

Engineering Standard

SAES-A-206

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Positive Material Identification

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Saudi Aramco DeskTop Standards

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1 Scope

This standard defines the minimum mandatory requirements for positive material identification (PMI) of pressure-retaining alloy material components, flange bolting, welds, weld overlays and cladding. It is intended to ensure that the nominal composition of the alloy components and associated welds have been correctly supplied and installed as specified. Where applicable, this entire standard shall be attached to and made a part of purchase orders.

Commentary Note:

Although this document addresses PMI requirements for alloy materials, provisions are also given for carbon steels under certain conditions.

2 Conflicts and Deviations

- 2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

The selection of materials, design, construction, maintenance, and repair of plant equipment covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco Documents

Saudi Aramco Engineering Procedure

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a
Mandatory Saudi Aramco Engineering
Requirement*

Saudi Aramco Engineering Standard

[SAES-W-014](#)

Weld Overlays and Welding of Clad Materials

Saudi Aramco Inspection Procedure

[00-SAIP-07](#)

Positive Material Identification Requirements

Saudi Aramco Inspection & Testing Requirements

[175-320300](#)

Inspection Requirements: Positive Material Identification (PMI)

3.2 Industry Codes and Standards

American Petroleum Institute

API RP 578

Material Verification Program for New and Existing Alloy Piping Systems

American Society of Mechanical Engineers

ASME SEC II

Boiler and Pressure Vessel Code Section II: Parts A, B and C

ASME B16.20

Spiral-Wound Gaskets

ASME B31.1

Power Piping

ASME B31.3

Chemical Plant and Petroleum Refinery Piping

ASME B31.4

Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids

ASME B31.8

Gas Transmission and Distribution Piping Systems

American Society for Testing and Materials

ASTM A193

Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service

ASTM A751

Standard Methods Practices and Terminology for Chemical Analysis of Steel Products

Pipe Fabrication Institute

PFI ES-22

Recommended Practice for Color Coding of Piping Materials

4 Definitions/Abbreviations

Alloy Material: Any metal (including filler metals for welding alloy materials) containing alloying elements such as chromium, nickel, or molybdenum, that are intentionally added to enhance mechanical or physical properties and/or corrosion

resistance. Does not include high-strength low-alloy (microalloyed) steels and impact-tested carbon steels.

Equipment Manufacturer: The company responsible for the plant or shop manufacturing of pressured equipment that is within the scope of this standard.

Fabricator: The company, organization, or agency responsible for the shop or field fabrication or assembly of piping and pressured equipment within the scope of this standard.

Material Specifications: ASME Section II, Parts A, B and C, or the relevant ASTM, or any other material specification.

Nonpressure Components: Items that are not part of the pressure-retaining envelope, and, therefore, do not affect the pressure retaining capacity of pressured components.

PWHT: Post-Weld Heat Treatment.

PMI: Positive Material Identification – Verification that the nominal chemical composition of an alloy material is as specified and ordered. The term applies to programs, processes, procedures, and tests in accordance with this standard.

PMI Testing: Any physical evaluation or test of a material, meeting the requirements of this standard, to confirm that the material which has been or will be placed into service is consistent with the selected or specified alloy material.

Pressure-retaining Components: Components acting as pressure envelope or boundary; breach of this envelope or boundary would lead to loss of containment and discharge of process fluids. Examples include, but not limited to, product forms used for the fabrication of pressured piping and equipment such as shells, heads, tubesheets, nozzles, tubes, flange bolting, gaskets, forgings, flanges, individual pipe lengths and fittings (tees, elbows, reducers, special pipe components), valve bodies and bonnets, pressure-retaining welds, weld overlays/cladding, expansion joints and bellows.

SAMS: Saudi Aramco Material System.

SAMSS: Saudi Aramco Materials System Specification.

Saudi Aramco Inspector: The person or company authorized by the Saudi Aramco Inspection Department to verify implementation of the requirements of this standard.

SSC: Sulfide Stress Cracking.

5 Requirements

5.1 General Requirements

- 5.1.1 The requirements in this standard shall apply to both new and repair or replacement alloy (see exceptions in Paragraph 5.2 regarding carbon steel) components. The requirements apply to shop, field fabrication and plant.
- 5.1.2 The testing methods outlined in this standard are not intended to establish the complete conformance of a material to its specification.
- 5.1.3 PMI testing shall be performed at a point in time that ensures proper alloy materials have been used in the fabrication of an identifiable assembly. Usually, this is during fabrication or immediately prior to fabrication. Although manufacturing quality control is an important issue, testing performed by a manufacturer or supplier of raw material or loose components is not considered to be PMI testing.

Commentary Note:

Construction and fabrication quality control is vital and PMI is a very important part of total quality control.

- 5.1.4 Retroactive PMI testing of existing systems and stocked materials shall be performed upon the recommendation by the Consulting Services Department or by decision of the plant manager.

5.2 Exemptions

- 5.2.1 Unless specifically required in the purchase order or SAMS catalog description or SAMSS, the following components and materials are exempt from PMI:
- 1) Nonpressure components.
 - 2) Components made from carbon steel or cast iron and filler metal for welding carbon steel, except as noted below.

Exceptions:

During the engineering review of a project proposal, to preclude alloy substitutions, selected PMI requirements may be adopted for certain carbon steel components and weldments by agreement of the proponent organization and the Chairman of Materials and Corrosion Control Standards Committee. Factors to be considered include the following:

- *Wet sour service*
 - *The potential for mixing of carbon steel and alloy components and filler metals at the job site*
 - *The potential for catastrophic failure*
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- *Other related provisions in the project Quality Plan*

Commentary Note:

Incorrect installation of low-alloy materials in place of carbon steels in components in wet sour service has been experienced. As these components are not in principle subject to PWHT, there is the potential for high hardness levels in the low-alloy material with the subsequent risk of SSC.

- 3) Rotating equipment internals and associated seal, lube oil, cooling water and steam equipment and piping.
 - 4) Valve internals (trim).
 - 5) Piping components in ASME B31.3 Category D Service or equivalent.
 - 6) All instrumentation provided with isolation valves.
- 5.2.2 If specified in a project design document, purchase order, or SAMS catalog description, PMI is required for operationally important nonpressure components.

Commentary Note:

Examples of important nonpressure components could include, but not be limited to, column trays, valve internals, internal attachment welds and certain load-bearing supports.

6 Responsibilities

- 6.1 For all new projects, Project Management or their designated representative shall be responsible for ensuring that proper PMI programs and procedures are developed and PMI testing is performed by the Equipment Manufacturer or the Fabricator, as applicable, prior to equipment installation and start-up. Project Management is normally supported by Project Inspection and Vendor Inspection.
- 6.2 For existing facilities, the plant manager or his designated representative, e.g. Inspection, shall be responsible for ensuring that a PMI program is developed and implemented based on [00-SAIP-07](#).

Commentary Note:

Facilities should acquire their own PMI equipment. For major PMI activities, a local Saudi Aramco approved vendor of PMI services can be contracted.

7 Verification Coverage

7.1 The PMI program covers the following:

- Alloy materials
- Shop and field-fabricated pressure-retaining components (base metal, welds and cladding)
- Materials used for repair or replacement of pressure-retaining components.

7.2 One hundred percent PMI testing shall be performed on all pressure components and welds of alloy materials, within the scope of this standard, with the following exceptions:

Exceptions:

- 1) *Tubes for shell / tube and air-cooled heat exchangers and fired boilers: 10 tubes or 10%, whichever is greater, from every heat number shall be selected at random and tested prior to installation. Note the rejection procedures in Section 10.*
- 2) *This testing frequency shall also apply to any replacement tubes for equipment listed in Exception 7.2 (1) above.*
- 3) *Alloy flange bolting may be verified by random 2% PMI testing if the project Quality Plan contains specific provisions for color coding, segregation, and visual inspection that are acceptable to Project Inspection and the proponent organization. The project inspector may implement up to 100% PMI testing of alloy bolting any time he determines that other quality procedures are not adequate or are not being observed.*

7.3 PMI testing of weld metal shall be subjected to the same coverage as for the base material.

7.4 The required number of PMI tests shall be as follows:

- 1) One test for each pressure-retaining component. If an assembly contains a number of components (parts), one test is required for each component (part).
- 2) One test for each pressure-retaining weld and weld repair, in addition to filler metal testing (Paragraph 7.7).

Commentary Note:

A strict filler metal control program is vital. Only the proper welding rodes for the current welding shall be allowed at the welding site.

7.5 The elements of the basic alloy materials to be verified shall be in accordance with Table 1.

Table 1

Basic Alloy	Elements to be Verified
Carbon-Molybdenum, Manganese-Molybdenum, and Chromium-Molybdenum steels	Chromium and Molybdenum
Copper-based alloys	Copper, Zinc, and other elements specified in purchase order or SAMS catalog description
Regular carbon grade stainless steels	Chromium, Nickel and Molybdenum
Low and high carbon stainless steels	Chromium, Nickel, Molybdenum and Carbon
Stabilized stainless steels	Chromium, Nickel, Molybdenum, Titanium and Niobium
Nickel-based alloys	Nickel, Iron, Copper, Chromium and Molybdenum
Nickel steels	Nickel

7.6 For alloys not listed in Table 1, the Supervisor of the Materials Engineering Unit of ME&CCD/CSD shall be consulted.

7.7 PMI Testing of Welding Consumables

7.7.1 Electrodes shall be properly stored and segregated in the store, shop, or ovens to avoid mix-up. Separate ovens are required for different welding consumable types. The Fabricator shall ensure that adequate inventory control is established to account for all consumables checked-out.

7.7.2 One consumable from each lot shall be PMI-tested. The remainder of the lot shall be compared to the identified consumable to verify that the markings of the electrodes/wires are correct.

7.7.3 PMI testing of weld metal (e.g. deposited or undiluted weld "buttons") is an acceptable alternative to PMI testing of an electrode or wire sample provided it is conducted immediately prior to welding or during the welding process.

Commentary Note:

Some weld rods have the alloying elements contained in the flux, and do not meet the alloy specification until welded.

7.7.4 In cases where PMI testing of the completed weld is not possible because of geometry (e.g., small fillet welds and narrow root beads), PMI testing of filler metal lots and visual inspection of electrodes as described in 7.7.2 and 7.7.3 is an acceptable substitute for testing of the completed weld.

8 Procedures

- 8.1 The Equipment Manufacturer or the Fabricator, as applicable, shall implement a written PMI Procedure, covering testing and reporting, which shall be made available to the Saudi Aramco Inspector for review, acceptance, and verification of implementation.
- 8.2 The Equipment Manufacturer or the Fabricator, as applicable, shall ensure that PMI is performed prior to completion of fabrication in the shop or at the site, for welds and for field-assembled items not previously PMI-tested.
- 8.3 The Saudi Aramco Inspector shall have the option to witness any or all of the PMI testing. The fabrication status schedule shall be submitted to Inspection two weeks before the fabrication.
- 8.4 PMI testing shall not be considered as a substitute for the required materials test reports.
- 8.5 Material test reports and welding with an approved welding procedure shall not be considered as alternatives to PMI testing and the requirements of this standard.
- 8.6 Each Equipment Manufacturer and each Fabricator shall use only trained, qualified, and experienced operators to perform PMI activities. Operator records attesting to such training, qualification and experience shall be made available for Saudi Aramco review and approval.

9 Methods

- 9.1 The instruments and methods used shall be suitable for identifying the material by quantitative measurement of the major alloying elements required in the applicable material specification or welding procedure specification.
- 9.2 The primary acceptable method is X-ray emission analysis, also known as X-ray fluorescence (XRF) analysis with a calibrated portable instrument. See also API RP 578 Paragraph 5.2.1.

Because of inherent limitations of XRF, it is not possible to detect all elements. Elements lighter than sulfur (S) can not be detected using portable X-ray fluorescence spectrometers. Therefore, this technique can not be used to detect carbon (C).

An optical emission spectrograph may be used to check for all the required elements, including carbon. A hot work permit may be required before using this equipment. Any burn damage resulting from the usage of the emission

spectrograph shall be removed by grinding. See also API RP 578 Paragraph 5.2.2.

- 9.3 As an alternative, a chemical analysis of samples cut out from the pieces requiring PMI, in accordance with one of the methods in ASTM A751, may be used to check for the alloying elements required by this standard.
- 9.4 Additional PMI testing techniques as listed in API RP 578 will be considered for use upon written request to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- 9.5 Prior to commencing PMI testing, instrument operators shall be qualified to operate approved equipment on a representative sample of the alloy materials with 100% correct assessment as the performance criteria. The instrument operator shall work to a written procedure and shall have been trained to use the instrument in accordance with that procedure. Training shall be documented.
- 9.6 The person(s) performing PMI testing shall calibrate and/or verify the test equipment performance as specified by the equipment manufacturer. Calibration shall be carried out on a standard calibration alloy sample, representative of the base material/weld being tested. The PMI test procedure shall specify the frequency interval for this calibration/verification. If calibration procedures are not provided by the equipment manufacturer, they shall be established by the owner/user. Typically, these procedures shall include calibration/verification using certified standards.
- 9.7 If sample removal is used, a written procedure for identification and traceability to original material is required.
- 9.8 Both inside and outside weld surfaces shall be tested where accessible. PMI testing of welds shall be done after removal of slag and/or oxide from the weld surface. See also 7.7.3.
- 9.9 The surface to be analyzed shall be clean bare metal, free of grease or oil, with a surface finish as specified by the instrument manufacturer.

Commentary Note:

Generally a fresh 60 grit finish and flat surface are required for the optical emission spectrograph, while no minimum surface finish is required for portable XRF analysis, only that the surface be clean bare metal.

10 Acceptance Criteria

- 10.1 For acceptance, it must be demonstrated that materials contain the amounts of alloying elements shown in the material specification. Alloys shall be acceptable if the alloying elements are each within 10% of the specified range of values.
- 10.2 Welds with consumables that match, or nearly match, the base metal composition shall be within $\pm 12.5\%$ of the ranges allowed in ASME SEC IIC for each element.
- 10.3 For weld overlays, the chemistry on the surface of overlays shall be in accordance with [SAES-W-014](#).
- 10.4 For dissimilar metal alloy welds (other than weld overlays), the effects of dilution from the different base metals and the filler metal shall be taken into account for determining the nominal as-deposited weld metal composition.

11 Rejection Procedures

- 11.1 If the PMI testing results fall outside the acceptable range using a method described in Section 8, the Equipment Manufacturer or the Fabricator, as applicable, has the option to conduct a more accurate analysis at his own expense to determine the component acceptance such as obtaining a chemical analysis performed by an independent testing laboratory. The alternative test method or independent laboratory must be acceptable to the Saudi Aramco Inspector. The results of the more accurate test method or independent chemical analysis shall govern.
- 11.2 If any component or weld is found unacceptable, it shall be replaced and the replacement shall be alloy verified in accordance with this standard.
- 11.3 Procedures shall be in place to ensure that rejected components are segregated and properly identified to prevent reuse.
- 11.4 If one of the tubes for heat exchangers and boilers is found unacceptable, all remaining tubes of the particular alloy shall be tested for the individual equipment. This also applies to the weld metal.
- 11.5 All rejected tubes shall be replaced and 100% of the replacement tubes shall be PMI-tested in accordance with this standard.

12 Records and Reports

- 12.1 Shop Fabrication Records
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- 12.1.1 A detailed recording/logging procedure shall be prepared by the Equipment Manufacturer or shop Fabricator.
 - 12.1.2 The log shall identify each component and weld corresponding to an individual equipment item or piping spool and shall include the equipment or spool number and purchase order number.
 - 12.1.3 The log shall identify all components and welds that have been alloy-verified and the results of testing.
 - 12.1.4 Test results shall include measured percentages of alloying elements for components that were accepted or rejected.
 - 12.1.5 The Equipment Manufacturer shall prepare a detailed PMI map of the pressured equipment being fabricated. The map shall show the alloy material specification of each alloy component and the extent of PMI required in accordance with this standard.
- 12.2 Field Fabrication Records
- 12.2.1 At least two weeks prior to the commencement of fabrication, the field Fabricator shall establish and present to the Saudi Aramco Inspector for review the proposed testing, logging, identification, and final installation procedures for all components requiring PMI testing onsite (such as fabricated pressured equipment, piping, valves, and welds).
 - 12.2.2 Shop-fabricated alloy pressure equipment or piping assemblies that have been alloy verified by the shop Fabricator need not be re-verified in the field. However, the field Fabricator shall have available, for review, the shop Fabricator's report of PMI testing. Material certificates are not allowable substitutes for PMI testing reports.
 - 12.2.3 The field Fabricator shall prepare a detailed PMI map of the pressured equipment being fabricated. The map shall show the alloy material specification of each alloy component and the extent of PMI required in accordance with this standard.
- 12.3 Final Report
- 12.3.1 Prior to final acceptance of alloy pressured equipment or piping, the Equipment Manufacturer or the Fabricator, as applicable, shall prepare a complete PMI Testing Report containing all relevant data. For pressured equipment, the PMI Testing Report shall be included as part of the Equipment Data Book.
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- 12.3.2 The PMI Testing Report shall be reviewed by the Saudi Aramco Inspector prior to final acceptance.

13 Inspection

- 13.1 The responsible Inspection Organization shall ensure and verify that alloy materials have been verified by PMI testing as required.
- 13.2 During repairs or alterations of materials required to be PMI-tested, the responsible Inspection Organization shall verify the correct compositions of the shop and field welds.
- 13.3 For applicable purchases, materials shall be subject to inspection by the Saudi Aramco Inspector in accordance with Saudi Aramco Inspection & Testing Requirement [175-320300](#).

14 Marking and Color Coding

14.1 Verification Marking

- 14.1.1 Paint marking shall be done with water-insoluble material that contains no substances that harmfully affect the metal at ambient or elevated temperatures. In particular, the marking material shall be free of lead, sulfur, zinc, cadmium, mercury, chlorine, or other halogens.
- 14.1.2 All components, and welds that are found unacceptable shall be marked immediately with a circled red "X" pending resolution in accordance with Section 11.
- 14.1.3 All verified materials with an acceptable analysis shall be marked with the letters "PMI" using a certified low-stress stamp. The marking shall be placed as follows:

Pipe: One mark, 75 mm from one end on the outer surface of the pipe. This marking shall be in addition to the requirements of PFI ES-22 and Attachment 3 of [00-SAIP-07](#).

Welds: Adjacent to the welder's mark on the weld. (Welds on tubes for heat transfer equipment shall be marked by either stenciling or vibro-etching on the tubesheet).

Fittings and Forgings: Adjacent to the manufacturer's markings.

Valves:	Adjacent to the valve manufacturer's markings on bodies and other pressure parts.
Castings:	Adjacent to the casting manufacturer's markings and heat numbers.
Plates:	75 mm from one edge, adjacent to manufacturer's markings.
Tubes:	Stenciled, 300 mm from each end.

- 14.1.4 When heat treating is performed after PMI, the identification marking must be recognizable after heat treatment. PMI markings shall be transferred when a plate or pipe is cut.

14.2 Color Coding

- 14.2.1 The color coding system for material identification described herein is intended to help prevent fabricators from using incorrect alloy material. The principal purpose of color coding is visual identification during storage and after the components have been cut for fabrication.
- 14.2.2 Color coding is not a substitute for PMI testing or other, permanent manufacturers' markings required by ASTM or other specifications. Permanent manufacturers' markings shall not be obscured by color coding.
- 14.2.3 Color coding may be done by the material manufacturer or material supplier. Color coding need not be retained after painting.
- 14.2.4 Prior to coding, surfaces shall be clean and free of dirt, loose scale, and oil. Paints used for coding shall be durable, bright, and distinctive and shall not contain substances that would harmfully affect the material at ambient or elevated temperatures. In particular, paints shall be free of lead, sulfur, zinc, cadmium, mercury, chlorine, and other halogens.
- 14.2.5 Each component shall be coded in accordance with PFI ES-22 and [00-SAIP-07](#) Attachment 3, and shall have painted characters indicating the specification number of the material if it is not permanently marked or tagged according to the applicable material specification.
- 14.2.6 Valves, flanges, and fittings do not require color coding if these components are permanently stamped or tagged by the manufacturer. If the materials are not easily legible, valves, flanges, and fittings shall be coded with a stripe of 5 mm minimum width. The color coding on valves should indicate the valve body material.
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- 14.2.7 ASTM A193, Grade B7 stud bolts do not require color coding if the grade of the material is stamped on one end of each bolt.
- 14.2.8 Spiral-wound gaskets shall be color coded in accordance with ASME B16.20. Sheet type gaskets do not require color coding.
- 14.2.9 Pipe and Fittings: Each length of pipe and fitting shall have a 5 mm or larger stripe running full length. One inch NPS and smaller may have a 3 mm stripe running full length.
- 14.2.10 Valves: When required, stripe across the body from flange to flange or end to end.
- 14.2.11 Flanges: When required, stripe across edge up to hub.
- 14.2.12 Bolting: When required, stripe around the midpoint of each bolt or stud.
- 14.2.13 Plate, sheet, and strip: Stripe on surface near two perpendicular edges for entire length.
- 14.2.14 Tubes and Bars: Stripe entire length.

15 Plant Assessment and Material Identification Subcommittee

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