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STANDARD FOR POSITIVE MATERIAL IDENTIFICATION OF PIPING COMPONENTS USING PORTABLE X-RAY EMISSION TYPE TEST EQUIPMENT

*Prepared by
Pipe Fabrication Institute Engineering Committee*



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STANDARD FOR POSITIVE MATERIAL IDENTIFICATION OF PIPING COMPONENTS USING PORTABLE X-RAY EMISSION TYPE TEST EQUIPMENT

1.0 SCOPE

- 1.1 This standard establishes basic requirements for conducting Positive Material Identification (PMI) tests on ferrous and nonferrous metal alloy materials using portable x-ray emission type equipment which is currently available for production shop and construction site verification of these materials.
 - 1.1.1 X-ray emission instruments are not capable of determining the carbon content of an alloy. Therefore, utilization of these instruments will not identify or confirm low-or high-carbon austenitic stainless steel ('L'-and 'H'-type) alloy grades. Other methods must be used if such identification is required.
- 1.2 This standard does not address material verification by methods other than usage of portable x-ray emission analysis equipment, nor is it intended to supplant the use of laboratory type testing methods as contained in ASTM A751, ASTM E353 and ASTM E354, if such level of accuracy is required.
- 1.3 This standard covers the verification of alloys in the form of pipe, flanges, fittings, forgings, bar, castings, plate, valves, welds, pressure retaining and supporting components of an assembly or any other components or materials specifically designated for PMI.
- 1.4 This standard does not establish the extent of PMI verification. When PMI is required, the purchaser specifications or purchase order, or other agreement between the purchaser and the contractor, should establish the requirement for, and the extent of the PMI testing. Definition should be given of the items to be verified by PMI and the percentage of each lot to receive PMI.
- 1.5 This standard does not address the safety factors associated with use of portable x-ray emission analysis equipment. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2.0 PURPOSE OF POSITIVE MATERIAL IDENTIFICATION

- 2.1 The purpose of PMI is to ensure that the nominal composition (i.e. type/grade) of the material specified has been correctly supplied and/or installed. PMI is not intended to establish certification of a material to a particular ASME/ASTM specification. PMI is not considered a substitute for required material test reports listing chemical composition. Material test reports are not to be considered PMI verification.

3.0 REFERENCES

- 3.1 The following publications are referenced in this standard. Unless otherwise specified herein, the latest edition shall be used:
 - A. ASTM (American Society of Testing and Materials) Standard Test Methods.
 - B. ASME Boiler and Pressure Vessel Code: Section II, Material Specifications (Parts A, B and C).
 - C. PFI (Pipe Fabrication Institute), Recommended Practice for Color Coding of Piping Materials (ES- 22).

4.0 DEFINITIONS

- 4.1 Alloy material - Any material whose specification contains measurable quantities of alloying elements other than carbon, manganese, silicon, and niobium or vanadium. Steels are not considered alloy steels if they contain only carbon (up to 2 percent), silicon (usually limited to 0.60 percent), and manganese (to approximately 1.65 percent).
- 4.2 Positive Material Identification (PMI) (for x-ray emission type testing) - The process of determining the nominal composition of an alloy component. Positive Material Identification is a semi-quantitative analysis to verify major element determination of alloys. For example, austenitic stainless steel would be primarily analyzed for chromium, nickel, and, molybdenum along with other necessary elements to identify specific material grades. The elements listed in Table 1 are to be considered as the minimum element determination for material verification. Additionally, with agreement between the purchaser and contractor, additional elements of an alloy may be analyzed if within the capability of the test equipment.

- 4.3 Purchaser - The organization which specifies the requirement for PMI.
- 4.4 Contractor - For purposes of this standard, the organization defined by the purchaser as responsible for the performance of PMI.
- 4.5 Material Manufacturer or Mill - An organization that performs or supervises and directly controls one or more of the operations that affect the chemical composition of an alloy material.
- 4.6 Material Supplier - An organization that supplies material, as a broker, to a manufacturer, fabricator, or erector.
- 4.7 Pressure Containing Components - Items that form the pressure containing envelope of the equipment or component.
- 4.8 Non-pressure Containing Components - Items that are not part of the pressure containing envelope of the equipment or component and, therefore, do not directly affect the pressure retaining capacity of the equipment or component.
- 4.9 Lot - A group of commodity components of identical type and material heat number identification.
- 4.10 Sample Lot - One or more components within a lot which are specified by the purchaser as representation of the lot for testing purposes.

5.0 ALLOY VERIFICATION - GENERAL REQUIREMENTS

- 5.1 PMI may be performed by the material manufacturer, fabricator, erector, supplier or other technically qualified agency. It is the responsibility of the contractor to ensure that the implementation and conduct of the PMI program is performed in accordance with written procedures, customer requirements and this standard.
- 5.2 If the purchaser wishes to witness PMI examinations, that requirement must be established by the purchaser before PMI is accomplished.
- 5.3 Mill or manufacturer ASTM/ASME specification markings shall be checked for compliance with the documented material description as part of the verification process. Materials with unacceptable markings or no markings shall be rejected.

- 5.4 Verification of element percentage is not required if the PMI analyzer is capable of identifying the specific alloy type. Verification shall include, as a minimum, the elements listed in Table 1. Where an alloy is not listed in Table 1, and upon agreement between purchaser and contractor, the contractor shall use the alloy's main elements as the basis for alloy verification.

- 5.5 Location - PMI may be performed at any step in a fabrication or inventory process depending on the purchaser's requirements.

- 5.5.1 Examinations of bulk material will preferably be done upon the contractor's receipt of the material, and marked per Section 10.0.

- 5.5.2 If a final PMI is required by the purchaser, it shall be performed after the components to be tested are permanently attached to an identifiable assembly.

- 5.5.3 All shop fabricated pipe spools requiring PMI shall have the verification performed at the fabricator's shop.

- 5.5.4 Field welds shall be tested in the field, if required. Shop-fabricated alloy assemblies that have been alloy verified in the Fabricator's shop need not be re-verified in the field. However, the construction contractor must have available the supplier's report of alloy verification. Material certifications are not allowable substitutes.

- 5.6 PMI of welds should normally be performed prior to performance of any required stress relief or other post weld heat treatment to avoid possibility of rework after post weld heat treatment.

- 5.7 PMI of undiluted deposited weld metal (for example, "buttons") is an acceptable alternative to PMI of an electrode or wire sample. Testing should preferably be done prior to production welding.

- 5.8 Autogenous (without filler metal) welded pipe and fittings require PMI verification of only the base metal composition.

6.0 CALIBRATION AND STANDARDIZATION

- 6.1 Both method and frequency of calibration and standardization shall be based upon equipment manufacturer's recommendations.

- 6.2 Certified reference materials are available from the National Institute of Standards & Technology and other international certification agencies.

7.0 WRITTEN PROCEDURES

- 7.1 Examinations shall be performed in accordance with written procedures established by the contractor. (These procedures will be submitted for purchaser review and approval upon request).
- 7.2 Written procedures will contain, as a minimum, the following information:
- A. Name and manufacturer of equipment to be used.
 - B. Description of equipment operating principle.
 - C. Calibration requirements.
 - D. Procedure steps in detail.
 - E. Procedure to follow when identification results are inconclusive (alloy type is indeterminable).
 - F. Analyzer manufacturer's safety operating and emergency procedures.
 - G. Personnel qualification procedures.
 - H. Acceptance criteria. (if not specified by purchaser)
 - I. Stamping or marking requirements. (if not specified by purchaser)
 - J. Documentation requirements. (if not specified by purchaser)

8.0 QUALIFICATION OF PERSONNEL

- 8.1 Personnel performing PMI tests shall have sufficient training, knowledge and experience in related fields to operate the testing equipment and to make proper evaluations on the acceptability of the materials tested. Personnel shall be trained, tested, and certified to:
- A. Safely use the PMI analyzer(s).
 - B. Properly apply material specifications such as ASTM and ASME.
- 8.2 Personnel qualifications shall be documented and shall be made available to the purchaser upon request.
- 8.3 When PMI is performed by a third party agency responsible to the contractor, the contractor shall assure that all PMI tests have been performed by qualified personnel who have been certified in accordance with an approved procedure.
- 8.4 The contractor shall ensure that all involved parties fully understand the PMI requirements, including the verification method to be used, the period during fabrication when verification will be conducted, and the method of marking verified material.

9.0 ACCEPTANCE / REJECTION CRITERIA

- 9.1 Materials shall comply with the applicable grade of material, within the allowances defined below.
- 9.2 For equipment that is designed to verify a material to a specific alloy type, such verification shall be considered acceptance for PMI marking and use of the material.
- 9.3 Material shall be checked for all applicable elements when any of the following conditions apply:
- A. The equipment fails to verify the correct alloy type or,
 - B. The equipment is not designed to verify by alloy type or,
 - C. The purchaser requires tests for individual elements or recorded results for each element.
- 9.3.1 Materials shall contain the amount of alloying elements specified in the applicable ASME/ASTM specification. Alloy materials, alloy castings and alloy welding filler materials (tested in their raw form or with the alternative described in para. 5.7) shall be acceptable under this procedure if each of the major alloy elements is detected to have a value no less than 10% below the minimum value nor more than 10% above the maximum value specified by the governing material specification.
- 9.3.2 Deposited production weld metal deposits shall be within ± 12.5 percent of the ranges allowed by ASME Section II Part C for each element.
- 9.3.3 Acceptance criteria for dissimilar metal alloy welds shall be such that the weld meets the chemical composition requirements as agreed upon between purchaser and contractor. The effects of dilution during deposition should be taken into account for deposited (diluted) weld metal.
- 9.4 If the PMI test results fall outside the acceptable range, the contractor may obtain a quantitative check analysis performed by an independent testing laboratory using the "referee" method referenced by the material specification. If no referee method is referenced, an appropriate method of laboratory analysis shall be used. Results of this analysis shall govern. Re-testing by a secondary PMI instrument

(for verification) may be done by agreement between purchaser and contractor.

- 9.5 If any material component or weld is found to be unacceptable, all other represented materials, components, or welds shall be considered suspect. The following options are available:

A. Replacing all those represented materials and components with new and tested components or filler metals (as applicable).

B. Performing 100 percent examination of the remainder of the represented materials, components, or welds, and replacing each item that fails the PMI check.

- 9.6 The contractor shall be responsible for segregating unexamined and/or rejected items and assuring that they are properly identified to prevent their unauthorized use.

10.0 MARKING AND IDENTIFICATION / COLOR CODING

- 10.1 Unless otherwise established by the contractor's written procedures, or in the absence of specific customer marking requirements, the following shall apply:

10.1.1 After PMI acceptance, all pieces and welds shall immediately be marked by means of roll marking, low stress die stamping, vibro-etching, pen, paint marks, ink stamp, or chemical etching to denote PMI conformance. Marking materials shall be used which are not detrimental to the materials being marked.

10.1.2 Each piece/weld analyzed and accepted will be marked with the letters "PMI". All remaining pieces of an accepted lot will be stamped or marked with the letters "LPMI". The marking shall be placed adjacent to the material ASTM/ASME markings when possible.

10.1.3 Pipe, before cutting, shall be marked near each end and at approximately 10 foot intervals. Before cutting pipe, markings shall be duplicated at appropriate locations which might otherwise be obliterated in the cutting process.

10.1.4 Marking of welds shall be within two inches of and parallel to the weld, preferably near the welder identification marking.

10.1.5 PMI markings shall be highlighted unless otherwise directed by the purchaser, with a small circle of paint, using a marking material which is clearly visible and of a type that is not detrimental to the verified material.

10.1.6 Steel die stamps shall not be used on light-wall (less than 3/16" thick) alloy material.

10.2 Every part which has been tested either individually or by representation shall bear the specified marks throughout the entire storage and fabrication process until obliterated by heating, welding, painting etc.

10.3 In addition to marking/stamping, verified alloy material shall be color coded with color stripes if the material is verified before fabrication or field installation as in the case of stock material. Color coding shall be per PFI Standard ES-22,

11.0 RECORDS

11.1 PMI is considered semi-quantitative since most instruments are field oriented as opposed to a laboratory environment. This standard verifies alloys and does not certify chemical elements.

11.2 Unless otherwise specified by the purchaser or contractor procedure, recording of specific element percentages is not required.

11.3 Results of all examinations will be recorded on report forms which will include, as a minimum, the following items of information:

- A. Name of firm performing examination.
- B. Date and location of examination.
- C. Method and identification of equipment used.
- D. Name & signature of person performing examination.
- E. Purchase order references, (if applicable).
- F. Job or project references (if applicable).
- G. Item description.
- H. Manufacturer & heat number.
- I. Number of pieces/welds in lot.
- J. Number of pieces/welds in sample lot.
- K. PMI results-Acceptance or Rejection. (If required by the purchaser or contractor procedure, actual percentage results for each element shall be recorded.)
- L. Marking/stamping and color coding completed.

11.4 Records of PMI examinations will be maintained on file for a minimum of one (1) year. Copies will be furnished to purchaser upon request or as specified in the purchase order/purchaser specifications.

Table 1
Essential Elements for Positive Material Identification

Material	UNS No.	Cr	Ni	Mo	Cb	Ti	Cu	W	Al
1-1/4 Cr, 1/2 Mo	K11597	X		X					
2-1/4 Cr, 1 Mo	K21590	X		X					
5 Cr, 1/2 Mo	K41545	X		X					
9 Cr, 1 Mo	S50400	X		X					
12 Cr, 4 Ni	S41500	X	X						
304	S30400	X	X	X					
308	S30800	X	X	X					
309	S30900	X	X	X					
310	S31000	X	X	X					
316	S31600	X	X	X					
317	S31700	X	X	X					
321	S32100	X	X	X		X			
347	S34700	X	X	X	X				
2205 ("Duplex")	S31803	X	X	X					
Alloy 20	N08020	X	X	X	X		X		
Alloy C-276	N10276	X	X	X				X	
Alloy 600	N06600	X	X	X					
Alloy 625	N06625	X	X	X	X	X			
Alloy 800	N08800	X	X			X	X		X
Alloy 825	N08825	X	X	X			X		
Alloy 400	N04400		X				X		
AL-6XN	N08367	X	X	X					
904L	N08904	X	X	X			X		
90/10 CuNi	C70610		X				X		
70/30 CuNi	C71580		X				X		

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