



NACE -MR0175-ISO-15156

NACE MRO-103 Material Compliance

Q: I have a material certified to be compliant with NACE MR0175. Is that material also compliant with NACE MR0103?

A: The short answer is: maybe, maybe not.

NACE MR0175 and NACE MR0103 both cover requirements relating to materials for resistance to sulfide stress cracking in sour applications (i.e., applications involving the presence of H₂S and liquid water). NACE MR0175 was initially released in 1975 and has undergone a number of revisions since then. In the 2003 revision, the scope of MR0175 was expanded to include chloride stress corrosion cracking in addition to sulfide stress cracking. Many requirements changed then, and environmental limits, such as temperature restrictions, were added. Shortly thereafter, MR0175 was merged into International Organization for Standards (ISO) 15156 parts 2 and 3, which resulted in additional changes in requirements.

Despite the fact that the only “official” version of NACE MR0175 is NACE MR0175/ISO 15156, people are still using and specifying NACE MR0175-2002 (the last version—before the scope change), and sometimes they also refer to NACE MR0175-2003, the version just prior to the ISO merger. Therefore, the question asked really needs to be clarified to indicate which version of MR0175 was referenced on the material certification.

Even after that clarification is made, the answer to the question is complex and depends on the specific material involved, and whether any welding is involved. Following are some examples of this complexity:

Scenario 1. Assume the material is a carbon steel casting in accordance with ASTM A216 Grade WCC. In this case, the basic material requirements are roughly the same for all of the NACE standards and versions. The heat treatment requirements are identical. The hardness requirement in all the MR0175 variants is 22 HRC maximum. MR0103 does not include a maximum hardness requirement for this material. At this

point, it seems like the MR0175-compliant material would also be MR0103-compliant. However, castings almost always contain weld repairs. MR0103 includes very specific welding requirements for carbon steels, specifying that welding is to be performed in accordance with NACE SP0472. The various MR0175 versions include different welding requirements, but none parallel the MR0103 requirements. Therefore, without reviewing the welding processes and procedures for weld repairs in the casting, compliance with MR0103 cannot be verified.

Scenario 2. Assume the material is an ASTM A995 Grade CD3MN casting. This material was never listed in NACE MR0175-2002 so it cannot be certified compliant to that standard. NACE MR0175-2003 and NACE MR0175/ISO 15156 both require the material to be solution-heat-treated and to contain 35 to 65 volume percent ferrite in the base metal. There is no maximum hardness requirement—both require the ferrite content in the weld deposit to be 30 to 70 volume percent. NACE MR0103 also requires 35 to 65 volume percent ferrite in the base metal. However, it also imposes a maximum hardness requirement of 28 HRC, requires weld deposits and heat-affected zones to contain 35 to 65 volume percent ferrite and requires a Vickers hardness survey to be performed as a part of the welding procedure qualification. Therefore, simply meeting either NACE MR0175-2003 or NACE MR0175/ISO 15156 does not guarantee compliance with NACE MR0103.

Scenario 3. Assume the certification is for an ASTM A105 NPS 4 Class 300 weld-neck flange. ASTM A105 allows this flange to be delivered in the as-hot-forged condition, with no subsequent heat treatment. All of the versions of NACE MR0175 specifically allow ASTM A105 forgings provided they meet a 187 HBW maximum hardness requirement, which is the standard maximum hardness requirement listed in ASTM A105. In other words, all versions of NACE MR0175 provide a specific waiver of the standard carbon steel heat treatment requirements for ASTM A105 material. However, NACE MR0103 does not include this specific waiver for ASTM A105 material. NACE MR0103 requires the material be subsequently heat-treated by annealing, normalizing, normalizing and tempering, or quenching and tempering. Therefore, without further information about the heat-treatment condition, conformance with NACE MR0103 cannot be verified.

Scenario 4. Let's turn this issue around: Assume an ASTM A351 Grade CF8M casting is certified to be compliant with NACE MR0103. In this case, the base material requirements for all of the NACE MR0175 variants and MR0103 are identical. However, NACE MR0175/ISO 15156 requires that all welding be performed using a procedure

that includes a Vickers hardness survey as part of the procedure qualification. NACE MR0175-2002 and 2003 and NACE MR0103 do not include this requirement. Therefore, a CF8M casting produced and weld-repaired in compliance with NACE MR0103 is also compliant with NACE MR0175-2002 and 2003, but is not necessarily compliant with NACE MR0175/ISO 15156. One would need to review the welding procedure used for repairs to see if it included the required Vickers hardness survey before compliance with NACE MR0175/ISO 15156 can be verified.

As this answer shows, there are no simple rules for determining the compliance of a material with one NACE standard based on its compliance with another one. The standards are similar in many ways, but they contain many requirements that do not coincide. Therefore, each must be considered individually to determine compliance. (Bush)

Cast vs Forged

Q: Should I be concerned whether my valve is cast or forged?

A: Just as in politics, everyone has an opinion on this issue.

The good news is that both types of valves should be able to provide you with acceptable performance, although a perception exists that forged valves are superior to cast valves. However, if cast valves are made properly, they can and have worked equally well in a variety of services and usually at a much lower cost than forged valves. Also, the belief that forged components are infallible is not true. Let's look at an example of a 4-inch diameter wrought valve stem in N07718 (Figure 1). A crack-like defect was seen on the end of the stem, so the part was cut in half, and the large shrink cavity you see here was discovered. This shows that forged material is not without its own problems. But let's examine how cast and forged valves are made and how we can assure we get a good valve.

What most people don't realize is that cast and forged valves start out the same way—molten metal is poured into a mold or ingot. As a result, both types can have defects such as the shrinkage in the above mentioned N07718 bar. Other defects associated with forgings are inclusions, laps, seams, cold shuts and cracks. Defects with common castings are inclusions, porosity, misrun and hot tears. As you can see, both have their

potential issues.

An issue with forgings often overlooked is that forgings and wrought products will have non-uniform mechanical properties. This is because they are worked or formed more in one direction than in another. Therefore, the grains will be elongated more in one direction than in the other, which has a direct effect (Spence) on mechanical properties, particularly impact strength. As a result, the design of forgings needs to take into account these anisotropic properties whereas castings have uniform properties no matter what the orientation of the test coupons.

Another advantage of cast valves is that they can be produced in more complex designs than forged valves. Certain valve designs such as a globe valve are simply difficult or impossible to produce as forgings. This flexibility of design in cast valves allows them to be more efficient in controlling flow than a similarly forged valve.

Something else to consider with forged valves is that they usually are made in halves, particularly the larger sizes. This means there is either an additional flanged connection that can be a potential leak path or the halves are welded together. Welding, however, is another process for cast metal that can have its own set of problems.

The questionable reputation that castings have is from two sources. First, most of the ASTM cast specifications are lenient in requirements for composition, heat treatment and inspection. Second, some foundries either use this latitude to their advantage or simply do not know enough to implement tighter controls when needed on chemistry or heat treatment. This concern about castings has resulted in equipment produced to ASME Section VIII having a quality factor on castings of 80% of the allowable stress values for a wrought component. However, this quality factor can be increased to 100% if sufficient NDE (non-destructive evaluation) per Appendix 7 is performed.

Casting purchasers need to understand that in most ASTM specifications these additional NDE requirements are not mandatory. They are simply listed as supplementary requirements at the end of the product specifications and are only invoked if included in the purchase order. Specifying additional NDE-like radiography or dye penetrant inspection is one way of helping ensure the quality of valves being purchased. However, a more cost-effective way is to deal with valve suppliers who already control the quality of the products they produce and have a long and successful track record. In either case, the decision to go with cast or forged valves depends on several factors, and cost is usually the determining one. (Spence)

Magnetic Identification

QUESTION:

I've seen people checking metal materials with a magnet. Is this a useful method of sorting materials, and if so, how does it work?

ANSWER:

Valve companies deal with a large number of pure metals and alloys due to the variety of applications in the process industry. Occasionally, alloy identification must be performed on parts due to customer inquiries, mix-ups in bar stock, questionable machining characteristics or for some other reason. Although positive material identification (PMI) has become quite common, a PMI tester is not always available in a timely manner. One common identification/sorting technique that is often overlooked—and sometimes misapplied—is magnetic inspection. Magnetic inspection can save a lot of time by quickly proving a material is not what it is supposed to be.

Categorizing Materials by Magnetic Attraction

Magnetic inspection refers to categorization of a material by observation of its magnetic attraction force. Various alloy groups behave differently when exposed to a magnet. However, virtually all alloys fall into one of four behavior categories:

- F - Fully magnetic: Materials such as carbon steels, alloy steels.
- N - Never magnetic: Materials such as aluminum alloys, copper alloys, most nickel-base alloys, some stainless steels, etc. These materials exhibit no perceptible attraction to a magnet.
- P - Partly magnetic: Materials such as some stainless-steel castings and wrought products. These materials exhibit some attraction to a magnet, but less than the fully magnetic materials.
- V - Varying: Materials such as some stainless steels, nickel-copper alloys, etc. These materials may or may not be attracted to a magnet, and when attracted to a magnet, the attraction strength may vary significantly, depending upon the exact composition and processing history.

Information on magnetic characteristics can usually be found in material product literature.

An unknown material's magnetic characteristic is determined by placing a magnet against the material and observing whether it is attracted or not. If there is no perceptible attraction, the material falls into category "N". If there is attraction, decide whether it is full or partial. This is best done by placing the magnet against the unknown material and then bringing a piece of carbon steel into contact with the opposite end of the magnet. If the carbon steel easily removes the magnet from the unknown material, then the unknown falls into category "P". If the magnet is attracted with approximately equivalent force by both materials, then the unknown falls into category "F". In performing this comparative test, it is important that the surface contour and finish of the unknown piece and the carbon steel piece be the same (preferably flat). It is also important that both parts are more massive than the magnet or, in the case of sheet materials, that both parts have approximately the same thickness.

Limitations of Magnetic Inspection

The most important thing to keep in mind regarding magnetic inspection is that, although it can prove that a part is not a particular material, it cannot prove that a part is a particular material.

Here are some example applications of magnetic inspection:

- Example 1: Records have been lost for a valve shaft that has been stored for several years. It is assumed the shaft is probably either S17400 or S20910, since these are the standard materials of construction for this part. Magnetic inspection determines that the shaft is fully magnetic. S17400 is fully magnetic, whereas S20910 is never magnetic. Therefore, the shaft is not S20910, and may be S17400. It could also be some other fully magnetic material.
- Example 2: A customer orders a "316" valve body, but upon receipt of the body finds that it is slightly magnetic. The customer calls and complains that he did not receive a "316" body as ordered, because he knows that 316 stainless steel is never supposed to be magnetic. The problem with this logic is that the body is not 316, but rather is a CF8M casting, the equivalent of 316 wrought material. The chemistry of the cast material is adjusted to intentionally produce a small percentage of "ferrite," which is a magnetic phase. This renders the casting partly

magnetic, and often leads to this type of confusion. This highlights the importance of accuracy in material designation and product form (cast, wrought, etc.) when using magnetic inspection.

- Example 3: A casting is sent to inspection for a material check because the machine operator noticed its machining characteristics were unusual. The casting is supposed to be CW2M. Magnetic inspection may save a great deal of time vs. performing a PMI. The casting is found to be partly magnetic. This proves that the casting is not CW2M, which is never magnetic.
- Example 4: Same situation as example 3. This time, the material is found to be non-magnetic. This does not mean that the material is CW2M. This is one of the most important limitations in magnetic inspection. Magnetic inspection can prove that a part is not a particular material, but it cannot prove that a part is a particular material. In this case the casting should be further evaluated by PMI or some other method to determine if it is CW2M or some other non-magnetic material.

Remember that magnetic inspection can be a valuable, time-saving technique, but if used improperly it can produce erroneous identification of materials. (Bush)

NACE MRO175/ISO

QUESTION:

I see that there is a new version of NACE MR0175 called NACE MR0175/ISO 15156. Why did MR0175 become an ISO standard, and how do the requirements in the ISO version differ from those in the previous version?

ANSWER:

This topic is too broad to cover completely in a column of this size. However, we would like to offer a brief history and a summary of one major change that will affect valve companies and their suppliers.

You may recall that MR0175-2003 invoked some major changes compared with the 2002 revision. Many of these changes were encouraged by the European Federation of Corrosion (EFC). The EFC had already issued two reports closely related to MR0175:

Publication 16, "Guidelines on Materials Requirements for Carbon and Low Alloy Steels for H₂S-Containing Environments in Oil and Gas Production," and Publication 17, "Corrosion Resistant Alloys for Oil and Gas Production: Guidance on General Requirements and Test Methods for H₂S Service" ISO requested that NACE work to merge MR0175 and these documents into a single ISO standard. The "rewrite" of MR0175, which was eventually published as MR0175-2003, was the first step in that merger.

The biggest change in the 2003 version was the introduction of environmental application limits (such as maximum H₂S partial pressures, maximum temperature limits, pH restrictions) for almost all of the CRAs (corrosion-resistant alloys-the various classes of stainless steels, nickel alloys, titanium alloys, etc). Some materials were actually deleted from the document (N06600 and N04400, to name two). However, for the materials that remained, there were few changes in actual metallurgical requirements. MR0175-2003 was then converted into ISO 15156, which was published in December 2003. In North America, it is sold by NACE as NACE MR0175/ISO 15156. NACE MR0175/ISO 15156 is actually published in three parts:

- **Part 1:** General principles for selection of cracking-resistant materials
- **Part 2:** Cracking-resistant carbon and low-alloy steels, and the use of cast irons
- **Part 3:** Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys

The format of the document changed dramatically from that of the MR0175-2003 standard. The PDF version of MR0175-2003 was 44 pages. The three-part ISO version totals 147 pages. Although much of this expansion is due to the different format of the ISO standard, some new information was added (such as information about H₂S-related cracking mechanisms other than sulfide stress cracking), and some new metallurgical requirements were imposed.

The environmental restrictions that originated in MR0175-2003 were passed along to the ISO 15156 document with essentially no changes, which means that selection of materials will not be affected vs. MR0175-2003.

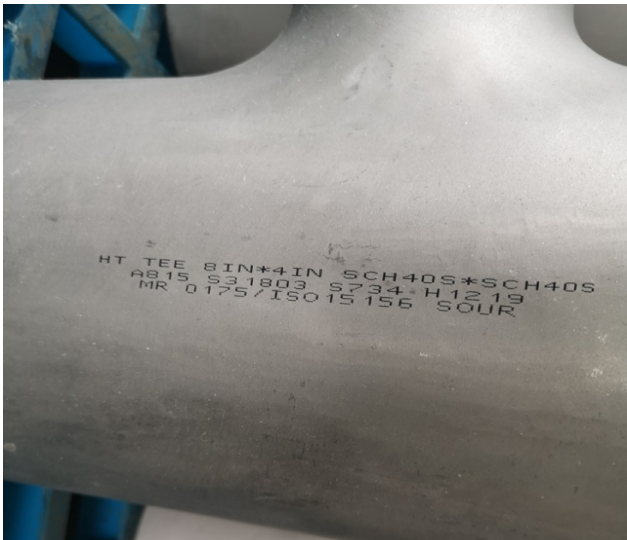
Obviously, there are many new requirements that need to be evaluated by each manufacturer. However, the change that will most affect equipment suppliers and their foundries relates to new requirements for the qualification of welding procedures. NACE

MR0175/ISO 15156 provides much more specific requirements for qualification of welding procedures than previous versions of MR0175. All procedure qualifications are required to include hardness surveys, whether or not post-weld heat treatment is performed. The hardness surveys must be performed using either 10 kg or 5 kg Vickers (HV 10 or HV 5) or Rockwell 15N (HR15N), and the indentations must be located according to specific survey layouts provided in the standard. Hardness surveys performed using Rockwell C (HRC) are allowed only if the design stress does not exceed two-thirds of specified minimum yield strength and if the welding procedure specification requires postweld heat treatment. Therefore, in most cases the use of HRC will not be acceptable.

The major implication of this new requirement is that it applies to all material categories, even those that are not hardenable by heat treatment. One normally associates the use of hardness surveys with the qualification of procedures for alloys that are hardenable by heat treatment, such as the carbon steels, alloy steels, martensitic stainless steels, and duplex stainless steels. Materials that are not hardenable by heat treatment usually are exempt from these kinds of tests. Per ISO 15156, even procedure qualifications for austenitic stainless steels and solid-solution, nickel-based alloys must include hardness surveys. Most equipment suppliers, including valve manufacturers, likely did not perform hardness surveys for these types of materials, and even hardness surveys included in existing procedure qualifications for materials hardenable by heat treatment are very unlikely to have been performed per the layout specified in the new standard.

These new requirements mean that foundries and valve manufacturers will need to update existing procedure qualifications by either performing the hardness surveys on leftover procedure qualification coupons (if they happen to still be available), or by creating new weld coupons for the hardness surveys. When the range of alloys supplied into sour applications is considered, updating welding procedures to meet these new requirements will consume a great deal of time and expense. (Bush)

ASTM A815 WP-S UNS S31803 SOUR SERVICE MR 0175/ISO15156 SOUR FITTING



NACE ASTM A234 Gr. WPB NACE MR 0175/ISO15156 SOUR BS381-COLOR-BAND-PIPE-FITTING

