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Overview of Quality and the Standards, Programs, and Certifications Used in the Coatings Industry

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THE QUALITY MOVEMENT can trace its roots back to medieval Europe, where craftsmen organized into guilds beginning in the late 13th century until the early 19th century. During the industrial revolution, emphasis shifted from the craftsmanship model to the factory model, which emphasized production inspection, according to the American Society for Quality (ASQ) (Ref 1).

Quality became vital to the U.S. war effort in World War II. There had to be consistent quality between various products; that is, bullets produced in one state had to work in guns manufactured in another. Inspection of virtually every product unit by the military gave way to inspection sampling backed by the publication of specifications and standards.

In 1951, Joseph Juran introduced groundbreaking work with his book *Quality Control Handbook*, which still is the standard reference work for quality managers. In it, Juran introduced the trilogy of quality management, as outlined in Table 1.

At approximately the same time as Juran published his work, W. Edwards Deming, through his work with the Department of the Census and the Bureau of Labor Statistics, developed the plan-do-check-act concept that still is used today (2014). Deming went on to work with the Japanese in the 1950s and 1960s as part of the quality revolution in Japan manufacturing industries, particularly automobiles, following World War II, focusing on defining, improving, and measuring all organizational processes through the people who used them.

Deming later introduced the 14 points of total quality management, a set of management practices to help companies increase their quality and productivity. The 14 points, which still are used today (2014), are as follows:

1. Create constancy of purpose for improving products and services.
2. Adopt the new philosophy.
3. Cease dependence on inspection to achieve quality.
4. End the practice of awarding business on price alone; instead, minimize total cost by working with a single supplier.
5. Improve constantly and forever every process for planning, production, and service.
6. Institute training on the job.
7. Adopt and institute leadership.
8. Drive out fear.
9. Break down barriers between staff areas.
10. Eliminate slogans, exhortations, and targets for the workforce.
11. Eliminate numerical quotas for the workforce and numerical goals for management.
12. Remove barriers that rob people of pride of workmanship, and eliminate the annual rating or merit system.
13. Institute a vigorous program of education and self-improvement for everyone.
14. Put everybody in the company to work accomplishing the transformation.

Philip B. Crosby, who in the late 1970s began advocating for a preventive mindset to do things right the first time, is widely recognized for promoting the concept of zero defects. Crosby's book *Quality Is Free* played a large role in launching the quality movement in the United States and Europe (Ref 1).

In the last few decades, quality management has moved beyond manufacturing into the service, construction, healthcare, education, and government sectors.

Table 1 Quality trilogy

Quality planning This is the activity of developing products and processes to meet customer needs. It deals with setting goals and establishing the means required to reach the goals.	• Identify who are the customers. • Determine the needs of those customers. • Develop a product that can respond to those needs. • Optimize the product features so as to meet our needs and customer needs. • Develop a process that is able to produce the product. • Develop infrastructure and resources. • Optimize the process. • Prove that the process can produce the product under operating conditions with minimal inspection. • Transfer the process to operations.
Quality implementation/improvement This process is for obtaining breakthroughs in quality performance.	
Quality control This process deals with the execution of plans, and it includes monitoring operations so as to detect differences between actual performance and goals.	

Defining Quality, Quality Assurance, Quality Control, and Quality Management

To understand quality, a common framework for the terms used must be established. The following definitions are taken from the ASQ glossary.

Quality itself is a subjective term, and nearly every industry sector, including the coatings industry, as well as every certifying or standards organization has its own definition. The ASQ provides two technical meanings for quality:

- The characteristics of a product or service that bears on its ability to satisfy stated or implied needs
- A product or service free of deficiencies

Other recognized definitions are fitness for use (from Juran) and conformance to requirements (from Crosby).

For coatings, quality requirements may apply to the equipment, the process of surface preparation and coatings application, all materials used, the company or personnel, subcontractors, and the end product, the finish coating system.

Quality often is coupled with the terms *assurance* and *control*. Assurance is the act of giving confidence, the state of being certain, or the act of making certain. Control is an evaluation to indicate needed corrective responses, or the act of guiding a process in which variability is attributable to a constant system of chance causes.

Quality assurance (QA) is the planned and systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled. Quality assurance is proactive and strategic; it flows across an organization and focuses on organizational management and control of the process. It is intended to prevent defects from occurring through process and product planning and controls, and the procedures created as part of the QA process govern how quality will be achieved.

Quality control (QC) is the observation techniques and activities used to fulfill requirements for quality. Quality control is reactive and tactical. Its function is to detect defects at all levels of the process and product development and to confirm conformance to QA or specified requirements for a specific process, product, or task.

Quality control is the responsibility of the person or company providing the product or service and is used to either verify conformance or detect and correct errors, flaws, and nonconformances as early as possible in each phase of work, production, or the process. It can be an automated system (such as an alarm that sounds when the conditions do not meet specified requirements), laboratory or field testing for specific characteristics or specified criteria, observations of in-process or final appearance or conditions, or some form of postproduction validation, all of which are documented to provide a record of conformance. If nonconformances do occur, QC should detect them as early as possible and begin corrective actions to the product and process.

The ASQ notes that due to the similarity in the definitions of QA and QC (and the interpretation by various organizations), *quality assurance* and *quality control* often are used interchangeably, referring to the actions performed to ensure the quality of a product, service, or process.

In field and shop coatings inspection, the observations, measurements, and testing performed by the contractor/fabricator are considered QC, while testing performed by the owner (or a third party working for the owner) generally is considered QA. Field coatings QC is described in detail in the article "Shop and Field Quality Control and Quality Assurance" in this Volume.

Quality management (sometimes referred to as total quality management or quality management system) is strategic and encompasses both QC and QA. Common definitions would include the following:

- *Quality management system (QMS):* A formalized system that documents the structure, processes, responsibilities, and procedures required to achieve effective quality management
- *Quality management (QM):* The application of a QMS in managing a process to achieve maximum customer satisfaction at the lowest overall cost to the organization while continuing to improve the quality of processes, products, and services

Evolution of Quality Control/ Quality Assurance in Coatings

Up into the 1950s, U.S. Department of Defense (DoD) agencies, as well as a large percentage of other public agencies such as state Departments of Transportation, accepted work by inspection using in-house inspectors. As funding and in-house staffs have been reduced or eliminated, many public and private organizations rely on design architect/engineer (A/E) firms, consultants, and coating inspectors to monitor the work and perform an accept/reject function.

In this scenario, the contractor or fabricator is expected to provide a continuous QC function, while the owner or their A/E firm or other third party generally provides either spot, periodic, or duplicate inspections to verify that the QC performed by the contractor was accurate.

The nuclear American National Standards Institute standards published in the 1960s and 1970s required that nuclear power facilities, coating manufacturers, contractors, consultants, and vendors establish quality programs meeting 10 Code of Federal Regulations (CFR) 50, Part B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants."

When the coatings inspection industry began to evolve in the 1970s, primarily during the construction of nuclear power facilities, there was little distinction between the roles of QC and QA related to coatings. Most early coating inspection was performed as a response to the inspection parameters established in the nuclear power industry and American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) N45.2.6, "Qualification of Inspection, Examination and Testing Personnel for Construction Phase of Nuclear Power Plants," and ANSI N101.4, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities." These standards defined the qualifications of coatings applicators, inspectors, and auditors as well as the inspection tasks that were required during installation or maintenance of nuclear power facilities. They also defined coatings characteristics and test methods. ANSI N45.2.6 specifically applied to third-party inspectors retained by the owner to perform hold-point inspection of contractor activities.

Most of the ANSI standards related to coatings have transitioned to ASTM International and Society for Protective Coatings (SSPC) standards (Ref 2).

The requirements in 10 CFR 50, Part B, have been further defined and elaborated upon through ANSI/ASME Nuclear Quality Assurance (NQA)-1:1994, "Quality Assurance Requirements for Nuclear Facility Applications" (applicable to most facilities); multiple updates through NQA-1:2008 have been published.

Vendors participating in the construction of new nuclear power plants, or the fabrication and coating of equipment for installation in new or old nuclear power plants, generally are held to NQA-1:1994 requirements.

As coating inspection expanded beyond nuclear power into industries such as transportation and water storage and supply in the 1980s and early 1990s, most owners continued to rely on third-party inspection to verify that contractor activities were performed according to the appropriate specification.

In the late 1980s, owners began to recognize that while third-party inspection still was desirable, it was not intended to replace QC by the contractor. With the increased recognition of International Organization for Standardization (ISO), ASQ, SSPC, and other certifications, more and more companies are moving to the concept of QM.

Today (2014), DoD and other federal agencies as well as public and private contracting and purchasing routinely use what DoD refers to as contractor quality control (CQC). Others use ISO 9001, SSPC contractor certification programs, or similar criteria to verify that contractors and suppliers have established and controlled processes. This methodology relies on written programs, qualified personnel, and evidence of implementation through internal and external auditing to verify they can control quality. Defining features of CQC include focusing on processes, using the contractor's QC and QA, including inspection, to accept work, and using various levels of owner QA to keep the contractor incentivized to produce only conforming work and to ensure consistent and effective inspection results. Contractor quality control also includes the use of corrective action to address any and all anomalies and deficiencies in the contractor's evidence of conforming work.

Owner requirements for use of SSPC-certified contractors and companies, ISO 9001 certification, laboratories and calibration vendors certified to ISO 17025, the National Voluntary Laboratory Accreditation Program, or accredited companies indicate a trend toward no longer

relying on just inspection but requiring that an organizational QMS is in place that incorporates both QA and QC to result in meeting specified requirements.

Standards, Quality Programs, and Certifications in the Coatings Industry

Quality management in the coatings industry applies to all levels of the supply chain, including manufacturers, contractors/fabricators, laboratories and calibration companies, and inspection/consulting firms. Various organizations have established standards; minimum program, training, or experience requirements; and certification for individuals and companies related to quality.

International Standards Organization Standards and Certifications

The ISO, which was established in 1947, published its first ISO 9000 standard related to organization quality in 1987. Since then, the ISO has issued multiple standards to address quality in a variety of industries and to provide clarification of varying levels of quality. The ISO concept relies on the ISO providing quality standards for companies to meet that include specific requirements related to defining and controlling processes (as applicable to the organization); controlling key items such as documents, records, review of contracts and client requirements, purchasing documents, subcontractor and managing deviations as nonconformance and corrective actions; and incorporating QC, QA, management reviews, and audits to provide feedback and adjustments to the system. The ISO relies on independent registrars to audit and certify that organizations are meeting ISO 9001.

The ISO 9000 standard is being revised continually by standing technical committees and advisory groups, which receive feedback from those professionals who are implementing the standard. The next version of the standard is expected to be published in December 2015.

A typical ISO 9001 program outline would include the following sections:

Section 4: Quality Management System
4.1 General Requirement
4.2 Document Requirements

Section 5: Management Responsibility
5.1 Management Commitment
5.2 Client Focus
5.3 Quality Policy
5.4 Planning
5.5 Responsibility, Authority, and Communication
5.6 Management Review

Section 6: Resource Management
6.1 Provision of Resources
6.2 Human Resources
6.3 Infrastructure
6.4 Work Environment

Section 7: Service Realization
7.1 Planning of Product Realization
7.2 Client-Related Processes
7.3 Design and Development—Excluded
7.4 Purchasing
7.5 Product Provision
7.6 Control of Monitoring Devices

Section 8: Measurement Analysis and Improvement
8.1 General
8.2 Monitoring and Measurement
8.3 Control of Nonconforming Service
8.4 Analysis of Data
8.5 Improvements

Many materials suppliers and coatings manufacturers and some contractors and fabricators are certified to ISO 9001. More and more government agencies at all levels are establishing internal and vendor systems based on ISO standards or requiring ISO registration.

The ISO 17025 is considered a higher-level quality standard specifically governing analytical and calibration laboratories. It incorporates all of the requirements of ISO 9001, plus it requires increased controls related to the environment in which work is performed, the calibration of equipment, standards and solutions used in testing or calibration, personnel, and written procedures. Similar to ISO 9001, ISO 17025 relies on independent technical organizations to audit for compliance with ISO 17025. Common entities include the American Association for Laboratory Accreditation, the National Voluntary Laboratory Accreditation Program, and several others.

Coatings laboratories, calibration providers, and some coatings inspection equipment manufacturers (that provide calibrations services) are accredited to ISO 17025.

Nuclear Regulations and Standards

As mentioned previously, 10 CFR 50, Appendix B and NQA-1 are the standards applicable to QM in the nuclear industry and apply to facility, coatings manufacturer, coatings contractor or equipment fabricator, and third-party inspection companies providing coatings inspection. Generally, companies providing services to the nuclear industry are subject to initial vendor requirements and periodic audits performed by the contracting nuclear facility, fabrication facility, or an organization representing multiple members, such as the Nuclear Utilities Procurement Issues Committee and the Nuclear Industry Assessment Committee, which represents other companies working in nuclear facilities.

Quality management systems under 10 CFR 50, Part B must address the following 18-point criteria:

1.0 Organization
2.0 Quality-assurance program
3.0 Design control
4.0 Procurement document control
5.0 Procedures, instructions, and drawings
6.0 Document control
7.0 Control of purchased items and services
8.0 Identification and control of materials, parts, and components
9.0 Control of special processes
10.0 Inspection
11.0 Test control
12.0 Control of measuring and test equipment
13.0 Handling, storage, and shipping
14.0 Inspection test and operating status
15.0 Control of nonconforming items
16.0 Corrective/preventive action
17.0 Quality records
18.0 Audits

The NQA-1:1994 and subsequent standards follow the 18-point criteria established in 10 CFR 50, Part B but expand on the mandatory requirements for compliance. For example, while 10 CFR 50, Part B, Item 17, "Records," requires that records be controlled and maintained, NQA-1 requires that records are controlled in fireproof conditions and are indexed, validated, and so on.

SSPC Standards and Certifications

Based on the ISO and initiated in 1989, the SSPC Painting Contractor Certification Program, specifically QP 1 ("Field Application to Complex Industrial and Marine Structures"), established specific requirements for the certification of coating contractors, which included:

- Management procedures
- Quality-control requirements
- Safety, health, and environmental compliance

The SSPC has since implemented similar contractor certification programs, including the following:

- QP 2 is a supplement to QP 1 and evaluates the contractor's ability to perform industrial hazardous paint removal in a field operation.
- QP 3 evaluates a contracting company's ability to perform surface preparation and protective coating application in a fixed shop facility. This standard was developed in conjunction with the American Institute of Steel Construction.
- QP 5 evaluates an inspection company's ability to provide consistent quality inspection of coatings and linings for its clients.
- QP 6 evaluates the qualifications of industrial thermal spray (metallizing).
- QP 7 ("Painting Contractor Introductory Program") verifies the capabilities of contractors with less than 6 months of experience performing industrial surface preparation and coating application in the field.
- QP 8 evaluates the qualifications of contractors hired to install polymer coatings or

surfacings on concrete and other cementitious surfaces in commercial, institutional, and industrial facilities.
- QP 9 verifies the capabilities of contractors performing surface preparation and architectural coating application on commercial and institutional buildings and their interiors.
- QS 1 sets a higher standard of practice for the QP 1, 3, 6, and 8 contractor to demonstrate an advanced QMS.

The SSPC QP certification programs establish requirements for organization management programs, quality-control procedures, staff training and qualification, and safety and health compliance. It relies on submission of initial information, an initial field and office audit, and annual and periodic unannounced audits of program compliance.

The SSPC company certifications apply to coating contractors and fabricators and third-party inspection firms.

In addition to the certification of companies, the SSPC has also undertaken developing certifications for individuals in abrasive blasting, coating application, and coatings inspection, including the following:

- Abrasive Blasting Program
- Aerospace Coating Application Specialist Certification Program
- Bridge Coatings Inspector Program
- Coating Application Specialist Certification Program
- Concrete Coating Inspector Program
- Marine Plural-Component Program
- Master Coatings Inspector Certificate
- NAVSEA Basic Paint Inspector
- Plural-Component Application for Polyureas and High-Solid Coatings
- Protective Coatings Inspector Program
- Protective Coatings Specialist Program
- Spray Application Basics
- Water-Jetting Program

As of January 1, 2013, SSPC, as part of the QP 1 program, established requirements for certification of applicators (CAS) on eligible industrial painting job sites. The long-range implementation plan calls for increasing the ratio of CAS-certified applicators to noncertified applicators over the next 10 years.

NACE International

Since the 1980s, the National Association of Corrosion Engineers (now NACE International) has been providing training and offering certification of individuals for coatings inspection (Ref 3). Currently, NACE International administers 23 certifications plus the original NACE International Coating Inspector Training and Certification Program. There are more than 35,000 NACE certification holders worldwide today (2014).

The NACE International training provides review of the observations, tests, and examinations that may be performed by a coating inspector during the coating process but does not define them relative to QC and QA.

The responsibilities related to field QC are discussed in the article "Shop and Field Quality Control and Quality Assurance" in this Volume.

Conclusion

Nearly every level of the coatings industry supply chain is embracing formal QMS as a means of achieving specified requirements. While still important and a component of QM, in-process inspection alone is no longer sufficient to measure overall quality, improvement, and conformance. While many see QM as a burden, appropriately implemented programs, with support from management, can yield tremendous dividends in client satisfaction, reduction of rework and repairs, and improvement of processes at all levels.

REFERENCES

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