



# **FROM PRODUCTS AND SERVICES TO INFRASTRUCTURE QUALITY**

**Connecting Infrastructure Quality with Products and Services**

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# ABSTRACT

Infrastructure depends on products and services from many organizations. Their Quality affects what the whole infrastructure can achieve. What is required from each contribution depends on its intended use and the conditions in which it will be used. This relationship applies to energy systems, buildings, bridges, water networks, and data centers.

This article explains how quality management for the infrastructure connects with quality management by product and service providers. The connection starts with the infrastructure's intended use and operating conditions. Available products, services, regulations, codes, and standards also influence how the infrastructure is designed and realized.

The main question is how requirements for the infrastructure as a whole become requirements for the products and services used within it. An applicable product or service standard can provide a common framework. The infrastructure then supplies the selections, values, conditions, or other data needed for the particular use. These requirements are allocated and, where needed, transferred to the provider and its Management System.

Two detailed energy examples show how this works: a gas transmission pipeline using API 5L line pipe and an offshore hydrocarbon production zone using an API 2C crane. Brief examples from other infrastructure types show the same relationship. Requirements, Interfaces, Work, and Results connect the infrastructure with its providers, while the Quality of each remains a distinct question.

## 1 Infrastructure and Its Products and Services

Infrastructure is created to realize Intended Functions and Intended Results under specified conditions. It depends on constituent products, services, Work, and Results provided through multiple organizations.

The quality of these constituent results can affect the quality of the infrastructure as a whole. At the same time, what is required from them depends on the particular infrastructure use and conditions.

### 1.1 Infrastructure as a Whole

The whole infrastructure must be examined in relation to what it is intended to do and achieve. Its Functional Requirements describe those Intended Functions and Intended Results and the relevant use conditions, Boundaries, and exclusions, without prescribing the technical solution.

These needs become the starting point for requirements for the products and services used in the infrastructure.

### 1.2 Products and Services

Products and services perform specific functions within the infrastructure.

A gas transmission pipeline requires line pipe; a bridge requires bearings and structural components; a building requires water and electrical systems; a water-treatment facility requires treatment equipment;

and a data center requires power and cooling systems. Infrastructure may also depend on design, construction, inspection, maintenance, and other external services.

Each product or service has its own requirements. These requirements must reflect its intended use within the particular infrastructure.

### **1.3 How Their Quality Is Connected**

The connection begins with the intended use of the infrastructure, but it does not develop in only one direction.

When infrastructure is planned and designed, available products and services, existing standards, codes, and regulatory requirements are already considered. They influence the possible design solutions and the requirements established for the infrastructure.

At the same time, the particular infrastructure and its conditions of use establish specific requirements for the products and services it needs.

Quality management must therefore connect these two levels: the infrastructure as a whole and the products and services needed to realize its intended use.

## **2 Where Requirements Come From**

Requirements for products and services are developed as the infrastructure itself is planned and designed.

They come from the intended use and conditions of the infrastructure, but also from existing regulations, codes, standards, and available technical solutions.

### **2.1 Intended Use**

The starting point is what the infrastructure is intended to do.

For a pipeline, this may include transporting gas at the required capacity and conditions. For a bridge, it may include carrying the intended traffic. For a water network, it may include delivering water at specified conditions. These functions and the associated Intended Results establish what is needed from constituent products and services.

The intended use helps determine what products and services will be needed.

### **2.2 Conditions of Use**

Requirements also depend on the actual conditions in which the infrastructure will operate.

These may include location, environment, operating conditions, expected loads, and other conditions that affect the infrastructure and its products and services.

Different conditions can therefore lead to different requirements even for the same type of infrastructure.

## **2.3 Design Requirements**

During design, the intended use and conditions are developed into technical requirements.

Designers also consider available products, technologies, services, and the standards that apply to them. These can influence the design solution itself.

Infrastructure design and available technical solutions therefore develop together rather than independently.

## **2.4 Regulations, Codes, and Standards**

The Applicable Basis identifies the requirements governing the declared object and examination. Regulations, codes, standards, contracts, and project requirements may contribute to that basis according to their applicability. A source is not binding merely because it is listed or consulted.

Some apply to the infrastructure as a whole or to particular infrastructure activities. Others apply to specific products or services.

They help shape both the infrastructure design and the requirements for the products and services used within it.

## **2.5 Requirements for Products and Services**

Through this process, the needs of the infrastructure become specific requirements for its products and services.

These requirements combine what is required by the particular infrastructure with the applicable requirements of regulations, codes, and standards.

They provide the connection between the infrastructure design and the organizations responsible for providing the required products and services.

# **3 Organizations Involved**

Infrastructure may involve owners or operators, designers, contractors, product providers, and service providers.

These functions may also be combined. An engineering, procurement, and construction contractor, for example, may perform functions otherwise divided among several organizations.

The particular arrangement determines how the work is divided and how infrastructure requirements are developed and passed to product and service providers.

## **3.1 Infrastructure Owner or Operator**

The owner or operator establishes the infrastructure and its intended use.

Some functions may be performed within the organization. Others may be assigned to designers, contractors, product providers, or service providers.

The exact division of work depends on the particular arrangement.

### **3.2 Designers and Contractors**

Designers develop infrastructure requirements within their assigned work.

Contractors may perform individual functions or combinations of functions. An engineering, procurement, and construction contractor, for example, may perform design, procurement, construction, and coordination with product and service providers.

These arrangements affect who performs particular work and how its results are passed to other organizations.

### **3.3 Product Providers**

Product providers supply products needed for the infrastructure.

They work with applicable product standards and with requirements established for the particular infrastructure use.

Their quality management must address the requirements that apply to the products they provide.

### **3.4 Service Providers**

Service providers perform services needed for the infrastructure.

Applicable standards may establish requirements for a type of service. The particular infrastructure may establish additional requirements based on its intended use and conditions.

Their quality management must address the requirements that apply to the services they provide.

### **3.5 Duties and Results**

Each participating Organization or organizational function performs defined work and is expected to achieve defined results within the applicable arrangement.

A designer may be required to develop design requirements. A contractor may be required to complete specified work. A product provider supplies a required product, and a service provider performs a required service.

These duties and expected results help establish what each participating Organization or function must achieve and form part of the basis for defining the applicable realization scope and management configuration.

The results of one Organization or function can also become requirements or inputs for the work of another. This creates material Interfaces among the participants involved in infrastructure realization.

### **3.6 Organization and Management System Boundaries**

WQI VOC1 defines an Organization as an organizational whole. Its Boundary does not have to follow the boundary of a company, subsidiary, employer, facility, or other legal or administrative unit. The

Organization relevant to a Quality Determination must be defined from the actual organizational whole being examined.

A Management System is different. Its Boundary follows the management actually used for the defined realization scope. That management may be within one Organization or may include management functions from more than one Organization. This does not make those Organizations one Organization.

This distinction matters across infrastructure types. Management of a pipeline, building, water network, data center, project, or life-cycle stage may cross organizational boundaries. In other cases, procurement or a contract connects separate Management Systems. The Boundary must follow the actual management arrangement rather than be inferred solely from the legal structure.

## **4 Quality Management of Products and Services**

Product and service providers must manage their work so that the required results are achieved.

Their quality management is based on the requirements for the product or service and on the quality management requirements that apply to the organization.

### **4.1 Product and Service Requirements**

Products and services have requirements that define what they must achieve.

Requirements may come from the particular infrastructure and its intended use, applicable regulations and other bases, and, where they exist and apply, product or service standards.

The provider must work with the complete set of applicable requirements for the product or service it provides, whether or not an independent product or service standard exists.

### **4.2 Quality Management Systems**

Management Systems direct and control realization within a defined realization scope. In industry practice, organizations may also operate Quality Management Systems under standards such as ISO 9001, API Q1, or API Q2.

For a defined product or service realization scope, the applicable Management System connects requirements with the management functions, people, resources, controls, information, and Interfaces needed to realize what is required.

Different Quality Management System standards may apply depending on the provider, the work performed, and the applicable scope. Under WQI, however, the Boundary of a Management System is established from the actual management configuration relevant to the defined realization scope and is not inferred solely from the Boundary of one Organization or legal entity.

### **4.3 ISO 9001**

ISO 9001:2026 provides general requirements for Quality Management Systems [1].

It can be used by organizations in many industries and for different types of work. It provides a general basis for managing quality but does not establish the technical requirements for a particular infrastructure product or service.

#### **4.4 API Q1 and Product Providers**

API Specification Q1, 10th Edition, provides Quality Management System requirements for organizations providing products for the petroleum and natural gas industry [2].

The product itself is governed by the applicable product requirements. API Q1 addresses how the provider manages the work needed to provide that product.

The provider therefore works with both the requirements for its Quality Management System and the requirements for the product.

#### **4.5 API Q2 and Service Providers**

API Specification Q2, 3rd Edition (2026), provides Quality Management System requirements within its defined scope for well-site service supply organizations in the petroleum and natural gas industries [3].

The service provider must manage its work according to the applicable Quality Management System requirements and the requirements for the particular service.

#### **4.6 API Monogram Program**

The API Monogram Program connects the provider's Management System with the applicable API product specification and the provider's capability to produce the product.

It provides an example of how quality management requirements for an organization can be connected with requirements for the product it provides.

This connection is important for our analysis because management of infrastructure realization must, in turn, connect with the management through which required products and services are realized.

### **5 Quality Management of Infrastructure**

Infrastructure realization requires management of the Work and Results needed for the whole infrastructure. The Quality of that management and the Quality of the infrastructure remain separate questions.

It begins with infrastructure requirements and connects the work and results of the Organizations and functions involved in realization and use.

#### **5.1 Infrastructure Requirements**

Infrastructure requirements define what the infrastructure must achieve and the conditions under which it must perform.

The IQI Infrastructure Standard — Core establishes fourteen invariant Quality Factors and eighty-three Indicators, each with a General Core Requirement. Context Guides may detail these requirements and establish context-specific Quality Outcome Criteria. Where a guide is unnecessary, criteria may be established directly under a General Core Requirement. The infrastructure's Intended Functions, conditions, and Applicable Basis connect this architecture to the requirements for particular products and services [7–8].

These requirements provide the basis for determining the requirements that must be met by its products and services.

## **5.2 Infrastructure Quality Management**

Management of infrastructure realization addresses how the requirements for the infrastructure are realized.

It must connect the work performed by different Organizations and functions with the results required from the infrastructure as a whole.

This includes ensuring that requirements developed at the infrastructure level are reflected in the work, products, and services needed to realize them.

## **5.3 Work Performed and Results Across the Lifecycle**

Different Organizations and functions may perform different work during planning, design, procurement, construction, operation, maintenance, modification, and other stages of the infrastructure Lifecycle.

The work performed at each stage produces results that are used in the same or subsequent stages. The Organizations, functions, and management configuration participating in this work may also change throughout the Lifecycle.

The applicable Management System must therefore maintain the connection between infrastructure requirements, the work performed, and the results achieved throughout the defined realization scope and applicable Lifecycle.

## **5.4 WQI Management System Quality Standard**

WQI QMS1 provides the framework used here to examine Management System Quality. In simple terms, it asks how well the management used for a defined realization scope works to achieve what is required [4].

For infrastructure, the realization scope may cover the whole object or a defined part of its life cycle or functions. The Management System may be within one Organization or include management functions from more than one Organization. Its actual configuration must be declared rather than assumed from the contractual structure.

Product and service providers may have separate Management Systems. These systems connect with infrastructure management where requirements, work, information, or results cross material Interfaces. The infrastructure, Organizations, Management Systems, products, and services remain different subjects and may be examined as separate Quality Objects.

## 5.5 Distinct Quality Objects

WQI VOC1 treats Organization Quality and Management System Quality as different. Organization Quality concerns the defined Organization as a whole. Management System Quality concerns the management used for a defined realization scope. Their Boundaries may overlap, but they are not the same Quality Object.

Infrastructure, Organizations, Management Systems, products, and services may each be examined as separate Quality Objects. Their Work, Results, and Evidence may be connected, but satisfactory Quality of one does not establish satisfactory Quality of another. Fractal examination applies across the relevant Factors and Indicators: a constituent contribution can be examined in its own right without treating its Quality as proof of the whole.

## 6 Connecting Infrastructure and Provider Quality Management

Management of infrastructure realization and management of provider realization may operate at different scopes but must remain connected where requirements, work, or results cross material Interfaces.

The fundamental connection is the development, allocation, transfer, and realization of requirements for the products and services needed by the infrastructure. Where a common product or service standard exists and is applicable, it can become part of the requirements used by both the infrastructure and the provider.

### 6.1 From Infrastructure Requirements to Provider Requirements

Infrastructure requirements establish what is needed from the infrastructure as a whole.

As the infrastructure is designed and developed, requirements for needed products and services are determined. Where applicable standards exist, they are considered and selected as part of this work. For example, API 5L may be selected for line pipe used in gas transmission pipeline infrastructure, or API 2C for an offshore crane used in offshore hydrocarbon production zone infrastructure.

Where such standards apply, they can establish common requirements, but they do not necessarily determine everything needed for a particular application. They may contain parameters, options, classifications, or other data that must be selected or specified according to the needs and conditions of the particular infrastructure.

In this article, we use the term open-to-data standards for standards of this kind: the standard provides a common requirements framework, while the particular infrastructure supplies selections, values, conditions, or other data needed to complete its application.

The infrastructure must therefore do more than identify the applicable standard: it must determine the infrastructure-specific data needed to complete the requirements for the particular product or service.

## 6.2 Common and Infrastructure-Specific Requirements

Where an applicable standard is selected, it becomes part of a common requirements basis for the infrastructure and the provider.

The provider works to the requirements of the standard. At the same time, the infrastructure determines the selections, values, conditions, and other application-specific requirements needed for the particular use.

Together, the standard and the infrastructure-specific data form the requirements that apply to the product or service.

## 6.3 Transfer of Requirements

Infrastructure-specific requirements must reach the Organization or function providing the product or service.

This may occur through designs, specifications, contracts, purchase documents, data sheets, technical instructions, or other appropriate means.

The provider therefore receives both the applicable standard and the data and selections needed for the particular infrastructure application.

## 6.4 Duties at the Interface

At an Interface between Organizations or organizational functions, the result required from one participant may become an input to the work of another.

The infrastructure side must determine and provide the application-specific requirements needed for the product or service. The provider must apply these requirements together with the applicable standard in performing its work and achieving the required result.

The Interface connects requirements, Work, and Results on both sides. Essential external Work and Results must be included in the declared scope or addressed through identified Interfaces. Outsourcing alone does not justify excluding them from Quality Determination, and does not bring an external organization's unrelated activities into the Quality Object.

## 6.5 Changes in Requirements

Infrastructure requirements can change during design, construction, operation, modification, or other stages of the lifecycle.

When a change affects the selections, parameters, conditions, or other requirements for a product or service, the relevant information must also be changed and passed to the affected provider.

The infrastructure-provider connection must therefore be maintained when requirements change.

## 6.6 Connecting Management Systems Across the Interface

In this example, one Management System covers the applicable infrastructure realization scope. A provider may use another Management System to realize the required product or service.

The requirements for that product or service connect the two sides. An applicable product or service standard can provide part of the common requirements basis. The infrastructure adds the requirements and data needed for its particular use.

If the Management Systems are separate, they connect where requirements, work, and results cross the material Interface. Whether they are separate depends on the actual management arrangements and realization scopes, not simply on whether different companies or Organizations are involved.

This is the central idea of the article: requirements for the infrastructure as a whole must reach the people and providers whose work, products, and services help realize those requirements.

## **7 Gas Transmission Pipeline Infrastructure Example**

A gas transmission pipeline illustrates the connection between infrastructure quality management and a product provider's quality management.

Here, the pipeline is the infrastructure and line pipe is one constituent product.

The Management System defined for the applicable pipeline realization scope directs and controls the development and management of requirements for the pipeline. In doing this, it works from the intended use and conditions of the infrastructure, applicable regulatory requirements, and available products and open-to-data product standards.

The resulting requirements for the line pipe are transferred through the procurement interface to the pipe manufacturer and its Quality Management System.

### **7.1 Intended Use of the Pipeline**

The process begins within the applicable infrastructure realization scope with the intended use and conditions of the pipeline.

The pipeline is intended to transport gas under defined operating and environmental conditions. Its route, operating pressure, surrounding population, crossings, stations, environmental conditions, and other conditions affect its design.

At the same time, the infrastructure is not designed independently from the products that can be used to realize it. Designers work with available line pipe and applicable product standards, including API 5L.

The applicable Management System must therefore connect the needs and conditions of the pipeline with the available technical solutions and standards that can be used to realize them.

### **7.2 Pipeline Requirements**

For a U.S. gas transmission pipeline, federal requirements provide a simple example of how infrastructure conditions affect requirements for the pipe.

For steel pipe, the design-pressure relationship is:

$$P = (2St / D) \times F \times E \times T$$

where, in simple terms:

- P = design pressure;
- S = yield strength determined in accordance with 49 CFR §192.107;
- t = nominal pipe wall thickness, subject to the provisions of §192.105;
- D = nominal outside diameter;
- F = design factor determined under §192.111;
- E = longitudinal joint factor under §192.113; and T = temperature derating factor under §192.115.

The relationship connects the pipeline conditions with characteristics required from the pipe. Consistent units and all applicable regulatory provisions are needed for an actual calculation.

For example, the calculation depends partly on the pipeline location. Section 192.5 establishes class locations using criteria that include buildings and human occupancy. Section 192.111(a) gives the general design factors below, subject to the lower factors required for specified situations in paragraphs (b)–(d). This table illustrates requirement development rather than providing a complete design basis [9].

| Class location | Design factor F |
|----------------|-----------------|
| Class 1        | 0.72            |
| Class 2        | 0.60            |
| Class 3        | 0.50            |
| Class 4        | 0.40            |

The pipe manufacturer does not determine whether the pipeline passes through a Class 1 or Class 4 location. That information comes from the infrastructure—its route and surrounding conditions.

The applicable Management System directs and controls the work through which these conditions, regulatory requirements, and available technical solutions are brought together in developing the pipeline requirements.

### 7.3 Requirements for Line Pipe

Available product standards are part of this process.

API Specification 5L, Line Pipe, 47th Edition (2026), provides standardized manufacturing requirements and an established product-standard framework for line pipe [5]. The pipeline can therefore be designed knowing that line pipe can be specified within this framework.

At the same time, API 5L cannot independently determine which pipe is required for a particular pipeline. It contains parameters, options, selections, and other data that must be specified according to the particular application.

This is why we describe API 5L in this article as an open-to-data standard.

The relationship works in both directions. API 5L provides an available standardized product framework that can be considered when the pipeline is designed. The needs and conditions of the particular pipeline, in turn, determine the selections and other data needed to complete the requirements for the particular line pipe.

Once API 5L is selected, it becomes a common requirements basis for both the infrastructure side and the pipe manufacturer.

The applicable Management System directs and controls determination of the required pipe characteristics and infrastructure-specific selections and data, and the allocation of applicable requirements to the Organization or function in which their realization resides.

## **7.4 Procurement Interface and Line Pipe Provider**

The requirements established for the line pipe must cross from the infrastructure side to the organization that will manufacture the product.

Procurement provides this organizational interface.

In WQI QMS1 terms, Requirement Allocation under Factor 1 — Requirements Realization concerns where responsibility for realizing the applicable line-pipe requirements resides. When those requirements cross the procurement interface, Interface Identification and Requirement Transfer under Factor 6 — Lifecycle and Interface Realization address recognition of the material interface and whether the requirements remain complete, understandable, and usable for realization [4].

Through procurement specifications, data sheets, purchase orders, contracts, and other applicable documents, the manufacturer receives:

- the applicable API 5L requirements; and
- the infrastructure-specific selections, parameters, characteristics, and other data determined from the requirements of the particular pipeline.

Together, these establish what the manufacturer is required to provide.

These transferred requirements become inputs to the manufacturer's Quality Management System.

Where API Q1 applies, the manufacturer's Quality Management System manages realization of the required product. Where product design activities are applicable, the relevant product requirements are addressed as design inputs within the manufacturer's design process.

The manufacturer then manages the work necessary to realize the line pipe required by the pipeline.

## **7.5 Connection Between the Management Systems**

The example shows a direct connection between two distinct Management Systems as bounded for this application.

The infrastructure-side Management System directs and controls the process through which the pipeline's intended use and conditions, applicable regulatory requirements, and available open-to-data product standards are considered in developing the pipeline and its requirements.

API 5L provides a common requirements basis for the infrastructure and the manufacturer. The infrastructure side determines and allocates the application-specific characteristics, selections, parameters, and other data needed to apply that standard to the particular pipeline.

Procurement forms a material Interface between the two sides. Through this Interface, the requirements determined and allocated within the infrastructure-side Management System are transferred to the manufacturer.

The transferred requirements become inputs to the manufacturer's Quality Management System and, where applicable under API Q1, provide the basis for product design inputs. The manufacturer's Quality Management System then manages realization of the required line pipe.

The complete connection can therefore be summarized as:

**Infrastructure-side Management System → intended use and conditions + available open-to-data product standards → pipeline requirements → required line-pipe characteristics and API 5L selections → Requirement Allocation → procurement Interface → Requirement Transfer → manufacturer Management System → product realization, including product design inputs where product design is applicable → required line pipe.**

The two Management Systems manage different realization scopes, work, and results, but they are connected through the common product standard and the requirements transferred across the procurement Interface. The output of the infrastructure-level requirements process becomes an input to the manufacturer's Management System.

## 8 Offshore Hydrocarbon Production Zone Infrastructure Example

An offshore hydrocarbon production zone provides a second example, extending the connection to multiple product and service providers.

Here, the production zone is the infrastructure, a pedestal-mounted offshore crane is one constituent product, and outside organizations provide additional services.

As in the gas transmission pipeline infrastructure example, the Management System defined for the applicable infrastructure realization scope directs and controls development and management of requirements. Available products, services, and open-to-data standards are considered as the infrastructure is designed. Requirements determined for particular products and services are then allocated and transferred across procurement and other material Interfaces to their providers.

### 8.1 Intended Use of the Offshore Hydrocarbon Production Zone

The process begins with the intended use and conditions of the offshore hydrocarbon production zone.

The infrastructure is intended to support offshore oil and/or gas production, together with the processing, handling, utilities, maintenance, logistics, and other activities necessary for that production.

These activities create requirements for the physical systems, equipment, products, and services used throughout the production zone. Among them are lifting requirements for moving materials, equipment, supplies, and other loads needed for oil and gas production and continued operation.

At the same time, the infrastructure is not designed independently from available equipment and technical standards. Available offshore cranes and applicable standards, including API 2C, can be considered as the offshore production facilities and their lifting arrangements are developed.

The applicable Management System must therefore connect the oil and gas production requirements and conditions of the offshore hydrocarbon production zone with the available technical solutions and standards that can be used to realize them.

## **8.2 Offshore Hydrocarbon Production Zone Requirements**

The applicable Management System directs and controls the work through which the intended use and conditions of the offshore hydrocarbon production zone are developed into infrastructure requirements.

These requirements concern the production zone as a whole and the different facilities, systems, equipment, products, and services needed for its realization and operation.

For the lifting function, it is not sufficient to state simply that an offshore facility requires a crane. The infrastructure side must determine what lifting work is required within the particular production zone and the conditions under which it must be performed.

These requirements may include the loads to be handled, required lifting locations, lifting radius and reach, installation location, available structural support, operating conditions, and the offshore environment.

They provide the infrastructure basis from which requirements for the particular offshore crane are established.

## **8.3 Requirements for the Offshore Crane**

Available product standards are part of this process.

API Specification 2C, Offshore Pedestal-Mounted Cranes, 8th Edition, provides an established product-standard framework for offshore pedestal-mounted cranes [6]. The offshore hydrocarbon production zone and its facilities can therefore be designed knowing that a crane can be specified within this framework.

At the same time, API 2C cannot independently determine which crane is required for a particular offshore application. It does not know the particular oil and gas production activities the crane must support, the loads that must be handled, the required lifting radii and reach, the crane location, the supporting structure, or the particular operating and environmental conditions.

These requirements and data come from the infrastructure.

This is why, in the same sense as API 5L in the gas transmission pipeline example, we describe API 2C in this article as an open-to-data standard.

The relationship works in both directions. API 2C provides an available standardized product framework that can be considered when the offshore production facilities and their lifting arrangements are designed. The oil and gas production needs and conditions of the particular infrastructure, in turn, determine the selections and other data needed to complete the requirements for the particular crane.

Once API 2C is selected, it becomes a common requirements basis for both the infrastructure side and the crane provider.

The applicable Management System directs and controls determination of the required crane characteristics and infrastructure-specific selections and data, and the allocation of applicable requirements to the Organization or function in which their realization resides.

## 8.4 Crane Provider

The requirements established for the crane must cross from the infrastructure side to the organization providing the product.

Procurement provides this organizational interface.

As in the pipeline example, WQI QMS1 distinguishes Requirement Allocation from Requirement Transfer. Requirement Allocation concerns where realization of the applicable requirement resides. Once a material organizational interface is involved, Interface Identification and Requirement Transfer concern recognition of that interface and preservation of the requirement in a complete, understandable, and usable form as it crosses the interface [4].

Through the procurement specification, equipment data sheets, purchase order, contract, and other applicable documents, the crane provider receives:

- the applicable API 2C requirements; and
- the infrastructure-specific lifting requirements, selections, operating conditions, installation conditions, and other necessary data.

Together, these establish what the crane provider is required to provide.

The transferred requirements become inputs to the provider's Management System. Where API Q1 applies, that Quality Management System manages realization of the required product. Where product design activities are applicable, the relevant product requirements are addressed as design inputs within the provider's design process.

The provider's Management System therefore manages realization of a crane that is not merely designed to an API product standard, but to the requirements established for its particular infrastructure use.

## 8.5 Service Providers

The offshore hydrocarbon production zone also depends on services performed by outside organizations.

A service may be associated with installation, inspection, maintenance, repair, testing, or other work required for the infrastructure or its equipment.

As with a product, the service cannot be defined only by the general type of work. The particular infrastructure establishes conditions, requirements, interfaces, and expected results that the service provider must address.

The applicable requirements must therefore be allocated to the organization or function responsible for their realization and, where they cross an organizational boundary, transferred to the service provider through the applicable contractual or other interface.

Where an applicable service standard exists, it can provide a common requirements basis between the infrastructure and the service provider, while infrastructure-specific information completes the requirements for the particular service.

The transferred requirements become inputs to the service provider's Management System. Where a service falls within the defined scope of API Q2, API Q2 may provide the applicable Quality Management System requirements for the service provider.

## 8.6 Connection Between the Management Systems

The offshore hydrocarbon production zone example shows that the Management System for an infrastructure realization scope may connect with several provider Management Systems.

The infrastructure-side Management System directs and controls the process through which the intended use and conditions of the offshore hydrocarbon production zone, applicable requirements, and available products, services, and open-to-data standards are considered in developing the infrastructure and its requirements.

For the offshore crane, API 2C provides a common product-standard basis. The infrastructure determines and allocates the application-specific lifting requirements, selections, conditions, and other data needed for its particular use.

Procurement forms the Interface through which these requirements are transferred to the crane provider. They become inputs to the provider's Management System and, where applicable under API Q1, provide the basis for product design inputs.

Comparable Interfaces connect the infrastructure-side Management System with service-provider Management Systems.

The overall connection can therefore be summarized as:

**Infrastructure-side Management System → intended use and conditions + available products, services, and open-to-data standards → offshore hydrocarbon production zone requirements → product and service requirements → Requirement Allocation → procurement/contractual Interfaces → Requirement Transfer → provider Management Systems → product or service realization, including design inputs where product design is applicable → required products and services.**

The offshore hydrocarbon production zone example therefore extends the gas transmission pipeline infrastructure example. Infrastructure quality management is not connected with only one product provider. It can connect the requirements and results of multiple product and service providers whose work contributes to realization of the infrastructure as a whole.

## 9 Discussion

The two detailed examples show the same relationship in different energy-infrastructure contexts. Comparable relationships arise when a building specifies an elevator, a bridge specifies a bearing, a water-treatment facility specifies a pump, or a data center specifies a cooling unit.

A gas transmission pipeline depends on products such as line pipe. An offshore hydrocarbon production zone depends on many products and services, including offshore cranes and the organizations that provide services throughout the infrastructure lifecycle.

In both cases, quality management at the infrastructure level must connect with quality management at the provider level.

## **9.1 What the Examples Show**

The examples show that the connection does not begin with procurement of a product or service. It begins earlier, as requirements for the infrastructure as a whole are developed and then related to the constituent work, products, and services needed for realization.

The intended use and conditions of the infrastructure establish what the infrastructure must achieve. At the same time, available products, services, regulations, codes, and standards influence the technical solutions through which these requirements can be realized.

In the two IQI examples examined here, open-to-data product standards provide an important additional mechanism for this connection.

API 5L provides a standardized requirements framework for line pipe, while the particular gas transmission pipeline provides the selections and other data needed for its application.

API 2C performs a similar function for the offshore crane, while the particular production zone provides lifting requirements and application-specific data. Elsewhere, a bridge bearing specification needs the applicable loads and movements; a treatment pump specification needs flow, head, and fluid conditions; and a data-center cooling specification needs the required heat removal and operating conditions. These are illustrative application inputs, not complete specifications.

In these examples, the common standard and the infrastructure-specific requirements together establish what the provider must realize. More generally, the methodological connection depends on determining, allocating, transferring, and realizing the requirements for the constituent product or service; it does not depend on the existence of an independent product or service standard.

## **9.2 Where the Connection Can Fail**

The existence of a product or service standard does not by itself ensure that the needs of the infrastructure will be realized.

The connection can fail if the infrastructure requirements are incomplete or unclear, if the required product or service characteristics are not correctly determined, if requirements are not properly allocated, or if necessary information is not transferred across the organizational interface.

For example, a line pipe may conform to API 5L but still not be the pipe required for the particular pipeline if the necessary pipeline-specific selections were incorrect or were not transferred to the manufacturer.

Similarly, an offshore crane may conform to API 2C but still not satisfy the needs of the particular offshore hydrocarbon production zone if its required lifting conditions were not correctly determined and transferred.

The quality of the provider's work therefore cannot by itself compensate for missing or incorrect requirements originating on the infrastructure side.

### 9.3 Infrastructure and Provider Work and Results

The infrastructure organization and the provider perform different work and produce different results.

The infrastructure side determines what is required from the infrastructure and, through design and other applicable work, what is required from its constituent products and services.

The provider works from the applicable requirements received across the interface and manages realization of the required product or service.

The applicable output of infrastructure-level work therefore becomes an input to provider-level work across the relevant Interface.

This relationship is particularly visible at the procurement or contractual interface:

**Infrastructure requirements → product or service requirements → Requirement Allocation → Interface → Requirement Transfer → provider Management System → required product or service.**

The connection depends on the Quality of Work and Results on both sides. Determining, allocating, and transferring a requirement does not demonstrate its fulfillment. Evidence about the actual product, service, installation, and relevant Interfaces is needed. A delivered product may meet its procurement requirements while integration into the whole infrastructure remains deficient.

### 9.4 Further Development

The examples also point to a broader connection between infrastructure requirements and Management System Quality.

The two examples illustrate a broader point. Requirements for the whole infrastructure must be connected to requirements for the products, services, and work used to realize it. They must also connect to the Management Systems that manage that realization.

The API Monogram Program illustrates a connection between product requirements and a provider's Quality Management System within a defined licensing scope. That connection must not be extended into an assurance about the Quality of the whole infrastructure.

A similar type of connection can be explored at the infrastructure level.

The IQI Infrastructure Standard — Core and relevant Context Guides provide the infrastructure requirements architecture [7–8]. WQI QMS1 provides the framework for examining the Quality of the Management System used for a defined realization scope [4]. Evidence Quality and Quality Claims are governed separately by WQI\_EQC1 and WQI\_QCC1 [12–13].

This suggests a structured connection between:

**infrastructure requirements → IQI Core and applicable Context Guide**

and

## **Management System Quality → WQI Management System Quality Standard.**

If useful, WQI Management System Quality Context Guides could later be developed for particular infrastructure classes or industries.

This would not copy the API Monogram Program and would not itself create a certification program. It would extend the WQI-IQI method by connecting infrastructure requirements with the Quality of the Management System used to realize them.

## **10 Conclusion**

Infrastructure depends on products and services from many organizations. Their Quality matters to the whole infrastructure, and the Management Systems used to realize them are part of that connection. The relationship applies across infrastructure types; the detailed energy examples make it concrete.

The connection starts with the intended use and conditions of the infrastructure. Available products, services, regulations, codes, and standards also influence how the infrastructure is designed and realized.

An applicable product or service standard can provide a common requirements basis. If the standard requires application-specific data, the infrastructure must supply the needed selections, parameters, conditions, or other information. If no such standard exists, the infrastructure must still determine and transfer the requirements needed from the product, service, or work.

Requirements are allocated to the Organizations or functions that will realize them. When they cross a procurement or other material Interface, they must be transferred to the provider. They then become inputs to the provider's Management System. If product design is part of the manufacturer's work, the relevant product requirements may become design inputs in that process.

The pipeline and offshore production-zone examples illustrate this connection at two infrastructure levels. Building systems, bridge components, water-treatment equipment, and data-center cooling involve the same need to connect whole-object requirements with constituent contributions. In each case, the basic relationship is:

**Infrastructure requirements → product and service requirements → Requirement Allocation → material Interface  
→ Requirement Transfer → provider Management System → required product or service.**

Infrastructure Quality, Organization Quality, Management System Quality, and product or service Quality are different when each is defined as a separate Quality Object. They are connected through requirements, Interfaces, management, work, and results, but the Quality State of one does not automatically establish the Quality State of another.

Define the whole Quality Object and what it must achieve; determine what is required from its products, services, and Work; identify responsibility for realization; and preserve requirements across material Interfaces. Then examine Evidence of actual fulfillment. For a whole-object Quality Determination, Synthesis of Material Findings must consider the contributions and their relationships, preserving justified Critical Conditions, Non-Compensability, uncertainty, and unresolved matters. The actual Quality State

exists independently of this examination. A Management System examined as its own Quality Object requires a separate determination.

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