INTERNATIONAL STANDARD

ISO 14922

First edition
2021-09

Thermal spraying — Quality requirements for manufacturers of thermal sprayed coatings

Projection thermique — Exigences qualité pour les fabricants de revêtement projeté thermiquement

Reference number
ISO 14922:2021(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 240, *Thermal spraying and thermally sprayed coatings*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 14922 cancels and replaces ISO 14922-1:1999, ISO 14922-2:1999, ISO 14922-3:1999 and ISO 14922-4:1999, which have been technically revised. The main changes compared with the previous editions are as follows:

— the four parts have been consolidated into one document;

— the requirements for the manufacturer now correspond to those of the parts;

— the weighting of requirements with +++ / ++ / + have been updated and are now requirements;

— the requirements have been separated: the quality assurance requirements former classified in 1, 2, 3 now clear as QRC and QAL C, S, E, the three assessment groups as comprehensive requirements, standard (normal) requirements, elementary requirements titled and presented in direct comparison in three columns in Annex C;

— the dependence on ISO 9001 has been removed;

— decision on QAL C, S, E by customer or manufacturer itself.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Thermal spraying processes are widely applied for producing industrial products and are mainly applied for preventive protection of surfaces. The application can take place both within the workshop as well as on site. Measures for the maintenance of worn coatings or of surfaces on components are also in the field of use. Thermal spraying can be found in all industries, but especially in the aerospace, stationary gas turbine, automotive, machinery construction, printing and chemical, and oil extraction and refining fluid control industries, as well as for medical purposes and for steel construction in the field of off-shore and on-shore, etc. Usually coatings are applied for anticorrosive and/or anti-wear purposes, high temperature protection and against chemical attack, as well as for aesthetic or electrical reasons.

Thermal spraying belongs to the so-called "special processes", where the quality of the coating cannot be unambiguously determined by testing without damaging the component. For an adequate use of thermal sprayed coatings and in order to avoid quality or cost-intensive problems when manufacturing and during service time, conditions and processes must be controlled. Therefore, a functional quality assurance system is made available for the coating factory, if necessary, in additional to a quality management system (e.g. ISO 9001).

This document provides three different levels of quality requirements (comprehensive level C, standard level S and elementary level E). These requirements can be defined by the customer's design engineering relating to the thermal sprayed coating or to the component.

The main elements of the quality assurance of the entire thermal spraying process for different applications in accordance with quality assurance levels C, S and E are listed in Annex B or Annex C. They can be used to check the proper function of the quality assurance system when applying a quality audit.

This document specifies requirements, tests and the scope of tests when qualifying the manufacturer. The specific requirements of the qualifying procedure in accordance with the quality assurance level C, S or E can be given by the general requirements of the quality management system of the company or a contract.

This document together with the relevant quality level can be stipulated by the customer/designer in order to require a minimum of quality assurance measures for the manufacturing of his or her component.

The requirements specified in this document can be helpful when a quality assurance system is being established.

Thermal spraying — Quality requirements for manufacturers of thermal sprayed coatings

1 Scope

This document specifies quality requirements for manufacturers of thermal sprayed coatings to ensure quality assurance for activities in the field of production.

NOTE It is independent of the availability of a quality management system, e.g. ISO 9001, ISO 14001 and ISO 45001, which concern the concept and organization of the quality management.

This document defines the quality requirements that are of importance for the manufacturing route.

This document is applicable to thermal spraying including all the pre- and post-treatments of the whole coating process for new parts, for repairs and maintenance (e.g. after service) at the workshop or on site.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 12690, *Metallic and other inorganic coatings — Thermal spray coordination — Tasks and responsibilities*

ISO 14917, *Thermal spraying — Terminology, classification*

ISO 14918, *Thermal spraying — Qualification testing of thermal sprayers*

ISO 14923, *Thermal spraying — Characterization and testing of thermally sprayed coatings*

EN 1395-1, *Thermal spraying — Acceptance inspection of thermal spraying equipment — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14917 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
contract
requirements for the coating or for the component to be coated agreed between the contracting parties, e.g. by specification, drawing, manufacturing instructions.

Note 1 to entry: In order to avoid coordination problems between the contracting parties, it is essential to indicate a reference to the standard, including the publication date, according to which a contract was defined

3.2
special process
manufacturing process, including surface preparation and certain post-treatments, where the results of manufacturing cannot be confirmed entirely by subsequent quality and product tests and where, for example, manufacturing faults might only be shown after putting the product into service

Note 1 to entry: For this document, "special process" refers to thermal spraying.

3.3
coating manufacturer
person or organization responsible for thermal spraying production

3.4
thermal spraying coordinator
person who is trained and qualified, e.g. in accordance with ISO 12690 or equivalent

Note 1 to entry: Such training may be the ETSS (European Thermal Spraying Specialist) in accordance with the EWF Guideline 459.

3.5
thermal sprayer
person who is trained and qualified in accordance with ISO 14918 or equivalent or qualified by job reference specimens for a particular application

Note 1 to entry: Such a training may be the ETS (European Thermal Sprayer) in accordance with the EWF Guideline 507.

3.6
component
part, structure or construction that is partially or entirely covered by a thermal sprayed coating

3.7
quality assurance level
QAL
systematic measures in the field of production/manufacturing, for maintaining the internally or externally required quality of the production/manufacturing processes with regard to the *components* (3.6)

3.8
quality requirement class
QRC
classification that defines requirements for the coating and relates to its importance for the proper function and safety of the *components* (3.6)

3.9
factory quality control
FQC
internal functioning unit of a company that is independent of the production unit and that is responsible for keeping the intended or required quality guidelines

Note 1 to entry: FQC can be ensured by quality audits.

3.10
thermal spray procedure specification
TSPS
instructions for thermal spraying including any necessary parameters

Note 1 to entry: Instructions for pre- and post-treatment can be part of the TSPS.

4 Quality requirements for manufacturers and thermal sprayed coatings

4.1 General

Using this document, the quality requirements for the manufacturer for thermal spraying can be selected in such a way that they fulfil the requirements for the component to be coated. In accordance with 4.2 to 4.5, the appropriate level shall be selected in accordance with the importance of the thermal spray coating for the function and safety of the component.

4.2 Quality requirements for the manufacturer

4.2.1 General

Planned manufacturing, an adequate control, and testing of the manufacturing are sufficient measures in order to ensure the required function of components with thermal sprayed coatings. The establishing of an adequate quality assurance system is an appropriate measure for a successful production and completion in the time schedule and serves to avoid reworks or other additional measures.

In general, the manufacturer establishes the quality assurance system in accordance with the components to be coated and the requirements of the coatings.

Different requirements, which form the basis of establishing and defining a quality assurance system for thermal spraying, are listed in Annex C in accordance with the levels C, S and E.

Audits, which can be executed by an external test organization or internally by a department (FQC) independent from the production, shall safeguard the functionality of the system and shall check that the stipulated conditions are maintained.

It is a task and responsibility of the company's executive officers to establish a regular cycle for carrying out external or internal quality assurance audits in accordance with the rules.

4.2.2 Requirements for the quality assurance — Selection of the quality assurance level

The appropriate quality assurance level (QAL) C, S or E can be selected in relation to the quality requirement class (QRC), which is given by the required properties of the sprayed coating and its importance for the proper function and safety of the component. For details, see 4.4.

The requirements of the factory related to the QAL are:

— quality requirements for the manufacturer in accordance with QAL-C: comprehensive quality requirements;

— quality requirements for the manufacturer in accordance with QAL-S: standard quality requirements;

— quality requirements for the manufacturer in accordance with QAL-E: elementary quality requirements.

4.3 Selection of the quality requirements for the thermal sprayed coating — quality requirement classes

4.3.1 General

The QRC depends on the requirements of the sprayed coating and its importance for the proper function and safety of the component. It can be required by the customer, by an agreement between the contracting parties or by a general determination of the executing company itself. The specific level of the requirements is specified as given in 4.3.2 to 4.3.4.

4.3.2 Quality requirement class QRC1

Coatings of QRC1 are those where the function of the coating performs a main element of the design and has a decisive influence on the function of the component. In the case of its failure under service conditions, the function of the component or of a main part of it will be lost.

4.3.3 Quality requirement class QRC2

Coatings of QRC2 are those that support the function of a component. In the case of its failure under service conditions, the function of the component or of a main part of it will be impaired. However, a safe service is safeguarded for a certain but limited time.

4.3.4 Quality requirement class QRC3

Coatings of QRC3 are those where the function of a component does not depend on the functionality of the coating. In the case of its failure under service conditions, the function of the component or of a main part of it will not be impaired.

4.4 Selection of the quality requirements for thermal spraying

In general, components which have a QRC of 1 are likely to require the manufacturer to use a QAL of C, whereas those with a QRC of 2 or 3 can require a QAL of S or E. However, this shall be decided by an assessment of the function of the coatings and the complexity of their production. The QAL may, for instance, be upgraded where repair is very difficult or downgraded if the required coating is very insensitive to process variations. Annex A, Figure A.1, presents a flow chart for defining the requirements.

The instructions given in Table B.1 regarding the importance of different elements for the quality assurance for the different systems C, S and E shall be followed.

The requirements specified in Table C.1 regarding the quality assurance elements for the quality assurance system comprehensive requirements, standard (normal) requirements and elementary requirements shall be followed.

4.5 Designation of the quality assurance level

The designation of the required quality assurance system shall include a reference to this document and the status of the requirements. The requirements shall be specified as follows:

— in the case of comprehensive requirements: ISO 14922-C:2021;

— in the case of standard (normal) requirements: ISO 14922-S:2021;

— in the case of elementary requirements: ISO 14922-E:2021.

Annex A
(informative)

Flow diagram for selection of thermal spraying quality requirements

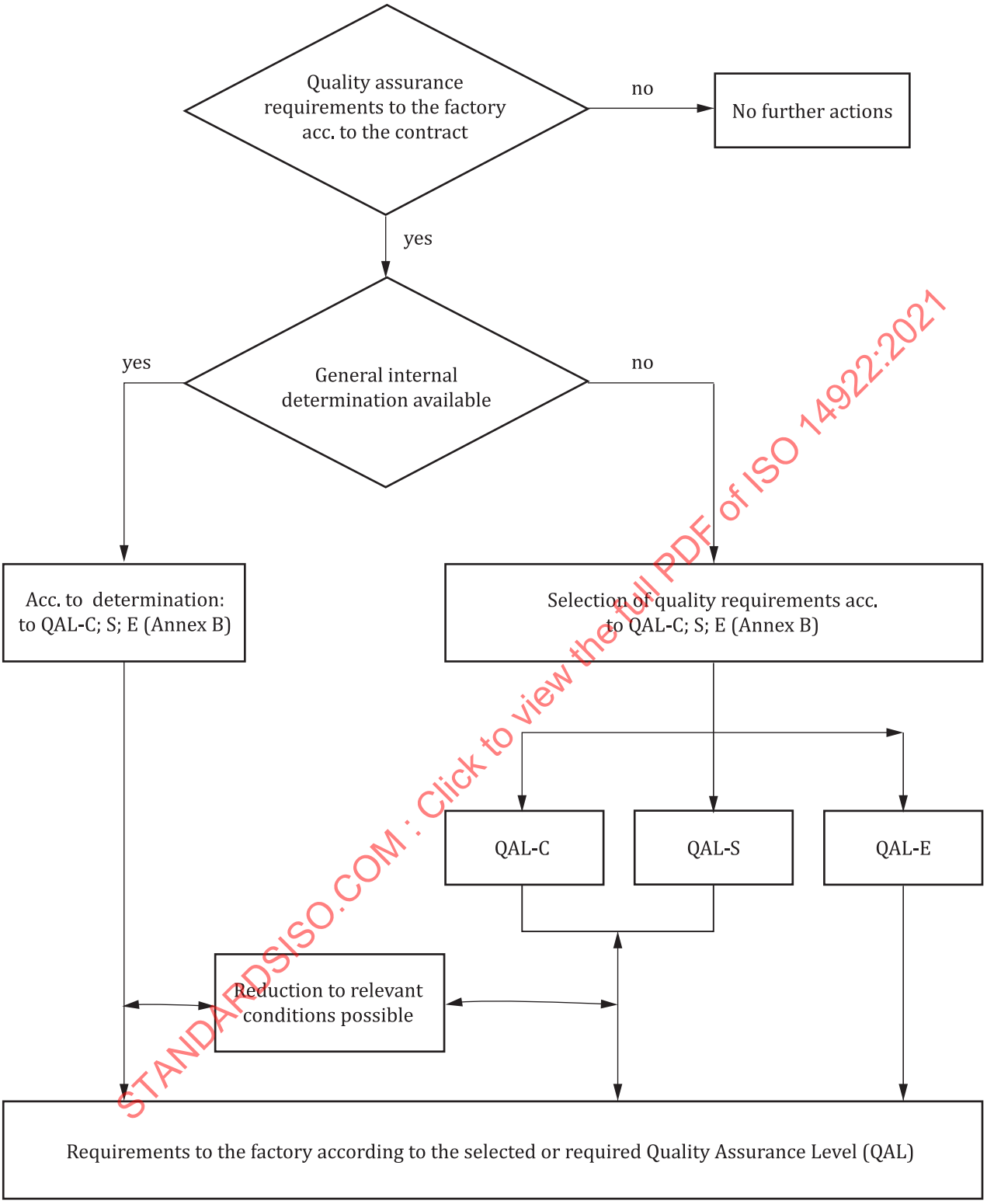

Figure A.1 — Flow diagram for selection of thermal spraying quality requirements

Annex B
(normative)

Requirements to the factory in accordance with QAL-C, QAL-S, and QAL-E

Requirements to the factory in accordance with QAL-C, QAL-S and QAL-E are given in Table B.1.

Table B.1 — Requirements to the factory in accordance with QAL-C, QAL-S and QAL-E

Code	Quality elements — Requirements	C	S	E
1	Contract review	+++	++	+
2	Design review (safe coatability)	+++	++	+
3	Subcontracting	+++	++	+
4	Personal qualification and training (subject and safety related)	+++	+++	++
4.1	Personal qualification for thermal sprayer, in accordance with ISO 14918, job reference specimen [a]	+++	+++	+
4.2	Personal qualification for thermal spraying coordinator, in accordance with ISO 12690	+++	++	+
5.1	Personal qualification for inspection in general	+++	++	+
5.2	Personal qualification for inspection personnel, in accordance with ISO 9712, if applicable	+++	++	+
	Procurement (materials, tools) [b]	+++	++	+
6.1	Equipment for production (machines, blasting and spray equipment, equipment for post-treatments, cranes, lifting devices, etc.)			
6.2	Description of the equipment [b]	+++	++	+
6.3	Suitability of the equipment, in accordance with EN 1395-1	+++	++	+
6.4	New equipment, in accordance with EN 1395-1 [b]	+++	++	+
7	Maintenance of equipment (planning, execution) [b]	+++	++	+
8	Health and environmental aspects	+++	+++	+++
9	Process control, work preparation, procurement of spray and auxiliary material, production course, testing, supporting services (maintenance, dispatch)	+++	++	+
9.1	Production planning, work sequence plan	+++	++	+
9.2	Establishment of a TSPS	+++	++	+
9.3	Qualification of the TSPS by a procedure qualification or by experience	+++	++	+
9.4	Work instruction for surface preparation and post-treatments	+++	++	+
9.5	Establishment of a test plan, determination of test procedures, scope of testing	+++	++	+
9.6	Performance of manufacturing	+++	++	++

Key

+++ = comprehensive requirements; ++ = standard requirements; + = elementary requirements; - = no deliver proof necessary.

[a] Job reference specimen shall be applied for specific applications only.

[b] Belongs to ISO 9001 and shall be checked only when not audited by ISO 9001.

[c] Usually supply instructions inclusive data sheet with order instructions are compared. A batch testing can be necessary in special cases only or in the case of contract requirements.

Table B.1 *(continued)*

Code	Quality elements — Requirements	C	S	E
10.1	Identification of the spray material [c]	+++	+++	++
10.2	Storage and handling of thermal spray material	+++	++	++
	Products delivered by the customer			
11.1	Testing of incoming material (identification, completeness, damages, differences of contract conditions) (complaint management)	+++	+++	++
11.2	Storage and handling of packing and dispatch [b]	+++	++	+
12.1	Testing before thermal spraying	+++	+++	++
12.2	Inspection during thermal spraying	+++	++	+
12.3	Testing after thermal spraying	+++	++	+
12.4	Status of testing, in time documentation of finished works and testing	+++	++	+
13	Test equipment calibration [b]	+++	++	+
14	Management of defective products	+++	+++	+
15	Corrective measures in the case of inadmissible imperfections [b]	+++	++	+
16	Marking and tracing back [b]	+++	++	+
17	Quality report, establishing, archive	+++	++	+

Key

+++ = comprehensive requirements; ++ = standard requirements; + = elementary requirements; - = no deliver proof necessary.

[a] Job reference specimen shall be applied for specific applications only.

[b] Belongs to ISO 9001 and shall be checked only when not audited by ISO 9001.

[c] Usually supply instructions inclusive data sheet with order instructions are compared. A batch testing can be necessary in special cases only or in the case of contract requirements.

Annex C
(normative)

Quality elements and measures covering the quality assurance in accordance with the comprehensive, standard and elementary requirements

Quality elements and measures covering the quality assurance are given in Table C.1.

Table C.1 — Quality elements and measures covering the quality assurance

Code	Quality elements	Comprehensive requirements	Standard requirements	Elementary requirements
1	Contract review	The factory's management shall review the contractual requirements and the design data. All information necessary to carry out the manufacturing shall be available prior to the commencement of the work. The factory's management shall affirm the capability by a confirmation to meet all thermal spraying contract requirements. An adequate planning of all activities related to manufacturing, testing and quality assurance shall be ensured.		
		The contract review carried out by the factory's management serves to confirm that the requirements of the contract can be fulfilled, that sufficient technical and organizational resources are available, spray coatings of the required quality can be produced, the time schedule can be kept and that the requirements are unambiguously defined. The factory's management should ensure that any variations between the contract and previous tender documentation are identified and that the client is notified of any programme, cost or engineering changes that can result. Intended subcontracting shall be notified too, if applicable. Contractual requirements are: — the specifications for applying the preparation (cleaning, degreasing, blasting), of thermal spraying procedures, destructive (if applicable) and non-destructive testing procedures, and post-treatments (heat treatment, sealing, machining); — preparation of the TSPS and its qualification by a procedure qualification, e.g. in accordance with EN 15648; — the application standard to be used, if appropriate; — the qualification of the personnel (for details, see Code 5); — inspection, testing, scope of tests and test equipment; — environmental conditions relevant to thermal spraying in the workshop or on site; — subcontracting; — handling in the case of nonconformity;		
		— selection, identification and/or traceability, e.g. for materials, qualification of the thermal sprayers and coatings (for details, see Code 17); — further requirements, e.g. as needed for batch testing of spray materials, if appropriate;		
		— measures for the internal quality assurance (executed by FQC or together with an independent external test body).		

Table C.1 *(continued)*

Code	Quality elements	Comprehensive requirements	Standard requirements	Elementary requirements
2	Design review	If no contract exists or in the case of manufacturing from stock, the factory's management shall deliver proof that the requirements of the design review had been considered in accordance with Code 3. Requirements for the constructional design: — location, accessibility and sequence of all coatings; — specification of the required coating properties in a coating specification (coating material, thickness and surface conditions of the as sprayed coating, e.g. as needed for the exclusion of particular characteristics in accordance with ISO 14923). General recommendations for design in accordance with EN 15520. Specific recommendations for atmospheric corrosion protection in accordance with ISO 2063-1.		
		— dimensions and details of prepared substrate surfaces;		
		— details of roughness in the as finished condition, if necessary, for an intermediate status too (surface preparation, as sprayed, sealed, etc);	— details of roughness in the as finished condition;	
		— requirements for the sprayed coating in the state of delivery;		
		— further requirements, e.g. as needed for surface preparation, applying the spray process, admissible maximum temperature of the component while spraying, post-treatments, and cooling, masking and heat treatments;	— further requirements, e.g. as needed for surface preparation, applying the spray process, post-treatments, and cooling, masking and heat treatments.	

Table C.1 *(continued)*

Code	Quality elements	Comprehensive requirements	Standard requirements	Elementary requirements
3	Subcontracting	In case of subcontracting (e.g. inspection, non-destructive testing, post-treatment), all relevant specifications and requirements shall be made available to the subcontractor. The subcontractor shall provide records and documentation of his work in a clear and order-related manner. Each subcontractor shall work on behalf and under the responsibility of the plant management and shall fully conform to the relevant requirements of this document.		
		All relevant data from the contract review (see Code 1) and the design review (see Code 2) shall be provided by the factory's management to the subcontractor. Additional requirements can be necessary if the design of a component is carried out by the subcontractor.		
4	Personnel for thermal spraying — General	The company shall have sufficient and competent personnel to plan, carry out and monitor the production of thermal spraying in accordance with the specified requirements. The management of the plant shall ensure adequate technical training and appropriate instructions in matters of safety and environmental protection.		
4.1	Thermal sprayer	The sprayer intended for doing the thermal spraying shall be qualified by testing in accordance with ISO 14918 or equivalent. All test records shall be maintained up to date. Any test certificates shall be stored in adequate manner, e.g. in a personal file, in order to be able to present them at a quality audit. The period of validity and re-testing shall be considered.		The personnel for thermal spraying shall be sufficiently skilled. Qualification of the spray personnel in accordance with ISO 14918 is desirable. A qualification by a job reference specimen can be necessary for certain applications.
4.2	Thermal spraying coordinator	The factory shall possess appropriate thermal spraying coordination personnel at its disposal so that the thermal spraying personnel can get the necessary thermal spraying and further work instructions (e.g. for surface preparation and post-treatments). Usually the parameters are stipulated in the TSPS. The spraying coordinator who is responsible for the quality assurance shall possess sufficient authority to enable any necessary measures to be taken. The tasks and duties of such persons shall be clearly defined. For details, see ISO 12690.		
5.1	Personnel for quality testing — General	The factory shall possess sufficient and competent personnel for planning, performing, inspection and testing of the thermal spraying production steps in accordance with specified requirements at its disposal.		
5.2	Personnel for non-destructive testing	The personnel employed (internal or external) for non-destructive testing shall be qualified in accordance with ISO 9712, if such testing is required.		
6	Equipment — General	The following equipment shall be available for the application, where necessary: — workshop in closed buildings, usually; — stores for the correct storage of components to be coated, spray materials and other auxiliaries for thermal spraying;		

Table C.1 *(continued)*

Code	Quality elements	Comprehensive requirements	Standard requirements	Elementary requirements
6.1	Equipment for manufacturing	— equipment for drying and homogenization/mixing of spray powders, if appropriate;		— equipment for the drying of spray powders, if appropriate;
		— equipment to prepare the components prior to spraying (e.g. machine tools, equipment for degreasing, blasting cabins) and for post-treatments (e.g. sealing), if appropriate; — spraying equipment, including equipment for the energy and gas supply, parameter setting and control; — handling systems (e.g. turntables, turning machines, industrial robots); — collecting and exhaust systems, dust filters, protective means against noise and UV-, IR- and intensive-light radiation; — cooling equipment; — equipment and means for testing and measuring of thermal sprayed coatings; — equipment for post-treatments, e.g. for sealing, if appropriate; — equipment for heat treatment, if this a part of the spraying process; — for spraying on site, adequate equipment shall be installed, (e.g. housing, heating, extraction equipment). — machines, tools and equipment for the post-treatment of thermal sprayed coatings (e.g. grinding, turning), as far as appropriate.		
6.2	Description of equipment	The factory's management should maintain a list of essential equipment used for thermal spraying production. This list shall contain details for a determination of workshop capacity and capability, e.g. as needed for: — the capacity of the biggest crane; — the size and weight of the components that could be coated; — the capacity of the cabins for blasting and spraying; — the capability for the safe storage of components supplied by the client.		
6.3	Suitability of the equipment	The equipment shall be adequate for the application concerned. The equipment for thermal spraying can be qualified in accordance with the EN 1395 series, even after a certain service time has elapsed, where necessary.	The equipment shall be adequate for the application concerned. In special cases, the equipment for thermal spraying can be qualified in accordance with the EN 1395 series.	The equipment shall be adequate for the application concerned

Table C.1 *(continued)*

Code	Quality elements	Comprehensive requirements	Standard requirements	Elementary requirements
6.4	New equipment	When new (or refurbished) equipment is put into service, tests in accordance with the EN 1395 series should be performed. These tests shall verify the correct function of the equipment. Records of such tests shall be maintained.		When new (or refurbished) equipment is put into service, tests should confirm the suitability. Records of such tests shall be maintained.
7	Maintenance	The factory's management shall have documented plans for the maintenance of such equipment which serve as a control of influencing data of the spraying process and are essential for the quality assurance of the thermal sprayed coating. Examples for such features are: — conditions of guides in equipment for mechanized thermal spraying; — conditions of industrial robot axis, if appropriate; — conditions of instruments for measuring current and voltage, flow meters, etc.; — conditions of cables, hoses, connections, etc. for energy and gas supply; — conditions of the control system in mechanized and/or automatic thermal spray processes; — conditions of thermocouples and other temperature measuring instruments; — condition of the powder feed unit, wire feeders and conduits; — condition of spray torches/spray guns (exchange of worn parts). Defective equipment shall not be used.		
8	Safety and environment protection	Personnel protection equipment and required equipment for safety, fire, and environment protection shall be available. Personnel shall be instructed and all necessary measures for achieving the work-related protection rules and fulfilling the requirements of emission limits shall be carried out. In the case of work on the construction site, the rules applicable on site shall be observed.		
9	Performance of thermal spraying — General — Process control	The process control contains all the functions and activities which are necessary in order to fulfil the quality requirements and the delivery conditions (delivery date, packing and dispatch). The factory's management shall organize the company in such a way that the functions for work preparation, procurement of spray and auxiliary materials, manufacturing courses, testing and services, maintenance and dispatch, which can be executed internally or externally, are available.		
		External activities shall be covered by a contract.		

Table C.1 *(continued)*

Code	Quality elements	Comprehensive requirements	Standard requirements	Elementary requirements
9.1	Manufacturing plan	The factory's management shall prepare an adequate manufacturing sequence plan. It shall be compatible with the necessary and available facilities for the workshop or on site. The plan can also be applied for the documentation of finished work and test steps. It shall contain at least: — sequence of the work steps for preparation, spraying, post-treatment and tests; — a reference to the qualified procedure specification (TSPS);		
		— a sequence in which the coatings are to be applied, if applicable;		— a sequence in which the coatings are to be applied, occasionally verbal, if applicable;
		— instructions for the masking of areas which shall not be coated; — instructions and timings for how the individual processes are to be performed; — a determination of inspection and testing, if appropriate with the involvement of an independent examining body;		— instructions for the masking of areas that shall not be coated, occasionally verbal; — instructions and timings for how the individual processes are to be performed; — determination of inspection and testing;
		— the environment conditions to be considered, e.g. protection against wind, cold and rain; (spraying on site or in workshops);		
		— the identification of batches, components or parts, as appropriate.		
		The documentation shall be adequately archived in accordance with the appropriate rules.		
9.2	Preparation of the TSPS	The factory's management shall prepare a component-related TSPS and shall ensure that it is used correctly when manufacturing.		use of the standard TSPS from the factory
		Instructions for surface preparation and surface finishing can, if applicable, be part of the TSPS or shall be prepared separately as a process specification. The factory management should make the TSPS and sprayer operating instructions available to everyone in the workshop.		
9.3	Qualification of the TSPS	A qualification of the TSPS shall be performed, e.g. in accordance with the standard for a component-related procedure qualification (see EN 15648), even if it is not required by a contract.	A qualification of the TSPS should be performed, e.g. in accordance with the standard for a component-related procedure qualification (see EN 15648), even if it is not required by a contract.	A qualification of the TSPS should be covered by existing knowledge. The qualification can be carried out in accordance with the standard for a component-related procedure qualification (see EN 15648).

Table C.1 *(continued)*

Code	Quality elements	Comprehensive requirements	Standard requirements	Elementary requirements
9.4	Work instructions for surface preparation and post-treatments	The factory's management is responsible for specifying and performance of the necessary surface preparation and of post-treatments, as far as they are required. The procedures shall be adequate for the component, its material and the coating. The coating manufacturer shall apply the procedure specifications for surface preparation and for post-treatments for information to the sprayer, if applicable.		
9.5	Preparation of the test plan — Specification of test procedures and scope of testing	The factory's management shall prepare a test plan that contains the required tests for surface preparation, spraying and post-treatments. Test procedures, the scope of testing and the documentation are to be specified in accordance with the contract or to internal company-related requirements.		
		If appropriate, test reports are to be prepared in accordance with the contract or to internal company-related requirements.	If appropriate, test reports are to be prepared if required by the contract.	
		Necessary accompanying test specimens for the destructive testing are to be defined and be prepared to accompany the manufacturing of the component.		
9.6	Performance of manufacturing	The factory's management shall ensure that the technical and organizational conditions of the manufacturing course are kept. The actual manufacturing status shall be perceptible in time. For details, see Code 12.4.		
		If a record for a treatment (pre- or post-treatment or performance of thermal spraying) is required to accompany the process, then the record shall contain all the information about following the instructions, and tracing back to the corresponding manufacturing step shall be possible.		
10	Spray material — General	Responsibility for storage, release and distribution of the spray material shall be specified by the factory's management.		
10.1	Identification of the spray material and batch testing	Usually a comparison of the delivery documents to the order instructions including the data sheet to the certificate in accordance with EN 10204, ISO 14919, ISO 14232 -1 and the designation on the package is sufficient.		
		Batch testing of spray materials shall be carried out only if required in the contract.		
10.2	Storage and handling	The factory's management shall define the procedures for storage, handling and use of the spray materials, in order to avoid moisture pick-up, oxidation, de-mixing and damage, etc. The procedure shall be in accordance with the supplier's specifications.		

Table C.1 *(continued)*

Code	Quality elements	Comprehensive requirements	Standard requirements	Elementary requirements
11.1	Products delivered by the client — Testing of incoming material	The factory's management shall specify the conditions of testing of incoming products delivered by the client. In that way it shall be ensured that the following tests will be performed: — identification of the products on the basis of delivery documents; — completeness of the delivery; — damages; — deviations from contract conditions (e.g. size, number, shape in detail); In the case of deviation, a complaint shall be done without loss of time.		
11.2	Storage and handling, package and dispatch	Parts shall be stored throughout the manufacturing process in such a way that the components cannot be damaged. A marking shall be applied and a clear designation for shipping.		
12	Testing and inspection related to thermal spraying — General	Inspection and testing shall be planned after important manufacturing steps and at appropriate points in the manufacturing course to ensure conformity with contract requirements. Location and frequency and/or the scope of such inspection and/or testing depend on the contract and/or application standard, the thermal spraying process and the type of the coating (for details, see Codes 2 and 3).		Inspection and testing shall be planned after important manufacturing steps and at appropriate points in the manufacturing course to ensure conformity with contract requirements.
		The coating manufacturer may carry out additional tests provided that they will not impair the coating. Results of such tests should be internally documented. However, they shall not be part of the documentation for the client.		
		Inspections applied by the thermal spraying coordinator or the thermal sprayer shall be specified in the prevailing work descriptions.		

Table C.1 *(continued)*

Code	Quality elements	Comprehensive requirements	Standard requirements	Elementary requirements
12.1	Testing before thermal spraying	Before starting the thermal spraying, the following shall be checked: — correspondence between the work instructions and the identification of the component and spray devices, if applicable; — validity of the TSPS for the application; — surface preparation; — necessity of masking, as far as it is not already done; — avoiding of loss of time: spraying shall be done immediately after finishing of the surface preparation; — arrangement of possible production tests;		
		— validity of the thermal sprayer's certificate by the spray coordinator;		— validity of the thermal sprayer's certificate by the spray coordinator, if applicable;
		— suitability of working and environment conditions for thermal spraying.		
12.2	Inspection during thermal spraying	During thermal spraying, the following shall be checked at suitable intervals or by continuous parameter control, where necessary: — essential thermal spraying parameters (e.g. current, voltage, spray distance, spray angle, travel speed, gas pressure and gas flow, deviation from the normal appearance of shape and noise of the spray jet); — surface temperature; — correct use and handling of consumables; — control of distortion/deformation; — any intermediate inspection, e.g. measurement of coating thickness, checking the environment conditions.		
		NOTE In special cases with extremely high requirements to the spray process or to the component, a control of, for example, particle temperature and velocity diagnostic methods and a process control in accordance with the closed loop method is recommended.		