Intent

To prevent loss of safety knowledge that can lead to repeated injuries, unsafe workarounds, or normalization of hazardous workplace conditions.

Scope and Boundaries

Includes assumptions, known vulnerabilities, interaction limitations, and observed workplace safety issues related to infrastructure behavior.
Excludes training records or personnel files.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include retained analyses, assumptions, lessons learned, and documented understanding of workplace interaction safety limitations.

Factor 9 — Competence of Personnel

Purpose of the Factor

To ensure that personnel whose decisions, actions, omissions, judgment, or authority can affect Function Realization, Infrastructure Results, Infrastructure Outcomes, Evidence, Quality Claims, or Critical Infrastructure Conditions possess and maintain Role-Appropriate Competence for the relevant Lifecycle and operating conditions.

Core architecture role: *Examines competence-dependent conditions where human decisions, actions, or omissions can materially affect the Infrastructure Quality Object.*

Competence is treated as a precondition for safe and reliable infrastructure behavior, not as an administrative or credentialing requirement.

Requirements in this Factor apply only where Function Realization, Infrastructure Results, Infrastructure Outcomes, Evidence, or Critical Infrastructure Conditions depend materially on Personnel Competence. They shall not be interpreted as prescribing personnel-management systems, training systems, or qualification frameworks.

Definitions and Governing Terms

Governing terms. Infrastructure Quality Object, Infrastructure Work, Evidence, Critical Infrastructure Condition, and the Factor 4 definitions of Abnormal Operating Condition and Degraded Condition apply with their established meanings.

Personnel Competence. Demonstrated ability to apply relevant knowledge, skill, judgment, and contextual understanding to work affecting the Infrastructure Quality Object.

Infrastructure-Critical Role. A role whose decisions, actions, omissions, judgments, or authority can materially affect Function Realization, Critical Infrastructure Conditions, Evidence, or Quality Claims.

Role-Appropriate Competence. Competence matched to the functions, decisions, conditions, authority, interfaces, and consequences associated with a specific role.

Technical Competence. Knowledge, skill, and judgment concerning the technical subjects and work relevant to a defined role.

Contextual Competence. Understanding of the actual Infrastructure Quality Object, Infrastructure Configuration, operating conditions, interfaces, lifecycle condition, responsibilities, and local context relevant to a defined role.

Authority. The legitimate scope of decision or action assigned to a person or role in relation to the Infrastructure Quality Object.

Expertise. Depth of specialized knowledge and judgment relevant to a defined subject. Expertise does not by itself establish formal Authority.

Competence Limit. A boundary beyond which a person or role lacks sufficient knowledge, skill, experience, Authority, or contextual understanding to act or conclude responsibly.

Non-Routine Condition. A work or operating condition outside routine repetition that requires additional judgment, preparation, coordination, or competence.

Context-specific boundary. *Qualifications, licenses, credentials, experience levels, scopes of practice, staffing arrangements, and training requirements are controlled by the applicable authority, Context Guide, or Reference Layer. IQC1 does not create credentials or legal permissions.*

Indicator 9.1 — Identification of Infrastructure-Critical Roles

Indicator Statement

Infrastructure-Critical Roles whose decisions, actions, or omissions can materially affect Infrastructure Safety, Structural or Functional Integrity, Operational Reliability, Environmental Protection, Evidence, or Quality Claims shall be explicitly identified.

Intent

To ensure that competence expectations are focused on roles that genuinely influence Function Realization, Infrastructure Results, Infrastructure Outcomes, Evidence, or Critical Infrastructure Conditions, rather than applied generically or administratively.

Scope and Boundaries

Includes roles involved in design, specification, assessment, operation, maintenance, modification, and decision-making affecting infrastructure behavior.
Excludes job titles, organizational charts, or employment classifications.

Lifecycle Coverage

Applies across all lifecycle stages.

Evidence Principle

Evidence may include documented identification of Infrastructure-Critical Roles and their relationship to Function Realization, Infrastructure Results, Infrastructure Outcomes, and Critical Infrastructure Conditions.

Indicator 9.2 — Role-Appropriate Technical and Contextual Competence

Indicator Statement

Infrastructure-critical roles shall be performed by personnel with competence appropriate to the technical, operational, and contextual demands of those roles.

Intent

To prevent reliance on nominal qualifications or narrow technical knowledge where broader contextual understanding and judgment are required.

Scope and Boundaries

Includes technical knowledge, practical experience, situational awareness, and understanding of infrastructure context.
Excludes specification of training programs, certifications, or qualification schemes.

Lifecycle Coverage

Applies whenever personnel perform or assume infrastructure-critical roles.

Evidence Principle

Evidence may include documented justification that role holders possess competence appropriate to their assigned responsibilities.

Indicator 9.3 — Competence for Abnormal, Degraded, and Non-Routine Conditions

Indicator Statement

Infrastructure performance shall not depend on competence limited to normal conditions and shall reflect the ability to recognize, interpret, and respond appropriately to abnormal, degraded, and non-routine conditions.

Intent

To prevent failures that arise when personnel are competent only for normal operation but unprepared for the conditions under which infrastructure risk is highest.

Scope and Boundaries

Includes response to degraded states, unexpected behavior, loss of information, or conflicting signals.
Excludes emergency response planning or drills.

Lifecycle Coverage

Applies during Operation, Repair/Modification, Commissioning, and life-extension activities.

Evidence Principle

Evidence may include documented consideration of competence expectations under non-routine conditions and justification of adequacy.

Indicator 9.4 — Recognition of Limits of Authority and Expertise

Indicator Statement

Infrastructure-related decisions shall reflect recognition of the limits of authority, knowledge, and expertise.

Intent

To prevent unsafe decisions driven by overconfidence, normalization of deviation, or unrecognized gaps in understanding.

Scope and Boundaries

Includes awareness of when escalation, consultation, or reassessment is required.
Excludes definition of reporting lines or escalation procedures.

Lifecycle Coverage

Applies whenever personnel exercise judgment affecting Function Realization, Infrastructure Results, Infrastructure Outcomes, Evidence, or Critical Infrastructure Conditions.

Evidence Principle

Evidence may include documented assumptions about decision authority limits and retained justification of how such limits are recognized.

Indicator 9.5 — Evolution of Competence with Lifecycle and Context

Indicator Statement

Infrastructure quality shall remain supported as lifecycle stages and operating contexts change, including where this depends on evolving competence.

Intent

To prevent erosion of infrastructure quality when roles change in substance but competence expectations remain static.

Scope and Boundaries

Includes changes associated with Commissioning, Degradation and Aging, new Operating Modes, repurposing, or external Context shifts.
Excludes workforce planning or retraining programs.

Lifecycle Coverage

Applies during lifecycle transitions and sustained operation.

Evidence Principle

Evidence may include documented consideration of changing competence demands and justification of continued adequacy.

Indicator 9.6 — Competence-Related Risk Awareness

Indicator Statement

Risks arising from gaps, degradation, or misalignment of Personnel Competence shall be explicitly recognized and documented where they affect Function Realization, Infrastructure Results, Infrastructure Outcomes, Evidence, or Critical Infrastructure Conditions. Such recognition shall not be interpreted as a requirement for formal competence-management or performance-management systems.

Intent

To ensure that competence is treated as a potential source of infrastructure risk, not as an assumed constant.

Scope and Boundaries

Includes known vulnerabilities related to experience loss, role complexity, or atypical operating conditions.
Excludes disciplinary or performance management actions.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include documented recognition of competence-related risks and retained justification of residual risk acceptance.

Indicator 9.7 — Retention of Competence-Relevant Knowledge

Indicator Statement

Information necessary to understand competence Assumptions, limitations, and dependencies affecting Function Realization, Infrastructure Results, Infrastructure Outcomes, Evidence, or

Quality Claims shall be documented and retained for the purpose of understanding infrastructure behavior, not for personnel evaluation or administrative tracking.

Intent

To prevent loss of critical knowledge through personnel turnover, organizational change, or informal practice.

Scope and Boundaries

Includes assumptions about expertise, judgment, and role dependencies relevant to infrastructure behavior.
Excludes personnel files or training records.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include retained assumptions, role-competence rationales, and documented understanding of competence dependencies.

Factor 10 — Regulatory and Standards Compliance

Purpose of the Factor

To ensure that Applicable Requirements from the Reference Layer are identified, interpreted, and supported by Evidence of Compliance for the declared Infrastructure Quality Object, Boundary, Lifecycle, and purpose, while preserving the distinction between Compliance, Conformity, and Infrastructure Quality.

Core architecture role: *Examines alignment with the applicable Reference Layer while preserving the rule that compliance is necessary in context but not sufficient for quality.*

Regulatory and standards compliance is a necessary but not sufficient condition for infrastructure quality.

Definitions and Governing Terms

Governing WQI and IQC1 terms. Reference Layer applies with its authoritative WQI_VOC1 meaning. Conformity and Conformity Statement apply as defined under Factor 3.

Applicable Requirement. A requirement from the Reference Layer identified as relevant and binding or otherwise controlling for the declared Infrastructure Quality Object, scope, lifecycle condition, jurisdiction or incorporation basis, and purpose.

Regulatory Obligation and Standards Obligation. Obligations whose content and status are controlled by the issuing authority, incorporation mechanism, contract, design basis, or other Reference Layer source. IQC1 describes their role but does not redefine their legal meaning.

Compliance Basis. The identified Applicable Requirements, object and Boundary, jurisdiction or incorporation basis, lifecycle period, Evidence, assumptions, limitations, and interpretations used to support a compliance conclusion.

Compliance. Used in IQC1 only in relation to identified Applicable Requirements. IQC1 does not establish a universal legal definition, and Compliance alone does not establish Infrastructure Quality.

Compliance Statement. A bounded communication of demonstrated Compliance with identified Applicable Requirements. It is distinct from an Infrastructure Quality Claim Statement.

Compliance Limitation. A scope, time, jurisdiction, Evidence, interpretation, exclusion, or Unresolved Condition restricting a compliance conclusion or Compliance Statement.

Conflicting or Overlapping Requirements. Requirements whose simultaneous application is unclear, duplicative, inconsistent, or potentially incompatible and therefore requires a declared interpretation.

Continued Validity of Compliance. The continuing applicability and evidentiary support of a compliance conclusion after changes in the object, Infrastructure Configuration, context, time, or governing Reference Layer sources.

Context-specific boundary. *Specific laws, codes, standards, jurisdictional hierarchy, legal interpretations, incorporation mechanisms, and evidentiary rules remain controlled by their authoritative Reference Layer sources. IQC1 does not make legal determinations.*

Core Quality Indicators

Indicator 10.1 — Identification of Applicable Regulatory and Standards Obligations

Indicator Statement

Applicable laws, regulations, permits, and recognized standards relevant to the infrastructure shall be explicitly identified and documented.

Intent

To prevent compliance failures arising from incomplete, assumed, or outdated understanding of applicable obligations.

Scope and Boundaries

Includes statutory requirements, regulations, permits, and formally recognized standards applicable to the infrastructure and its lifecycle stage.
Excludes informal guidance, voluntary best practices, or internal policies unless explicitly adopted as requirements.

Lifecycle Coverage

Applies from Design through Operation, Repair/Modification, and Decommissioning/Transition.

Evidence Principle

Evidence may include documented identification of applicable obligations and their relevance to infrastructure scope and lifecycle stage.

Indicator 10.2 — Integration of Regulatory and Standards Requirements into Infrastructure Decisions

Indicator Statement

Regulatory and standards requirements shall be reflected in infrastructure decisions affecting functional intent, technical specifications, realization, and operation.

Intent

To ensure that compliance obligations are not treated as external constraints applied after the fact, but as integral inputs to infrastructure decision-making.

Scope and Boundaries

Includes incorporation of compliance obligations into specifications, design assumptions, operating envelopes, and lifecycle decisions.
Excludes prescription of organizational compliance processes.

Lifecycle Coverage

Applies whenever infrastructure decisions are made that affect compliance-relevant outcomes.

Evidence Principle

Evidence may include documented linkage between regulatory or standards requirements and infrastructure decisions or specifications.

Indicator 10.3 — Demonstration of Conformity with Applicable Requirements

Indicator Statement

Conformity with applicable regulatory and standards requirements shall be demonstrable for the infrastructure and relevant lifecycle stage.

Intent

To prevent reliance on presumed compliance or historical approvals where actual conformity is uncertain or outdated.

Scope and Boundaries

Includes demonstration of conformity to requirements applicable at the time and place of operation.
Excludes substitution of Compliance Statements for broader quality evidence.

Lifecycle Coverage

Applies during Construction, Commissioning, Operation, Repair/Modification, and Decommissioning/Transition, as relevant.

Evidence Principle

Evidence may include permits, approvals, inspection outcomes, assessments, or documented determinations of conformity.

Indicator 10.4 — Treatment of Conflicting or Overlapping Requirements

Indicator Statement

Conflicting, overlapping, or ambiguous regulatory or standards requirements affecting infrastructure shall be explicitly identified and addressed.

Intent

To prevent selective compliance, silent prioritization, or inconsistent application of requirements that can undermine infrastructure quality or safety.

Scope and Boundaries

Includes conflicts between jurisdictions, standards bodies, or lifecycle requirements.
Excludes resolution mechanisms imposed by regulators or authorities.

Lifecycle Coverage

Applies whenever multiple requirements apply to the same infrastructure function or condition.

Evidence Principle

Evidence may include documented identification of conflicts, assumptions made, and justification of how requirements are addressed.

Indicator 10.5 — Continued Validity of Compliance Under Change

Indicator Statement

The continued applicability and validity of regulatory and standards compliance shall be considered when infrastructure, operating conditions, or context change.

Intent

To prevent infrastructure from drifting out of compliance as a result of Repair/Modification, repurposing, or evolving Reference Layer requirements.

Scope and Boundaries

Includes changes to configuration, throughput, use, location, or governing requirements.
Excludes prescription of regulatory monitoring or tracking systems.

Lifecycle Coverage

Applies whenever changes occur that may affect compliance obligations.

Evidence Principle

Evidence may include documented reassessment of compliance applicability and justification of continued conformity.

Indicator 10.6 — Recognition of Compliance Limitations

Indicator Statement

Limitations of regulatory or standards compliance in assuring infrastructure quality shall be explicitly recognized and documented.

Intent

To prevent false confidence that arises when Compliance is treated as equivalent to Infrastructure Safety, integrity, or acceptability of Infrastructure Results, Infrastructure Outcomes, or the Infrastructure Quality State.

Scope and Boundaries

Includes acknowledgment of areas where compliance does not address infrastructure-specific risks, uncertainties, or system-level behavior.
Excludes critique of regulatory frameworks.

Lifecycle Coverage

Applies whenever compliance is relied upon as part of quality justification.

Evidence Principle

Evidence may include documented recognition of compliance boundaries and retained justification for reliance on additional quality considerations.

Indicator 10.7 — Traceability of Compliance Statements

Indicator Statement

Claims of regulatory or standards compliance shall be traceable to the applicable requirements, scope, and lifecycle stage to which they apply.

Intent

To prevent over-generalized or misleading Compliance Statements that obscure scope limitations or lifecycle relevance.

Scope and Boundaries

Includes traceability between Compliance Statements, applicable obligations, and supporting evidence.
Excludes reporting formats or disclosure mechanisms.

Lifecycle Coverage

Applies whenever Compliance Statements are made or relied upon.

Evidence Principle

Evidence may include traceable compliance statements, referenced obligations, and documented scope and lifecycle applicability.

Factor 11 — Stakeholder and Community Satisfaction

Purpose of the Factor

To ensure that Infrastructure Quality interpretation accounts for Infrastructure Impacts on Stakeholders and Communities, including relevant effects on Infrastructure Safety, Environmental Protection, accessibility, Operational Reliability, Declared Commitments, Relevant Stakeholder Expectations, and trust across the Lifecycle.

Core architecture role: *Examines infrastructure effects, commitments, transparency, and responsiveness in relation to affected stakeholders and communities; it is not reduced to opinion polling.*

Stakeholder and Community Satisfaction reflects whether Infrastructure Results and Infrastructure Outcomes align with Declared Commitments, Relevant Stakeholder Expectations, and observed effects on people and communities affected by the declared Infrastructure Quality Object.

Definitions and Governing Terms

Governing WQI terms. Stakeholder / Interested Party and Boundary Transparency apply with their authoritative WQI_VOC1 meanings.

Community. A geographically, functionally, socially, economically, or otherwise connected group affected by or having a legitimate interest in the Infrastructure Quality Object.

Affected Stakeholder. A Stakeholder / Interested Party experiencing or credibly exposed to an Infrastructure Impact within the declared context and claim Boundary.

Affected Community. A Community experiencing or credibly exposed to an Infrastructure Impact within the declared context and claim Boundary.

Infrastructure Impact. A beneficial, adverse, direct, indirect, cumulative, or long-term effect of the Infrastructure Quality Object, its operation, change, or failure on people or Communities.

Declared Commitment. An explicit undertaking, representation, condition, or obligation relevant to stakeholder or Community effects and incorporated into the determination basis.

Relevant Stakeholder Expectation. An expectation that is declared, evidenced, legitimate within the context, and relevant to Intended Functions, Infrastructure Impacts, Declared Commitments, or Quality Outcome Criteria.

Community Concern. A communicated or evidenced issue relevant to infrastructure effects on a Community.

Responsiveness. Evidenced consideration and appropriate treatment of a Community Concern or stakeholder issue. Responsiveness does not require automatic agreement with every concern or expectation.

Stakeholder and Community Satisfaction. The degree to which applicable Declared Commitments and Relevant Stakeholder Expectations concerning Infrastructure Impacts are realized. It is not popularity, absence of complaint, or a substitute for another Core Quality Factor.

Cumulative and Long-Term Community Effect. An effect produced through repeated, interacting, distributed, persistent, or delayed Infrastructure Impacts on a Community.

Context-specific boundary. *Consultation duties, benefit agreements, notification rules, social-impact methods, public-participation requirements, and acceptance criteria remain controlled by the Context Guide or applicable Reference Layer.*

Indicator 11.1 — Identification of Affected Stakeholders and Communities

Indicator Statement

Stakeholders and communities affected by infrastructure behavior shall be explicitly identified and documented.

Intent

To prevent unrecognized or excluded stakeholder impacts that can lead to community harm, loss of trust, or latent infrastructure quality failure.

Scope and Boundaries

Includes individuals, groups, and communities affected by safety, environmental, accessibility, service reliability, or nuisance impacts of the infrastructure.
Excludes stakeholder engagement methods or consultation processes.

Lifecycle Coverage

Applies from Design through Operation, Repair/Modification, and Decommissioning/Transition.

Evidence Principle

Evidence may include documented identification of affected Stakeholders and Communities and their relationship to Infrastructure Impacts, Infrastructure Results, and Infrastructure Outcomes.

Indicator 11.2 — Identification of Infrastructure Impacts Relevant to Stakeholders and Communities

Indicator Statement

Infrastructure impacts relevant to stakeholder and community experience shall be explicitly identified and documented.

Intent

To ensure that stakeholder and community considerations are grounded in actual infrastructure behavior and outcomes, not inferred from technical performance alone.

Scope and Boundaries

Includes impacts related to safety, environmental effects, accessibility, service continuity, nuisance, disruption, and cumulative effects.
Excludes public perception management or messaging strategies.

Lifecycle Coverage

Applies throughout the infrastructure lifecycle.

Evidence Principle

Evidence may include documented identification of impact mechanisms linking infrastructure behavior to stakeholder and community experience.

Indicator 11.3 — Alignment with Declared Commitments and Expectations

Indicator Statement

Infrastructure Results and Infrastructure Outcomes affecting Stakeholders and Communities shall be interpreted against Declared Commitments, applicable obligations, Relevant Stakeholder Expectations, and associated Quality Outcome Criteria.

Intent

To prevent divergence between what infrastructure owners or operators claim or promise and what communities actually experience.

Scope and Boundaries

Includes commitments arising from permits, agreements, public statements, or formal obligations.
Excludes creation of new commitments or stakeholder agreements.

Lifecycle Coverage

Applies whenever commitments or expectations are relied upon to justify infrastructure acceptability.

Evidence Principle

Evidence may include documented Declared Commitments and demonstrated alignment between those commitments and observed Infrastructure Results and Infrastructure Outcomes.

Indicator 11.4 — Consideration of Cumulative and Long-Term Community Effects

Indicator Statement

Cumulative and long-term effects of infrastructure behavior on stakeholders and communities shall be explicitly considered and documented.

Intent

To prevent gradual erosion of community well-being or trust due to repeated disruption, persistent nuisance, or long-term environmental and social impacts.

Scope and Boundaries

Includes cumulative exposure, repeated disturbances, long-term accessibility effects, and interaction with existing community burdens.
Excludes social impact assessment methodologies.

Lifecycle Coverage

Applies throughout Operation, life extension, and Decommissioning/Transition planning.

Evidence Principle

Evidence may include documented consideration of cumulative effects and assumptions affecting long-term community outcomes.

Indicator 11.5 — Responsiveness to Infrastructure-Related Community Concerns

Indicator Statement

Infrastructure-related concerns raised by stakeholders or communities shall be recognized and addressed where they indicate potential infrastructure quality issues.

Intent

To ensure that stakeholder and community input is treated as a potential signal of infrastructure behavior or impact, not dismissed as external noise.

Scope and Boundaries

Includes concerns related to safety, reliability, environmental effects, access, or disruption arising from infrastructure behavior.
Excludes complaint-handling processes or engagement mechanisms.

Lifecycle Coverage

Applies whenever infrastructure behavior gives rise to stakeholder or community concern.

Evidence Principle

Evidence may include documented recognition of concerns and justification of how they are considered in relation to infrastructure quality.

Indicator 11.6 — Transparency of Infrastructure Impacts and Limitations

Indicator Statement

Limitations, residual impacts, and known effects of infrastructure on stakeholders and communities shall be documented and made transparent at an appropriate level.

Intent

To prevent loss of trust resulting from undisclosed impacts, unacknowledged limitations, or misleading assurances regarding infrastructure behavior.

Scope and Boundaries

Includes acknowledgment of residual risk, nuisance, or impact that cannot be fully eliminated. Excludes public communication strategies or disclosure formats.

Lifecycle Coverage

Applies whenever infrastructure impacts materially affect stakeholders or communities.

Evidence Principle

Evidence may include documented acknowledgment of limitations and retained justification of acceptability.

Indicator 11.7 — Retention of Stakeholder and Community Impact Knowledge

Indicator Statement

Information necessary to understand stakeholder and community impacts arising from infrastructure behavior shall be documented and retained.

Intent

To prevent loss of knowledge that can result in repeated harm, unresolved conflict, or erosion of trust over time.

Scope and Boundaries

Includes impact assumptions, known sensitivities, historical issues, and observed outcomes. Excludes records of engagement activities or public relations materials.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include retained impact analyses, assumptions, and documented understanding of stakeholder and community effects.

Factor 12 — Monitoring and Performance Evaluation

Purpose of the Factor

To ensure that behavior, Infrastructure Results, and Infrastructure Outcomes of the declared Infrastructure Quality Object are monitored, evaluated, and interpreted so that Degradation and Aging, deviation, Uncertainty, and Emerging Risk are detected in time to prevent or limit unacceptable consequences.

Core architecture role: *Examines whether infrastructure behavior remains sufficiently observable and interpretable to detect deviation, degradation, emerging risk, and loss of function.*

Monitoring and performance evaluation focus on infrastructure-level signals, trends, and meaning, rather than isolated data points or historical absence of failure.

Requirements in this Factor apply to the condition under which infrastructure behavior and performance are observed, interpreted, and understood. They shall not be interpreted as prescribing monitoring systems, performance management processes, data platforms, or organizational reporting structures.

Definitions and Governing Terms

Governing WQI and IQI terms. Data, Evidence, Evidence Sufficiency, Intended Result, Infrastructure Outcome, Infrastructure Operating Condition, and Degradation and Aging apply with their authoritative meanings. Systemic Risk applies as defined under Factor 5.

Monitoring. Planned or continuing observation, measurement, detection, collection, or review of information about the Infrastructure Quality Object, its context, interfaces, or behavior over time.

Performance Evaluation. Reasoned interpretation of monitored or otherwise available information in relation to Intended Functions, Intended Results, operating conditions, applicable criteria, and Boundaries.

Monitoring-Relevant Infrastructure Behavior. A behavior, condition, change, or interaction whose observation can reveal Function Realization, degradation, deviation, uncertainty, or Emerging Risk.

Monitoring Adequacy. The sufficiency of monitoring scope, sensitivity, coverage, timeliness, continuity, and interpretability for the intended determination or claim.

Deviation. A departure from an expected, specified, previously established, or otherwise relevant condition or behavior. Its quality significance depends on applicable criteria and context.

Emerging Risk. A developing or newly visible Risk whose mechanism, magnitude, likelihood, consequence, or relevance is changing or not yet fully resolved.

Performance Baseline. A bounded reference condition or pattern against which observed Infrastructure Behavior is interpreted.

Expected Behavior. The behavior of the Infrastructure Quality Object anticipated under specified conditions and supported by applicable requirements, criteria, models, experience, or Evidence.

Infrastructure Behavior. The observable response, condition, interaction, or performance of the Infrastructure Quality Object under specified conditions.

Context-specific boundary. *Monitoring frequencies, alarm settings, thresholds, technologies, sensor coverage, baselines, and tolerances are established by Context-Specific Quality Outcome Criteria and the applicable Reference Layer. Monitoring Data are not automatically sufficient Evidence.*

Core Quality Indicators

Indicator 12.1 — Identification of Monitoring-Relevant Infrastructure Behaviors

Indicator Statement

Infrastructure behaviors relevant to detecting degradation, deviation, or loss of function shall be explicitly identified.

Intent

To prevent monitoring from being driven by convenience, tradition, or available data rather than by what actually signals infrastructure quality or emerging risk.

Scope and Boundaries

Includes behaviors, conditions, and outcomes that indicate degradation, loss of margin, deviation from assumptions, or abnormal interaction.
Excludes specification of metrics, sensors, or data technologies.

Lifecycle Coverage

Applies from Commissioning through Operation, Repair/Modification, and Decommissioning/Transition.

Evidence Principle

Evidence may include documented identification of behaviors and outcomes selected for monitoring and their relevance to infrastructure quality.

Indicator 12.2 — Adequacy of Monitoring to Detect Degradation and Deviation

Indicator Statement

Monitoring shall be sufficient to detect degradation, deviation, or loss of function before unacceptable consequences occur.

Intent

To ensure that monitoring is sufficient to provide early warning, rather than merely confirming failure after harm has occurred.

Scope and Boundaries

Includes detection of gradual degradation, step changes, and loss of safety margin.
Excludes prediction guarantees or real-time control requirements.

Lifecycle Coverage

Applies throughout operation and during periods of change or increased uncertainty.

Evidence Principle

Evidence may include documented justification that monitoring is capable of revealing relevant degradation or deviation in time.

Indicator 12.3 — Interpretation of Monitoring Information in Context

Indicator Statement

Monitoring information shall be interpreted in context such that observed infrastructure behavior is correctly understood and not misrepresented.

Intent

To prevent misinterpretation of data, normalization of abnormal conditions, or false confidence arising from isolated indicators.

Scope and Boundaries

Includes consideration of trends, interactions, operating context, and known uncertainties. Excludes analytical methods, thresholds, or dashboards.

Lifecycle Coverage

Applies whenever monitoring information is interpreted or relied upon for decisions.

Evidence Principle

Evidence may include documented interpretation assumptions, contextual evaluations, and justification of conclusions drawn from monitoring data.

Indicator 12.4 — Detection of Emerging and Systemic Risk

Indicator Statement

Emerging or systemic risk shall be identifiable from observed patterns of infrastructure behavior over time.

Intent

To prevent latent risk accumulation that remains invisible until a major failure or unacceptable outcome occurs.

Scope and Boundaries

Includes recognition of patterns, weak signals, and interactions across systems or time. Excludes formal risk analysis techniques or predictive modeling requirements.

Lifecycle Coverage

Applies continuously across Operation and life extension.

Evidence Principle

Evidence may include documented recognition of emerging risks and justification of how monitoring supports early awareness.

Indicator 12.5 — Monitoring Relevance Under Change

Indicator Statement

Monitoring shall remain relevant to infrastructure behavior as conditions, configuration, or operating context change.

Intent

To prevent reliance on monitoring that no longer reflects current infrastructure behavior or risk profile.

Scope and Boundaries

Includes changes in operating envelope, throughput, environment, interfaces, or use patterns.
Excludes prescription of monitoring management or update processes.

Lifecycle Coverage

Applies whenever changes occur that affect monitored behaviors or assumptions.

Evidence Principle

Evidence may include documented reassessment of monitoring relevance and justification of continued adequacy.

Indicator 12.6 — Interpretation of Infrastructure Behavior in Relation to Intended Results

Indicator Statement

Observed infrastructure behavior shall be interpreted in relation to Infrastructure Intended Functions and Infrastructure Intended Results so that deviation, Degradation and Aging, instability, or loss of Function Realization can be understood.

Intent

To ensure that monitoring supports meaningful understanding of how infrastructure behavior relates to its intended function, including identification of deviation, degradation, or loss of function, rather than merely confirming that it is operating.

Scope and Boundaries

Includes interpretation of observed infrastructure behavior in relation to Functional Intent, Infrastructure Intended Results, and applicable Quality Outcome Criteria.
Excludes Conformity Assessment and establishment of context-specific performance targets or numerical benchmarks.

Lifecycle Coverage

Applies throughout Operation and during life-extension or repurposing decisions.

Evidence Principle

Evidence may include documented observation and interpretation of infrastructure behavior in relation to Infrastructure Intended Functions and Infrastructure Intended Results, including identification of deviation, Degradation and Aging, instability, or loss of Function Realization.

Indicator 12.7 — Retention of Monitoring and Performance Knowledge

Indicator Statement

Information necessary to understand monitoring assumptions, performance trends, limitations, and interpretations shall be documented and retained for the purpose of understanding infrastructure behavior over time, not for performance tracking systems or organizational reporting.

Intent

To prevent loss of institutional understanding that can lead to repeated misinterpretation, missed signals, or erosion of infrastructure quality.

Scope and Boundaries

Includes assumptions, known blind spots, interpretation limitations, and historical performance context.
Excludes data storage systems or retention schedules.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include retained analyses, interpretation rationales, and documented understanding of monitoring limitations.

Nothing in this Factor establishes or implies a monitoring system, performance management framework, or reporting requirement. Monitoring serves only to support understanding of infrastructure condition and behavior.

Factor 13 — Documentation and Traceability

Purpose of the Factor

To ensure that decisions, Assumptions, requirements, findings, determinations, claims, and changes affecting Infrastructure Quality are documented and traceable across the Lifecycle, enabling understanding of Infrastructure Configuration, Decision Rationale, Evidence, Uncertainty, and the basis of the current Infrastructure Quality State.

Core architecture role: *Examines whether quality-relevant knowledge and Evidence remain available, connected, traceable, and usable across lifecycle and responsibility changes.*

Documentation and traceability preserve infrastructure knowledge beyond individuals, projects, and organizational change, and are essential to accountability and informed decision-making.

Requirements in this Factor apply to the availability and continuity of information necessary to understand infrastructure condition and behavior. They shall not be interpreted as prescribing document control systems, record management processes, or administrative documentation practices.

Definitions and Governing Terms

Governing WQI and IQI terms. Data, Evidence, Evidence Sufficiency, Unresolved Condition, and Infrastructure Evidence Continuity apply with their authoritative WQI_VOC1 and IQI_VOC1 meanings.

Documentation. Recorded information used to describe, preserve, communicate, or support understanding of the Infrastructure Quality Object, decisions, assumptions, Evidence, or claims. Documentation is not automatically Evidence.

Traceability. The ability to follow a supported relationship from a statement, requirement, decision, finding, or claim to its source, object, context, Evidence, time, and subsequent use.

Decision Rationale. The recorded reasoning, assumptions, Evidence, alternatives, limitations, and Reference Layer basis supporting an infrastructure decision.

Quality-Critical Information. Information whose loss, inaccessibility, corruption, ambiguity, or misinterpretation can materially affect Function Realization, Critical Infrastructure Conditions, Infrastructure Quality State determination, or claim validity.

Information Accessibility. The ability of authorized and relevant users to retrieve information when needed for the intended infrastructure decision or determination.

Information Usability and Interpretability. The degree to which retained information remains understandable, attributable, contextually connected, and fit for its intended use.

Information Retention. Preservation of relevant information for the period and conditions needed to support lifecycle understanding, decisions, determinations, and claims.

Documentation Substitution for Quality. The prohibited inference that the existence, completeness, or volume of Documentation by itself demonstrates Function Realization, Evidence Sufficiency, or a positive Infrastructure Quality State.

Context-specific boundary. *Document-control systems, record-management systems, retention periods, data platforms, access permissions, formats, and technology-specific controls remain governed by the Context Guide or Reference Layer.*

Indicator 13.1 — Documentation of Infrastructure-Relevant Decisions and Assumptions

Indicator Statement

Information necessary to understand infrastructure-relevant decisions and underlying assumptions shall be available and retained.

Intent

To prevent loss of rationale, intent, and judgment that can lead to unsafe modification, misinterpretation of design intent, or erosion of safety margins over time.

Scope and Boundaries

Includes decisions related to functional intent, technical specifications, integrity, safety, environmental protection, reliability, and stakeholder impact.
Excludes documentation of routine administrative or operational actions with no quality significance.

Lifecycle Coverage

Applies from Design through Operation, Repair/Modification, and Decommissioning/Transition.

Evidence Principle

Evidence may include documented decision rationales, recorded assumptions, and retained justification for infrastructure-relevant choices.

Indicator 13.2 — Traceability Between Functional Intent, Technical Requirements, and Realized Infrastructure

Indicator Statement

Traceability shall be maintained between functional specifications, technical specifications, and the realized infrastructure to support understanding of how infrastructure has been defined and realized, not as a requirement for formal traceability systems or documentation structures.

Intent

To ensure that infrastructure configuration can be understood and assessed in relation to its original and evolving intent, and that divergence does not occur silently.

Scope and Boundaries

Includes bidirectional traceability across lifecycle stages and documentation sets.
Excludes prescription of traceability tools or formats.

Lifecycle Coverage

Applies continuously and shall be preserved during change, Repair/Modification, and life extension.

Evidence Principle

Evidence may include traceability records linking functional intent, technical requirements, and realized infrastructure elements.

Indicator 13.3 — Documentation of Uncertainty, Limitations, and Known Vulnerabilities

Indicator Statement

Identified uncertainties, limitations, and known vulnerabilities affecting infrastructure quality shall be explicitly documented and retained to ensure limitations of infrastructure understanding are visible and not obscured.

Intent

To prevent deterministic interpretation of infrastructure capability where uncertainty or limitation is inherent.

Scope and Boundaries

Includes geological, environmental, technical, operational, human, and organizational uncertainties and limitations.
Excludes speculative or undocumented concerns without relevance to infrastructure behavior.

Lifecycle Coverage

Applies at all lifecycle stages and shall be updated as knowledge evolves.

Evidence Principle

Evidence may include uncertainty descriptions, limitation statements, and documented linkage to assumptions or decisions.

Indicator 13.4 — Traceability of Assessments, Evaluations, and Conformity Statements

Indicator Statement

Assessments, evaluations, and Conformity Statements shall be traceable to their scope, basis, assumptions, and lifecycle stage to support transparency of how infrastructure condition has been understood and assessed, not to establish audit trails or certification records.

Intent

To prevent over-generalized or misleading claims that obscure limitations or applicability.

Scope and Boundaries

Includes traceability for conformity assessment, integrity evaluation, safety assessment, and performance evaluation.
Excludes reporting formats or publication mechanisms.

Lifecycle Coverage

Applies whenever assessments or claims are relied upon for decisions or quality justification.

Evidence Principle

Evidence may include traceable assessment records, scope definitions, and documented assumptions underlying claims.

Indicator 13.5 — Documentation of Changes and Their Rationale

Indicator Statement

Changes affecting infrastructure quality shall be documented together with their rationale and implications for the purpose of understanding infrastructure evolution, not to prescribe change management processes or documentation systems.

Intent

To ensure that evolution of the infrastructure is understandable and auditable, and that cumulative change does not erode original intent unnoticed.

Scope and Boundaries

Includes changes to configuration, operating envelope, assumptions, interfaces, and lifecycle expectations.
Excludes procedural change-management systems.

Lifecycle Coverage

Applies whenever the Infrastructure Quality Object undergoes Repair/Modification, repurposing, or life extension.

Evidence Principle

Evidence may include documented change descriptions, rationale, and linkage to affected requirements or assumptions.

Indicator 13.6 — Accessibility and Continuity of Quality-Critical Information

Indicator Statement

Information necessary to understand infrastructure condition shall remain accessible and usable when needed to support decisions affecting infrastructure behavior.

Intent

To prevent loss of critical knowledge due to personnel turnover, organizational restructuring, or system changes.

Scope and Boundaries

Includes accessibility of information relevant to safety, integrity, environment, reliability, and stakeholder impact.
Excludes document management systems or IT platforms.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include demonstration that quality-critical information can be retrieved and understood when needed.

Indicator 13.7 — Prevention of Documentation Substitution for Quality

Indicator Statement

Documentation shall not substitute for evidence of actual infrastructure behavior or performance, and its existence shall not be taken as demonstration of infrastructure quality.

Intent

To prevent false confidence arising from complete Documentation that masks unsatisfactory Infrastructure Results, Infrastructure Outcomes, or unmanaged Risk.

Scope and Boundaries

Includes recognition of the limits of documentation in demonstrating quality.
Excludes critique of documentation practices.

Lifecycle Coverage

Applies whenever documentation is relied upon to justify infrastructure quality.

Evidence Principle

Evidence may include documented acknowledgment of documentation limitations and justification of reliance on additional evidence.

Nothing in this Factor establishes or implies a document control system, record management framework, or administrative documentation requirement. Documentation serves only to support understanding of infrastructure condition, behavior, and decisions over time.

Factor 14 — Adaptability and Innovation Readiness

Purpose of the Factor

To ensure that the declared Infrastructure Quality Object can undergo responsible Adaptation and Innovation without compromising Infrastructure Safety, Structural or Functional Integrity, Operational Reliability, Environmental Protection, Infrastructure Intended Results, Evidence, Critical Infrastructure Conditions, or claim validity.

Core architecture role: *Examines whether change and innovation can occur without loss of functional alignment, safety, integrity, evidence sufficiency, or claim validity.*

Adaptability and innovation readiness reflect the infrastructure’s capacity to evolve intentionally and safely, rather than through ad hoc or reactive modification.

Technology, digital systems, automation, Monitoring, modeling, and other Innovation shall be interpreted as means of supporting the Infrastructure Quality State, not as substitutes for Infrastructure Quality State determination, Evidence Sufficiency, lifecycle validation, or bounded Infrastructure Quality Claim Statements.

Definitions and Governing Terms

Governing WQI and IQI terms. Technology, Technology Governance, Infrastructure Technology Governance, Intended Function, Intended Result, Boundary, Interface, Infrastructure Configuration, and Infrastructure Quality Object apply with their authoritative WQI_VOC1 and IQI_VOC1 meanings.

Adaptation. A deliberate change to configuration, operation, technology, interfaces, capability, or use intended to respond to changed conditions or needs.

Adaptability. The evidenced capacity of the Infrastructure Quality Object to undergo suitable Adaptation while preserving required Function Realization, Critical Infrastructure Conditions, Evidence, and claim validity.

Innovation. Introduction or application of a materially new or differently used technology, method, configuration, material, information system, or operating arrangement.

Innovation Readiness. The demonstrated preparedness of the Infrastructure Quality Object, Interfaces, Evidence basis, responsibilities, and controls to evaluate and incorporate Innovation without loss of required Function Realization or Infrastructure Quality State validity.

Adaptability Constraint. A condition limiting responsible Adaptation. The specific physical, technical, commercial, organizational, or regulatory constraint remains context-specific.

Adaptability Opportunity. A condition enabling responsible Adaptation or improved capability while preserving the applicable quality basis.

Reversibility. The practical capability to return from an Adaptation to a previously acceptable Infrastructure Configuration or condition without unacceptable consequence.

Recoverability of Adaptation. The capability to restore acceptable Function Realization after an Adaptation produces unintended or unsatisfactory effects, even when exact reversal is not possible.

Learning from Adaptation and Innovation. Evidence-supported interpretation of observed Infrastructure Results and Infrastructure Outcomes used to inform later infrastructure decisions. The concept does not prescribe a management-system continuous-improvement process.

Context-specific boundary. *Technology-readiness levels, pilot requirements, modularity criteria, spare-capacity requirements, roadmaps, commercialization criteria, and technology-specific acceptance thresholds remain in Context Guides or the Reference Layer.*

Core Quality Indicators

Indicator 14.1 — Identification of Adaptability-Relevant Constraints and Opportunities

Indicator Statement

Constraints and opportunities affecting the infrastructure’s ability to adapt or incorporate innovation shall be explicitly identified and documented.

Intent

To prevent unintended rigidity or unsafe improvisation arising from unrecognized design, physical, or operational constraints.

Scope and Boundaries

Includes physical configuration, interfaces, spare capacity, modularity, and dependency structures relevant to adaptation.
Excludes technology roadmaps or modernization plans.

Lifecycle Coverage

Applies from Design through Operation, Repair/Modification, and life extension.

Evidence Principle

Evidence may include documented identification of constraints and opportunities affecting adaptability.

Indicator 14.2 — Preservation of Safety and Integrity During Adaptation

Indicator Statement

Adaptation and innovation shall not compromise structural integrity, process safety, workplace safety, or environmental protection.

Intent

To ensure that change is bounded by infrastructure quality obligations and does not erode critical safeguards or margins.

Scope and Boundaries

Includes consideration of how adaptation affects existing safety, integrity, and protection provisions.
Excludes innovation approval processes or technology selection criteria.

Lifecycle Coverage

Applies whenever changes or innovations are introduced.

Evidence Principle

Evidence may include documented evaluation of adaptation impacts on safety, integrity, and protection outcomes.

Indicator 14.3 — Compatibility with Functional Intent, Boundaries, and Interfaces

Indicator Statement

Adaptation and innovation shall remain compatible with the infrastructure’s functional intent and defined Boundaries.

Intent

To prevent innovation from introducing misalignment between what the infrastructure is intended to do and how it is modified to do it.

Scope and Boundaries

Includes compatibility with functional specifications, interface definitions, and system-of-systems boundaries.
Excludes development of new functional requirements.

Lifecycle Coverage

Applies during Repair/Modification and other lifecycle transitions, including life extension or repurposing where relevant.

Evidence Principle

Evidence may include documented assessment of compatibility between proposed adaptation and functional intent.

Indicator 14.4 — Treatment of Uncertainty Introduced by Innovation

Indicator Statement

Uncertainty introduced by adaptation or innovation shall be explicitly identified and considered.

Intent

To prevent false confidence in novel solutions where behavior, interactions, or failure modes are not yet well understood.

Scope and Boundaries

Includes uncertainty related to new technologies, materials, operating modes, or interfaces.
Excludes experimental validation or pilot program design.

Lifecycle Coverage

Applies whenever innovation introduces new or modified infrastructure behavior.

Evidence Principle

Evidence may include documented identification of uncertainties and justification of acceptability.

Indicator 14.5 — Reversibility and Recoverability of Adaptation

Indicator Statement

Where practicable, adaptation and innovation shall allow for reversibility or recovery if unintended consequences arise.

Intent

To limit long-term lock-in to unsafe or underperforming configurations and preserve the ability to respond to unforeseen effects.

Scope and Boundaries

Includes design and configuration choices that affect reversibility or recovery.
Excludes contractual or commercial considerations.

Lifecycle Coverage

Applies during Repair/Modification and Innovation deployment.

Evidence Principle

Evidence may include documented consideration of reversibility or recovery options.

Indicator 14.6 — Learning from Adaptation and Innovation Results and Outcomes

Indicator Statement

Infrastructure Results and Infrastructure Outcomes associated with Adaptation and Innovation shall be evaluated to inform future infrastructure decisions.

Intent

To ensure that innovation contributes to organizational and infrastructure learning rather than repeating avoidable mistakes.

Scope and Boundaries

Includes evaluation of observed behavior, performance, and unintended effects following adaptation.
Excludes continuous improvement programs or feedback systems.

Lifecycle Coverage

Applies after implementation of adaptation or innovation.

Evidence Principle

Evidence may include documented evaluation of Infrastructure Results and Infrastructure Outcomes and retained lessons relevant to future Adaptation.

Indicator 14.7 — Retention of Adaptation and Innovation Knowledge

Indicator Statement

Information necessary to understand Adaptation and Innovation decisions, Assumptions, Infrastructure Results, Infrastructure Outcomes, Uncertainty, and limitations shall be documented and retained.

Intent

To prevent loss of knowledge that can lead to unsafe replication, inappropriate scaling, or erosion of quality over time.

Scope and Boundaries

Includes assumptions, constraints, uncertainties, and observed effects related to adaptation and innovation.
Excludes innovation management documentation.

Lifecycle Coverage

Applies continuously across the infrastructure lifecycle.

Evidence Principle

Evidence may include retained analyses, assumptions, and documented understanding of adaptation-related risks and outcomes.

4 Infrastructure Quality Object, Boundaries, and Context Guide Determination

4.1 Object Declaration and Structural Checkpoints

Before the Core Quality Factors and Core Quality Indicators are interpreted, the Infrastructure Quality Object shall be declared and described in accordance with IQI_VOC1.

A Structural Checkpoint shall confirm, at minimum, that the following are sufficiently identifiable for the intended determination:

- the object name, class, Scale, composition, and relevant Infrastructure Configuration;
- the Infrastructure Intended Functions and Infrastructure Intended Results;
- the Infrastructure Operating Medium, Infrastructure Operating Conditions, and applicable Infrastructure Lifecycle Stage or transition;
- the relevant physical, functional, informational, organizational, and responsibility Boundaries and the proposed Infrastructure Quality Claim Boundary;
- the Interfaces through which materials, energy, information, authority, responsibility, Risk, or consequences are transferred; and
- the Evidence sources, Assumptions, Uncertainty, Unresolved Conditions, and proposed Infrastructure Quality Claim scope.

A Structural Checkpoint does not determine Infrastructure Quality or establish an Infrastructure Quality State. If the Infrastructure Quality Object Description is incomplete or ambiguous, detailed Core interpretation shall not proceed without refinement, restriction, or explicit qualification.

4.2 Purpose of Context Guides

The Core Quality Factors and Core Quality Indicators defined in this Standard are invariant across IQI energy-infrastructure contexts. A Core Quality Indicator identifies what is examined; it does not by itself establish the expected or acceptable state. That state is defined through applicable Quality Outcome Criteria.

Energy Infrastructure Quality Objects differ materially in physical regime, dominant Risk mechanisms, Infrastructure Configuration, Interfaces, Infrastructure Lifecycle Stages, Infrastructure Operating Conditions, and Reference Layer anchors. Applying the Core Quality Indicators without sufficient Context-Specific Interpretation may therefore risk misleading Evidence-Supported Findings, Quality Factor Interpretations, or Infrastructure Quality Claim Statements.

Context Guides provide that bounded context-specific interpretation without changing the invariant Core architecture.

Context Guides:

- do not introduce alternative Core Quality Factors or Core Quality Indicators;
- do not modify the meaning or intent of the Core Quality Indicators;
- identify Context-Specific Quality Outcome Criteria, clarify Boundaries and Interfaces, and describe relevant Evidence sources, Failure Modes, and Critical Infrastructure Conditions where the Core alone is insufficient for responsible interpretation.

A separate Context Guide is used only when justified by the interpretive-sufficiency logic defined in this section.

4.3 Infrastructure Boundary Definition

Application of the Core Standard requires an explicit declaration of the Boundary of the Infrastructure Quality Object under determination.

The terms Infrastructure Quality Object, Infrastructure Asset, Infrastructure System-of-Systems, Boundary, Interface, and Scale apply with their authoritative WQI_VOC1 and IQI_VOC1 meanings.

- The declared Infrastructure Quality Object may be an Infrastructure Asset, facility, network, subsystem, zone, lifecycle program, interface condition, asset population, or Infrastructure System-of-Systems. IQC1 does not restrict an Infrastructure Asset to a single legal, procurement, or capital-construction classification.
- Infrastructure Quality shall be interpreted at the declared Scale and Boundary where Function Realization, Interfaces, dependencies, and emergent behavior are relevant, not solely at the level of individual Infrastructure Elements / Components or products.

Boundary definition shall consider, as applicable:

- the physical extent of the declared Infrastructure Quality Object;
- the functional extent and relevant Interfaces;
- interaction with upstream, downstream, supporting, and external systems;
- the applicable Infrastructure Lifecycle Stage or transition within the principal IQI sequence.

Where the declared object forms part of an Infrastructure System-of-Systems, the Boundary and Infrastructure Quality Claim Boundary shall explicitly identify the Interfaces, dependencies, and responsibilities included and excluded.

A sufficiently transparent Boundary is a prerequisite for determining whether the Core Quality Indicators can be interpreted responsibly without a separate Context Guide.

4.4 When a Context Guide Is Required

A Context Guide shall be developed or applied when one or more of the following conditions materially affect interpretation of Core Quality Indicators, Quality Outcome Criteria, Evidence, Critical Infrastructure Conditions, or the Infrastructure Quality Claim Boundary:

a) Physical Regime Change

A change in physical regime that fundamentally alters infrastructure behavior (e.g., pressure, temperature, phase, geotechnical, marine, cryogenic, or radiological conditions).

b) Dominant Risk Mechanism Change

A shift in the dominant mechanisms by which harm, failure, or unacceptable consequence may occur (e.g., from mechanical failure to corrosion, from localized failure to cascading system effects).

c) System Topology Change

A material change in system configuration or topology that alters failure propagation, redundancy, or dependency structure.

d) Critical Interface Change

Introduction or modification of interfaces where failure or misalignment can dominate system behavior or risk (e.g., human–infrastructure interfaces, cross-system transfer points, jurisdictional handoffs).

e) Regulatory Anchor Change

A regulatory or jurisdictional context that materially reshapes Reference Layer obligations, Assumptions, or interpretation of Infrastructure Results, Infrastructure Outcomes, or the Infrastructure Quality State.

Interpretive Sufficiency Test

A Context Guide is required when application of the Core Quality Indicators without context-specific interpretation would reasonably risk misrepresenting Function Realization, Infrastructure Safety, Structural or Functional Integrity, Environmental Protection, Operational Reliability, Stakeholder or Community effects, or the resulting Infrastructure Quality State.

Complexity or uniqueness alone does not justify a Context Guide. The controlling test is whether interpretation would otherwise be insufficient for a responsible bounded determination or claim.

4.5 What a Context Guide Is - and Is Not

A Context Guide may interpret Core Quality Indicators through context-specific object descriptions, Boundaries, Interfaces, lifecycle and operating conditions, Failure Modes, Context-Specific Quality Outcome Criteria, Reference Layer anchors, Evidence limitations, Critical Infrastructure Conditions, and Infrastructure Quality Claim Boundaries. It does not create new Core Quality Factors or Core Quality Indicators and does not convert IQI into a compliance manual or certification scheme.

A Context Guide may:

- clarify infrastructure boundaries and interfaces for a specific context;
- identify Context-Specific Quality Outcome Criteria and relevant Infrastructure Results or Infrastructure Outcomes;
- provide illustrative examples of Evidence relevant to that context;

- highlight material Assumptions, Uncertainty, or sensitivities.

A Context Guide shall not:

- introduce alternative Core Quality Factors or Core Quality Indicators;
- redefine or weaken Core Quality Indicator intent;
- prescribe methods, procedures, technologies, or management systems;
- substitute regulatory compliance, component conformity, or documentation for Infrastructure Quality State determination.

Context Guides are downstream interpretation documents governed by the Core Standard. Infrastructure Quality Claim Statements shall reference the applicable Core Quality Indicators and identify any Context Guide relied upon.

5 Application of the Core Standard and Infrastructure Quality State Determination

5.1 How to Read and Apply the Core Quality Indicators

The Core Quality Factors identify invariant dimensions of Function Realization, and the Core Quality Indicators identify what is examined within those dimensions. They do not by themselves define the expected or acceptable state and do not prescribe methods, technologies, organizational structures, or management systems. Applicable Quality Outcome Criteria define the expected conditions or results against which the Core Quality Indicators are interpreted.

Application shall proceed from the declared Infrastructure Quality Object and satisfied Structural Checkpoints to the relevant Core Quality Indicators, applicable Context-Specific Quality Outcome Criteria, Evidence-Supported Findings, and Quality Factor Interpretation. The resulting Quality Factor Interpretations shall then undergo Critical-Condition and Non-Compensability Review before the Infrastructure Quality State and any bounded Infrastructure Quality Claim Statement are established.

A Context Guide supports this interpretation by identifying the context-specific Infrastructure Quality Object Description, Boundaries, Interfaces, lifecycle and operating conditions, Infrastructure Realization Pathways, Failure Modes, Context-Specific Quality Outcome Criteria, Evidence sources, Critical Infrastructure Conditions, Uncertainty, and Infrastructure Quality Claim Boundary. It does not alter the invariant Core.

Each Indicator is composed of:

- an Indicator Statement, identifying what is examined;
- an Intent, clarifying why the Indicator exists;
- **Scope and Boundaries**, defining what is included and excluded;
- **Lifecycle Coverage**, indicating when the Indicator applies;

- an Evidence Principle, describing the types or relationships of Evidence that may support interpretation without itself establishing Evidence Sufficiency.

Application of a Core Quality Indicator requires consideration of all of these elements together with the applicable Quality Outcome Criteria. Reliance on the Indicator Statement alone, without regard to Intent, Scope and Boundaries, lifecycle applicability, criteria, or Evidence may result in incomplete or misleading interpretation.

Core Quality Indicators shall be applied:

- within the declared Boundary of the Infrastructure Quality Object (see Section 4.3);
- for the stated Infrastructure Lifecycle Stage or transition;
- in a manner consistent with the declared Infrastructure Quality Claim Boundary.

5.2 Evidence Principle

Evidence and Evidence Sufficiency shall be interpreted using their authoritative WQI_VOC1 meanings. Evidence Sufficiency is relative to the declared Infrastructure Quality Object, applicable Core Quality Indicator and Quality Outcome Criterion, consequence, Uncertainty, time, lifecycle and operating conditions, and Infrastructure Quality Claim Boundary.

Absence of Observed Failure shall not by itself be interpreted as proof of satisfactory Infrastructure Quality. It may be relevant only when interpreted with Monitoring Adequacy, Evidence Sufficiency, Uncertainty, lifecycle history, Critical Infrastructure Conditions, and the Infrastructure Quality Claim Boundary.

Infrastructure Quality State determination and communication shall be based on Evidence relevant to the declared Infrastructure Quality Object, Core Quality Indicators, applicable Quality Outcome Criteria, Infrastructure Results and Infrastructure Outcomes where relevant, Boundaries, lifecycle and operating conditions, and the intended claim.

Evidence shall:

- relate to the declared Infrastructure Quality Object, the relevant Core Quality Indicator and Quality Outcome Criterion, and the time and context of the determination;
- distinguish the realized condition, Infrastructure Result, or Infrastructure Outcome from the Infrastructure Intended Function, Infrastructure Intended Result, design basis, or Assumption;
- be sufficient to support an Evidence-Supported Finding and subsequent Quality Factor Interpretation for the applicable Core Quality Indicator.

Evidence shall not be substituted by:

- the existence of procedures, programs, or management systems;
- statements of intent, Conformity Statements, Compliance Statements, or assertions of design adequacy;
- Documentation that is not relevant and traceable to the intended finding, determination, or claim.

The sufficiency and relevance of Evidence shall be interpreted in accordance with Section 8.6 (Evidence Over Assertion).

5.3 Relationship Between Evidence and Documentation

Documentation may contain, preserve, describe, or contextualize Evidence, but Documentation is not automatically Evidence and shall not by itself be interpreted as demonstration of Infrastructure Quality. Its evidentiary value depends on relevance, credibility, coverage, consistency, timeliness, traceability, and connection to the declared object, Core Quality Indicator, Quality Outcome Criterion, and intended determination.

The existence, completeness, correctness, or volume of Documentation shall not substitute for Evidence Sufficiency, an Evidence-Supported Finding, Quality Factor Interpretation, or Infrastructure Quality State determination.

5.4 Application Across Lifecycle Stages

The Core Standard applies across the principal IQI lifecycle sequence:

- Design, including early functional definition, planning, design development, and technical specification;
- Construction;
- Commissioning;
- Operation;
- Maintenance;
- Repair/Modification;
- Decommissioning/Transition.

Application at each stage shall reflect:

- the information reasonably available at that stage;
- the nature of decisions being made;
- the consequences of error or uncertainty at that stage.

Infrastructure Quality State determinations and Infrastructure Quality Claim Statements shall identify the applicable Infrastructure Lifecycle Stage or transition and shall not imply coverage of other stages.

Early lifecycle application of this Core Standard is independent of the name, legal form, or jurisdictional status of the planning, justification, or approval document used for an energy-infrastructure project. Such documents may include feasibility studies, business cases, alternatives analyses, preliminary engineering documents, environmental review documents, capital asset plans, financial plans, technico-economic justification documents, or other planning instruments. The Core question is whether the early Design-stage record makes visible the Infrastructure Quality Object, Infrastructure Intended Functions and Infrastructure Intended Results, Boundaries, Interfaces, Critical Infrastructure Conditions, Uncertainty, Evidence needs,

lifecycle controls, Technology implications, and proposed Infrastructure Quality Claim Boundary early enough to support responsible later-stage decisions. Budget, funding, or Technology-selection information is treated as Context, support, or constraint for Infrastructure Quality State determination, not as a substitute for Evidence Sufficiency or a determined Infrastructure Quality State.

5.5 Use of Context Guides in Application

Where a Context Guide is applicable under Section 4, it shall be used to:

- clarify the Infrastructure Quality Object Description, Boundaries, Interfaces, or dominant Risk mechanisms;
- interpret Core Quality Indicators through Context-Specific Quality Outcome Criteria and the applicable Reference Layer;
- identify relevant Evidence sources, Evidence limitations, Failure Modes, and Critical Infrastructure Conditions.

Context Guides do not replace the Core Standard. Application of the Core Quality Indicators remains mandatory, and reliance on a Context Guide shall be explicitly stated in any Infrastructure Quality Claim Statement.

6 Lifecycle Applicability of Infrastructure Quality State Determinations and Claims

6.1 General Principle

Infrastructure Quality is realized progressively across the Lifecycle. Accordingly, Infrastructure Quality State determinations and Infrastructure Quality Claim Statements shall be explicitly tied to the applicable Infrastructure Lifecycle Stage or transition and to the time and Evidence basis of the determination.

An Infrastructure Quality Claim Statement:

- applies only to the Infrastructure Lifecycle Stage or transition explicitly stated;
- shall not be inferred to apply to earlier or later stages without a new or updated Infrastructure Quality State determination;
- shall reflect the Evidence, Evidence Sufficiency, Assumptions, Uncertainty, and operating conditions appropriate to that stage.

Absence of Observed Failure at one Infrastructure Lifecycle Stage shall not be interpreted as Evidence of satisfactory Infrastructure Quality at a subsequent stage.

6.2 Design-Stage Infrastructure Quality State Determinations and Claims

Design-stage Infrastructure Quality State determinations and claims relate to the definition and technical translation of Infrastructure Intended Functions and Infrastructure Intended Results, not to constructed condition or operational Infrastructure Results and Infrastructure Outcomes.

Such claims may address:

- completeness and clarity of functional specifications;
- adequacy of technical specifications relative to functional intent;
- treatment of assumptions, uncertainties, and margins;
- consideration of foreseeable operating and environmental conditions.

Design-stage Infrastructure Quality Claim Statements do not demonstrate:

- construction quality;
- as-built condition;
- operational performance;
- long-term integrity or reliability.

6.3 Construction-Stage Infrastructure Quality State Determinations and Claims

Construction-stage Infrastructure Quality State determinations and claims relate to Infrastructure Work and Infrastructure Results associated with construction, including Conformity Findings concerning the constructed Infrastructure Quality Object and applicable Technical Specifications.

Such claims may address:

- conformity of materials, components, and assemblies;
- execution of construction activities relative to specifications;
- preservation of design intent during realization.

Construction-stage Infrastructure Quality Claim Statements do not demonstrate:

- fitness for sustained operation;
- performance under full operating conditions;
- adequacy of monitoring, maintenance, or operational response.

6.4 Commissioning-Stage Infrastructure Quality State Determinations and Claims

Commissioning-stage Infrastructure Quality State determinations and claims relate to the initial Evidence-supported demonstration of functional readiness and specified Infrastructure Results under declared commissioning conditions.

Such claims may address:

- verification of functional behavior;
- initial confirmation of safety and protection provisions;
- readiness to transition to operation.

Commissioning-stage Infrastructure Quality Claim Statements do not demonstrate:

- long-term operational performance;
- resilience under degraded or abnormal conditions;
- performance over time.

6.5 Operation-Stage Infrastructure Quality State Determinations and Claims

Operation-stage Infrastructure Quality State determinations and claims relate to observed behavior, Infrastructure Results, and Infrastructure Outcomes during Operation, including performance, Degradation and Aging, and interaction with the environment and other systems.

Such claims may address:

- operational reliability and availability;
- integrity over time;
- effectiveness of environmental protection;
- workplace interaction and safety outcomes;
- stakeholder and community impact.

Operation-stage determinations and claims shall consider:

- accumulated degradation;
- changes in operating context;
- monitoring information and trends.

6.6 Maintenance-Stage Infrastructure Quality State Determinations and Claims

Maintenance-stage Infrastructure Quality State determinations and claims relate to Infrastructure Work and Infrastructure Results undertaken to inspect, service, preserve, or restore the declared Infrastructure Quality Object without unexamined change to its

Infrastructure Intended Functions, Infrastructure Intended Results, or authorized Infrastructure Configuration.

Such determinations and claims shall identify:

- the condition identified before Maintenance;
- the Maintenance Work performed and the Infrastructure Result achieved;
- the post-Maintenance condition, Infrastructure Configuration, readiness, and applicable operating limitations; and
- the Evidence supporting return to service or continued Operation.

A Maintenance-stage Infrastructure Quality Claim Statement does not by itself establish the adequacy of a Repair/Modification, life-extension, reconstruction, or repurposing change.

6.7 Repair/Modification-Stage Infrastructure Quality State Determinations and Claims

Repair/Modification-stage Infrastructure Quality State determinations and claims, including life extension, reconstruction, or repurposing where relevant, shall:

- explicitly identify what changed and why;
- identify affected Infrastructure Intended Functions, Infrastructure Intended Results, Infrastructure Configuration, Boundaries, Interfaces, Assumptions, and Quality Outcome Criteria;
- state which prior lifecycle Assumptions, Evidence, determinations, or claims are no longer valid; and
- define the scope of reassessment and the current Evidence basis.

Such Infrastructure Quality Claim Statements do not inherit validity from earlier lifecycle claims without explicit reassessment against the Core Quality Indicators, applicable Quality Outcome Criteria, Critical Infrastructure Conditions, and current Evidence.

6.8 Decommissioning/Transition-Stage Infrastructure Quality State Determinations and Claims

Decommissioning/Transition-stage Infrastructure Quality State determinations and claims relate to:

- safe cessation of operation;
- containment or removal of hazards;
- environmental protection during and after decommissioning;
- residual obligations and long-term impacts.

These claims are distinct from Operation-stage claims and shall be supported by a determination appropriate to the Decommissioning/Transition condition.

6.9 Prohibition of Implied or Rolling Claims

An Infrastructure Quality Claim Statement shall not silently roll forward from one Infrastructure Lifecycle Stage, transition, or Infrastructure Operating Condition to another. Continued validity

requires that the Evidence basis, Evidence Sufficiency, Assumptions, limitations, Unresolved Conditions, Interfaces, Critical Infrastructure Conditions, Infrastructure Operating Conditions, and Infrastructure Quality Claim Boundary continue to support the claim.

Infrastructure Quality Claim Statements shall not:

- imply lifecycle coverage beyond what is explicitly stated;
- combine multiple lifecycle stages into a single undifferentiated claim;
- rely on earlier-stage claims to justify later-stage quality without reassessment.

Each Infrastructure Quality Claim Statement shall stand on its explicit lifecycle scope, Infrastructure Quality Claim Boundary, and Evidence basis.

7 Infrastructure Quality Claim Statements

7.1 Purpose of an Infrastructure Quality Claim Statement

An Infrastructure Quality Claim Statement is a bounded communication derived from an Infrastructure Quality State determination. It communicates the determined Infrastructure Quality State, a Quality Factor Interpretation, or another Evidence-supported quality conclusion about the declared Infrastructure Quality Object.

An Infrastructure Quality Claim Statement shall:

- not exceed the Infrastructure Quality State determination from which it is derived;
- identify the applicable Evidence basis and Evidence limitations;
- be interpreted within its Infrastructure Quality Claim Boundary and conditions of continued validity.

An Infrastructure Quality Claim Statement is not IQI certification, approval, endorsement, legal compliance, or continuing conformity unless a separate authorized process expressly establishes such status.

Infrastructure Quality Claim Statements shall be interpreted in light of the principle of alignment described in Section 8.9.

7.2 Required Content of an Infrastructure Quality Claim Statement

An Infrastructure Quality Claim Statement shall identify the Infrastructure Quality Object; Scale; Infrastructure Quality Claim Boundary; applicable lifecycle and operating conditions; Core Standard edition; Context Guide, if used; Core Quality Factors and Core Quality Indicators examined; applicable Quality Outcome Criteria; Quality Factor Interpretations; Critical-Condition and Non-Compensability Review; Evidence basis and Evidence Sufficiency; included and excluded Interfaces; Reference Layer anchors; Assumptions; Uncertainty; Unresolved Conditions; known Evidence gaps; limitations; time or evaluation period; and conditions of continued validity.

Each Infrastructure Quality Claim Statement shall include, at a minimum, the following elements.

a) Identification of the Infrastructure Quality Object

– name or identifier of the Infrastructure Quality Object
– object class, Scale, and description sufficient to distinguish the object and its Infrastructure Intended Functions

b) Infrastructure Quality Claim Boundary

– physical, functional, informational, organizational, and temporal scope relevant to the claim
– Interfaces, dependencies, and responsibilities included or excluded
– reference to the Boundary declaration under Section 4

c) Lifecycle and Operating Conditions Covered

– explicit identification of the Infrastructure Lifecycle Stage or transition and applicable Infrastructure Operating Conditions
– confirmation that no other lifecycle or operating conditions are implied (see Section 6)

d) Applicable Core Standard Edition

– reference to the edition/version of the Infrastructure Quality Core Standard applied

e) Core Quality Factors, Core Quality Indicators, and Quality Outcome Criteria

– identification of the Core Quality Factors and Core Quality Indicators examined
– identification of the applicable Quality Outcome Criteria
– identification and explanation of any Core Quality Indicator not examined

f) Infrastructure Quality State Determination and Conformity Basis

– description of the Infrastructure Quality State determination process and resulting Quality Factor Interpretations
– reference to relevant Conformity Findings or Conformity Statements under Factor 3
– description of the Critical-Condition and Non-Compensability Review

g) Use of Context Guides (if applicable)

– identification of any Context Guide relied upon
– confirmation that Core Quality Indicators remain authoritative

h) Assumptions, Limitations, and Uncertainties

– explicit statement of material Assumptions
– known limitations of the determination
– Uncertainty affecting interpretation of the Infrastructure Quality State or claim

i) Date and Validity Context

– date of the claim
– statement of conditions under which the claim remains valid
– acknowledgment that change may invalidate the claim

j) Evidence Basis and Evidence Sufficiency

– description of the nature, scope, relevance, credibility, coverage, consistency, timeliness, and traceability of Evidence supporting the claim
– identification of key Evidence limitations, gaps, Unresolved Conditions, or Uncertainty
– indication of how the Evidence supports Evidence-Supported Findings, Quality Factor Interpretations, and the Infrastructure Quality State.

7.3 Relationship Between Conformity and Infrastructure Quality State Determination

A Conformity Finding or Conformity Statement may support an Infrastructure Quality State determination, but conformity to a specified requirement or criterion is not automatically equivalent to a satisfactory Infrastructure Quality State or a valid Infrastructure Quality Claim Statement.

A Conformity Finding or Conformity Statement:

- shall be based on Evidence relevant to the declared Basis for Conformity Assessment;
- shall not be inferred from Documentation alone, Compliance Statements, design intent, or Absence of Observed Failure; and
- shall state relevant Assumptions, limitations, Uncertainty, Assessment Limitations, and Evidence limitations.

Where Evidence is absent, incomplete, limited, or uncertain, the Conformity Finding or Conformity Statement shall be bounded accordingly and shall not be overstated. Neither conformity nor Infrastructure Quality shall be assumed.

7.4 Prohibition of Misleading or Implied Claims

Infrastructure Quality Claim Statements shall not:

- imply a level of certainty or completeness not supported by Evidence;
- extend beyond the Infrastructure Quality Claim Boundary, applicable lifecycle and operating conditions, or Core Quality Indicators examined;
- rely on assertion, implication, or omission of relevant limitations;
- present Documentation, compliance status, activity completion, or procedural completeness as proof of Infrastructure Quality;
- interpret absence of contradictory Evidence as Evidence of adequacy;

Claims that do not meet these conditions shall be considered unsupported or misleading representations of Infrastructure Quality.

7.5 Conditions of Continued Validity

An Infrastructure Quality Claim Statement remains valid only within its declared Infrastructure Quality Claim Boundary, lifecycle and operating conditions, time or evaluation period, Evidence basis, Assumptions, Uncertainty, limitations, and conditions of continued validity.

The Infrastructure Quality State or Infrastructure Quality Claim Statement shall not be assumed to remain valid where:

- conditions change;
- new information becomes available;
- Degradation and Aging, Repair/Modification, or external influences affect infrastructure behavior;
- previously unrecognized Uncertainty or Unresolved Conditions emerge.

Continued validity shall depend on the continuing relevance and sufficiency of Evidence, visibility of Critical Infrastructure Conditions, validity of Assumptions, stability of Boundaries and Interfaces, and absence of material changes requiring a new or updated Infrastructure Quality State determination.

8 Key Principles of Energy Infrastructure Quality

8.1 Infrastructure Quality and the Work-Result-Outcome Relationship

Infrastructure Quality is the degree to which the declared Infrastructure Quality Object realizes its Infrastructure Intended Functions and Infrastructure Intended Results within declared Boundaries and Interfaces, as interpreted against applicable Quality Outcome Criteria and supported by sufficient Evidence. Infrastructure Work and Infrastructure Result form an Infrastructure Outcome, but the existence of Work, a Result, or an Outcome does not by itself establish a satisfactory Infrastructure Quality State.

Infrastructure Work, Infrastructure Results, and Infrastructure Outcomes shall be interpreted separately and together, as applicable, against Quality Outcome Criteria and within declared Boundaries, Interfaces, lifecycle and operating conditions, Evidence, Uncertainty, and Critical Infrastructure Conditions.

A positive Infrastructure Quality State may be determined only when the supporting findings and interpretations demonstrate:

- realization of the applicable Infrastructure Intended Functions and Infrastructure Intended Results;
- satisfaction of applicable Quality Outcome Criteria, including criteria concerning Infrastructure Safety, integrity, Operational Reliability, and Environmental Protection;
- sufficient Evidence and transparent treatment of Uncertainty, Unresolved Conditions, Critical Infrastructure Conditions, and limitations.

8.2 Infrastructure Safety and Unacceptable Risk

Infrastructure Safety applies with the IQI_VOC1 meaning: the condition in which unacceptable Risk to people, workers, communities, the environment, the Infrastructure Quality Object, and the conditions necessary for its essential intended functions is prevented or controlled within declared Boundaries and Interfaces.

Infrastructure Safety interpretation includes, as applicable:

- Risk to people, workers, Communities, the environment, and the Infrastructure Quality Object;
- Risk arising from normal Infrastructure Operating Conditions, Abnormal Operating Conditions, Transient Conditions, and Degraded Conditions;
- Risk resulting from Interfaces and interactions among Infrastructure Elements / Components, Infrastructure Subsystems, systems, operating media, and human activity.

Infrastructure Safety is not demonstrated by Absence of Observed Failure or absence of incidents alone. IQC1 does not establish a universal acceptable-Risk threshold.

8.3 System-Level Behavior Over Component Compliance

An Infrastructure Quality Object may be an Infrastructure Asset, facility, network, subsystem, or Infrastructure System-of-Systems.

Conformity of individual Infrastructure Elements / Components or products does not by itself establish Infrastructure Quality. The Infrastructure Quality State shall be determined for the declared Infrastructure Quality Object at the Scale and Boundary where Function Realization, emergent behavior, Interfaces, and dependencies are relevant.

8.4 Lifecycle Realization of Quality

Infrastructure Quality is realized progressively across the Lifecycle and may differ by Infrastructure Lifecycle Stage, Boundary, Scale, Infrastructure Operating Condition, or time.

Decisions and Assumptions originating in one stage may shape Infrastructure Results, Infrastructure Outcomes, Evidence, and Critical Infrastructure Conditions in later stages. Infrastructure Quality Claim Statements are therefore meaningful only when bounded by an explicit Infrastructure Lifecycle Stage or transition, Infrastructure Quality Claim Boundary, operating conditions, time, and Evidence basis.

No determination at one Infrastructure Lifecycle Stage automatically establishes the Infrastructure Quality State at another stage.

8.5 Transparency of Assumptions, Limitations, and Uncertainty

Infrastructure Quality State determination requires explicit treatment of Assumptions, Assumption Drift, limitations, Uncertainty, and Unresolved Conditions.

Concealed Uncertainty or implied completeness can invalidate interpretation or overstate a claim. Boundary Transparency and explicit limitations support responsible decisions, accountability, and trust.

8.6 Evidence Over Assertion

Evidence Sufficiency exists only when available Evidence has adequate relevance, credibility, coverage, consistency, timeliness, and traceability for the intended Infrastructure Quality State determination or Infrastructure Quality Claim Statement. Data, records, Documentation, Compliance Statements, and observations become Evidence only when connected to the declared Infrastructure Quality Object, Boundary, Core Quality Indicator, Quality Outcome Criterion, lifecycle and operating conditions, and intended claim.
Absence of Observed Failure is not a substitute for Evidence Sufficiency.

Interpretation of Infrastructure Quality shall be based on Evidence and Evidence-Supported Findings as described in Section 5.2, not on assertion.

Assertions, including:

- statements of compliance,
- design intent,
- procedural completeness,
- or documented justification,

shall not be considered sufficient to support an Infrastructure Quality State determination unless they provide relevant, credible, traceable, and bounded Evidence for the applicable Core Quality Indicators and Quality Outcome Criteria.

Where Evidence is absent, incomplete, or uncertain, the resulting Evidence-Supported Finding, Quality Factor Interpretation, Infrastructure Quality State, and Infrastructure Quality Claim Statement shall be limited or qualified accordingly.

The absence of contradictory Evidence shall not be interpreted as Evidence of adequacy.

8.7 Non-Compensability and Infrastructure Non-Substitutability

Critical Infrastructure Conditions may arise from Intended Functions, integrity, Infrastructure Safety, Environmental Protection, Operational Reliability, human interaction, Personnel Competence, compliance, Stakeholder or Community effects, Monitoring, Documentation,

lifecycle transition, Adaptation, Evidence Sufficiency, or Interfaces. They are not limited to a fixed list of critical components.

Conditions identified as critical under Section 2.8 shall be treated in accordance with Non-Compensability and Infrastructure Non-Substitutability.

Failure, prohibition, unresolved status, or insufficient Evidence for such a condition cannot be offset, balanced, or compensated by favorable findings for other Core Quality Indicators or Core Quality Factors.

A responsible positive Infrastructure Quality State shall not be determined where one or more Critical Infrastructure Conditions are failed, prohibited, unresolved, or insufficiently evidenced, regardless of overall Core Quality Indicator coverage or apparent performance.

8.8 Context Without Fragmentation

Context affects application, but WQI Root meanings, IQI Applied meanings, and the IQC1 Core architecture remain invariant.

Context Guides provide Context-Specific Interpretation without fragmenting the Core Standard. All Infrastructure Quality State determinations remain anchored to the same Core Quality Factors and Core Quality Indicators.

8.9 Loss of Alignment as a Primary Failure Mechanism

Loss of Infrastructure Quality may arise from progressive misalignment among Infrastructure Intended Functions and Infrastructure Intended Results, Infrastructure Configuration, observed Infrastructure Results and Infrastructure Outcomes, Assumptions, Evidence, human interaction, Interfaces, and evolving Infrastructure Operating Conditions.

Such loss of alignment may occur gradually and may not be visible through isolated Core Quality Indicators, Documentation, or nominal conformity. It may occur where Assumptions have drifted, Monitoring does not reveal Degradation and Aging or Emerging Risk, human interaction is misaligned with actual behavior, Interfaces are not controlled, or Infrastructure Operating Conditions move beyond those previously considered.

Accordingly, Infrastructure Quality shall be interpreted through continuing alignment among Function Realization, Infrastructure Results and Infrastructure Outcomes, Assumptions, human interaction, Interfaces, Evidence, and Context across the Lifecycle. Loss of alignment may invalidate otherwise favorable findings for individual Core Quality Indicators and may establish an Unresolved Condition or Critical Infrastructure Condition.

8.10 Closing Statement

These principles summarize the intent and application of IQC1. They are not additional requirements, but interpretive anchors for consistent, transparent, and responsible use of the invariant Core across energy-infrastructure contexts and Infrastructure Lifecycle Stages.

Annex A (Informative) — Illustrative Examples of Applying the Infrastructure Quality Core Standard

A.1 Purpose of This Annex

This Annex provides illustrative examples to support understanding of how the Infrastructure Quality Core Standard may be applied in practice.

These examples:

- are informative only and do not introduce requirements;
- do not prescribe methods, procedures, or technologies;
- do not define minimum or sufficient evidence;
- are intended to demonstrate interpretation, boundary definition, and claim structuring, not implementation detail.

Absence or difference of examples shall not be interpreted as a deficiency in application of the Core Standard.

A.2 How to Read the Examples

Each example illustrates:

- declaration of the Infrastructure Quality Object and its Boundary;
- identification of relevant Core Quality Factors, Core Quality Indicators, and Quality Outcome Criteria;
- the Infrastructure Lifecycle Stage or transition to which the claim applies;
- how Evidence, Assumptions, Uncertainty, limitations, and conditions of continued validity may be expressed;
- when a Context Guide may or may not be required.

Examples are deliberately simplified and do not represent complete Infrastructure Quality State determinations.

A.3 Example 1 — Design-Stage Infrastructure Quality State Determination and Claim

Context

A new onshore energy transmission asset at the design stage.

Boundary Definition

- Infrastructure Quality Object and Boundary: transmission line and associated fixed facilities
- Interfaces: upstream supply interface, downstream distribution interface
- Infrastructure Lifecycle Stage: Design only

Application Highlights

- Factors emphasized:
  - Factor 1 (Functional Specification Quality)
  - Factor 2 (Technical Specification Quality)
  - Factor 3 (Conformity Assessment – design stage)
- Environmental and stakeholder considerations addressed at the level of assumptions and design intent, not realized performance.

Infrastructure Quality Claim Characteristics

- Explicit statement that no Construction-stage condition or Operation-stage Infrastructure Result or Infrastructure Outcome is claimed
- Identification of key uncertainties (e.g., subsurface conditions, future demand)
- Recognition that operational reliability and integrity cannot yet be demonstrated

Context Guide Determination

- No Context Guide required where Core Quality Indicators are sufficient to interpret design intent and assumptions.

A.4 Example 2 — Operation-Stage Infrastructure Quality State Determination and Claim

Context

A declared Infrastructure Quality Object in continuous Operation.

Boundary Definition

- Infrastructure Quality Object and Boundary: operating facility and included on-site systems
- Interfaces: workforce interaction points, environmental discharge interfaces

- Infrastructure Lifecycle Stage: Operation

Application Highlights

- Factors emphasized:
  - Factor 4 (Structural and Functional Integrity)
  - Factor 6 (Environmental Protection)
  - Factor 7 (Operational Reliability)
  - Factor 8 (Workplace Human Interaction and Safety)
  - Factor 12 (Monitoring and Performance Evaluation)

Infrastructure Quality Claim Characteristics

- Use of Monitoring trends as Evidence of observed behavior, Infrastructure Results, and Infrastructure Outcomes.
- Explicit treatment of degradation mechanisms and residual risks
- Clear limitation that claim reflects current operating conditions only

Context Guide Determination

- Context Guide may be required if dominant risk mechanisms or physical regime differ materially from generic infrastructure assumptions.

A.5 Example 3 — Repair/Modification and Life-Extension Determination and Claim

Context

Repair/Modification of an existing Infrastructure Quality Object to extend service life.

Boundary Definition

- Infrastructure Quality Object and Boundary: modified Infrastructure Subsystems plus affected Interfaces
- Infrastructure Lifecycle Stages: Repair/Modification and subsequent Operation

Application Highlights

- Factors emphasized:
  - Factor 4 (Structural and Functional Integrity)
  - Factor 5 (Process Safety and Risk Mitigation)
  - Factor 13 (Documentation and Traceability)
- Explicit comparison of original assumptions versus current conditions

Infrastructure Quality Claim Characteristics

- Clear statement of what prior claims no longer apply

- Identification of newly introduced uncertainties
- Bounded claim focused on the modified object extent and affected Interfaces

Context Guide Determination

- Context Guide required where modification changes dominant risk mechanisms or system topology.

A.6 Example 4 — Context Guide Application

Context

An Infrastructure Quality Object operating in a physical or regulatory regime that materially alters interpretation of Infrastructure Results, Infrastructure Outcomes, or the Infrastructure Quality State.

Application Highlights

- Core Quality Indicators remain authoritative
- Context Guide used to:
    - clarify Boundary and Interface interpretation
    - identify Context-Specific Quality Outcome Criteria
    - identify relevant Evidence sources and Evidence limitations

Key Point

The Infrastructure Quality Claim Statement references:

- the Core Standard, and
- the applicable Context Guide,
  without implying that the Context Guide replaces the Core.

A.7 What These Examples Do Not Show

These examples do not:

- define acceptable methods or tools;
- establish performance thresholds;
- prescribe document formats, management-system procedures, or organizational records;
- suggest certification or approval pathways.

Their sole purpose is to illustrate interpretation, not execution.

A.8 Closing Note

This Annex supports consistent understanding of the Infrastructure Quality Core Standard across diverse energy-infrastructure contexts. It reinforces that an Infrastructure Quality State is determined through bounded, transparent, lifecycle-specific interpretation supported by relevant Evidence and explicit acknowledgment of limitations, and is communicated through a bounded Infrastructure Quality Claim Statement.

Annex B (Informative) — Use of Infrastructure Context Guides

B.1 Purpose of This Annex

This Annex explains the role, use, and limits of Infrastructure Context Guides within the Infrastructure Quality document set.

It is intended to:

- support consistent interpretation of the Core Standard;
- prevent misuse or over-extension of Context Guides;
- reinforce the authority and invariance of the Core Quality Factors and Core Quality Indicators.

This Annex is informative only and does not introduce additional requirements.

B.2 Position of Context Guides in the IQI Document Set

Context Guides are downstream interpretation documents governed by the Infrastructure Quality Core Standard.

They exist to:

- support interpretation of the Core Quality Indicators in specific energy-infrastructure contexts;
- clarify boundaries, interfaces, and dominant mechanisms where necessary;
- reduce the risk of misleading conclusions when applying the Core alone.

Context Guides:

- do not constitute standalone standards;
- do not replace the Core Standard;
- do not establish an alternative Core or an independent basis for Infrastructure Quality State determination.

B.3 Relationship Between the Core Standard and Context Guides

The relationship between the Core Standard and Context Guides is as follows:

- The Core Standard establishes invariant requirements through the Core Intended Function architecture, Core Quality Factors, and Core Quality Indicators.
- Context Guides clarify how those same Core Quality Indicators are interpreted through Context-Specific Quality Outcome Criteria, Evidence, Failure Modes, and Critical Infrastructure Conditions in particular energy-infrastructure contexts.

Context Guides interpret the invariant Core Intended Function architecture at a declared Scale. They do not redefine Intended Function or establish a separate functional basis for Infrastructure Quality State determination.

All Infrastructure Quality Claim Statements shall:

- reference the Core Standard as the primary normative basis;
- identify any Context Guide relied upon for interpretation;
- remain bounded by the scope and lifecycle applicability defined in the Core.

B.4 When Context Guides Are Used

Context Guides are used only when justified by the determination logic in Section 4 of the Core Standard.

They are appropriate when:

- physical regime, dominant Risk mechanisms, Infrastructure Configuration, Interfaces, or Reference Layer anchors materially affect interpretation;
- application of the Core Quality Indicators alone would risk misunderstanding Function Realization, Infrastructure Results, Infrastructure Outcomes, or the Infrastructure Quality State.

Context Guides are not required simply because:

- an asset is complex or unique;
- a sector has established practices;
- specialized technology is involved.

B.5 What Context Guides May Contain

A Context Guide may include:

- clarification of Boundaries and Interfaces relevant to the context;
- explanation of dominant Risk mechanisms and Failure Modes affecting interpretation;
- Context-Specific Quality Outcome Criteria aligned with Core Quality Indicators;
- illustrative examples of Evidence sources and Evidence limitations relevant to the context;
- discussion of material Assumptions, Uncertainty, or sensitivities.

Context Guides may reference:

- regulatory frameworks;
- industry standards;
- physical or operational characteristics;

but only to support interpretation, not to redefine requirements.

B.6 What Context Guides May Not Contain

A Context Guide shall not:

- introduce alternative Core Quality Factors or Core Quality Indicators;
- alter the intent or meaning of Core Quality Indicators;
- prescribe methods, procedures, tools, or technologies;
- function as a management, compliance, or certification scheme;
- independently invent technical performance thresholds or acceptance criteria outside the applicable Reference Layer; a Context Guide may identify or connect Context-Specific Quality Outcome Criteria to authorized Reference Layer sources.

Any document that does so exceeds the role of a Context Guide and is outside the scope of the IQI Core framework.

B.7 Referencing Context Guides in Infrastructure Quality Claim Statements

Where a Context Guide is used, the Infrastructure Quality Claim Statement shall:

- identify the Context Guide by title and edition;
- state the purpose for which it was used;
- confirm that the determination and claim remain anchored to the Core Quality Indicators, not to the Context Guide as an independent normative basis.

Reliance on a Context Guide shall not imply broader scope, completeness, or higher assurance than is supported by the Infrastructure Quality State determination and Infrastructure Quality Claim Boundary.

B.8 Evolution and Maintenance of Context Guides

Context Guides may evolve over time to reflect:

- improved understanding of infrastructure behavior;
- changes in technology or operating context;
- new regulatory or environmental conditions.

Revision of a Context Guide:

- does not revise the Core Standard;
- does not by itself invalidate prior Infrastructure Quality Claim Statements; continued validity remains governed by their declared conditions;
- shall be transparent as to scope, assumptions, and applicability.

B.9 Closing Note

Context Guides are tools for clarity, not substitution.

Used properly, they enhance the applicability of the Infrastructure Quality Core Standard without fragmenting it. Used improperly, they risk undermining the very consistency and transparency the Core is designed to ensure.

This Annex reinforces that the invariant Core governs Infrastructure Quality State determination and that context serves interpretation, not an alternative authority.

Annex C (Informative) — Terminology Governance and Definition Placement

C.1 Purpose and Status

This Annex records the terminology-governance rules applied during the controlled update of IQC1. It is informative and does not create additional Core requirements.

C.2 Governing Placement Rules

A cross-domain methodological concept is defined in WQI_VOC1.

An energy-infrastructure-wide Applied Concept is defined in IQI_VOC1.

An invariant concept needed specifically to interpret a Core Quality Factor or Core Quality Indicator may be defined in IQC1.

An asset-, technology-, method-, threshold-, jurisdiction-, or context-specific meaning belongs in the applicable Context Guide or Reference Layer.

Each concept has one authoritative definition. IQC1 adopts WQI Root Concepts and IQI Applied Concepts by reference and shall not create competing definitions.

C.3 Terms Governed by WQI_VOC1 and IQI_VOC1

WQI_VOC1 governs Root Concepts including Quality Object, Intended Function, Intended Result, Function Realization, Boundary, Interface, Context, Lifecycle, Quality Factor, Quality Indicator, Quality Outcome Criterion, Evidence, Evidence Sufficiency, Evidence-Supported Finding, Quality Factor Interpretation, Critical Condition, Non-Compensability, Quality State, Quality State Determination, Quality Claim, Assumption, Uncertainty, Unresolved Condition, and Reference Layer.

IQI_VOC1 governs energy-infrastructure Applied Concepts including Infrastructure Quality Object, Infrastructure Quality Object Description, Structural Checkpoint, Infrastructure Asset, Infrastructure System-of-Systems, Infrastructure Configuration, Infrastructure Operating Medium, Infrastructure Operating Condition, Infrastructure Intended Function, Infrastructure Intended Result, Infrastructure Work, Infrastructure Result, Infrastructure Outcome, Critical Infrastructure Condition, Infrastructure Non-Substitutability, Infrastructure Quality State, Infrastructure Quality State Determination, Infrastructure Quality Claim Statement, Infrastructure Quality Claim Boundary, and Infrastructure Evidence Continuity.

C.4 IQC1 Factor-Specific Definitions

Section 3 defines only invariant Factor- or Indicator-specific terms required for consistent Core interpretation. These include, among others, Functional Specification, Technical Specification, Conformity Assessment, Structural Integrity, Functional Integrity, Hazard, Risk Control Objective, Operational Reliability, Workplace Human-Infrastructure Interaction, Personnel Competence, Applicable Requirement, Infrastructure Impact, Monitoring and Performance Evaluation, Documentation and Traceability, Adaptation, and Innovation.

Shared Factor-level terms are defined once and cross-referenced where reused. For example, Traceability and Information Retention are governed under Factor 13, while Abnormal Operating Condition, Transient Condition, and Degraded Condition are governed under Factor 4.

C.5 Context Guide and Reference Layer Boundary

Context Guides may identify context-specific Infrastructure Quality Object descriptions, Boundaries, Interfaces, Infrastructure Realization Pathways, Failure Modes, Context-Specific Quality Outcome Criteria, Evidence sources, Critical Infrastructure Conditions, Infrastructure Operating Conditions, technical limits anchored in the Reference Layer, and Infrastructure Quality Claim Boundaries.

Technical values, acceptance thresholds, inspection or testing methods, jurisdictional meanings, asset-specific mechanisms, and other Reference Layer requirements are not universal IQC1 definitions.

C.6 Cross-Platform Review Items

The concepts Work-Result-Outcome, Competence, Conformity Assessment, Traceability, Monitoring, and Documentation may have significance across more than one Whole Quality platform. Their present IQC1 treatment remains valid for this Core Standard unless and until a

controlled WQI_VOC1 or Applied Vocabulary decision establishes a different authoritative location.

C.7 Implementation Status

The detailed Pass 3A drafting register guided Passes 3B and 3C and was removed from the publication structure after implementation. Pass 5 confirms that the remaining terminology follows the governing placement rules and the one concept - one authoritative definition principle. Future additions or relocations of terms shall follow the same controls.

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