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# VALVE

M A G A Z I N E

*Reduced Maintenance & Operating Costs  
Enabled by Intelligent Valve Technology*

*The Design and Application  
of Advanced Composite Valves*

*Control Valves Provide  
Key to Process Profitability*

*NACE MR0175 and the Valve Industry*

by Don Bush

# NACE MR0175 *and the Valve Industry*

## WHAT IS NACE?

NACE International is a technical society concerned with corrosion and corrosion-related issues. NACE used to stand for the “National Association of Corrosion Engineers”, but the name of the society was changed to “NACE International” several years ago to signify the international scope of NACE membership and activities. Within the new name, “NACE” doesn’t stand for anything. NACE activities include technology exchange, publication of corrosion and corrosion-related information, standards development and publication, educational services, and other activities to aid in the advancement of corrosion control.

## WHAT IS NACE MR0175?

NACE MR0175, *Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment*, is a standard issued by NACE Task Group T-1F-1 to provide guidelines for the selection of materials that are resistant to failure in hydrogen sulfide-containing oil and gas production environments.

## WHAT IS TASK GROUP

NACE’s technical committees are arranged in fourteen group committees that deal with either corrosion problems in a specific industry or with a particular type of corrosion mechanism. For example, the T-1 Committee deals with petroleum production issues, T-8 works on the refining industry problems, and T-5 covers the process industry. The Group Committees are further divided into Unit Committees, which focus on more specific tasks. For example, two of the Unit Committees under T-1 are T-1F, *Metallurgy of Oilfield Equipment* (approximately 325 members in 1995), and T-1G, *Protective Coatings, Elastomers, and Other Nonmetallics for Oilfield Sealing Service*. Task Groups working under the direction of the Unit Committees work on specific projects. The T-1F-1 Task Group, *Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment*, is the task group that originally developed the MR0175 document, and is now responsible for its maintenance. Examples of other T-1F Task Groups include T-1F-9, *Metallic Materials Testing Techniques for Sulfide Corrosion Cracking*, T-1F-22, *Criteria for Inclusion of Materials in NACE Standard MR0175*, and T-1F-24, *Performance of Fabrication and Repair Weldments in H<sub>2</sub>S Environments*.<sup>1</sup>

*Valve producers are often required to supply valves in materials that meet NACE Standard MR0175, Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment. Despite the frequency with which MR0175 is specified, there is quite a lot of confusion regarding the document and its application to products. This article uses a question and answer format to cover some of the more common questions and issues regarding MR0175, as well as some of the less obvious pitfalls that can affect the valve industry.*

*(Note: The information contained in this article represents the views of the author, and has not been reviewed or endorsed by NACE.)*

## HOW WAS NACE MR0175 DEVELOPED?

In 1963, NACE Technical Committee T-1B which had originally formed in 1959 as an informal group of corrosion engineers, released Publication 1B163, *Recommendations on Materials for Sour Service*, which included several tentative specifications, including Tentative NACE Specification 150 on valves. In 1968, the T-1F Task Group released NACE Recommendation 1F166, *Sulfide Cracking-Resistant Metallic Materials for Valves for Production and Pipeline Service*. After several years of work to develop a standard on materials selection, T-1F-1 released the original version of MR0175, entitled *Materials for Valves for Resistance to Sulfide Stress Cracking in Production and Pipeline Service*<sup>2</sup>, in 1975. The Texas Railroad Commission adopted MR0175 as an equipment requirement in 1976, which prompted the revision of MR0175 to be more general<sup>3</sup>. The new version was released in 1978 under the title *Sulfide Stress Cracking Resistant Metallic Material for Oilfield Equipment*.<sup>4,5</sup> The “s” was added to “Materials” in the 1984 revision.

## WHAT DOES THE NAME “MR0175” STAND FOR?

The “MR” stands for “Material Requirements”. The “75” stands for the year 1975. The “01” indicates it was the first “Material Requirements” standard issued in 1975 by NACE. This scheme is used for all NACE standards, including Recommended Practices (beginning with “RP”) and Test Methods (beginning with “TM”).

## SULFIDE STRESS CRACKING BACKGROUND

### **What is Sulfide Stress Cracking?**

According to NACE MR0175, sulfide stress cracking is defined as "brittle failure by cracking under the combined action of tensile stress and corrosion in the presence of water and H<sub>2</sub>S." Actually, sulfide stress cracking is a special case of hydrogen embrittlement that occurs when H<sub>2</sub>S dissociates, in the presence of water, into hydrogen and sulfide ions. Diffusion of hydrogen into the metal is catalyzed by the presence of the sulfide ions, promoting hydrogen embrittlement. As such, all materials that are susceptible to hydrogen embrittlement are very susceptible to sulfide stress cracking. In addition, some metals that are resistant to other forms of hydrogen embrittlement are susceptible to sulfide stress cracking.

The term "sulfide stress cracking", or SSC, is used most commonly in the oil and natural gas production industry. This term leads to some confusion, since the sulfide ion is not actually the embrittling species. The refining industry prefers the term "wet H<sub>2</sub>S cracking", which is actually a more accurate designation.

NACE MR0175 defines the term "sour" as a fluid containing water as a liquid and H<sub>2</sub>S exceeding particular limits.

### **What are the factors affecting sulfide stress cracking susceptibility?**

There are actually quite a number of factors affecting the susceptibility of a material to sulfide stress cracking. NACE MR0175 paragraph 1.3 lists the following factors:

1. Chemical composition, strength, heat treatment and microstructure of the material; Certain compositional elements (for example, nickel in steels) have been identified as SSC promoters. Within a particular alloy, as strength (and hardness) increase, the susceptibility to sulfide stress cracking increases.
2. Hydrogen ion concentration (pH) of the process environment.
3. H<sub>2</sub>S concentration and total pressure (or, H<sub>2</sub>S partial pressure) of the process environment.
4. Total tensile stress (accounting for both applied and residual stresses).
5. Process temperature.
6. Exposure Time.

## NACE MR0175 ACCEPTABLE MATERIALS

### **What is the "NACE test" that can be done to certify that a material meets NACE MR0175?**

This is a common misconception regarding NACE MR0175. There is no "NACE test" that can be used to certify that a material meets MR0175. MR0175 is essentially a listing of materials that have been deemed "acceptable". Acceptable materials are always listed with some type of hardness requirement, and there are often other stipulations regarding hot- or cold-working, heat treat conditions, etc.

### **How are new materials added to MR0175?**

The addition of a new material is one type of technical change to MR0175. All technical changes, i.e., changes other than editorial, are made by a ballot process:

1. The proposed change and supporting data are sent to NACE Headquarters.
2. The T-1F-1 committee reviews the proposed ballot item. If

the proposal is judged to be acceptable, a liaison is assigned to help the submitter with the ballot information and the voting process.

3. The ballot item is reviewed at the next Corrosion conference (held every spring) so the ballot item submitter can learn of concerns that may be raised by voters during the upcoming ballot.

4. The ballot is mailed to all NACE Unit Committee T-1F members (approximately 325 in 1995).

5. In order for a ballot item to pass, all votes must be positive or abstaining, and all negative votes must be either resolved or determined to be incomplete. A negative vote can be resolved by supplying additional information as requested by the negative voter, or by modifying the proposed change to satisfy the negative voter's concern. Modifications are only allowed if they make the wording more restrictive than the original ballot request. Examples would include reducing the maximum allowable hardness, adding a maximum temperature where one was not originally listed, or only allowing the material to be used for certain components or applications. In order to be complete, a negative vote must include a written technical reason for the negative vote, accompanied by a statement regarding whether it is possible to resolve the negative, and what actions are required by the ballot item submitter to attain resolution.

6. After all negatives are either resolved or determined to be incomplete, the item is forwarded to the NACE T-1F, T-1, and TPC Chairmen for final approval.

7. The revision is published in NACE's monthly publication, *Materials Performance*, and included in the next revision of the standard.

There are two options available to the ballot item submitter if there are negative votes that cannot be resolved:

1. A request can be made with the T-1 chairman for a Unit Override Ballot. In effect, information supplied by the ballot item submitter and the negative voter(s) is sent to all T-1 (note: not just T-1F) members. In order for the negative(s) to be overridden, two-thirds of all non-abstaining voters must vote to override the negative(s).

2. The item can be re-balloted in the following year, in which case only 90% of the non-abstaining votes must be positive in order for the item to pass. In order to be considered a re-ballot, the wording of the item cannot change from the previous ballot. However, additional supporting data can be supplied with the ballot information.

### **How long does it take to complete the ballot process?**

Proposed ballot items must be submitted to NACE Headquarters no later than January 31 of a given year. The ballot items are reviewed at the annual Corrosion conference, after which they are mailed (in April or May) to all of the T-1F members for voting. The voters have six weeks to return their ballots, after which NACE headquarters will spend two to four weeks processing them. The results are then mailed to the ballot item submitters. If there are negatives to resolve, the ballot item submitters have thirteen months from the mailing date to obtain resolution.

From the time the proposed ballot is submitted to NACE, it can take anywhere from five months (if there are no negatives)

to eighteen months (to resolve negative votes) to obtain approval. Approved changes are published shortly thereafter in *Materials Performance*, as well as in the next revision of MR0175.

#### **How often are new revisions of MR0175 published?**

New revisions of MR0175 are published at the beginning of the year.

#### **What information is required in a ballot to add a new material?**

In order for the T-1F-1 Task Group to accept a ballot, it must meet certain criteria. The item must generally include NACE TM0177 test data on at least three commercial heats of material. No less than two of those heats must display a hardness level at least as high as the maximum hardness listed in the proposed wording. The Task Group knows from experience that ballot items failing to meet at least these minimum requirements will receive a large number of negative votes.

#### **What information is generally necessary in order for a ballot item to pass?**

It depends a great deal on the type of material in question. For carbon and alloy steels, successful ambient temperature TM0177 test data are usually enough, since these materials are not targeted for high-temperature and/or corrosive environments. However, the stainless steels and non-ferrous alloys (commonly denoted as Corrosion-Resistant Alloys, or CRAs) generally require more in-depth testing to determine acceptable H<sub>2</sub>S, chloride, and temperature limits, whether they perform acceptably when coupled with steel, and whether they are resistant to environments which contain elemental sulfur. It can cost tens of thousands of dollars to develop adequate test data to successfully ballot a CRA, especially if the alloy is targeted for very severe service.

#### **Why are environmental restrictions listed for some materials, whereas others are listed with no restrictions?**

Although the NACE standards governing the ballot process have remained fairly constant since MR0175 was released, voting practices have evolved through 4 identifiable time periods:

**1. 1975-1978:** The materials included in the original version of MR0175 were grandfathered into the document based upon years of acceptable field experience as well as laboratory test data. Until the 1978 revision was released, successful field history was the primary consideration for acceptance of new alloys, and laboratory data was used to substantiate the field history data.

**2. 1978-1990:** The 1978 revision converted the document from a valve standard to a general standard. MR0175 had been adopted as a requirement for sour oilfield construction in Texas by the Texas Railroad Commission, after which the opportunity to obtain field history data on new alloys was greatly diminished. Laboratory data eventually became the primary consideration for acceptance, although field history data was still strongly influential if it was available.

**3. 1990-1996:** In the early 1990s, voters began to cast negative votes based upon the fact that certain alloys were likely to be specified for more severe environments that might cause catastrophic failure modes other than simple, ambient temperature sulfide stress cracking. The negative voters usually requested additional test data to either prove that the mate-

rial was resistant to all of the likely combinations of environmental parameters (higher H<sub>2</sub>S partial pressure, presence of chlorides, elevated temperature, and presence of elemental sulfur), or that environmental restrictions be placed upon the alloy in MR0175. Most CRAs added to the document during this time frame included environmental restrictions such as maximum temperatures, maximum H<sub>2</sub>S partial pressures, maximum chloride levels, or restriction from use when elemental sulfur is present

**4. 1996-1997:** Because of the wide variety of tests that could be requested by negative voters, it took a great deal of time, money, and tenacity to successfully ballot a new material. Many ballot item submitters had become very frustrated with the process, and wanted some type of standard requirements that, if met, would provide some level of assurance that a material would be accepted into the document. A brainstorming session was held at a NACE Corrosion conference in 1994 to attempt to develop a standardized set of acceptance criteria for CRAs. The concepts developed in that session eventually resulted in an alternative balloting process for new materials. The 1997 and 1998 versions of MR0175 contain the new Paragraph 1.6.2 and Table 1 that describe a means of balloting whereby a material is evaluated using standard tests of varying severity levels (labeled Level I through Level VII). The ballot item submitter can choose the level(s) at which to test. Additions to MR0175 that are balloted in this manner list the successfully-tested severity level(s) in the document text. In addition, summarized test data is added to Table 2, which will contain a perpetual record of summarized test data for all alloys that are added in the future.

Because voting and negative resolution practices have not been consistent throughout the life of the document, there are many instances where: a) materials that are very resistant to environmental cracking are either listed with restrictions, or not included in the document at all, b) materials that are very similar to each other are listed with very different levels of restrictions, and c) materials that are only somewhat resistant in certain applications, but were grandfathered into the document or added before the early 1990s, are listed with no restrictions whatsoever.

The index at the back of MR0175 lists all of the materials included in the document along with the year of inclusion and an indication of the type of data that the addition was based upon. The year of inclusion data can often provide some insight into the differences in environmental restrictions for two similar alloys.

#### **COMMON QUESTIONS REGARDING HARDNESS TESTING**

##### **Why is hardness emphasized so strongly?**

One of the most influential factors affecting a given material's susceptibility to sulfide stress cracking is its ultimate tensile strength. For a given alloy processed in a particular way (i.e., heat treated and/or mechanically formed), there is a strong relationship between the tensile strength and the hardness of the material. Since measurement of material hardness is universally simpler, quicker, and less costly, hardness was adopted as the primary acceptability criterion for materials rather than tensile strength.

The maximum hardness listed for a given alloy is the highest hardness at which it has demonstrated acceptable resistance to sulfide stress cracking either in the field or in laboratory tests.

**How many hardness readings must be run on each part? Does each part have to be hardness tested?**

These are probably the most common inquiries received by the T-1F-1 Task Group. A quick look at two of the statements in paragraph 1.7.2 provides a preview to their typical response:

- a. "Sufficient hardness tests should be made to establish the actual hardness of the material or component being examined."
- b. "The number and location of test areas are outside the scope of this standard".

T-1F-1 typically responds by stating that the practice used to determine the actual hardness is a quality assurance issue, and that NACE MR0175 is not a quality assurance document. It is their position that it is up to the manufacturer to determine the correct method for verifying material hardness.

In practice, the lack of explicit hardness testing requirements causes problems between valve producers (and other equipment manufacturers) and customers. There are some customers who interpret the first statement above to mean that every part must be hardness tested. In fact, some assume that it means each part should be hardness surveyed, even down to the point that fabrication and repair weld heat-affected zones should be tested.

In practice, the number of parts that are tested, as well as the number and location of hardness tests per part, should be based upon the material and manufacturing processes involved. For example, it is virtually impossible for a CF8M casting to exceed the 22 HRC maximum if it is never cold deformed in some manner. On the other hand, a carbon steel part can exceed the 22 HRC maximum due to uneven cooling from a normalizing treatment, in the heat-affected zone of a fabrication or repair weld, or in the heat-affected zone adjacent to a flame cut surface. Thus the hardness testing plans and/or manufacturing process controls for these two materials should account for these differences in potential for excessive hardness.

**Do parts have to be tested with the Rockwell "C" scale?**

Although Rockwell "C" is the scale of choice, it is recognized that it is not a practical means for testing all products in all forms. Other types of tests may be used where they are appropriate (again, the most appropriate test method for a given application is a quality assurance issue that is outside the scope of NACE MR0175).

**Do other hardness testing methods have to be recognized by ASTM in order to meet MR0175?**

There are no requirements in MR0175 that stipulate hardness tests to be performed only by ASTM specified hardness test methods.

**How should conversions from other scales to Rockwell "C" be handled?**

If ASTM E140<sup>6</sup> includes a conversion table that is appropriate for both the hardness test method and the material being tested, then MR0175 requires the conversion be performed using that ASTM E140 table. However, if no appropriate table exists in ASTM E140, then other empirically developed conversions may be used.

**What is the meaning of the terms "Class I, II, and III Nuts and Bolts" in Section 6 of MR0175?**

"Class I", "Class II", and "Class III" are terms used in American Petroleum Institute (API) specifications to refer to classes of bolting materials. Classes I and II are required for applications where the bolting could be exposed to the H<sub>2</sub>S-containing environment. For example, in API Spec 6A<sup>7</sup>, "NACE Class I" studs are either N05500 (Monel K500<sup>®</sup>) with a maximum hardness of 35 HRC, or ASTM A453 Grade 660 (UNS S66286) with a maximum hardness of 35 HRC. "NACE Class II" studs are ASTM A193-B7M or ASTM A230-L7M. Class III studs are intended for services where the bolts will never be exposed to hydrogen sulfide. API Spec 6A specifies that Class III studs be either ASTM A193-B7 or ASTM A320-L7. Nuts for all three classes must be either ASTM A194-2HM, N05500, or ASTM A453 Grade 660.

The API "Class" terms were adopted in NACE MR0175, but with a slightly different meaning. Classes I and II were combined to pertain to bolting that would be either: 1) directly exposed (in contact with the H<sub>2</sub>S environment), or 2) external, but that might be exposed due to confinement of the equipment by enclosure, burial, insulation, etc. Any material that meets the requirements of Sections 3 and 4 in MR0175 can be used as Class I or II bolting. Class III refers to bolting that is never exposed to H<sub>2</sub>S, in which case MR0175 doesn't apply. Due to the great deal of confusion regarding this terminology, the "Class" terms were removed from MR0175 in the 1997 version. The document now only refers to "exposed" and "nonexposed" bolting.

**Are B7M and 2HM the only acceptable stud and nut materials that can be used for exposed bolting?**

From a NACE MR0175 standpoint, any material that meets the requirements of Section 3 or Section 4 in MR0175 is acceptable as a stud or nut material. B7M and 2HM are merely listed as examples of stud and nut materials that automatically meet MR0175 requirements. On the other hand, many of the materials that meet Section 3 or 4 requirements may not provide adequate strength to be used as stud or nut materials. Both strength and MR0175 acceptability must be considered.

**What are the NACE MR0175 requirements for rolled threads?**

Since thread rolling cold-forms the thread region, the acceptability of this process depends upon the acceptability of cold working on the particular material in question. Examples:

- Since carbon and alloy steels require stress relieving after cold working, roll-forming of B7 threads would require subsequent heat treatment. This heat treatment could be either a stress relief or the standard quenching and tempering procedure.
- Since the 300-series austenitic stainless steels may not contain cold work, B8M Class 1 studs created by thread rolling of solution annealed bar would not be acceptable. Therefore, in order to meet MR0175, B8M Class 1 studs must either be produced by thread cutting, or they must be solution annealed after thread-rolling, which actually makes them B8MA Class 1A.
- Since cold-worked and aged N09925 is acceptable per Sec-

tion 4, studs produced by rolling threads on solution annealed N09925 (Inconel 925® bar, followed by age hardening, would be acceptable provided the hardness didn't exceed 40 HRC.

**Can products made of 904L be certified as NACE MR0175 acceptable?**

UNS N08904 (904L) is a superaustenitic stainless steel that is targeted for chloride-containing environments where the conventional 300-series stainless steels do not provide adequate pitting and crevice corrosion resistance. Unfortunately, 904L is not included in NACE MR0175 in any form, even though it is sometimes requested by customers for valves which must also meet MR0175 requirements.

**Can products made of 254 SMO® be certified as NACE MR0175 acceptable?**

Avesta 254 SMO® is another superaustenitic stainless steel. It is probably the most commonly known of the "6 Mo" materials (materials which contain a minimum of 6% molybdenum for pitting and crevice corrosion resistance). The wrought form, UNS S31254, is acceptable. The cast form, CK3MCuN, was successfully balloted in 1996/1997 and now appears in the 1998 revision.

There has been a lot of confusion over this matter, because when wrought S31254 was originally balloted and passed, it was inadvertently added to Table 3. The wording in the general paragraph on austenitic stainless steels (currently paragraph 3.5.1) states that "Austenitic stainless steels with chemical compositions as specified in accordance with the standards listed in Table 3, either cast or wrought, are acceptable at a hardness of 22 HRC maximum in the annealed condition...". Thus it appeared that CK3MCuN was acceptable based upon the inclusion of S31254 in Table 3. An inquiry to the T-1F-1 Task Group in 1993 requested clarification on this issue, and it was determined that CK3MCuN had never been balloted and approved. The reference to S31254 was subsequently removed from Table 3, and the cast form was unacceptable until the recent ballot passed.

**Are 300-series stainless steels acceptable for use as springs and bourdon tubes?**

Since springs and bourdon tubes both require high strength levels to function properly, 300-series stainless steels must be used in the cold-worked condition in these components. However, the 300-series stainless steels are only acceptable in the annealed condition in NACE MR0175. Therefore, the use of these materials in springs and bourdon tubes for sour service is really not feasible.

**What cast materials commonly used in valves are unacceptable, even though their wrought counterparts are acceptable?**

There are several casting alloys used for bodies, bonnets, or other cast components in the valve industry that are not MR0175-acceptable even though their wrought counterparts are:

1. CD3MN, the cast version of duplex stainless steel S31803 (commonly called 2205).
2. Cast alloy 255, the counterpart of S32550 (Ferralium® 255).
3. CN3MN, the cast version of N08367® AL6XN®.
4. CW6MC, the cast version of N06625® Inconel(625).

There has been a great deal of confusion regarding N08825 (Incoloy® 825), and its cast counterpart, N08826 (designated

CU5MCuC in ASTM A494). N08826 was added to MR0175 in 1994, and a large percentage of the users and equipment manufacturers are still not familiar with the "N08826" designation. Many customers request quotations for NACE-acceptable N08825 equipment, and when N08826 is quoted, they become confused. This is merely an educational issue, but is sometimes a stumbling block nonetheless.

**Are cast iron materials acceptable?**

Gray cast iron materials can only be used for non-pressure-retaining components. Ductile (nodular) iron per ASTM A395 is acceptable for use wherever other applicable codes (such as ASME/ANSI) allow its use. Malleable irons are not acceptable.

**Does MR0175 cover nonmetallic materials such as elastomers, plastics, ceramics, etc.?**

These materials are all outside the scope of MR0175, as is indicated in the document title. NACE Committee T-1G, *Protective Coatings, Elastomers, and Other Nonmetallic Materials for Oilfield Use*, provides coverage of some nonmetallic materials. Many elastomers are affected by H<sub>2</sub>S, water, and/or petroleum fluids, making selection of o-rings and other elastomeric components a complicated issue that is still not covered by any industry standards.

**How is the conversion from weight percent H<sub>2</sub>S and overall system pressure to H<sub>2</sub>S partial pressure performed?**

There are two situations where this question is commonly asked: 1) when someone is trying to decide whether NACE MR0175 applies or not based upon paragraph 1.3, and 2) when someone is trying to decide whether to quote a material with an H<sub>2</sub>S partial pressure restriction.

In the first case, MR0175 paragraph 1.9 specifically states that the user (the valve company's customer) is responsible for specifying when MR0175 applies, so valve companies shouldn't really ever have to perform this calculation to determine if the document should have been specified.

In the second case, it is probably much easier to go back to the customer and ask whether the material is acceptable, or if the H<sub>2</sub>S partial pressure is known.

The actual calculation is not a direct conversion based upon H<sub>2</sub>S percentage and pressure. If you do want to perform the calculation, you will need to know the complete chemical breakdown of the gaseous phase, and use that information to determine the mole fraction of H<sub>2</sub>S. The H<sub>2</sub>S partial pressure can be calculated by multiplying the mole fraction of H<sub>2</sub>S by the absolute system pressure. A complete description of the steps involved in performing this calculation is beyond the scope of this article.

**Who is responsible for determining whether a given material is acceptable for a particular sour application—the valve supplier, or the customer?**

If NACE MR0175-compliant materials are specified by the customer, equipment manufacturers are responsible for verifying that the materials supplied in the product meet the requirements set forth for those materials in NACE MR0175. However, NACE MR0175 contains very explicit language that places the responsibility for determining the suitability of the materials of construction on the user. This is true whether a material is listed with or without environmental restrictions.

**How can inconsistently applied environmental restrictions cause material selection problems?**

There are several different types of problems that can occur:

1. The lack of environmental restrictions on some materials can promote their use in applications where they really aren't suitable. Some examples:

- Type 410 stainless steel is listed with no restrictions, although it is only resistant to mildly sour environments. Because of its low cost, type 410 might be chosen for an unacceptably aggressive application because of its lack of environmental restrictions in the document.
- The cast duplex stainless steel Z6CNDU20.08M per the French standard NF A32-055<sup>8</sup> is acceptable with no restrictions. A newer cast super-duplex stainless steel, J93380 (Zeron® 100), is listed with quite restrictive chloride concentration and H<sub>2</sub>S partial pressure limitations. **Table 1** is a comparison of their metallurgical properties:

As you can see, the Z6CNDU20.08M alloy is really not a duplex in the modern sense of the word (usually the term “duplex stainless steel” is reserved for alloys that are approximately 50% ferrite/50% austenite), and its alloy content would not afford it as much resistance to sulfide stress cracking as J93380. However, Z6CNDU20.08M was balloted as a duplex stainless steel, and was added to the document in that section in 1985. This has resulted in the use of Z6CNDU20.08M to produce NACE MR0175-acceptable “duplex stainless steel” valves. The J93380 material was not added until 1994, and its environmental restrictions preclude its use in many applications.

2. In several cases, materials that are nearly equivalent are listed with quite different environmental restrictions. Differences in environmental restrictions can cause commercial issues among similar alloys, since an alloy with no listed environmental restrictions has a competitive advantage in the oilfield marketplace over similar alloys that are restricted in some way. For example, the requirements for the superaustenitic stainless

	Composition		
	Z6CNDU20.08M	J93380	CG8M (Cast 317, for reference)
C	0.08	0.03	0.08
Cr	19.0-23.0	24.0-26.0	18.0-21.0
Ni	7.0-9.0	6.5-8.5	9.0-13.0
Mo	2.0-3.0	3.0-4.0	3.0-4.0
Cu	1.0-2.0	0.5-1.0	-
W	-	0.5-1.0	
N	-	0.20-0.30	
Ferrite (volume%)	25-40	40-60	Not a requirement, but sometimes as high as 25-30%
PREN <sup>a</sup>	25.6-32.9	40.0-44.0	27.9-34.2

<sup>a</sup>Pitting Resistance Equivalency Number = PREN = %Cr + 3.3 • %M<sup>+</sup> + 16 • %N

**Table 1**

steels S31254, N08367, and N08926, all of which are “6 Mo” materials, are summarized in **Table 2**.

The major alloying elements in these alloys are listed in **Table 3**.

Note that both N08367 and N08926 have higher overall alloy content than S31254, and would be expected to perform as well as, or better than, S31254 in hot, sour applications. However, for any application that is over 150°C (302°F), S31254 is the only “acceptable” material. The reason for this is that S31254 ballot was approved in 1991, when superaustenitic stainless steels were not being scrutinized for environmental restrictions. N08367 was approved in 1992, and received negative votes demanding either successful test data for more severe, higher-temperature environments, and/or the addition of environmental restrictions. N08926 was added in 1997 using the new Severity Level balloting process, and as such is also listed

Alloy	Maximum Hardness	Maximum Temperature	Maximum H <sub>2</sub> S Partial Pressure	Maximum Cl <sup>-</sup>	Maximum CO <sub>2</sub>	Acceptable if S <sup>0</sup> Present?
S31254	35 HRC	No Restriction	No Restriction	No Restriction	No Restriction	No Restriction
N08367	35 HRC	150°C (302°F)	310 kPa (45 psi)	5000 mg/L	No Restriction	No
N08926 <sup>b</sup>	35 HRC	121°C (250°F)	700 MPa (101.5 psi)	60,700 mg/L (=10% NaCl)	1.4 MPa (203 psi)	No Restriction

<sup>b</sup>Note: N08926 was successfully balloted using the new Severity Level method. The text in paragraph 3.5.8 regarding N08926 states that it is acceptable for “Environment V” according to paragraph 1.6.1 (it should read 1.6.2), Table 1. In paragraph 1.6.2, Table 1, Level V equates to 150°C (302°F), 91,000 mg/L (15%) NaCl, no S<sup>0</sup>, and the H<sub>2</sub>S and CO<sub>2</sub> levels listed above.

**Table 2**

with environmental information, although the environmental references are actually listed as guidelines rather than explicit restrictions.

**Is anything being done about the inconsistencies in environmental restrictions?**

Yes. The T-1F-1 Task Group has balloted a complete re-write of MR0175 that, instead of listing all alloys individually, groups similar alloys into "CRA Categories". The CRA Categories give broad compositional ranges that would cover commercial alloys that belong in each category. Each category has environmental restrictions and notes regarding applicability limits. Example CRA Categories in the draft document include:

- Austenitic stainless steels (Cr 16% minimum, Ni 8% minimum, P 0.045% maximum, and S 0.03% maximum)
- Conventional duplex stainless steels (35-65% ferrite, PREN 27-40)
- Nickel-base alloy group 3 (Cr 14% minimum, Ni + Co 52% minimum, and Mo 12% minimum)

There are several definite advantages of this approach:

- Materials with limited resistance, which were previously listed with no environmental restrictions, will no longer appear to be universally resistant.
- All alloys within a given category will have the same environmental restrictions.
- New alloys that fit into an existing category are automatically acceptable.

Alloys which do not fit into the CRA Categories will be listed individually as in the current specification. Any new alloys that do not fit into existing CRA Categories will have to be balloted to be included in MR0175.

It is anticipated that a document of this format will be much easier to work with from both manufacturing and material selection standpoints. This document has not yet been approved. The task group is in the process of resolving negative votes.

**Where can I get answers to questions about MR0175?**

Task Group T-1F-1 will respond to requests for interpretation if they are submitted in writing to NACE Headquarters. The Task Group will supply a written response based upon the text of MR0175, previous responses on similar subjects, data from MR0175 ballots, NACE data archives, etc. (Note: It is not within the Task Group's scope to entertain requests for evaluation of specific products or designs to determine whether they meet MR0175 requirements.)

Inquiries may be sent to NACE Headquarters as follows:

NACE International  
P.O. Box 218340, Houston, TX 77218-8340  
FAX: 281.228.6300

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	S31254	N08367	N08926
C	0.02 max.	0.03 max.	0.02 max.
Cr	19.50-20.50	20.0-22.0	19.0-21.0
Ni	17.50-18.50	23.50-25.50	24.0-26.0
Mo	6.00-6.50	6.00-7.00	6.0-7.0
N	0.18-0.22	0.18-0.25	0.15-0.25
Cu	0.50-1.00	-	0.5-1.5

**Table 3**

**TRADEMARKS**

AL6XN is a trademark of Allegheny Ludlum  
254 SMO is a trademark of Avesta Sheffield  
Ferralium is a trademark of Bonar Langley Alloys Ltd.  
Incoloy is a trademark of Inco International  
Inconel is a trademark of Inco International  
Monel is a trademark of Inco International  
Zeron is a trademark of Weir Materials.

**FOOTNOTES**

<sup>1</sup> NACE Technical Committees Directory 1994-1995, NACE International

<sup>2</sup> NACE MR0175, Original 1975 Version, *Materials for Valves for Resistance to Sulfide Stress Cracking in Production and Pipeline Service*, NACE International, 1975.

<sup>3</sup> *A History of MR0175 in Regulations*, Materials Performance, NACE International, July 1994, pp. 6-7.

<sup>4</sup> *Status of Specifications Related to Materials for Sour Service*, V. P. Milo, *H<sub>2</sub>S Corrosion in Oil & Gas Production - A Compilation of Classic Papers*, ed. Tuttle, R. N. and Kane, R. D., NACE International, 1981, p. 1075.

<sup>5</sup> NACE MR0175-1997, *Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment*, NACE International, 1997.

<sup>6</sup> ASTM E140, *Hardness Conversion Tables for Metals (Relationship Between Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness, and Knoop Hardness)*, American Society for Testing and Materials.

<sup>7</sup> API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*, Seventeenth Edition, American Petroleum Institute, 1997.

<sup>8</sup> NF A32-055, *Produits de fonderie - Aciers moulés soudables pour chaudières et appareils à pression (Castings - Weldable Cast Steels for Boilers and Pressure Vessels)*, Association Francaise de Normalisation.

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