Infrastructure Quality Standard - Core

IQI STANDARD IQC1

Second Draft Edition - June 2026

Aligned with IQI_VOC1 Second Draft Edition and IQI Context Guides MNT1 and LDN1

INFRASTRUCTURE QUALITY INITIATIVE

Foreword (Informative)

Energy infrastructure underpins modern society. Systems for energy production, processing, transport, storage, and delivery enable daily life, economic activity, public safety, environmental protection, and long-term community stability. When these systems function as intended, they are often invisible. When they do not, the consequences can be severe, long-lasting, and widespread.

Infrastructure quality is often discussed through separate lenses: regulatory compliance, product conformity, engineering codes, operating procedures, or organizational management systems. Each of these is important, but none by itself answers the central infrastructure-quality question:

Does the assembled infrastructure asset, as a system, demonstrate the required quality outcomes across its lifecycle?

This Infrastructure Quality Core Standard addresses that question.

This Standard is an **asset- and system-outcome standard**. It defines the quality conditions that must be demonstrably true of an infrastructure asset or system-of-systems. It does not prescribe how an organization shall manage itself, structure its departments, operate a quality management system, conduct audits, or obtain certification.

The Standard focuses on the realized condition and behavior of infrastructure: whether intended functions are defined and preserved; whether technical requirements remain aligned with those functions; whether integrity, safety, reliability, environmental protection, human interaction, stakeholder impact, monitoring, documentation, and adaptability are sufficient for the defined lifecycle stage and boundary.

Accordingly, IQI_IQC1 separates:

- **infrastructure quality outcomes** — what must be true of the asset/system; from
- **means of achievement** — the organizational methods, procedures, technologies, management systems, or governance arrangements used to produce those outcomes.

Existing laws, regulations, engineering codes, product standards, and management-system standards remain essential. IQI_IQC1 does not replace them. Instead, it provides a structured way to evaluate the quality of the assembled infrastructure asset above and across those instruments.

A claim made under this Standard is not an IQI certification, approval, license, audit result, or endorsement. It is a bounded Quality Claim Statement only, limited by Infrastructure Quality Object, claim boundary, lifecycle stage, assessed Indicators, assumptions, limitations, unresolved conditions, evidence sufficiency, uncertainty, and Reference Layer context.

Infrastructure Quality as a System Outcome

Energy infrastructure is not a single product or activity. It is a **system of systems**, assembled from many conforming components, realized progressively across lifecycle stages, and

operated within evolving physical, environmental, social, and regulatory contexts. The quality of energy infrastructure emerges from the **results produced by infrastructure work**, expressed through the observed behavior and performance of the assembled asset over time.

Accordingly, this Standard defines infrastructure quality in terms of **outcomes**, not activities or intentions. It focuses on what must be demonstrably true of energy infrastructure across design, construction, commissioning, operation, modification, and decommissioning, rather than prescribing how organizations should manage their work.

Relationship to Existing Standards and Regulations

This Core Standard does not replace existing laws, regulations, engineering codes, product standards, or management system standards applicable to energy infrastructure. Regulatory compliance and product conformity are treated as **necessary but not sufficient** conditions for infrastructure quality.

This Standard provides an overarching framework for evaluating whether an infrastructure asset or system demonstrates the required quality outcomes across its lifecycle, independent of the management systems or processes used to produce those outcomes.

Outcome-Based and Non-Prescriptive by Design

This Standard is intentionally **non-prescriptive**. It does not mandate technologies, procedures, organizational structures, staffing models, or management systems. It does not function as a checklist, audit program, or certification scheme.

Instead, it defines:

- invariant **Quality Factors** representing fundamental dimensions of infrastructure quality;
- **Indicators** that articulate required conditions and outcomes;
- principles for applying these Indicators transparently across lifecycle stages and contexts.

How these outcomes are achieved remains the responsibility of the relevant parties, consistent with applicable regulations, professional judgment, and local conditions.

Lifecycle and Transparency

Infrastructure quality is realized progressively across the lifecycle. Decisions made at early stages shape outcomes at later stages, often irreversibly. Claims of quality are therefore meaningful only when **explicitly bounded** by lifecycle stage, scope, assumptions, and uncertainty.

This Standard requires transparency regarding:

- what has been assessed and what has not;
- assumptions, limitations, and uncertainty;
- the boundaries within which quality claims are made.

Transparency is essential for informed decision-making, accountability, and trust.

Context Without Fragmentation

While the Core Quality Factors and Indicators defined in this Standard are invariant, energy infrastructure contexts differ. In certain circumstances, applying the Core alone may be insufficient to convey how outcomes should be interpreted.

For this reason, the Infrastructure Quality framework includes Context Guides, which support interpretation in specific energy-infrastructure contexts without altering the Core requirements. Context Guides interpret invariant Core Indicators through context-specific boundaries, interfaces, lifecycle conditions, critical conditions, Reference Layer anchors, evidence limitations, and Quality Claim boundaries.

By analogy, the framework defined in this Standard may also be applied to other forms of critical infrastructure that exhibit similar system-of-systems behavior (such as water extraction and delivery), provided that such application does not conflict with the vocabulary, concepts, and boundaries defined in the Infrastructure Quality Vocabulary Standard (IQI_VOC1).

Intended Use

This Core Standard is intended for use by owners, operators, designers, constructors, assessors, regulators, financiers, insurers, and other stakeholders involved in **energy infrastructure**, who require a clear, outcome-focused understanding of infrastructure quality.

It supports structured assessment, transparent communication of quality, and informed decisions where infrastructure performance, safety, environmental protection, and long-term societal impact matter.

How This Standard Should Be Read (Informative)

This Infrastructure Quality Core Standard is written for readers who engage with energy infrastructure at different levels and for different purposes. It is not intended to be read linearly from beginning to end, nor does effective use require familiarity with every section.

Readers new to the Infrastructure Quality framework may begin with the **Foreword** and **Sections 1 and 2**, which explain the purpose, scope, structure, and conceptual foundations of the Standard.

Section 3 contains the **normative Core requirements**, expressed through invariant Quality Factors and Indicators. These define what infrastructure quality means and apply across lifecycle stages and contexts.

Sections 4 through 7 explain how the Core Indicators are applied in practice, including infrastructure boundary definition, determination and use of Context Guides, lifecycle applicability of quality claims, and the content and interpretation of Quality Claim Statements. These sections are essential for readers involved in assessment, assurance, review, or communication of infrastructure quality.

Section 8 summarizes the key principles that guide interpretation of the Core Standard.

Annexes A and B are informative and provide illustrative examples and clarification of Context Guide use. They do not introduce additional requirements.

This Standard does **not** prescribe methods, procedures, management systems, or certification schemes. It defines infrastructure quality in terms of outcomes and conditions to be demonstrated, leaving the means of achievement to the responsible parties.

The term ‘shall’ in this Standard applies to the required condition of infrastructure quality, not to prescribed actions by organizations.

A plain-language explanation of the Infrastructure Quality framework, the role of this Core Standard within the IQI document set, and guidance on navigating the documents is provided in **“How to Read the Infrastructure Quality Standard — Core (IQI_RIQ1)”**.

Table of Contents

This edition remains the Core Standard. It does not add engineering design requirements, inspection thresholds, certification requirements, audit methods, or context-specific Quality Outcome Criteria. The 14 Core Quality Factors and their Indicators remain invariant.
The principal updates are: alignment with the terms Infrastructure Quality Object, Quality State, Quality Determination, Evidence Sufficiency, Reference Layer, Boundary Transparency, Critical Condition, Absence of Observed Failure, and Quality Claim Boundary; stronger distinction between evidence, data, documentation, compliance, conformity, and quality; stronger boundary and lifecycle language for Quality Claim Statements; and clearer treatment of Context Guides as context-specific interpretation documents that do not create new Core Quality Factors or Core Indicators. This controlled update also clarifies jurisdiction-invariant early lifecycle application and the role of technology and planning documents as supports for, not substitutes for, quality determination.
This Second Draft Edition is a controlled alignment update. It preserves the Core Quality Factors and Indicators developed in the January/May 2026 draft, while aligning IQI_IQC1 with IQI_VOC1 Second Draft Edition and with the interpretive logic demonstrated in IQI Context Guides MNT1 and LDN1.

1. Scope and Purpose

1.1 Scope

This Infrastructure Quality Core Standard applies to energy infrastructure assets and systems, including infrastructure for energy production, processing, transport, storage, and delivery.

The Standard applies at the level of the assembled infrastructure asset and, where applicable, the system of systems in which that asset operates.

This Standard defines infrastructure quality as an **asset/system outcome condition**. It does not define requirements for an organization's quality management system, management structure, governance model, audit program, certification scheme, or operating procedures.

It applies across the infrastructure lifecycle, including concept and functional definition, design and specification, construction and realization, commissioning and pre-start, operation and maintenance, modification, life extension, repurposing, and decommissioning.

This Standard does not prescribe:

- engineering methods or design solutions;
- construction or operational procedures;
- organizational roles, staffing models, or governance structures;
- quality management systems;
- audit programs or certification schemes;
- regulatory or compliance mechanisms.

1.2 Purpose

The purpose of this Core Standard is to define what infrastructure quality means for energy infrastructure in a clear, consistent, and outcome-focused manner.

Specifically, this Standard:

- defines invariant Quality Factors and Indicators for assessing infrastructure quality;
- focuses on the condition, behavior, and lifecycle performance of the assembled asset/system;
- supports transparent, bounded quality claims;
- helps stakeholders distinguish infrastructure-quality outcomes from organizational management processes.

This Standard is not intended to determine whether an organization has an adequate quality management system. It is intended to determine whether the infrastructure asset/system demonstrates the quality outcomes required within a defined boundary and lifecycle stage.

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2. Document Structure and Infrastructure Quality Framework

2.0 Interpretive Note — Asset/System Standard, Not QMS

This Standard shall be interpreted as an infrastructure asset/system outcome standard. Requirements in this Standard apply to the demonstrated quality condition of the infrastructure asset or system-of-systems. They shall not be interpreted as requirements to establish, maintain, certify, or audit an organizational quality management system.

Where this Standard refers to assessment, evaluation, determination, evidence, documentation, competence, monitoring, or conformity, such terms are used solely to support understanding and characterization of infrastructure condition and behavior. They shall not be interpreted as prescribing management-system elements, procedures, organizational structures, audit frameworks, or certification activities, unless explicitly associated with conformity assessment under Factor 3.

Documentation and evidence referenced in this Standard serve to demonstrate infrastructure quality conditions. They shall not be interpreted as requirements for document control systems, administrative processes, or formal record-keeping structures.

2.1 Document Structure and Status

This Infrastructure Quality Core Standard is a **normative document** within the Infrastructure Quality Initiative (IQI) document set and shall be interpreted consistently with the **Infrastructure Quality Vocabulary Standard (IQI_VOC1)**.

The IQI document set consists of:

- this **Core Standard**, defining invariant Quality Factors and Indicators;
- **Foundational Guidance**, providing explanatory and educational material;
- **Context Guides**, providing context-specific interpretation where justified;
- **Informative Annexes**, illustrating application without introducing requirements.

Only the Core Standard defines **normative definitions of infrastructure quality conditions.** These requirements define the *state of infrastructure quality*, not organizational obligations. All other documents are informative unless explicitly stated otherwise.

2.2 Infrastructure Work, Outputs, and Outcomes

For clarity, this Standard distinguishes between:

- **Infrastructure work** — activities performed to conceive, design, realize, operate, modify, or retire infrastructure;
- **Infrastructure outputs** — tangible or documented results of infrastructure work;
- **Infrastructure outcomes** — the **results produced by infrastructure work**, expressed through the observed behavior and performance of the assembled infrastructure asset over time.

This Core Standard is concerned primarily with **infrastructure outcomes**, as defined in IQI_VOC1. Infrastructure work and outputs are relevant only insofar as they explain or support those outcomes.

Infrastructure quality shall be interpreted as the quality state of the Infrastructure Quality Object, usually an infrastructure asset or system-of-systems, reflecting its ability to perform intended functions within defined boundaries, interfaces, lifecycle conditions, applicable criteria, acceptable risk, and evidence sufficiency.
This quality state is determined by the condition of Quality Factors and Indicators as supported by sufficient, relevant, current, traceable, and bounded evidence. It is not established by completion of activities, existence of processes, presence of management systems, documentation volume, data volume, compliance status, component conformity, or absence of observed failure alone.

2.3 Infrastructure Functions and Lifecycle Realization

Infrastructure **functions** describe the intended system-level purpose of the infrastructure asset. Functions are realized progressively through infrastructure work and are reflected in infrastructure outcomes.

Functions are:

- defined at the asset or system level;
- independent of specific methods or tasks;
- realized across lifecycle stages rather than at a single point in time.

2.4 Quality Factors, Indicators, and Claims

Infrastructure quality is defined in this Standard through a set of invariant **Quality Factors**, each expressed through one or more **Indicators**.

Quality Factors and Indicators:

- apply across energy-infrastructure contexts;
- are outcome-focused and non-prescriptive;
- are interpreted with respect to lifecycle stage and boundary definition.

Infrastructure quality is communicated through **Quality Claim Statements**, which are bounded declarations of assessed conformity. A Quality Claim Statement is **not a certification,**

approval, or endorsement, and shall be interpreted in accordance with IQI_VOC1 and Section 7 of this Standard.

2.5 Recognition of Critical Conditions

Certain Indicators represent conditions whose failure would directly permit unacceptable risk, compromise essential system function, or invalidate the basis on which infrastructure quality can be understood.

Such conditions shall be interpreted as **critical to the determination of infrastructure quality state**.

Where such conditions are not satisfied, infrastructure quality **cannot be interpreted as acceptable**, regardless of the presence of other satisfied conditions.

These conditions form the basis for the principle of **non-substitutability defined in Section 8.7**.

This Standard recognizes the existence of such conditions but does not prescribe methods for their identification, classification, or evaluation. These aspects are addressed within the broader Infrastructure Quality framework.

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3. Quality Factors and Indicators (Normative Core)

Factor 1 — Functional Specification Quality

Purpose of the Factor
To ensure that the intended functions of the infrastructure asset are explicitly defined, complete, coherent, and traceable across the lifecycle, forming a valid basis for all technical, operational, and integrity decisions.

Indicator 1.1 — Completeness of Functional Requirements

Indicator Statement

The intended functions of the infrastructure asset shall be explicitly defined, documented, and complete for all lifecycle stages within the defined system 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 concept through decommissioning and must 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 absence of unresolved ambiguity during review or change activities.

Indicator 1.3 — Explicit Treatment of Functional Boundaries and Interfaces

Indicator Statement

The functional boundaries of the infrastructure asset and its interfaces with external systems shall be explicitly defined and documented.

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- failure. level

Scope and Boundaries

Includes physical, functional, informational, and organizational interfaces relevant to function realization.
Excludes detailed interface design, which is addressed under technical and interface-specific Factors.

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 uncertainties that materially affect functional performance.
Excludes selection of mitigation measures, which are addressed under later Factors.

Lifecycle Coverage

Applies at all lifecycle stages and must 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 definition through realization, operation, modification, and decommissioning.

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 operating conditions.
Excludes verification methods, which are addressed under conformity and assurance-related Factors.

Lifecycle Coverage

Applies continuously and is especially critical during modification, life-extension, and 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, asset modification, or repurposing.
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 modification, life extension, and decommissioning 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, verifiable technical definitions that remain valid across the infrastructure lifecycle.

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 procurement, construction, or inspection practices, which are addressed under later Factors.

Lifecycle Coverage

Applies from initial specification development through modification and life extension, and must 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 must 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 must 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 must 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 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

Conformity assessment in this Standard refers exclusively to the evaluation of infrastructure outcomes and conditions at the asset or system level. It does not refer to, and shall not be interpreted as, organizational audit, certification, or management-system verification activities. Assessment activities referenced in this Factor exist only to support determination of infrastructure quality conditions and shall not be interpreted as a prescribed assurance, audit, or certification system.

Purpose of the Factor
To ensure that the condition of infrastructure, and its alignment with functional intent and technical requirements, is sufficiently understood and demonstrated such that claims of conformity reflect actual infrastructure behavior rather than assumption or unverified assertion.

Indicators in this Factor define the conditions under which conformity of infrastructure is considered demonstrable. They do not prescribe assessment methods, organizational responsibilities, or assurance structures.

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 claims 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 claims and applicable functional and technical requirements.

Indicator 3.2 — Assessment of Conformity to Technical Specifications

Indicator Statement

Conformity of **design outputs 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 outputs, 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, modification, and decommissioning**, 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, 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 Findings

Indicator Statement

Identified non-conformities and unresolved assessment findings 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 claims.

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 Claims

Indicator Statement

Conformity claims 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 claims, 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 infrastructure maintains its ability to perform required functions safely and reliably over time, considering degradation, damage, aging, interaction effects, and foreseeable abnormal conditions across the full lifecycle of the integrated asset.

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

Indicator Statement

Functions whose loss or degradation would compromise safety, reliability, or infrastructure outcomes 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, modification, life extension, and decommissioning.

Evidence Principle

Evidence may include documented identification of integrity-critical functions, failure modes, and their relationship to required infrastructure outcomes.

Indicator 4.2 — Integrity of the Integrated Asset

Indicator Statement

Structural and functional integrity shall be evaluated and demonstrated for the **integrated infrastructure asset**, not solely for individual components or 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 integrated asset behavior.

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, modification, and end-of-life 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 at design, commissioning, operation, and modification stages.

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 modifications, uprating, life extension, repurposing, and temporary 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 must 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, materials, and processes associated with infrastructure are identified, understood, and controlled so that risks are reduced to levels that are not unacceptable, including prevention of low-probability, high-consequence events and cascading infrastructure failures.

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, modification, and decommissioning.

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 effects with high-consequence 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 at design, commissioning, operation, modification, and life-extension stages.

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 prevention of defined 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 infrastructure quality incorporates environmental protection as an intrinsic obligation, addressing emissions, discharges, releases, and long-term environmental interactions arising from infrastructure behavior across the full lifecycle.

Environmental protection in this Standard is treated as an **infrastructure outcome**: infrastructure shall prevent or limit environmental harm under expected operating conditions and foreseeable abnormal or degraded conditions.

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, modification, and decommissioning.

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 at design, operation, modification, and abnormal condition stages.

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 at design, commissioning, operation, and modification stages.

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 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 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 infrastructure performs its intended functions consistently and predictably under expected operating conditions, while remaining resilient to disturbances, variability, and foreseeable disruptions across the lifecycle.

Indicator 7.1 — Definition of Reliability-Critical Functions

Indicator Statement

Functions whose loss, degradation, or interruption would materially affect intended infrastructure outcomes 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, modification, and decommissioning planning.

Evidence Principle

Evidence may include documented identification of reliability-critical functions and their relationship to infrastructure outcomes.

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 or emergency conditions, which are addressed under other Factors.

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, 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 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 modifications, 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 how human interaction with infrastructure **at the workplace** affects safety and system behavior across the lifecycle, including how infrastructure design, condition, interfaces, and operating context influence human performance, error, and exposure to harm.

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.

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, modification, and decommissioning.

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 at design, operation, and modification stages.

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 at design, commissioning, operation, and modification stages.

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 at design and during 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 individuals whose decisions, actions, or omissions can affect infrastructure outcomes possess and maintain competence appropriate to their roles, responsibilities, and the lifecycle stage of the infrastructure, including the ability to exercise judgment under normal, abnormal, and degraded conditions.

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 to conditions under which infrastructure outcomes depend on human competence and shall not be interpreted as prescribing personnel management, training systems, or qualification frameworks.

Indicator 9.1 — Identification of Infrastructure-Critical Roles

Indicator Statement

Roles whose decisions, actions, or omissions can materially affect infrastructure safety, integrity, reliability, or environmental outcomes shall be explicitly identified.

Intent

To ensure that competence expectations are focused on roles that genuinely influence infrastructure outcomes, 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 infrastructure outcomes.

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, 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 infrastructure outcomes.

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, aging infrastructure, 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 infrastructure outcomes and such recognition shall not be interpreted as a requirement for formal competency management systems or performance management processes.

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 infrastructure outcomes 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 infrastructure conforms to applicable laws, regulations, permits, and recognized standards across its lifecycle, and that such obligations are explicitly identified, understood, and fulfilled in a manner consistent with functional intent, technical specifications, and lifecycle accountability.

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

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 concept and design through operation, modification, and decommissioning.

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 claims for broader quality evidence.

Lifecycle Coverage

Applies during construction, commissioning, operation, modification, and decommissioning, 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 modification, repurposing, or evolving regulatory frameworks.

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 safety, integrity, or acceptability of infrastructure outcomes.

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 Claims

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 claims that obscure scope limitations or lifecycle relevance.

Scope and Boundaries

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

Lifecycle Coverage

Applies whenever compliance claims 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 accounts for impacts on stakeholders and communities arising from infrastructure behavior across its lifecycle, including effects on safety, environment, accessibility, reliability, and trust.

Stakeholder and community satisfaction reflects whether infrastructure outcomes align with declared commitments, societal expectations, and observed effects on people and communities affected by the infrastructure.

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 concept and design through operation, modification, and decommissioning.

Evidence Principle

Evidence may include documented identification of affected stakeholders and communities and their relationship to 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 outcomes affecting stakeholders and communities shall be consistent with declared commitments, obligations, and stated expectations.

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 commitments and demonstrated alignment between those commitments and observed 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 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 infrastructure behavior and outcomes are observed, evaluated, and understood so that degradation, deviation, and emerging risk are detected in time to prevent unacceptable consequences.

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.

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, modification, and decommissioning.

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 Outcomes

Indicator Statement

Observed infrastructure behavior shall be interpreted in relation to intended functional outcomes such that deviations, degradation, or loss of function 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 and declared outcome expectations.
Excludes determination of conformity, 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 intended functional outcomes, including identification of deviation, degradation, or loss of function.

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, assessments, and changes affecting

infrastructure quality are documented and traceable across the infrastructure lifecycle, enabling understanding of *why* the infrastructure is configured as it is, *how* decisions were made, and *what assumptions and uncertainties* underpin current operation.

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.

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 concept through design, operation, modification, and decommissioning.

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 must be preserved during change, 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 must 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 Claims

Indicator Statement

Assessments, evaluations, and conformity claims 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 infrastructure is modified, repurposed, or life-extended.

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 records that mask poor 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 infrastructure can accommodate change, innovation, and evolving requirements without compromising safety, integrity, reliability, environmental protection, or stakeholder outcomes.

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 innovations shall be interpreted as means of supporting the defined infrastructure quality state, not as substitutes for quality determination, evidence sufficiency, lifecycle validation, or bounded Quality Claim Statements.

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, 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 and System Boundaries

Indicator Statement

Adaptation and innovation shall remain compatible with the infrastructure’s functional intent and defined system 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 modification, repurposing, and life-extension activities.

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 modification and innovation deployment.

Evidence Principle

Evidence may include documented consideration of reversibility or recovery options.

Indicator 14.6 — Learning from Adaptation and Innovation Outcomes

Indicator Statement

Outcomes of 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 outcomes and retained lessons relevant to future adaptation.

Indicator 14.7 — Retention of Adaptation and Innovation Knowledge

Indicator Statement

Information necessary to understand adaptation decisions, assumptions, outcomes, 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.

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4. Infrastructure Boundaries and Context Guide Determination

4.1 Purpose of Context Guides

The Quality Factors and Indicators defined in this Core Standard are **invariant** and apply across infrastructure types, sectors, and lifecycle stages. They express *what must be true* for infrastructure quality, independent of technology, geography, or regulatory regime.

However, infrastructure assets differ materially in physical regime, dominant risk mechanisms, system topology, interfaces, and regulatory anchoring. In certain circumstances, applying the Core Indicators without additional contextual clarification would risk **misleading interpretation of infrastructure outcomes**.

Context Guides exist to address this need.

Context Guides:

- do **not** introduce new Quality Factors or Indicators;
- do **not** modify the meaning or intent of the Core Indicators;
- provide **context-specific outcome criteria, boundary clarification, and illustrative evidence considerations**where the Core alone is insufficient to convey infrastructure behavior or risk.

Not all infrastructure requires a Context Guide. Context Guides are created **only when justified** by the determination logic defined in this section.

4.2 Infrastructure Boundary Definition

Application of the Core Standard requires an explicit definition of the **infrastructure boundary** under consideration.

For the purposes of this Standard:

- An infrastructure asset is a **capital construction object** that performs defined functions and exhibits system-level behavior over time.
- Infrastructure quality must be evaluated at the level where **emergent behavior** arises, not solely at the level of individual components or products.

Boundary definition shall consider, as applicable:

- the physical extent of the asset;
- functional scope and interfaces;
- interaction with upstream and downstream systems;

- lifecycle stage(s) under consideration (design, construction, commissioning, operation, modification, decommissioning).

Where infrastructure operates as part of a **system of systems**, boundary definition shall explicitly state which interfaces and interdependencies are included in the quality claim and which are excluded.

Clear boundary definition is a prerequisite for determining whether application of the Core Indicators alone is sufficient or whether a Context Guide is required.

4.3 When a Context Guide Is Required

A Context Guide shall be developed or applied when **one or more of the following conditions** are present and materially affect interpretation of infrastructure quality outcomes:

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 infrastructure obligations, assumptions, or outcome interpretation.

Outcome Test

A Context Guide is required when application of the Core Indicators **without context-specific clarification** would reasonably risk **misrepresenting infrastructure performance, safety, integrity, environmental protection, or stakeholder impact**.

The presence of complexity alone does not justify a Context Guide. The test is **interpretive sufficiency**, not asset uniqueness.

4.4 What a Context Guide Is — and Is Not

A Context Guide may interpret Core Indicators through context-specific boundaries, interfaces, lifecycle conditions, critical conditions, Reference Layer anchors, evidence limitations, and Quality Claim boundaries. It does not create new Core Factors or Core 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;
- describe context-specific outcome considerations relevant to Core Indicators;
- provide illustrative examples of evidence appropriate to that context;
- highlight dominant assumptions, uncertainties, or sensitivities.

A Context Guide **shall not**:

- introduce new Quality Factors or Indicators;
- redefine or weaken Core Indicator intent;
- prescribe methods, procedures, technologies, or management systems;
- substitute regulatory compliance for infrastructure quality assessment.

Context Guides are **informative extensions** governed by the Core Standard. Claims of infrastructure quality shall always reference the Core Indicators and shall identify any Context Guide relied upon.

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5. Application of the Core Standard

5.1 How to Read and Apply the Core Indicators

The Quality Factors and Indicators defined in this Core Standard describe **conditions and outcomes** that shall be demonstrated for infrastructure quality. They do not prescribe methods for applying Indicators, processes, technologies, organizational structures, or management systems.

Each Indicator is composed of:

- an **Indicator Statement**, defining the required condition or outcome;
- 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 nature of acceptable supporting evidence.

Application of an Indicator requires consideration of all of these elements together. Reliance on the Indicator Statement alone, without regard to intent or boundaries, may result in incomplete or misleading interpretation.

Indicators shall be applied:

- within the explicitly defined infrastructure boundary (see Section 4.2);
- at the stated lifecycle stage(s);
- in a manner consistent with the declared scope of the quality claim.

5.2 Evidence Principle

Evidence shall be interpreted using the VOC1 concept of evidence sufficiency: evidence should be adequate, relevant, traceable, current, and bounded enough to support the declared Infrastructure Quality Object, lifecycle condition, Indicator, Quality Outcome Criterion, and 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 conditions, and claim boundaries.

Determination and communication of infrastructure quality shall be based on **evidence of infrastructure outcomes, behavior, condition, or performance** within the defined boundary and lifecycle stage.

Evidence shall:

- relate to **observed, demonstrated, or otherwise supportable characteristics** of the infrastructure asset or system;
- reflect the **realized state of the infrastructure**, not the intended, designed, or assumed state;
- be sufficient to support interpretation of infrastructure quality in relation to applicable Indicators.

Evidence shall **not be substituted** by:

- the existence of procedures, programs, or management systems;
- statements of intent, compliance, or design adequacy;
- documentation that does not demonstrate infrastructure behavior or condition.

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 support, describe, or contextualize evidence, but shall not be interpreted as evidence of infrastructure quality unless it demonstrates or substantiates infrastructure outcomes, behavior, condition, or performance.

The existence, completeness, or correctness of documentation shall not be treated as a substitute for evidence of actual infrastructure quality.

5.4 Application Across Lifecycle Stages

The Core Standard applies across the full infrastructure lifecycle, including:

- concept and functional definition;
- design and specification;
- construction and realization;
- commissioning and pre-start;
- operation and maintenance;
- modification, life extension, and decommissioning.

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.

Claims of infrastructure quality shall always identify the lifecycle stage(s) to which they apply.

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 the 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 investment-justification and planning instruments. The Core question is not the document title, but whether the early lifecycle record makes visible the Infrastructure Quality Object, intended functions, boundaries, interfaces, critical conditions, uncertainty, evidence needs, lifecycle controls, technology implications, and Quality Claim Boundary early enough to support responsible design, realization, operation, modification, and later lifecycle claims. Where budget, funding, or technology-selection information appears in such documents, it is interpreted under this Standard as context, support, or constraint for quality determination, not as a substitute for evidence sufficiency or for the 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 infrastructure boundaries, interfaces, or dominant risk mechanisms;
- interpret Core Indicators in a context-appropriate manner;
- inform selection and interpretation of evidence.

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

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6. Lifecycle Applicability of Quality Claims

6.1 General Principle

Infrastructure quality is realized progressively across the lifecycle.
Accordingly, **quality claims shall be explicitly tied to the lifecycle stage(s)** at which the assessment is made.

A quality claim:

- applies **only** to the lifecycle stage(s) explicitly stated;
- shall not be inferred to apply to later or earlier stages without reassessment;
- shall reflect the information, evidence, and uncertainty appropriate to that stage.

Absence of failure at a given lifecycle stage shall not be interpreted as evidence of quality at subsequent stages.

6.2 Design-Stage Quality Claims

Design-stage quality claims relate to the **definition and specification of intended infrastructure behavior**, not to realized performance.

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 claims **do not demonstrate**:

- construction quality;
- as-built condition;

- operational performance;
- long-term integrity or reliability.

6.3 Construction and Realization-Stage Quality Claims

Construction-stage quality claims relate to the **realization of specified requirements**, including conformity of the constructed asset to approved 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 claims **do not demonstrate**:

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

6.4 Commissioning and Pre-Start Quality Claims

Commissioning-stage quality claims relate to the **initial demonstration of functional readiness** under controlled or limited conditions.

Such claims may address:

- verification of functional behavior;
- initial confirmation of safety and protection provisions;
- readiness to transition to operation.

Commissioning-stage claims **do not demonstrate**:

- long-term operational performance;
- resilience under degraded or abnormal conditions;
- performance over time.

6.5 Operational-Stage Quality Claims

Operational-stage quality claims relate to **observed infrastructure behavior during use**, including performance, degradation, and interaction with its environment.

Such claims may address:

- operational reliability and availability;
- integrity over time;
- effectiveness of environmental protection;
- workplace interaction and safety outcomes;
- stakeholder and community impact.

Operational-stage claims shall consider:

- accumulated degradation;
- changes in operating context;
- monitoring information and trends.

6.6 Modification, Life-Extension, and Repurposing Claims

Claims made following modification, life-extension, or repurposing shall:

- explicitly identify what has changed;
- state which lifecycle assumptions are no longer valid;
- define the scope of reassessment performed.

Such claims **do not inherit validity** from earlier lifecycle claims without explicit reassessment against the Core Indicators.

6.7 Decommissioning-Stage Quality Claims

Decommissioning-stage quality 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 operational quality claims and shall be assessed accordingly.

6.8 Prohibition of Implied or Rolling Claims

A quality claim shall not silently roll forward from one lifecycle condition to another unless the evidence basis, assumptions, limitations, unresolved conditions, interfaces, and Quality Claim Boundary continue to support the claim.

Quality claims 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 quality claim shall stand on its **explicit lifecycle scope and evidence basis**.

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7. Quality Claim Statements and Conformity

7.1 Purpose of a Quality Claim Statement

A Quality Claim Statement provides a **bounded, evidence-based declaration** of the infrastructure quality condition for a defined asset, boundary, and lifecycle stage.

A Quality Claim Statement shall:

- reflect the **demonstrated condition of the infrastructure**, not intended or assumed condition;
- be based on **evidence as defined in Section 5.2**;
- be interpreted in accordance with **Section 8.6 (Evidence Over Assertion)**.

A Quality Claim Statement is not a certification, approval, or endorsement.

A Quality Claim Statement shall be based on evidence as defined in Section 5.2 and shall be interpreted in accordance with Section 8.6 (Evidence Over Assertion).
It shall reflect the demonstrated condition of the infrastructure, not an intended, assumed, or inferred condition.

Quality claims shall be interpreted in light of the principle of alignment described in Section 8.9.

7.2 Required Content of a Quality Claim Statement

A Quality Claim Statement shall identify the Infrastructure Quality Object, physical and functional boundary, lifecycle condition, applicable Core Standard edition, applicable Context Guide if used, assessed Factors and Indicators, evidence basis, included and excluded interfaces, Reference Layer anchors, assumptions, limitations, unresolved conditions, known evidence gaps, and temporal validity of the claim.

Each Quality Claim Statement shall include, at a minimum, the following elements.

a) Identification of the Infrastructure Asset

– name or identifier of the infrastructure asset or system
– description sufficient to distinguish the asset and its function

b) Infrastructure Boundary Definition

– physical and functional boundaries assessed
– interfaces and interdependencies included or excluded
– reference to boundary definition per Section 4

c) Lifecycle Stage(s) Covered

– explicit identification of the lifecycle stage(s) to which the claim applies
– confirmation that no other lifecycle stages are implied (see Section 6)

d) Applicable Core Standard Edition

– reference to the edition/version of the Infrastructure Quality Core Standard applied

e) Quality Factors and Indicators Assessed

– identification of the Quality Factors and Indicators included in the assessment
– identification of any Indicators not assessed, with explanation

f) Basis of Conformity Assessment

– description of the basis on which conformity was determined
– reference to assessments, evaluations, or evidence considered
– alignment with Factor 3 (Conformity Assessment)

g) Use of Context Guides (if applicable)

– identification of any Context Guide relied upon
– confirmation that Core Indicators remain authoritative

h) Assumptions, Limitations, and Uncertainties

– explicit statement of material assumptions
– known limitations of the assessment
– uncertainties affecting interpretation of quality outcomes

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) Basis of Evidence

– description of the nature, scope, and sufficiency of evidence supporting the claim
– identification of key evidence limitations, gaps, or uncertainties
– indication of how evidence relates to observed infrastructure outcomes, behavior, condition, or performance.

7.3 Interpretation of Conformity

Conformity stated in a Quality Claim shall be interpreted as a **bounded conclusion supported by available evidence**, not as absolute or unconditional assurance.

Conformity:

- shall be based on **evidence of infrastructure outcomes, behavior, condition, or performance**, as defined in Section 5.2;
- shall not be inferred from:
    - documentation alone,
    - statements of compliance,
    - design intent,
    - or absence of observed failure;
- shall be interpreted in light of:
    - identified assumptions,
    - limitations,
    - uncertainties,
    - and completeness of evidence.

Where evidence is limited, incomplete, or uncertain, the degree of conformity shall be interpreted accordingly and shall not be overstated.

Conformity shall not be inferred from documentation alone, statements of compliance, design intent, or absence of observed failure. Where evidence is absent, incomplete, or uncertain, infrastructure quality shall be interpreted accordingly and shall not be assumed.

7.4 Prohibition of Misleading or Implied Claims

Quality Claims shall not:

- imply a level of certainty or completeness not supported by evidence;
- extend beyond the defined boundary, lifecycle stage, or assessed Indicators;
- rely on assertion, implication, or omission of relevant limitations;
- present documentation, compliance status, or procedural completeness as evidence of infrastructure quality;
- interpret absence of contradictory evidence as evidence of adequacy;
- present documentation, procedural completeness, or compliance status as evidence of infrastructure quality.

Claims that do not meet these conditions shall be considered invalid representations of infrastructure quality.

7.5 Relationship Between Conformity and Ongoing Infrastructure Quality

Conformity expressed in a Quality Claim Statement reflects the **infrastructure condition within the defined boundary and lifecycle stage at the time of assessment**, based on the evidence available.

Infrastructure quality shall not be assumed to remain valid where:

- conditions change,
- new information becomes available,
- degradation, modification, or external influences affect infrastructure behavior,
- or previously unrecognized uncertainties emerge.

Ongoing interpretation of infrastructure quality shall remain dependent on the continued availability, relevance, and sufficiency of evidence, as defined in Section 5.2.

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8. Key Principles of Infrastructure Quality

8.1 Infrastructure Quality as an Outcome

Infrastructure quality is defined by **what the infrastructure achieves and how it behaves**, not by the activities performed, documents produced, or systems implemented.

Quality exists when infrastructure outcomes are consistent with:

- declared functional intent;
- acceptable levels of safety, integrity, reliability, and environmental protection;
- transparent treatment of uncertainty and limitation.

8.2 Safety as Freedom from Unacceptable Risk

Safety is an integral component of infrastructure quality and is understood as **freedom from unacceptable risk**.

This includes:

- risk to people, the environment, and communities;
- risks arising from normal, abnormal, and degraded conditions;
- risks resulting from interactions among components, systems, and human activity.

Safety is not demonstrated by the absence of incidents alone.

8.3 System-Level Behavior Over Component Compliance

Infrastructure functions as a **system of systems**.

Conformity of individual components or products does not, by itself, assure infrastructure quality. Quality must be demonstrated at the **asset and system level**, where emergent behavior, interaction, and dependency determine outcomes.

8.4 Lifecycle Realization of Quality

Infrastructure quality is realized **progressively across the lifecycle**.

Decisions made at early stages shape outcomes at later stages. Quality claims are therefore meaningful only when bounded by explicit lifecycle stage, scope, and evidence.

No single lifecycle stage can assure quality for all others.

8.5 Transparency of Assumptions, Limitations, and Uncertainty

Infrastructure quality requires **explicit acknowledgment** of assumptions, limitations, and uncertainty.

Concealed uncertainty or implied completeness undermines quality more than acknowledged limitation. Transparency enables informed decision-making, accountability, and trust.

8.6 Evidence Over Assertion

Evidence is sufficient only when it is adequate, relevant, traceable, current, and bounded enough to support the declared claim. Data, records, documentation, compliance statements, and observed operation become quality evidence only when connected to the declared object, boundary, Indicator, Outcome Criterion, lifecycle condition, and Quality Claim Statement. Absence of observed failure is not a substitute for evidence sufficiency.

Interpretation of infrastructure quality shall be based on **evidence as defined 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 a determination of infrastructure quality unless supported by relevant evidence of infrastructure outcomes, behavior, condition, or performance.

Where evidence is absent, incomplete, or uncertain, infrastructure quality shall be interpreted accordingly and shall not be assumed or inferred.

The absence of contradictory evidence shall not be interpreted as evidence of adequacy.

8.7 Non-Substitutability of Critical Conditions

Critical conditions may arise from function, integrity, safety, environment, reliability, human interaction, competence, compliance, stakeholder/community effects, monitoring, documentation, lifecycle transition, or adaptability. They are not limited to a fixed list of critical components.

Conditions identified as **critical under Section 2.5** shall be treated as non-substitutable in the interpretation of infrastructure quality.

Failure to satisfy such conditions **cannot be offset, balanced, or compensated** by the satisfaction of other Indicators.

Infrastructure quality shall therefore not be interpreted as acceptable where one or more critical conditions are not satisfied, regardless of overall Indicator coverage or apparent system performance.

8.8 Context Without Fragmentation

Context matters, but infrastructure quality principles remain **invariant**.

Context Guides may clarify interpretation, but they do not fragment the Core Standard. All infrastructure quality assessments remain anchored to the same Quality Factors and Indicators.

8.9 Loss of Alignment as a Primary Failure Mechanism

Infrastructure quality failure often arises not from the absence of compliance, documentation, or individual control measures, but from progressive loss of alignment between observed infrastructure behavior, underlying assumptions, human interaction, and evolving operating conditions over time.

Such loss of alignment may occur gradually and may not be visible through isolated indicators, documentation, or nominal conformity. It frequently manifests where assumptions are no longer valid, where monitoring does not reveal emerging degradation, where human interaction is misaligned with actual system behavior, or where operating conditions evolve beyond those originally considered.

Accordingly, infrastructure quality shall be interpreted not only through the presence of defined conditions, but through continued alignment between behavior, assumptions, human interaction, and context across the lifecycle. Failure to maintain such alignment may invalidate otherwise satisfactory individual Indicators and shall be considered a potential indicator of systemic quality failure.

Section 8 — Closing Statement

These principles summarize the intent and application of the Infrastructure Quality Core Standard. They are not additional requirements, but interpretive anchors that guide consistent, transparent, and responsible use of the Core across infrastructure types, sectors, and lifecycle stages.

Annex A (Informative)

Illustrative Examples of Applying the Infrastructure Quality Core Standard

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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:

- definition of the **infrastructure boundary**;
- identification of **relevant Quality Factors and Indicators**;
- the **lifecycle stage** at which the claim is made;
- how **evidence, assumptions, and limitations** may be expressed;
- when a **Context Guide** may or may not be required.

Examples are deliberately simplified and do not represent complete assessments.

A.3 Example 1 — Design-Stage Infrastructure Quality Claim

Context

A new onshore energy transmission asset at the design stage.

Boundary Definition

- Asset boundary: transmission line and associated fixed facilities
- Interfaces: upstream supply interface, downstream distribution interface
- 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.

Quality Claim Characteristics

- Explicit statement that no construction or operational performance 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 Indicators are sufficient to interpret design intent and assumptions.

A.4 Example 2 — Operational-Stage Quality Claim for Existing Infrastructure

Context

An existing, operating infrastructure asset in continuous service.

Boundary Definition

- Asset boundary: operating facility and on-site systems
- Interfaces: workforce interaction points, environmental discharge interfaces
- 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)

Quality Claim Characteristics

- Use of monitoring trends as evidence of observed behavior
- 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 — Modification or Life-Extension Claim

Context

Modification of an existing infrastructure asset to extend service life.

Boundary Definition

- Asset boundary: modified subsystems plus affected interfaces
- Lifecycle stage: modification and post-modification 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

Quality Claim Characteristics

- Clear statement of what prior claims no longer apply
- Identification of newly introduced uncertainties
- Limited scope claim focused on modified elements

Context Guide Determination

- Context Guide required where modification changes dominant risk mechanisms or system topology.

A.6 Example 4 — Context Guide Application

Context

Infrastructure operating in a physical or regulatory regime that materially alters outcome interpretation.

Application Highlights

- Core Indicators remain authoritative
- Context Guide used to:
  - clarify boundary interpretation
  - identify context-specific outcome considerations
  - illustrate evidence relevance

Key Point

The Quality Claim 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;
- imply required documentation;
- suggest certification or approval pathways.

Their sole purpose is to **illustrate interpretation**, not execution.

Annex A — Closing Note

This Annex supports consistent understanding of the Infrastructure Quality Core Standard across diverse infrastructure contexts. It reinforces the principle that quality is demonstrated

through **bounded, transparent, lifecycle-specific claims**, supported by relevant evidence and explicit acknowledgment of limitations.

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 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 **subordinate, informative documents** governed by the Infrastructure Quality Core Standard.

They exist to:

- support interpretation of the Core Indicators in specific 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;
- have no authority independent of the Core Indicators.

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** defines *what infrastructure quality means* through invariant Quality Factors and Indicators.
- **Context Guides** clarify *how those same Indicators are interpreted* in particular infrastructure contexts.

All infrastructure quality claims 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, system topology, interfaces, or regulatory anchoring materially affect outcome interpretation;
- application of the Core Indicators alone would risk misunderstanding infrastructure behavior or quality outcomes.

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 infrastructure boundaries and interfaces relevant to the context;
- explanation of dominant risk mechanisms affecting outcome interpretation;
- context-specific outcome considerations aligned with Core Indicators;
- illustrative examples of evidence relevant to the context;
- discussion of common assumptions, uncertainties, 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 new Quality Factors or Indicators;
- alter the intent or meaning of Core Indicators;
- prescribe methods, procedures, tools, or technologies;
- function as a management, compliance, or certification scheme;
- establish performance thresholds or acceptance criteria.

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 Quality Claims

Where a Context Guide is used, the Quality Claim Statement shall:

- identify the Context Guide by title and edition;
- state the purpose for which it was used;
- confirm that conformity is claimed against the Core Indicators, not against the Context Guide itself.

Reliance on a Context Guide shall not be used to imply broader scope, completeness, or higher assurance than is supported by the Core assessment.

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** invalidate prior quality claims unless explicitly stated;
- shall be transparent as to scope, assumptions, and applicability.

Annex B — 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 **infrastructure quality remains defined by the Core**, and that context serves interpretation—not authority.

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