

THE ENGINEERING EQUIPMENT AND MATERIALS USERS ASSOCIATION

CODE OF PRACTICE FOR THE IDENTIFICATION AND CHECKING OF MATERIALS OF CONSTRUCTION IN PRESSURE SYSTEMS IN PROCESS PLANTS

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THE ENGINEERING EQUIPMENT AND MATERIALS USERS ASSOCIATION

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1. FOREWORD

The purpose of this Code of Practice is to outline measures to be taken to minimize the likelihood of in-service failure, primarily of pipework, due to the use of incorrect material and where the consequences of such a failure would be unacceptable. The Code is, however, applicable to other types of equipment. It is not intended necessarily to ensure the complete absence of incorrect materials or the complete conformity of materials to any given specification; where such guarantees are considered necessary, more rigorous measures may be needed.

The original, 1986, issue of this Code of Practice was intended to be applied to new equipment. This 1997 edition has been comprehensively revised by the EEMUA Inspection & NDT Technology Committee to include in-service equipment and the latest available and relevant NDT techniques, and to align the document with the Pressure Systems and Transportable Gas Containers Regulations (1989).

Publications referenced in this document are listed in Appendix II.

2. INTRODUCTION AND SCOPE

Many process plants use a range of ferritic and austenitic alloy steels in addition to plain carbon steels to safely withstand process conditions. Such steels may be required for enhanced strength, increased strength at high temperature, enhanced ductility at low temperatures, resistance to attack by hot hydrogen, resistance to corrosion etc.

It is not possible by visual means alone to distinguish between different ferritic or austenitic alloy steels. Potential therefore exists for materials of different specifications to become mixed up unless a rigorous system of segregation, marking and other necessary controls is in place.

Major failures have occurred when incorrect material has been accidentally fabricated or introduced into pressure systems. Such rogue materials usually survive the final hydrostatic acceptance test, only to reveal themselves in service when the material has been weakened to the point of failure by the operating conditions.

The consequences of failure due to the use of a wrong material are potentially at their worst in systems operating under the more aggressive, environmentally hostile, or similarly demanding process conditions — the very systems that often require special materials. There will also be cases where a higher strength, alloy material is built in error into a carbon steel system. In such cases the consequences are likely to be potentially less damaging. Although not having undergone a pre- and/or post-weld heat treatment, the material may survive, or due to embrittlement may become visibly cracked or even fail the hydrotest.

Experience shows that the greatest number of errors occur in pipework, in particular those systems which include components that are fabricated and assembled on construction sites from bulk issue materials. This Code of Practice therefore addresses itself mainly to pipework and is primarily applicable to pipe, tubing, valves, flanges, other fittings and the welds used to join together or fabricate those components. It covers classification of pipework systems, and material control procedures for identification of materials during manufacture, at stockists or fabricators, during pre-commissioning on site, and in service. Appendix I describes the methods and equipment used for such checking. Many of the recommendations are, however, also applicable to fired heaters, boilers, pressure vessels and other pressure equipment.

3. DEFINITIONS

Authority

That person or body authorised by the owner to undertake a specific function and responsibility.

Design Authority

The Authority responsible for the design of the plant and equipment in the owner's works. Typically this would be a group within the works, a contractor, a consultant or the owner company's central engineering department.

Inspection Authority

The Authority responsible for the inspection of plant and equipment forming part of any pressure system in the owner's works and for the inspection of any repairs or modifications to that plant and equipment. The Inspection Authority may be owner-company personnel (a User Inspectorate), a contractor or an engineering inspection company.

Operations Authority

The Authority responsible for the operation of the owner's plant.

Pipeline

A pipe or system of pipes used for the conveyance of fluid across the boundaries of premises, together with any equipment or apparatus incorporated therein including valves, valve chambers, pumps, compressors and similar equipment.

Pipework

A pipe or system of pipes incorporated in a plant together with associated valves, pumps, compressors and other pressure-containing components including hoses and bellows but not pipelines or any protective devices.

Pressure System

- a) A system comprising one or more pressure vessels of rigid construction and associated pipework and protective devices;
- b) the pipework with its protective devices to which a transportable gas container is, or is intended to be, connected; or
- c) a pipeline and its protective devices.

4. IDENTIFICATION AND CLASSIFICATION OF PIPEWORK REQUIRING TO BE SUBJECTED TO MATERIAL VERIFICATION (SMV)

4.1 Identification

4.1.1 Pipework should always be subjected to material verification when the conditions under which it operates are such that a failure attributable to the inclusion of incorrect materials may occur, and when the consequences of such failure are unacceptable in regard to the likely hazards to personnel or plant and production losses. A pragmatic decision may be taken to check all equipment in the pressure system which contains alloy materials. There are, however, a number of sophisticated *risk based inspection* (RBI) procedures which may be used to calculate a risk factor based on the likelihood and consequences of failure — e.g. those to be included in API 580 (see Appendix II). The extent to which a pressure system is to be subjected to material verification may, therefore, range from those parts of the pipework containing alloy materials and liable to unacceptable failure, to an entire pressure system allotted a given risk factor.

4.1.2 The conditions to be assessed include pressure, temperature, nature of fluid (toxic and/or flammable) and location of the pipework or component thereof in relation to plant, buildings or personnel. From the above it follows that due to location, or changes in other conditions, parts of a pipework system may have differing degrees of risk associated with a possible loss of containment. It may not therefore be necessary for an entire system to be subjected to material verification.

4.2 Classification

4.2.1 Systems requiring material verification, either in whole or in part, in accordance with the foregoing criteria should be classified 'SMV' and this should be stated in the appropriate documents.

4.2.2 For new projects, all pipework (and other equipment if considered necessary) should be considered by the Design Authority and classified SMV, in whole or in part, where appropriate.

4.2.3 For existing plants, thorough and systematic consideration should be given to classifying all alloy-containing pipework (and other equipment if considered necessary) as SMV. As an immediate precaution, whenever replacement pipework is required or pipework modifications are to be carried out and the original drawings do not clearly and unambiguously indicate the classification of the relevant pipework, then the Operations Authority should, in conjunction with the Design Authority, identify and classify the pipework as required by this section.

5. IDENTIFICATION OF PIPEWORK (OR OTHER EQUIPMENT) OTHER THAN SMV

No special action is required for 'non-SMV' systems or components. This is not to be taken as meaning that it is of no concern whether or not the correct material is used for those systems. All the usual checks for correct specification, identification, scrutiny of test certificates etc., should apply.

6. MATERIAL SUPPLY

The supply chain from raw material to installed component involves a number of processes and organisations — e.g. material and component manufacture, material stockist, site receipt and storage — where errors leading to incorrect identification can arise. It is in the longer term interest of all parties that procedures and controls at all stages of the chain should be adequate to prevent mistakes (e.g. through the use of techniques such as those in the applicable standards in the BS EN ISO 9000-9004 series of quality standards — see Appendix II).

Visual identification of components by means of colour coding is an essential part of the total quality control system; one widely used standard is BS 5383.

It is the duty of the manufacturer or stockist to ensure that materials are correctly marked. However colour coding, character printing and hard stamping are only *aids* to identification. The purchaser should require the supplier to ensure that adequate measures are taken to satisfy himself, and the purchaser, beyond reasonable doubt that the materials which he supplies are those which were ordered and that they are correctly marked. In the case of SMV systems it will be necessary to carry out positive material identification (PMI) checks using one of the methods outlined in Appendix I as mutually agreed with the Inspection Authority; elements to be verified and method of checking are to be mutually agreed in advance.

Material subjected to conformance checks should, if found to conform, be so marked with an appropriate symbol. The supplier or stockist should supply a certificate of conformity traceable against material supplied with each consignment detailing:

- (a) the specification with which the goods purport to conform
- (b) the check tests applied by him
- (c) a facsimile of the symbol indicating that appropriate check tests have been applied and the material has been found to conform
- (d) the marks identifying the consignment.

Such certificates should be additional to any certification required by the specification relating to the components in question.

7. SHOP AND SITE FABRICATION

The possibility of accidental use of the wrong material increases as the number of separate material specifications for pipework (or other equipment) increases. The potential for error can be reduced by restricting the number of different specifications and by segregating specifications for off- or on-site fabrication in different workshops, by different contractors etc., as well as by rigorous control of materials as stated in this Code.

8. SITE MATERIAL CHECKS AND RECORDS

8.1 Pre-service Site Material Checks

It is recommended that all parts of SMV systems be checked either during or after erection and before going into service to ensure that all materials conform to those specified. Every component which is built into the system should be subjected to PMI, including weld metal. For some services, it will also be necessary to check flange bolting and gaskets. Checking should be carried out using an approved instrument or method defined in Appendix I, or in such other way as may be agreed.

In some cases it is very difficult to positively identify special grades of material by means of the non-destructive testing methods outlined in Appendix I, e.g. impact tested carbon steel or low carbon grades of austenitic steel. Metallurgical advice should be sought on the best technique to use and the accuracy which may be expected from it. In some cases reliance may have to be placed on specially detailed documentation, and marking of materials adequately tested at an earlier stage.

It should also be noted that, at the present time, the materials checking methods available can only check the surface composition of welds which may not be representative of earlier passes. When it is essential that the whole of the weld metal be verified, then checks during the welding cycle should be made on deposits of the actual electrodes or filler wire used.

The checks referred to above apply to both shop and site fabricated pipework items at the time they are erected to occupy their final place in the pipework system. In some cases checking may be relaxed for clearly marked, identified and documented items which have been prefabricated off site under similar close control. Such relaxation should be agreed by the responsible Authorities. In no case should final checking be totally eliminated; a recommended 10% minimum of all items should be checked after erection, even when it is believed that rigorous offsite control was applied.

8.2 Retrospective Site Material Checks

Existing in-service equipment that has been retrospectively classified SMV under paragraph 4.2.3 should be subjected to material verification by PMI.

8.3 Records

Records of all materials checked in accordance with this Code, and of any heat treatment, both on- and off-site, should be retained in the plant history files and be traceable to the installed pipework and/or other equipment.

APPENDIX I: METHODS USED FOR CHECKING MATERIALS

The method adopted for the positive identification of materials will depend on many factors, e.g. the variety of different materials which have to be scanned, their key (chemical) elements for positive identification, the analytical capability of the method or instrument used, environmental factors (temperature, access, area classification), and the importance of accuracy.

Some of the methods available, with their advantages and disadvantages, are outlined below. New and improved instruments using these principles are being continually introduced and the balance of advantages and disadvantages may differ from those described. This, coupled with the implications of the specific requirements in each particular case, make it advisable to consult materials specialists on the appropriate method to use.

1. Spectrography

An electric arc is struck between the instrument and the material being tested, and is analysed spectrographically.

(a) Portable equipment.

- Advantages:
- small and light
 - fully portable with battery pack power supply
 - materials accurately identified if equipment used correctly
 - safe for operator (36 volts at electrodes).
- Disadvantages:
- specially trained and experienced operator required
 - under site conditions, difficult to differentiate between various grades of low alloy steel, e.g. 1¼ %Cr ½ %Mo from 2¼ %Cr 1 %Mo and other low alloy steels with a Cr content < 1 %
 - carbon content determination is not possible with an air arc
 - possibility of electrode contamination by the element from the previous sample; periodic grinding of electrodes required
 - shallow arc strike damage to sample possible
 - body of instrument becomes hot after protracted use
 - open arc, hence cannot be used in hazardous areas
 - operator fatigue.

(b) Semi-portable equipment.

Larger semi-portable, fully automatic analysers are also available, some utilising appropriate gas atmospheres for the arc thereby allowing carbon content determination. These analysers require less operator skill; also fatigue is less of a problem.

2. X-ray Fluorescence

Small radioactive sources are used to excite surface layer atoms of the sample causing them to fluoresce, emitting secondary radiation. A detector and associated electronics are used to detect and analyse the emitted radiation to determine the chemical composition of the sample material. Generally only two excitation isotopes (Fe-55 and Cd-109) are required.

Advantages: – can be calibrated for quantitative results
– suitable for sorting of austenitic stainless steels
– comparison with library alloy analysis possible when used in grade or sort mode
– possible to use less experienced operators.

Disadvantages: – for fully quantitative measurement calibration curves or standard samples may be needed
– length of setting up procedure may limit application where only a small number of specimens are to be tested
– surface has to be free of scale and oil
– possible radiation hazard
– high costs associated with source replacement and recalibration.

3. Chemical Analysis

(a) Physical removal of a piece of metal for laboratory analysis by wet chemical or spectrographic means.

Advantages: – very accurate results possible.

Disadvantages: – danger of sample contamination (from cutting tool or otherwise)
– potential for sample mix up
– could weaken component from which sample is taken.

(b) In-situ spot analysis by depositing reagent on specimen.

Advantages: – cheap
– quick
– simple to apply.

- Disadvantages: – only for horizontal surfaces
- non quantitative
 - colour changes of reagent difficult to detect in poor light
 - only at ambient temperature
 - safety aspects of handling concentrated reagents.

4. Carbon Determination by Combustion Method

Rugged, transportable instrumentation for on-site measurement of carbon level in carbon steels is available.

Principle. A sample (0.1 g minimum) is burnt in oxygen in the equipment's induction furnace unit, converting carbon into CO₂. The CO₂ content is measured by a solid state infra-red detector, and the percentage of carbon in the sample is automatically calculated and displayed.

- Advantages: – presently the only known method for carbon measurement on-site
- fully automated, accurate
 - very small sample needed.

- Disadvantages: – not portable, has to be sheltered from the elements
- care must be taken to obtain a representative sample, avoiding contamination by the cutting / abrading tool.

5. Eddy Current

Variations in electrical conductivity and permeability between carbon and alloy steels is sufficient to differentiate between them. Low energy eddy currents are induced in the material under test by a probe placed on its surface. The signature from each specimen tested has to be compared with those of known compositions to enable the actual material to be identified.

- Advantages: – quick results
- small size instrument
 - simple to operate
 - suitable for sorting certain grades of carbon steel according to the different carbon contents.

- Disadvantages: – readings affected by surface scale and finish
- readings affected by dimensions (for small samples) and material heat treatment
 - requires frequent calibration checks
 - not suitable for sorting of austenitic stainless steels.

6. Thermoelectric

The voltage difference between two metal-metal junctions at different temperatures can be used to give a measure of alloying elements in one of the metals.

A lead from the instrument is clamped to the test piece; this becomes the cold junction. The hot junction is created by briskly filing the sample with a file electrically connected to the cold junction via a meter.

The instrument can separate e.g. 5%Cr ½ %Mo steel from other chromium and carbon steels, austenitic stainless steel from 12%Cr steel, and cast iron from carbon steel, and can identify Monel.

Advantages: – small size and simple operation
– quick results
– diagnosis not affected by size and grain structure of material.

Disadvantages: – operator dependent, limited accuracy
– scale or foreign material on file will produce an erroneous reading
– cannot be used for sorting of austenitic stainless steels.

7. Magnetic

A permanent magnet can be used to segregate metals into three groups:–

Non-Magnetic

Most non-ferrous metals and alloys e.g. copper, brasses, bronzes, aluminium, titanium, zinc, cupro-nickels, Hastelloys, Incolloys, Inconels, K-Monel, S-Monel; certain austenitic stainless steels* e.g. types 304, 316, 309, 310.

Slightly Magnetic

Certain Monels (not K- or S-), cold worked welded or cast types 304 and 316 steels*.

Strongly Magnetic

Carbon steels, chrome steels (e.g. 12%Cr and 27%Cr), all the Cr-Mo steels, nickel steels, nickel.

* N.B. Austenitic stainless steels types 304 and 316 may contain sufficient ferrite to render them slightly magnetic, particularly in the case of welds and castings.

8. Resistivity

A test method known generally as 'resistivity' is becoming available. However, although there has been some satisfactory experience of the method under laboratory conditions, little is known of its viability in field applications.

The principle employed in this test method, the Seebeck effect (or thermocouple principle), is the same as that in the thermoelectric approach described under 6 above. A heated junction

of dissimilar metals is created between a heated (150°C) probe and the metal under test. The voltage generated at this junction is representative of the chemistry and crystalline structure of the metal being tested. Every metal that has the same crystalline structure will generate the same voltage regardless of the geometry or size of the piece being tested or the pressure applied. By references to known standards, these instruments are capable of sorting and identifying a wide range of ferrous and non-ferrous materials. Alloy sorters have not proved to be completely capable of sorting low alloy (<5%Cr) and stainless steels.

APPENDIX II:

PUBLICATIONS REFERENCED IN THIS DOCUMENT

API 580	(This is the document number allocated to a current API project on Risk Based Inspection; the document exists only in draft form at the time of writing (Sept 97))
BS 5383	Specification for Material Identification of Steel, Nickel Alloy and Titanium Alloy Tubes by Continuous Character Marking, and Colour Coding of Steel Tubes
BS EN ISO 9000-9004	(Various quality standards commonly collectively referred to as the '9000 series')

SUMMARY LIST OF CURRENT EEMUA PUBLICATIONS

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Publications are listed in numerical order under the following headings: Electrical, Instrumentation & Control, Mechanical Plant and Equipment, Offshore, Storage Tanks and Vessels, Noise, and General. (For further details see website www.eemua.co.uk/publications.)

An asterisk (*) indicates a publication in preparation

Amendments Where amendments have been issued, these are listed in bracketed italics after the title of the publication. It is intended that amendments be placed on the website www.eemua.co.uk/publications/amendments.

Publication No.

ELECTRICAL

- 132 : 88 Specification for Three-phase Cage Induction Motors (*Amdt No 1, Mar 02*)
- 133 : 88 Specification for Underground Armoured Cable Protected against Solvent Penetration and Corrosive Attack
- 181 : 95 A Guide to Risk Based Assessments of In-situ Large Ex 'e' and Ex 'N' Machines
- 186 : 97 A Practitioner's Handbook—Electrical Installation, Inspection and Maintenance in Potentially Explosive Atmospheres (*Updated & reprinted 2002*)
- 198* Electromagnetic Compatibility A User Guide to Installations and Standards

INSTRUMENTATION & CONTROL

- 138 : 88 Design and Installation of On-Line Analyser Systems
- 138 S1 : 93 Design and Installation of On-Line Analyser Systems: A Guide to Technical Enquiry and Bid Evaluation
- 155 : 88 Standard Test Method for Comparative Performance of Flammable Gas Detectors against Poisoning
- 175 : 95 Code of Practice for Calibration and Checking Process Analysers—Formerly IP Code of Practice 340
- 178 : 94 A Design Guide for the Electrical Safety of Instruments, Instrument / Control Panels and Control Systems
- 187 : 00 Analyser Systems - A Guide to Maintenance Management
- 189 : 97 A Guide to Fieldbus Application for the Process Industry
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- 201: 02 Process Plant Control Desks Utilising Human-Computer Interfaces—A Guide to Design, Operational and Human Interface Issues

MECHANICAL PLANT AND EQUIPMENT

- 107 : 92 Recommendations for the Protection of Diesel Engines for Use in Zone 2 Hazardous Areas
- 143 : 85 Recommendations for Tube End Welding: Tubular Heat Transfer Equipment, Part 1 — Ferrous Materials (*No subsequent parts issued*)
- 151 : 87 Liquid Ring Vacuum Pumps and Compressors
- 153 : 96 EEMUA Supplement to ASME B31.3 —1996 Edition, Process Piping (*Amdts Dec 2000 & Feb 02*)
- 164 : 93 Seal-less Centrifugal Pumps: Class 1
- 167 : 91 Specification for Quality Levels for Carbon Steel Valve Castings
- 168 : 91 A Guide to the Pressure Testing of In-Service Pressurised Equipment
- 169 : 93 Specification for High Frequency Electric Welded Line Pipe (*Obsolescent*)
- 170 : 91 Specification for Production Testing of Valves—Part 1 Ball Valves (*Reprinted 2001 incorporating Amdt No 1 Apr 96 & other minor changes*)
- 171 : 94 Specification for Production Testing of Valves—Part 2 Plug Valves (*Errata & Amdt No 1 Apr 96*)
- 172 : 95 Specification for Production Testing of Valves — Part 3 Gate Valves (*Amdt No 1 Jan 96*)
- 173 : 95 Specification for Production Testing of Valves — Part 4 Butterfly and Globe Valves
- 179 : 96 A Working Guide for Carbon Steel Equipment in Wet H₂S Service (Developed largely from Oil Refinery experience)
- 182 : 95 Specification for Integral Block and Bleed Valve Manifolds for Direct Connection to Pipework (Incorporating Information Sheet No 20: Application Guidelines) (*Reprinted incorporating Amdt No 1 Nov 98*)
- 184 : 96 Guide to the Isolation of Pressure Relieving Devices
- 185 : 96 Guide for Hot Tapping on Piping and other Equipment (*Reprinted 2000 incorporating Amdt No 1 Dec 97*)
- 188 : 99 Guide for Establishing Operating Periods of Safety Valves
- 192 : 98 Guide for the Procurement of Valves for Low Temperature (Non-cryogenic) Service
- 196 : 99 Valve Purchasers' Guide to the European Pressure Equipment Directive (*Reprinted 2002 incorporating Amdts 1–3, Nov 00, Feb 02 & Aug 02, respectively*)

- 199 : 00 On-Line Leak Sealing of Piping - Guide to Safety Considerations
- 200 : 00 Guide to the Specification, Installation and Maintenance of Spring Supports for Piping
- 202 : 01 Guide to the Use of ISO 15649 and ANSI/ASME B31.3 for Piping in Europe in Compliance with the Pressure Equipment Directive (*Reprinted 2002 incorporating Amdt No 1 May 02*)

OFFSHORE

- 144 : 87 90/10 Copper Nickel Alloy Piping for Offshore Applications—Specification: Tubes Seamless and Welded
- 145 : 87 90/10 Copper Nickel Alloy Piping for Offshore Applications—Specification: Flanges Composite and Solid
- 146 : 87 90/10 Copper Nickel Alloy Piping for Offshore Applications—Specification: Fittings
- 158 : 94 Construction Specification for Fixed Offshore Structures in the North Sea (*Reprinted 2000 incorporating Amdts 1 (Rev'd) & 2, Apr 97, & 3 Sep 02, and other minor emendations*)
- 166 : 91 Specification for Line Pipe for Offshore Pipelines (Seamless or Submerged Arc Welded) (*Obsolescent*)
- 176 : 98 Specification for Structural Castings for Use Offshore
- 194 : 99 Guidelines for Materials Selection and Corrosion Control for Subsea Oil and Gas Production Equipment (*Under revision, 2003*)
- 197 : 99 Specification for the Fabrication of Non-Primary Structural Steelwork for Offshore Installations

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- 154 : 02 Guidance to Owners on Demolition of Vertical Cylindrical Steel Storage Tanks and Storage Spheres (2nd Edition)
- 159 : 03 Users' Guide to the Inspection, Maintenance and Repair of Aboveground Vertical Cylindrical Steel Storage Tanks (3rd Edition) (*In two volumes, completely revised and expanded*)
- 180 : 96 Guide for Designers and Users on Frangible Roof Joints for Fixed Roof Storage Tanks
- 183 : 99 Guide for the Prevention of Bottom Leakage from Vertical Cylindrical Steel Storage Tanks
- 190 : 00 Guide for the Design, Construction and Use of Mounded Horizontal Cylindrical Bulk Storage Vessels for Pressurised LPG at Ambient Temperatures

NOISE

- 104 : 85 Noise: A Guide to Information required from Equipment Vendors
- 140 : 85 Noise Procedure Specification
- 141 : 85 Guide to the Use of Noise Procedure Specification
- 161 : 88 Guide to the Selection and Assessment of Silencers and Acoustic Enclosures

GENERAL

- 101 : 94 Lifting Points—A Design Guide
- 105 : 02 Factory Stairways, Ladders and Handrails (Including Access Platforms and Ramps) New edition 2002
- 148 : 86 Reliability Specification—Model clauses for inclusion in purchasing specifications for equipment items and packages
- 149 : 97 Code of Practice for the Identification and Checking of Materials of Construction in Pressure Systems in Process Plants
- 193 : 99 EEMUA Recommendations for the Training, Development and Competency Assessment of Inspection Personnel
- 195 : 99 Compendium of EEMUA Information Sheets on Topics Related to Pressure Containing Equipment (*Amdt No 1 Jan 00*)