Material Verification Program for New and Existing Alloy Piping Systems

API RECOMMENDED PRACTICE 578
SECOND EDITION, MARCH 2010

AMERICAN PETROLEUM INSTITUTE

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Downstream Segment

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Contents

Material Verification Program for New and Existing Alloy Piping Systems

1 Scope

The purpose of this recommended practice (RP) is to provide the guidelines for a material and quality assurance system to verify that the nominal composition of alloy components within the pressure envelope of a piping system is consistent with the selected or specified construction materials to minimize the potential for catastrophic release of toxic or hazardous liquids or vapors.

This RP provides the guidelines for material control and material verification programs on ferrous and nonferrous alloys during the construction, installation, maintenance, and inspection of new and existing process piping systems covered by the ASME B31.3 and API 570 piping codes. This RP applies to metallic alloy materials purchased for use either directly by the owner/user or indirectly through vendors, fabricators, or contractors and includes the supply, fabrication, and erection of these materials. Carbon steel components specified in new or existing piping systems are not specifically covered under the scope of this document unless minor/trace alloying elements are critical to component corrosion resistance or similar degradation.

2 Normative References

The following referenced documents are indispensable for the application 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.

API 570, *Piping Inspection Code: Inspection, Repair, and Rerating of In-service Piping Systems*

API Publ 581, *Risk-Based Inspection—Base Resource Document*

API RP 571, *Damage Mechanisms Affecting Fixed Equipment In the Refining Industry*

API RP 939-C, *Guidelines for Avoiding Sulfidation Corrosion Failures in Oil Refineries*

ASME[1] *Boiler and Pressure Vessel Code: Section II, Material Specifications Part A, Ferrous Materials Part B, Nonferrous Materials Part C, Welding Rods, Electrodes, and Filler Metals*

ASME B31.3, *Process Piping*

CSB[2] Chemical Safety Board Bulletin 2005-04-B, "Positive Material Verification: Prevent Errors During Alloy Steel Systems Maintenance"

NACE[3] Paper No 03651, "Specification for Carbon Steel Materials for Hydrofluoric Acid Alkylation Units"

PFI[4] ES22, *Recommended Practice for Color Coding of Piping Materials*

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1 ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.
2 U.S. Chemical Safety and Hazard Investigation Board, Office of Prevention, Outreach, and Policy, 2175 K Street NW, Suite 400, Washington, D.C. 20037-1848, 202-261-7600, www.csb.gov. Most CSB publications are posted on, and can be downloaded from the CSB web site, http://www.csb.gov/safety_publications/docs/SB-Nitrogen-6-11-03.pdf.
3 NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77218-8340, www.nace.org.
4 Pipe Fabrication Institute, 511 Avenue of the Americas, #601, New York, New York 10011. www.pfi-institute.org.

3 Definitions

3.1
alloy material
Any metallic material (including welding filler materials) that contain alloying elements that are intentionally added to enhance mechanical or physical properties and corrosion resistance, or a combination thereof (e.g. Chromium, Nickel, or Molybdenum).

3.2
distributor
A warehousing supplier for one or more manufacturers or suppliers of alloy materials or components.

3.3
fabricator
One who fabricates piping systems or portions of a piping system as defined by ASME B31.3.

3.4
inspection lot
A group of items or materials of the same type from a common source from which a sample is to be drawn for examination.

NOTE An inspection lot does not include items from more than one heat.

3.5
level of examination
The specified percentage of the number of components (or weldments when specified) to be examined in an inspection lot.

3.6
lot size
The number of items available in the inspection lot at the time a representative sample is selected.

3.7
material manufacturer
An organization that performs or supervises and directly controls one or more of the operations that affect the chemical composition or mechanical properties of a metallic material.

3.8
material nonconformance
A positive material identification (PMI) test result that is not consistent with the selected or specified alloy.

3.9
material supplier
An organization that supplies material furnished and certified by a material manufacturer, but does not perform any operation intended to alter the material properties required by the applicable material specification.

3.10
material verification program
A documented quality assurance procedure used to assess metallic alloy materials (including weldments and attachments where specified) to verify conformance with the selected or specified alloy material designated by the owner/user.

NOTE This program may include a description of methods for alloy material testing, physical component marking, and program record-keeping.

3.11
mill test report
A certified document that permits each component to be identified according to the original heat of material from which it was produced and identifies the applicable material specification (including documentation of all test results required by the material specification).

3.12
owner/user
An owner or user of piping systems who exercises control over the operation, engineering, inspection, repair, alteration, testing, and rerating of those piping systems.

3.13
positive material identification (PMI) testing
Any physical evaluation or test of a material to confirm that the material which has been or will be placed into service is consistent with the selected or specified alloy material designated by the owner/user. These evaluations or tests may provide either qualitative or quantitative information that is sufficient to verify the nominal alloy composition.

3.14
pressure-containing components
Items that form the pressure-containing envelope of the piping system.

3.15
random
Selection process by which choices are made in an arbitrary and unbiased manner.

3.16
representative sample
One or more items selected at random from the inspection lot that are to be examined to determine acceptability of the inspection lot.

3.17
standard reference materials
Sample materials for which laboratory chemical analysis data are available and are used in demonstrating test instrument accuracy and reliability.

4 Extent of Verification

4.1 General

The owner/user should establish a written material verification program indicating the extent and type of PMI testing to be conducted during the construction of new piping systems, retroactively on existing piping systems, and during the maintenance, repair, or alteration of existing piping systems.

For higher-risk systems, the owner/user should consider the need for employing a higher percentage of examination (up to 100 %) rather than random sampling which may be more appropriate for lower-risk systems. Inadvertent material substitution problems tend to be sporadic; therefore, small sample sizes may not locate all inadvertent alloy substitutions. The owner/user should also consider the need to conduct examinations after fabrication is complete, to ensure that incorrect substitutions did not occur at the work site.

4.1.1 Alloy Substitutions in Carbon Steel Systems

When determining the need to perform material verification on carbon steel systems, the owner/user should evaluate the effect that the process stream could have on substituted alloy materials. In some cases, the substitution of hardenable alloy materials in carbon steel piping systems resulted in failure and loss of containment. Examples of such systems include wet hydrogen sulfide (H_2S), hydrofluoric acid (HF), and sulfuric acid (H_2S0_4) services.

4.2 New Construction Quality Assurance (QA) Material Verification Program

This section covers alloy piping during fabrication either in the shop or in the field prior to the items being placed into service and is restricted to the pressure-containing boundaries.

4.2.1 Roles and Responsibilities

A material verification program for piping systems may involve participation of several groups within the operating plant or the shop of a contractor, vendor, or fabricator. When establishing a material verification program, consideration should be given to the roles and responsibilities that each group has within the specific organization. These roles and responsibilities should be clearly defined and documented. Within the operating plant, this can include those groups responsible for purchasing, engineering, warehousing/receiving, operations, reliability, maintenance, and inspection.

It is the responsibility of the owner/user or designee to determine the extent of examination required and to verify that the implementation and conduct of the material verification program is properly performed in accordance with this RP. It is also the responsibility of the owner/user to verify that the alloy materials subsequently placed into service are as specified, and that the documentation of the material verification program is in accordance with this RP.

4.2.2 Material Verification Test Procedure Review

When PMI testing is performed by the material supplier or third-party agency, the owner/user or designee should review and approve the adequacy of the material verification program and testing procedure of the fabricator or material supplier prior to testing.

4.2.3 Scheduling of Material Verification Testing

PMI testing should be performed at the point in time that ensures that proper alloy materials have been used in the fabrication of an identifiable assembly.

4.2.4 Mill Test Report

Mill test reports should not be considered a substitute for a PMI test. However, mill test reports are an important part of an overall material quality assurance program.

4.2.5 Components Covered in a Material Verification Program

Examples of pressure-containing components that make up fabricated piping systems that are covered by this RP include:

a) pipe lengths;

b) pipe fittings, such as tees, elbows, reducers, special pipe components, blinds and plugs;

c) flanges;

d) special forgings;

e) process valves (including control valves) and relief valves;

f) pressure-containing welds;

g) instruments (all pressure containing parts);

h) weld overlays or cladding;

i) bolting;

j) expansion joints and bellows;

k) gaskets.

4.2.6 PMI Testing of Welding Consumables

When welding is conducted, one electrode or wire sample from each lot or package of alloy weld rod should be positively identified. The remainder of the lot should be compared to the sample to verify that the markings of the wires/electrodes are correct. Some weld rods have the alloying elements contained in the flux, and do not meet the alloy specification until welded. PMI testing of weld metal (e.g. deposited weld metal or undiluted weld “buttons”) is a permissible alternative to PMI testing of an electrode or wire sample provided it is conducted immediately prior to welding or during the welding process.

4.2.6.1 Longitudinal Pipe and Fitting Welds

Where there is reason to suspect problems, longitudinally welded alloy pipe and fittings should receive random PMI testing verification of the base metal and weld metal.

4.2.6.2 Autogenous Welds

If the owner/user determines that material verification testing is required on autogenous-welded (with no added filler metal) alloy pipe or fittings, it is necessary to conduct testing on only the base metal.

4.2.7 PMI Testing of Components Supplied by a Distributor

A higher degree of PMI testing verification should be conducted on alloy material supplied by stocking distributors due to the potential for material mix-ups as a result of handling.

4.3 Material Verification Program for Existing Piping Systems

4.3.1 General

This section covers alloy piping systems that are already in service where the material verification program procedures for the construction were not in accordance with 4.2. Material verification is limited to the pressure-containing components and their attachment welds. It is important to recognize that previous maintenance activities, as well as new construction practices, may influence the likelihood of inadvertent materials substitutions.

4.3.2 Responsibilities

The owner/user is responsible for determining if a retroactive material verification program is appropriate for each existing piping system, for prioritizing the piping systems to receive retroactive PMI testing, and for determining the extent of PMI testing required.

4.3.3 Prioritizing Piping Systems for Retroactive PMI Testing

If the owner/user elects to prioritize piping systems for the material verification program or needs to determine whether PMI testing is needed at all, the owner/user should consider the following.

a) Likelihood of a material mix-up during previous project and maintenance activities. A key factor is the effectiveness of the material verification program at the time of these activities.

b) Consequences of a failure. Some factors to be considered include flammability, fire potential, toxicity, proximity to other equipment or community, temperature, pressure, mode of failure, and size of release.

c) Reason for alloy specification (i.e. corrosion resistance or product purity).

d) Historical data relating to inadvertent material substitutions. This may be related to previous experience with material nonconformities in the process unit or within the operating plant.

Taken together, these factors can be used to determine the risk associated with possible material nonconformances in a piping system. The owner/user should establish a methodology for estimating the relative priority for PMI testing of various piping circuits within a given unit. This methodology may be based on qualitative or quantitative risk analysis. API 581 discusses several risk-based approaches and the factors that should be considered when conducting a risk analysis such as material, service conditions, service fluid, and mode of failure.

4.3.3.1 Carbon Steel Substitutions in Low Alloy Steel Systems

In determining the likelihood of material nonconformances, it is worth noting that historically the greatest number of material nonconformances with serious consequences have involved carbon steel components in low alloy steel (e.g. 1¼ Cr–½ Mo, 2¼ Cr–1 Mo, 5 Cr–½ Mo, 9 Cr–1 Mo) piping systems. There have been fewer nonconformances in stainless steel and nonferrous (e.g. Monel, Inconel) systems because of appearance and weldability issues.

4.3.3.2 Residual Elements In Carbon Steels In Hydrofluoric Acid Alkylation Units

Carbon steels in some specific locations in HF acid service have been reported to suffer increased corrosion rates based on the residual elements (RE) (i.e. C, Ni, Cr, and Cu) in the steels, and is discussed in API 751. PMI methods can be used to assess the potential for enhanced corrosion in HF service. Consideration should be given to the ability of the PMI method to detect the various elemental concentrations.

4.3.3.3 Gasket Materials

Incorrect gasket materials in incompatible service may cause premature failings. The main principles outlined in this document can be applied to gasket materials. The owner/user is required to ascertain the potential material variations and select analytical methods capable of providing the required data. The actual test procedures can be more detailed due to the geometric structure of the gasket materials.

4.3.3.4 Process Units Susceptible To Sulfidation.

Carbon steels with low silicon (< 0.10 %) content can corrode at an accelerated rate when exposed to hydrogen-free sulfidation conditions. These phenomena are discussed more extensively in AP 571 and API 939-C. Owner/users with assets at risk from this type of degradation should consider the risks and the requirements to apply PMI control in order to determine Silicon levels and the extent to which the material may corrode.

4.3.3.5 Other Factors to Consider When Prioritizing Piping Systems

Site-specific or experienced-based factors should be considered when prioritizing piping systems. Factors to consider include the following.

a) Construction and maintenance practices. In assessing the likelihood of material nonconformances, the owner/ user should also consider the materials handling, material control, and any PMI testing procedures followed during construction of the process unit. Process-unit maintenance procedures are also important. Process units in which rigorous procedures for material verification are used would be expected to have a lower likelihood of nonconformances.

b) Reason for the alloy specification. In some cases, alloys are used in piping systems for reasons other than corrosion resistance or structural integrity. In these cases, the structural integrity of the system would not be harmed by material nonconformances. A material verification program may not be necessary in these systems. An example would be stainless steel lube oil systems in which stainless steel is used for maintaining oil purity.

4.3.4 Component Prioritization Factors

Based on experience, some types of piping system components can have a higher likelihood of inadvertent substitution of a nonspecified material. This can provide a basis for prioritizing specific equipment in a given system or process unit. Examples are:

a) warm-up and bypass lines on pumps or check valves;

b) small diameter piping systems, including welds, with a diameter less than or equal to 2 in. (50 mm);

c) valves and other removable devices such as rupture discs, spacer blinds, or ring joint gaskets;

d) thermowells;

e) bolting;

f) piping as a part of a packaged system;

g) components without an ASTM stamp;

h) specific process systems with corrosion issues (e.g. residual elements in Carbon Steels in HF Acid service or high Silicon content in potential sulfidation conditions).

4.3.5 Factors to Consider When Determining the Extent of PMI Testing

The owner/user should determine the extent of PMI testing. Factors to consider when determining the extent of PMI testing for an existing process unit include:

a) historical inspection and material verification program records,

b) number of plant modifications,

c) materials control during original construction and during modifications,

d) material verification program quality during construction and fabrication,

e) consequence of release,

f) likelihood of corrosion/degradation.

4.4 Material Verification Program as an Element of Maintenance Systems

The principles associated with materials verification as part of a new piping installation should also be applied to provide confidence that proper materials are being used as part of maintenance activities. The concepts noted previously in 4.2 and API 570 should be reviewed and applied as applicable to the maintenance function.

4.4.1 Responsibilities

It is the responsibility of the owner/user to evaluate maintenance systems so that material verification programs can be designed and implemented to effectively support the mechanical integrity of alloy piping systems. The owner/user should establish a written procedure for the material verification program to be used for repair of piping systems during maintenance outages. This procedure should be documented by the owner/user.

4.4.2 Control of Incoming Materials and Warehousing

A material verification program should be directly applied to activities associated with receiving alloy materials into warehouse systems. PMI testing may be performed as part of this receiving function, or, when appropriate, may be performed at the supplier's location as a condition of release for shipment. The material verification program that is adopted should provide for proper documentation and methods for indicating which materials have been tested and are approved for use.

The use of material verification program principles to check materials received into a warehouse system should be regarded as a quality assurance practice to minimize the potential for discovering an alloy material discrepancy during subsequent PMI testing. PMI testing within the warehouse should not be regarded as an alternative to PMI testing of the fabricated piping system when testing is specified.

4.4.3 Maintenance Activities of Piping Systems

There are a number of in-service maintenance activities where material verification should be established. Temporary removal of spool pieces needs to be managed in such a way that material mix-ups cannot occur. Incidents have occurred when same size spool pieces have been removed during turnarounds and substituted into the wrong locations during installation. Consideration shall be given to a firm control system or a verification prior to re-installation to prevent these incidences occurring. A process where a system of 'tagging' spools as they are removed to ensure correct replacement should be considered

It is important that repair procedures include consideration of PMI testing as part of obtaining satisfactory alloy materials to be used for the repair. As appropriate, this may include any of the components noted in 4.2.5.

Much of this can be controlled through awareness of the issues at all levels within the repair process. Consulting with an inspector prior to commencement of work can ensure that systems, processes and activities are in place to ensure good material control.

5 Material Verification Program Test Methods

5.1 Material Verification Program Test Method Objectives

The test methods outlined in this RP are intended to identify alloy materials and are not intended to establish the exact conformance of a material to a particular alloy specification. Depending on the test method selected, the PMI test method may identify the nominal composition of alloy materials. Identification of materials by visual stamps/markings alone should not be considered as a substitute for PMI testing but may be an important component of an overall quality assurance program.

5.2 PMI Test Methods

5.2.1 General

A variety of PMI test methods are available to determine the identity of alloy materials. The primary methods include portable X-ray fluorescence, portable optical emission spectroscopy, and laboratory chemical analysis. A description of several test methods is listed below. In addition to these methods, there are a variety of alloy sorting techniques that may be appropriate for the purposes of this RP including magnetic testing to differentiate between ferritic and austenitic materials. It is important that users verify what the objectives and accuracies are required from the PMI tool they wish to use. All of the tools have benefits and limitations on the elements they can or cannot detect, in addition to the accuracy and ability to differentiate between different material grades which have only slight variations in alloying elements.

5.2.2 Portable X-ray Fluorescence

There are several variants of portable X-ray fluorescence (XRF) spectrometers available. The principle of operation is that one or more gamma ray or X-ray sources are used to generate a beam of low energy radiation to excite the material under analysis. The material under analysis then emits a characteristic radiation spectrum which can be analyzed both qualitatively and quantitatively to determine which elements are present and in what quantity.

The results of this analysis can be reported in either or both of the following formats.

a) as a match against one of many reference spectra stored in the instrument, i.e. 316 stainless steel or 5 Cr – 1/2 Mo steel;

b) each element present is reported as a percentage.

Because of the inherent limitations of the technique it is not possible to detect all elements. XRF analyzers are capable of detecting elements from Ti to U in the periodic tables. This may exclude some of the important elements in carbon steels such as C, Si, and S. In addition many analyzers are sold with basic element packages so it is important to decide exactly what elemental analysis is required and select an appropriate instrument.

5.2.3 Portable Optical Emission Spectrometry

An electric arc stimulates atoms in the test sample to emit a characteristic spectrum of light for each element in the sample. The combined light spectra from different elements are passed through a light guide to the optical analyzer. In the analyzer, the light is dispersed into its spectral components, and then measured and evaluated against stored calibration curves.

These devices fall into two groups the first being a light portable and operator evaluated device that can typically identify up to 16 elements but depends upon operator evaluation of a light spectra. These devices do not directly indicate alloy grade or composition, but produce an output in the form of visible light spectra that permits semiqualitative alloy identification The technique is also sensitive to operator skill and experience.

The second group are field portable laboratory grade analyzers. These were originally difficult to use due to their size and weight. Modern units are now available weighing only 33 lbs including small Argon cylinders. Some operate in a pure arc mode for routine PMI applications and the more sophisticated units have a spark mode allowing laboratory quality analysis. The significant advantage of these instruments is the expansion of elements that can be analyzed including C. These more advanced instruments are also not subject to operator interpretation.

Similar to X-ray fluorescence devices, results can be reported in either a spectral match or elemental percentage mode. As these techniques generate arcs and sparks a potential ignition source occurs therefore prior to use of this technique in the field, a review should be conducted to determine if gas testing and hot work permits are required.

5.2.4 Chemical Laboratory Chemical Analysis

Owner/user-approved material analysis laboratories using X-ray emission spectrometry, optical emission spectrometry, or wet chemical analysis can provide the most accurate analytical results for all elements. The accuracy is typically much higher than is normally needed for PMI testing. Laboratory analysis may involve the removal of significant amounts of material, and is typically slower than field PMI test techniques.

5.2.5 Other Qualitative Tests

5.2.5.1 Chemical Spot Testing

The chemical spot test is typically accomplished by electrochemically removing a minute amount of surface metal and depositing it onto moistened filter paper. Reagents dropped onto the paper produce distinct colors that are indicative of the presence of specific elements in the sample tested. Chemical spot testing is much slower than the other field PMI test methods and interpretation is subjective.

5.2.5.2 Resistivity Testing

The principle employed in the test method is known as the Seebeck Effect, or thermoelectric principle. A heated junction of dissimilar metal is created when the heated probe [300 °F (150 °C)] and the metal being tested are in contact with each other. The voltage generated at this junction is representative of the chemistry and crystalline structure of the metal being tested. Every alloy of a given 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 nonferrous materials. Alloy sorters have not proved to be consistently capable of sorting low alloy (< 5 % Cr) and austenitic stainless steels.

5.2.5.3 Other Techniques

Techniques such as eddy-current sorters, electromagnetic alloy sorters, triboelectric testing devices (e.g. ferrite meters), and thermoelectric tests are qualitative and as such may only be appropriate for limited sorting applications and not for specific alloy identification.

5.3 Equipment Calibration

The person(s) performing the PMI testing should calibrate and/or verify the test equipment performance as specified by the equipment manufacturer. The PMI test procedure should provide the frequency interval for this calibration/ verification. If calibration procedures are not provided by the equipment manufacturer, they should be established by the owner/user. Typically, these procedures should include calibration/verification using certified standards.

5.4 Equipment Precision

The precision of the test equipment should be consistent with the established test objectives (see 5.1). When component composition is desired, the owner/user should establish the acceptable precision and repeatability.

The accuracy and the method in which accuracy is determined needs to be understood. For example, in some tools, the sensitivity may be dependent upon how long you conduct the test in order to improve signal averaging algorithms. Failure to understand these issues may produce inaccurate results.

5.5 Personnel Qualifications

The person(s) performing the PMI test should be knowledgeable about all aspects of operation of PMI test equipment and the PMI test method used. Qualifications of the person performing the PMI test, including training and experience, should be submitted for review and approval by the owner/user.

Owner/users should ensure that personnel using testing devices are adequately trained not only in the specific instrument but also in the alloys they will be examining. In some cases for critical application a formal documented program and some form of testing of personnel may be required. The higher the degree of operator analysis the more important this aspect of the whole procedure becomes.

5.6 Safety Issues

The specific requirements for each PMI test technique should be clearly reviewed as to the amount of mechanical preparation. Consideration should be given to the anticipated thickness of the sample before mechanical methods are used to prepare the sample. In addition, considerations for electrical arcing and “hot spots” should be considered as well as appropriate electrical and hot work permits. Chemical spot testing involves the use of a variety of chemicals. Appropriate safety precautions should be taken when handling these chemicals.

6 Evaluation of PMI Test Results

6.1 Material Acceptance Methods

The owner/user may elect any one of the following methods of material acceptance.

a) Materials can be confirmed to contain the nominal amounts of alloying elements specified in the relevant materials specification (e.g. ASME Section II or ASTM specifications).

b) Materials can be classified through a qualitative sorting technique (see 5.2.4) to establish the conformance with the intended material.

c) When PMI testing indicates alloying elements are outside the ranges indicated in the material specification, the owner/user may still choose to allow the use of the tested materials in situations where a person knowledgeable of the appropriate damage mechanisms confirms that the material will perform satisfactorily in the service.

d) If testing using one of the portable or qualitative analysis methods (see 5.2.1 or 5.2.2) leads to the potential rejection of a component, a more accurate analysis may be used to determine component acceptance (see 5.2.3).

6.2 Dissimilar Metal Welds and Weld Overlays

Results from testing dissimilar metal welds should take into account the effects of dilution, which occurs during weld deposition. The owner/user should establish the minimum compositional requirements of the as-deposited weld metal necessary for the intended service.

6.3 Follow-up PMI Testing after Discovery of a Nonconformity

If any one of a representative sample is rejected, all items of that inspection lot should be considered suspect. A more extensive inspection of the remaining lot should be considered.

7 Marking and Recordkeeping

7.1 Materials Identification Process

Alloy materials should be identified by their alloy designation or nominal composition. Examples of some acceptable identification methods are:

a) color coding by alloy,

b) a low-stress stamp marking indicating that the test has been performed,

c) documentation showing both the PMI test results and the PMI test locations.

Test locations should be shown on appropriate drawings so that each test site can be traceable to the fabricated piping components.

7.1.1 Color Coding/Marking

If the material verification program procedure established by the owner/user requires a visual identification such as color coding or marking, the owner/user should maintain a record of the alloy material/color code combinations. Pipe Fabrication Institute (PFI) Standard ES22 is an example of one such system. Materials identification by color coding is not a substitute for permanent manufacturers' markings required by applicable ASTM or other materials specifications.

7.1.2 Marking of Components

If the owner/user's documentation process requires physical marking of piping components, it should specify one of the following.

a) Whether or not the marking system should remain legible for the expected life of the component without deterioration due to corrosion or elevated temperature.

b) Whether or not the marking system is only temporary to facilitate proper handling and identification from the point of PMI testing to final installation. This marking can be semi permanent paint applied to each item. The markers should not contain additives such as metallic pigments (Al, Pb, or Zn), sulfur or chlorides.

7.2 Material Certifications

Material certifications, mill test reports, or certificates of compliance should not be considered a substitute for PMI testing, but may be an important part of an overall quality assurance program.

7.3 Shop and Field PMI Test Documentation

Those individuals performing PMI testing should obtain and follow the PMI test procedure approved by the owner/user. This procedure should cover the technique used, equipment calibration, the qualification requirements of PMI test personnel, the testing methodology, and documentation requirements.

When documentation, such as drawings, is used in lieu of physical marking, the documentation should allow the owner/user to identify which components were tested.

7.4 New and Existing Piping System Documentation

When PMI testing is conducted on new or existing piping systems, records of the results should be kept as long as the piping system exists in its original location. If a piping system or a portion of a piping system that has not received material verification is relocated, the owner/user should consider the need for PMI testing prior to placing the relocated components into service.

7.5 PMI Test Records

Typical PMI test records should contain the following.

a) Reference to the PMI test procedure(s) used.

b) Date of testing.

c) Test instrument identification number or serial number where appropriate.

d) Name of each person and company performing the tests.

e) Results of the tests.

f) Basis and action for resolving and documenting PMI test nonconformances including those that have been left in service.

g) Documentation of the criteria used for prioritization of piping systems and extent of PMI testing performed. Alternately, the owner/user may choose to include this within the written material verification procedure. When included in the owner/user's written material verification procedure, the date and edition number of the written procedure should be documented in the test record.

7.6 PMI Test Procedures

The PMI test procedure should include the techniques used, equipment calibration elements, the qualification requirements for PMI test personnel, the testing methodology, acceptance criteria and the documentation requirements.

7.7 Traceability to Field Components

The information listed in 7.5 should be reported in such a manner that they are traceable to the point of installation.

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