



CANADIAN ASSOCIATION
OF PETROLEUM PRODUCERS

GUIDE

Use of International Standard NACE MR0175/ISO15156

**International Standard NACE MR0175/ISO15156 -
Petroleum and Natural Gas Industries – Materials for use
in H₂S-containing Environments in Oil and Gas
Production**

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The Canadian Association of Petroleum Producers (CAPP) represents 150 companies that explore for, develop and produce natural gas, natural gas liquids, crude oil, oil sands, and elemental sulphur throughout Canada. CAPP member companies produce more than 95 per cent of Canada's natural gas and crude oil. CAPP also has 130 associate members that provide a wide range of services that support the upstream crude oil and natural gas industry. Together, these members and associate members are an important part of a \$100-billion-a-year national industry that affects the livelihoods of more than half a million Canadians.

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1 Objective

The NACE MR0175/ISO 15156 International Standard for the selection of crack-resistant materials for use in H₂S-containing environments has had a significant impact on various aspects of the oil & gas industry in Canada. For this reason, CAPP Pipeline Technical Committee felt it was important to create a supporting document, which could be used by industry as a reference tool to:

- provide a brief overview of the NACE/ISO publication, outlining the most significant changes and their implication to the industry,
- provide guidance and assistance on how to apply the new publication using simple to follow flowcharts, and clarification examples,
- provide sample forms which could be used to meet the intent of the publication.

This document is not intended to supersede the NACE MRO175/ISO 15156 International Standard. It is intended to serve as a Guide for working with and complying with the NACE MRO175/ISO 15156 International Standard. In the case of any inconsistencies between the NACE MRO175/ISO 15156 International Standard and the guidance provided in this document, the International Standard should be adhered to.

2 Background

The first edition of the NACE Standard MR0175 was published in 1975 by the National Association of Corrosion Engineers, now known as NACE International. The objective of NACE Standard MR0175 was to establish limits of H₂S partial pressure for precautions against sulfide stress cracking (SSC). It was also designed to provide guidance for the selection and specification of SSC-resistant materials when the H₂S thresholds were exceeded. In more recent editions, NACE MR0175 has also provided application limits for some corrosion-resistant alloys, in terms of environmental composition and pH, temperature and H₂S partial pressure.¹

In a joint, cooperative effort, the members of NACE and the European Federation of Corrosion (EFC) became co-leaders of the ISO/TC 67/WG 7 project. This effort introduced fundamental changes to the MR0175, incorporating industrial practices and testing methodologies previously not addressed by MR0175.2. The first full edition of MR0175/ISO 15156 was published in 2003.

As stated above, the new standard addresses issues which were not considered in the previous versions of NACE MR0175-2002 and which may have significant implications for the users of the document. For example, the new standard:

- acknowledges, in addition to sulphide stress cracking, other potentially catastrophic failure mechanisms resulting from sour environments. Such mechanisms are specified in MR0175/ISO 15156-1:2001 as chloride stress corrosion cracking, hydrogen-induced cracking and stepwise cracking, stress

oriented hydrogen-induced cracking, soft zone cracking and galvanically-induced hydrogen stress cracking;

- addresses the synergistic effects of H₂S with other environmental factors (chloride content, temperature, pH, etc.) on the cracking resistance of many approved materials;
- limits the use of many of the approved metals through additional environmental restrictions which were not taken into account by the previous NACE MR0175 versions;
- has improved the balloting and approval process for adding new alloys.

Note: All abbreviations used in this document are defined in the NACE MR0175/ISO15156 standard.

2.1 Abbreviated Terms

SCC - Stress corrosion cracking SZC – Soft zone cracking

SSC - Sulfide stress cracking SWC – Stepwise cracking

GHSC – Galvanically-induced hydrogen stress cracking

HIC – Hydrogen-induced cracking

SOHIC – Stress-oriented hydrogen-induced cracking

3 NACE MR0175 / ISO 15156 Interpretation and Maintenance

NACE STG 32 and ISO/TC67/WG 7 have established a two-tiered hierarchical system for handling the interpretation and maintenance of the MR0175/ISO 15156.

- Maintenance Panel (MP) – composed of 15 members, each serving for a maximum of 4 years
- NACE Technology Group TG299, the ISO Oversight Committee (OSC) for the MP - composed of 30-50 members, each serving for a maximum of 5 years.

All maintenance issues such as interpretation, amendments or total revisions must be submitted directly to the designate or focal point appointed by the MP. Each task is considered and voted upon by the MP; if an ‘affirmative’ vote or consensus is reached, the task resolution is forwarded to the OSC for balloting. An exception is made for the interpretation of technical content: a MP ‘affirmative’ vote by-passes the OSC and is forwarded directly to ISO/TC67/WG 7, and only when consensus cannot be reached will the MP forward the task to the ISO Oversight Committee for resolution.

The ISO Oversight Committee receives and reviews the ballots sent from the MP. These ballots are presented to the OSC membership for voting. A voting consensus of 2/3rds is considered a ‘positive’ ballot and is forwarded to the

ISO/TC67/WG 7. ‘Negative’ ballots are resolved by building consensus and re-balloting the task or making technical changes and re-balloting the task. All resolved ballots are forwarded to the ISO/TC67/WG 7 with a 2/3rds positive consensus, otherwise they are considered ‘dead’.

Additional information on the Maintenance Panel and the ISO Oversight Committee deadlines as well as Sample Ballot for Qualifying Materials can be found in Appendix A or on the NACE website:

<http://www.nace.org/NACE/Content/technical/MR0175/Mr0175index.asp>

Additional information on the standard and use of it can be found at www.iso15156maintenance. This site allows users of the standard to access other information such as:

- view the list of Inquiries and Answers provided by the Maintenance Panel
- participate in the ISO 15156 Users’ Forum, which is an open discussion forum allowing the users to share their views on the document
- access the FAQ on the ISO 15156

4 From NACE MR0175 to NACE MR0175/ISO15156

Figure 4.1 illustrates where the information from the various sections of MR0175-2002 can be found in the new NACE MR0175/ISO15156. The most substantial change in the document was to stainless steels. This category of materials was moved from ferrous metals to non-ferrous metals or NACE MR 0175/ISO 15156-3, Corrosion-Resistant Alloys.

Figure 4.1 – NACE MR 0175 to NACE MR 0175/ISO 15156

4.1 Significant changes to previous MR0175:

4.1.1 Responsibilities for Various Users of the Document

In preparation for the publication of NACE MR0175/ISO 15156, one of the most significant changes to NACE MR0175 (2003) was on procurement or end user responsibility. The increased emphasis on end user responsibility was established to ensure the correct material was being selected for the intended environment. In all parts of the NACE MR0175/ISO 15156, the importance of end users responsibility for both material selection and documentation is referenced. Such references are exemplified by NACE MR0175/ISO 15156 2001-1, Clause 6.1:

*“Before selecting or qualifying materials using other parts of NACE MR0175/ISO 15156, the **user of the equipment shall** define, evaluate and document the service conditions to which materials may be exposed for each application.”*

This indication of equipment/end-user responsibility as well as equipment user/equipment supplier cooperation, can be found throughout the standard; such responsibilities are outlined below:

It is the Equipment/End User's responsibility to:

- select the carbon and low alloy steels, cast irons, CRAs (corrosion-resistant alloys) and other alloys suitable for the intended service. (Part 1: Section 5 & Section 6)
- document the selection and qualification of materials used in the H₂S environment. (Part 1: Section 5 & Section 9)
- assume the ultimate responsibility for the in-service performance of all materials selected by delegated Engineering Consultants/ Engineering and Procurement Companies (EPC). There is no reference to EPC responsibility in MR0175/ISO15156.

It is the Supplier/Manufacturer's responsibility to:

Although there is no direct reference to supplier/fabricator responsibility in MR0175/ISO15156 the following sections imply responsibility.

- cooperate and communicate in an exchange of information between the end users and materials suppliers/manufacturers concerning required or suitable service conditions. (Part 1: Section 5)
- ensure the material purchased meets the end users requirements and the requirements of the standard. (Part 3: Section 7)

Other standards, such as API 6A Annex O, do define manufacturer's responsibilities in relation to MR0175/ISO15156.

4.1.2 Changes that affect only the Carbon Steel Alloys

Regions of environmental or SSC severity. (Figure 1 of Part 2: Clause 7.2.1.2)

- Four severity regions are defined based on the effect of the in situ pH and H₂S partial pressure on the carbon and low alloy steels. This differs from previous editions where only the partial pressure of the H₂S was considered.

Hardness requirements for welds (Part 2: Clause 7.3.3.2)

- Three different hardness test methods are acceptable for weld procedure qualification: Vickers (HV10 or HV5), Rockwell 15N, and HRC (with specified restrictions). Other test methods require the agreement of the equipment user. This differs from previous editions where HRC was the primary basis of acceptance.

Consideration of HIC/SOHIC/SZC/SWC (Part 2: Section 8)

- Additional cracking mechanisms, which result from the synergy of H₂S exposure and various material factors (steel chemistry, hardness and manufacturing method), should be considered. Previous standard versions only considered SSC as the governing cracking mechanism.

4.1.3 Changes that affect only the Corrosion Resistant Alloys

Consideration of environmental limits for SCC and GHSC (Part 3: Section 6)

- The new standard provides principles for selecting cracking resistant materials for use in the presence of H₂S in combination with other environmental factors, such as chlorides. The cracking mechanisms addressed include:
- SCC caused by the presence of chlorides in the H₂S containing environment.
For example, austenitic stainless steels (e.g. 304, 316) will be limited to a maximum service temperature of 60°C (140°F) because of their susceptibility to chloride stress corrosion cracking at higher temperatures. In previous editions, only sulfide stress cracking (SSC) was considered; there were no temperature restrictions.
- GHSC caused by the presence of dissimilar alloys in contact with an H₂S environment

New Environmental Restrictions (Part 3: Clause A.1.3)

- Depending on the alloy, environmental restrictions may include: maximum chloride content, maximum H₂S partial pressure, maximum temperature, minimum pH, and application limits depending on the presence of free sulfur in the system. In previous editions of MR0175, several legacy materials had no environmental restrictions, implying they were suitable for any sour service environment.
For example, wrought precipitation hardening nickel alloy 718 (UNS N07718) had no environmental restrictions in previous editions of MR0175; in the current standard this alloy has H₂S partial pressure limitations based on the maximum operating temperature.
- Some alloys may have a range of acceptable environmental parameters depending on the severity of the in-service conditions. The environmental limits listed in Tables A.2-A.42 give the allowable parameters for the H₂S partial pressure, temperature, chloride content and pH. As cracking behavior can be affected by the complex interactions of these parameters, there is some discretionary latitude for interpolation depending on the materials intended application or service conditions; a specific H₂S partial pressure or production temperature, chloride content, pH is permitted provided the maximum H₂S partial pressure and /or the maximum allowable temperature, chloride content, pH are not exceeded.
For example, austenitic steels such as AISI 316 are limited to a maximum of 100 kPa partial pressure of H₂S at a maximum temperature of 60°C for any combination of chloride concentration and in situ pH in the production fluid. The same alloy can also be used at 350 kPa partial pressure of H₂S and 60°C if the maximum concentration of chlorides is 50mg/l or less.

Deletion of Previously Approved Materials

- The general usage of some previously approved materials has been restricted to specified components only.
For example, 17-4 martensitic, precipitation hardening stainless steel was deleted from the general usage section, but remains an acceptable

material for various components of wellheads and Christmas trees, provided a maximum H₂S partial pressure of 0.50 psi and minimum pH of 4.5.

Corrosion Resistant Alloy Categories (Part 3: Clause A.1.1)

- In NACE MR0175/ISO 15156, a CRA category is a broad-based group of alloys defined in terms of chemical composition, manufacturing process, and finished condition. These categories or materials groups (austenitic steel, martensitic steels, etc) are further split into material types (similar compositional limits) and individual alloys.

For example, Annex A, Table A.2 outlines the environmental and materials limits for the general usage of austenitic steels (AISI 304SS, AISI 316SS, etc). This table is sectioned into general materials type and individual alloys, e.g. UNS S20910. The individual alloys tend to have broader environmental limits than those set for the group. In this case, the UNS S20910; it can be used at a slightly higher temperature than AISI 316 at similar partial pressures of H₂S.

4.1.4 Other Options for Material Qualifications

The new standard allows the equipment user two options for qualifying materials which do not appear as ‘pre-qualified’ materials in NACE MR0175/ISO 15156:

- Document a successful laboratory test of the material in an environment at least as severe as the intended service.
- Document field experience with the material in a specified environment and for a specific equipment.

4.1.5 Requirements for Marking (Part 2, Section 9; Part 3, Section 7)

The new standard requires that all compliant materials be made traceable by marking, before delivery. Suitable labeling or documentation is also acceptable.

5 Structure of New Document

The new NACE MR0175/ISO 15156 consists of 3 parts:

- Part 1- General Principles for Selection of Cracking-Resistant Materials
- Part 2- Cracking-Resistant Carbon and Low Alloy Steels
- Part 3- Cracking-Resistant CRAs (Corrosion-Resistant Alloys) and Other Alloys

5.1 Part 1 - General Principles for Selection of Cracking-Resistant Materials

Part 1 of the NACE MR0175/ISO 15156 addresses the background and general principles for using Parts 2 and 3. A summary of the content described below is presented in a flowchart diagram in Appendix B, see Appendix B.1.

5.1.1 Scope of the Standard - Equipment and Component Design (Section 1)

The general principles for the selection of cracking-resistant materials are outlined in Part 1. This document supplements, but does not replace, the material requirements given in the appropriate design codes, standards or regulations; its intent is to address and apply to:

- all the mechanisms of cracking that can be caused by H₂S, excluding loss of material by general or localized corrosion;
- a selective list of equipment (Table 1 lists the applicable equipment including the permitted exclusions) used in oil and gas production;
- materials for equipment designed and constructed using conventional elastic design criteria. For design using plastic criteria (strain-based and limit states) use of this standard may not be appropriate.
- the selection or qualification of metallic materials which are resistant to cracking in defined H₂S-containing environments in oil and gas production, but are not necessarily immune under all service conditions (NACE MR0175/ISO 15156-1).

Conversely, NACE MR0175/ISO 15156 is not necessarily intended for or applicable to:

- equipment used in refining or downstream processes and equipment; or
- components loaded only in compression. This statement has been omitted from Part1 of NACE MR0175/ISO 15156 but is included in both Part2 and Part3.

Note: All items in this section are repeated in both Part2 and Part3 of the standard.

5.1.2 Service Conditions: Evaluation and Definition (Section 6)

- Outlines all the service conditions required to evaluate whether or not the standard applies. (Clause 6.1)
- Specifies how the service conditions can be used in the selection of the material qualification method. (Clause 6.2)

5.1.3 Pre-Qualified Materials Selection Guide (Section 7)

Selection of a pre-qualified material means that no additional laboratory testing or documented field experience qualifications are necessary. The materials listed have given acceptable performance under the stated metallurgical, environmental and mechanical conditions based on either previous field experience and/or laboratory testing.

5.1.4 Material Qualification Alternatives and Implementation (Section 8)

There are two methods by which a material may be qualified for service in H₂S-containing environments: field experience and laboratory testing.

- Qualification by Field Experience – requires the equipment user to provide the intended service conditions, a minimum of 2 years documented field

experience, and the severity of the intended service ensuring it does not exceed that of the documented service conditions. (Clause 8.2)

Note: The data used to qualify a material based on field service, once submitted to NACE, may be used by the public as reference for identical applications.

- Qualification by Laboratory Testing – is used to qualify materials, which do not qualify as a ‘pre-qualified’ material due to either chemistry or required service conditions. Testing may be conducted under service conditions similar to the limits applied to pre-qualified materials or under service conditions outside these limits. (Clause 8.3)

Note: Test requirements as well as the qualification process involved are specified in greater details in Annex B of NACE MR0175/ISO15156-2 and NACE MR0175/ISO15156-3.

5.1.5 Materials Qualification Documentation (Section 9)

Materials selected or qualified in accordance with MR0175/ISO 15156 shall have the method of selection documented by reporting the service conditions and the relevant sub-clause pertaining to the pre-qualified material, or the relative field experience (mechanism of cracking addressed, material used and experience), or the relative laboratory testing (mechanism of cracking addressed, material tested, test methodology and results).

5.2 Part 2: Cracking-Resistant Carbon and Low Alloy Steels

Part 2 outlines the requirements and recommendations for the selection and qualification of carbon steels, low alloy steels and cast irons for service in equipment used in H₂S-containing environments of oil and natural gas production and natural gas treatment plants. A summary of the content described below is presented in a flowchart diagram in Appendix B, see Appendix B.2.

5.2.1 Scope of the Standard - Equipment and Component Design (Section 1)

See section 5.1.1 of this document for details.

5.2.2 Carbon and Low Alloy Steels in H₂S environments (Section 6)

The complex interaction of environment factors and materials properties should be considered in the materials selection for use in H₂S-containing environments. The parameters affecting the behavior of carbon and low alloy steels in H₂S environments are explicitly listed (metallurgy, H₂S partial pressure, pH, chloride content, etc.).

5.2.3 Qualification and Selection (Section 7)

- Two qualification options are outlined for selecting carbon and low alloy steels with resistance to SSC, SOHIC and SZC, although the occurrence of SOHIC and SZC are rare.
 - Option one (Clause 7.1) - allows the user to specify material using Annex A.2 for systems with an H₂S partial pressure greater than or equal to 0.05 psi; while,
 - Option two (Clause 7.2) - allows the user to qualify and select SSC resistance materials for specific or for ranges of sour service applications. The user must evaluate the severity of the service environment based on a combination of H₂S partial pressure and in service pH. Depending on the region of environmental severity extrapolated from the graph given in MR0175/ISO 15156-2 (Figure 1), the user is referred to Annex 2, Annex 3 or Annex 4 for material selection.
 - Option Three (Clause 7.2) - there are two methods by which a material may be qualified for service in H₂S-containing environments: field experience and laboratory testing.
- Hardness Requirements
 - As hardness control is an acceptable means of demonstrating SSC resistance, hardness testing requirements for the parent material, welds, and HAZ must be considered by the user. Three hardness testing methods are specified: Vickers (HV10 or HV5), Rockwell 15N and HRC (with restrictions). Any other test method requires explicit user approval. (Clause 7.3)
 - Requirements for weld procedure qualification and acceptance criteria which are based on hardness and options for hardness testing are outlined. (Clause 7.3.3)
 - Hardness surveys should be specified in all fabrication procedure qualifications for all fabrication methods, which cause hardness changes in the material. Hardness testing shall be specified as part of the qualification for fabrication methods such as burning and cutting if any HAZ remains in the final product. (Clause 7.4)

5.2.4 Evaluation for resistance to HIC and SWC (Section 8)

Material chemistry, such as sulfur content and certain manufacturing methods, such as flat rolling and seamless drawing, increase the probability of HIC/SWC. To address this prospect, additional testing and specific acceptance criteria may be required. The details for laboratory testing for HIC/SWC are listed in Annex B of NACE MR0175/ISO15156-2.

5.2.5 Marking (Section 9)

Specifies requirements for traceability by marking, labeling and /or documentation. Details listed in Annex E of NACE MR0175/ISO15156-2.

5.2.6 Annexes

- Annex A lists SSC-resistant carbon and low alloy steels, and A.2.4 includes requirements for the use of cast irons.
- Annex B provides requirements for qualification of carbon and low alloy steels for H₂S service by laboratory testing
- Annex C provide recommendations for calculating the partial pressure of H₂S for systems involving gas and or two phase flow (Clause C.1) or liquid phase (Clause C.2)
- Annex D provides recommendations on the determination of pH based on the partial pressure of H₂S and CO₂.
- Annex E provides marking designations for material identification.

5.3 Part 3: Cracking-Resistant CRAs and Other Alloys

Part 3 gives the requirements and recommendations for the selection and qualification of CRAs (corrosion-resistant alloys) and other alloys for service in equipment used in H₂S-containing environments of oil and natural gas production and natural gas treatment plants. A summary of the content described below is presented in a flowchart diagram in Appendix B, see Appendix B.3.

5.3.1 Scope of the Standard - Equipment and Component Design (Section 1)

See section 5.1.1 of this document for details.

5.3.2 Corrosion Resistant Alloys in H₂S environments (Section 5)

As in part 2, all relevant factors (metallurgy, H₂S partial pressure, pH, chlorides etc.) affecting the susceptibility of CRAs to cracking must be considered by the user and are explicitly outlined by the standard.

5.3.3 Qualification and Selection (Section 6)

The qualification and selection of CRAs for SSC, SCC and GHSC cracking resistance using MR0175/ISO 15156-3 is defined by the intended application and service environmental severity.

- General compliance (*Clause 6.1*)
 - The limits for CRA selection vary depending on the material type or the individual alloy. CRA's and other alloys compliant to part 3 of the standard can be selected from the tables in Annex A.

For example, when selecting any austenitic stainless steel for a general application, the service environment limits and material requirements are listed in Table A.2 (Annex A). However, if the austenitic stainless steel is UNS S20910, then the specific limits listed for this particular austenitic grade must be used.

- CRA's can also be qualified based on field experience or by laboratory testing. For general details refer to MR0175/ISO 15156-1 (or Section 5.1.4 of this document), otherwise, more specific details for laboratory testing are given in Annex B.
- Evaluation of Material Properties (*Clause 6.2*)
 - Hardness Requirements - for CRAs hardness testing and acceptance criteria must be specified by the user. The hardness limits for material types or individual alloys are listed in Annex A. For processes, such as welding, which increase a materials susceptibility to SSC, SCC and GHSC, require the consideration of hardness in the weld procedure qualification. Options for hardness testing for weld procedure qualification are Vickers (HV10 or HV5) or Rockwell 15N. Any other test method requires explicit user approval. Note: The use of the HRC method requires specific user approval.
 - Fabrication - metallurgical changes in CRAs resulting from fabrication, require the user to specify crack-resistance qualification testing for all the affected material. This includes qualification testing for fabrication methods such as burning and cutting if any HAZ remains in the final product. (Clause 6.2.3)
- PREN number (Clause 6.3, Tables A.24 & A.25-NACE MR0175/ISO 15156-3 Annex A)

The formula for the calculation of PREN number for CRA pitting resistance is given in this section. Some environmental restrictions are placed on certain alloys based on the PREN number

5.3.4 Purchasing Information and Marking (Section 7)

Requirements for traceability by marking, labeling and /or documentation are specified, as well as requirements for documentation of the environmental conditions for which a material was qualified. Examples of the purchasing information (Clause 7.1) and potential markings (Clause 7.2) are listed in Annex C of MR0175/ISO15156-3.

5.3.5 Annexes

- Annex A materials are identified by materials groups. Each group of alloys are identified by **materials type** (within compositional limits) or as **individual alloys**. Acceptable metallurgical conditions and environmental limits are given, for which alloys are expected to resist cracking.
- Annex B provides requirements for qualification of CRAs (corrosion-resistant alloys) and other alloys for H₂S service by laboratory testing.
- Annex C provides marking designations for material purchasing
- Annex D provides chemical compositions for CRA's based on their UNS number.

6 End User's Application Guideline for MR0175/ISO 15156

The purpose of this section is to provide the end user with a guideline on how to approach a material selection project in the light of the NACE MR0175/ISO 15156 specifications. End User decision flow charts are included in Appendix C and must be used in conjunction with section.

Note: Each of the paragraph numbers below have been recorded on the corresponding Appendix C charts for easier cross-reference.

6.1 Select Qualification Method (Refer to Appendix C, Figure C.1)

6.1.1 Scope of MR0175/ISO 15156

The end user is responsible for determining the applicability of the NACE MR0175/ISO15156 to their particular project. The applicability of the Standard can be determined in two steps:

1. Use Table 1 of NACE MR0175/ISO 15156-1 for an overall assessment of the applications and corresponding equipment covered by the NACE/ISO standard.
 - NACE MR0175/ISO 15156 applies to "upstream" oil & gas facilities (e.g downhole, field facilities, pipelines, gas sweetening facilities)
 - Material selection for refineries and chemical plants is not covered by this standard.
2. Determine the level of H₂S in the environment by calculating the partial pressure of H₂S. If the $P_{H_2S} \geq 0.05\text{psi}$ then the NACE/ISO standard must be used for material selection. Instructions for this calculation are covered in Annex C of NACE MR0175/ISO 15156-2.

For "upstream" oil & gas facilities with $P_{H_2S} \geq 0.05\text{psi}$, proceed to step 6.1.2.

6.1.2 Existing Facilities vs. New Projects

Once it is established that the document applies, the user has to define the type of application involved. Even though similar options are available for all application types, there are different considerations when selecting materials for existing facilities (such as replacement in kind or small projects on existing installations). For this reason, it may be more advantageous to investigate all methods of material qualifications available to ensure the most economical solution.

Situation Examples:

- Replacement-in-kind situation - The user has a corroded stem in a valve and wants to purchase a replacement stem of the same material.
- New Equipment at existing installation – The user has to add a new well tie-in to an existing gathering system
- New Project - Building a new gathering system

Materials Selection for existing facilities, proceed to step 6.1.3, or in the case of new facilities, proceed to step 6.1.4.

6.1.3 Existing Facilities

For each component/material in an existing facility, check the integrity of the existing material to rule out any environmental cracking, as defined in this document (7.1.3).

6.1.3.1 Material Inspection

6.1.3.1 (a) No Cracking

If no cracking is found then proceed to step 6.1.3.2.

6.1.3.1 (b) Cracking Present

In case of cracking, different materials may need to be selected for those components. Refer to the list of pre-qualified materials in Annex A of NACE MR0175/ISO 15156 Part 2 and/or Part 3.

Cross-reference material to Material Requirements Tables

For each un-cracked component, compare the environmental conditions and material's metallurgical conditions with the requirements listed in Annex A of NACE MR0175/ISO 15156 Part 2 and/or Part 3. A sample form for material selection is presented in Appendix E. If the existing material complies with the requirements of the pre-qualified material, the same material can be used. If the existing material does not comply, proceed to step 6.1.5, Alternative Materials Qualification

6.1.4 New Projects

For each component/material in a new project or proposed facility, the material selection must be based on the intended service conditions. If the designs for a new facility are modeled after an existing facility and intended for the same service, the materials requirements can be documented based on the existing facility. For new facilities operating in the same service conditions, refer to 6.1.3: Existing Facilities.

If the new project or facility is intended for operation under different, more severe service conditions, the materials selection process cannot be based on previous documentation and must be re-evaluated by the user, refer to NACE MR0175/ISO 15156-1 or Appendix B, Flowchart B.1.

6.1.5 Alternative Materials Qualification

For any project (replacement in kind, small projects on existing installations or new projects), a certain material desired for a specific component may not be on the NACE/ISO pre-qualified material lists. In this case, the user has three distinct options, they can:

- 1) select a new material which is pre-qualified and referenced in the Annex A Tables,
- 2) check material's history of successful use or field experience in an identical application for at least 2 years. If documentation exists to support this history, then proceed to Appendix C, Flowchart C.2. Otherwise, refer to Clause 8.2 of NACE MR0175/ISO15156-1, or
- 3) use laboratory testing to demonstrate that the material is suitable for the proposed service conditions. This method is further discussed in Section 6.3 or Appendix C, Flowchart C.3.

6.2 Qualification By Field Experience (*Refer to Appendix C, Figure C.2*)

6.2.1 Material Qualification by Field Experience

Qualification by field experience can be used to qualify materials which are not included on the NACE MR0175/ISO 15156 pre-qualified lists. The requirements for this method are described in Clause 8.2 of NACE MR0175/ISO15156-1. The field qualification method can be used for any type of application (such as replacement in kind, small projects at existing installations or new projects) provided that the specified requirements are met. These requirements are discussed in more details in the steps below.

6.2.2 Describe and document the materials to be qualified

These requirements are covered in Clause 8.1 of NACE MR0175/ISO15156-1 and include information such as, chemical composition, method of manufacture, strength, hardness, amount of cold work, heat treatment condition and microstructure.

This information is usually available to the user through Material Test Reports, which are associated with various components.

6.2.3 Describe and document the service environment

The information required for the description of service conditions is covered in Clause 6.1 of NACE MR0175/ISO15156-1. Service conditions include data on H₂S partial pressure, in situ pH, concentration of dissolved chlorides, presence of sulphur, temperature, and stress. Paragraphs 6.2, 8.1, 8.2 and 9.0 provide a description of the documentation required for 2 years successful field service. See Appendix D for a sample spreadsheet of data required.

These service conditions should be specified for each material/component exposed through either intended or unintended (accidental) service.

6.2.4 Compile the Service History for a minimum of 2 years

At least 2 years of service history must be gathered in the form of documented field experience for any material or equipment/component to be considered

qualified based on field experience. The field experience documentation should also contain relevant information on maintenance, inspections and repairs. Such documentation can only be acquired through a good maintenance/inspection program with detailed reports on the equipment performance in a particular environment.

For example: In a wet sour gas system with Chlorides the 316 SS valve seats have provided over 15 years of service without CI stress corrosion cracking failures. In several cases these seats have pitted and have been replaced in kind by the end user. The user can continue to add new valves in this system and replace existing 316SS valve seats as long as the user documents that the old seats did not crack in service.

6.2.5 Inspection of the in-service material

Post-service inspections and current inspection records are critical for establishing and documenting the material behavior during operation in known service conditions. In the case of NACE MR0175/ISO 15156, documentation for material qualification by field experience must include an acknowledgement of the mechanism of cracking for which the material is being qualified. If no cracking is evidenced in a post-service inspection, the material's post-service condition can be documented and the same material re-selected for the same service. If cracking is observed, the mechanism should be identified and documented, and a different material selected for the intended service.

6.2.6 Intended Service Environment <= Documented Service Environment

In order for a user to qualify a material using documented field experience, the user must ensure the severity of the intended service for a material or component is less than or equal to the documented service environment. The user should be able to verify this with the data collected in steps 6.2.1 through 6.2.5. If the severity of the intended service condition is within the documented range of field experience, the material qualifies; otherwise, the material must be qualified using laboratory testing as outlined in Section 6.3, below.

6.2.7 Report and file documentation

The documentation on materials, service conditions and service history can be used to qualify materials that are not classified as pre-qualified alloys in NACE MR0175/ISO 15156. Keeping this documentation on file for future reference or audit is the end user's responsibility. This documentation can be used to select materials for replacement in kind and/or small projects in existing facilities. However, it can also be used to select materials for new projects, if the metallurgical and service conditions of the project match existing applications. Detailed information on the required content of this documentation is covered in Clause 9, NACE MR0175/ISO1516-1.

6.3 Qualification by Laboratory Testing (Refer to Appendix C, Figure C.3)

6.3.1 Material Qualification by Laboratory testing

This method can be used to qualify materials, which are not on the NACE MR0175/ISO 15156 pre-qualified lists. The general requirements for this method are described in Clause 8.3 of NACE MR0175/ISO15156-1.

6.3.2 Select material type and refer to the applicable part of NACE/ISO standard

Laboratory testing requirements for carbon and low alloy steels are covered in Annex B of NACE MR0175/ISO1516-2. Laboratory testing for corrosion resistant alloys and other (non-ferrous) alloys are covered in Annex B of NACE MR0175/ISO1516-Part 3.

6.3.3 Select the laboratory qualification option that best fits the application

- The manufactured products option allows qualification of certain materials for specific equipment and service conditions defined by the end user. The results cannot be generalized to other applications.
- The second option pertains to a laboratory testing for the qualification of a production route. This method allows a supplier to qualify the material for service in a specific range of service conditions, which can apply to other end users as well.

6.3.4 Identify the Qualification Required

Identification and documentation of the potential cracking mechanism(s) is necessary for material qualification using laboratory testing. The potential cracking mechanisms identified by NACE MR0175/ISO 15156 for carbon and low alloys steels are SSC, SOHIC, SZC, HIC/SWC and for CRA's, SSC, SCC and GHSC or a combination of mechanisms must be considered. For further details refer to Clause B.3 of either Part 2 or Part3 of NACE MR0175/ISO1516.

6.3.5 Select the Test Method

In addition to recording the potential cracking mechanism for which the material resistance is being qualified for, the type, number and the size of the specimens that would best fit the test purpose must be documented.

6.3.6 Establish the Test Conditions

The test conditions are determined based on the intended service conditions or maximum critical environment the material will contact. The terms of severity of the testing environment should directly reflect the intended service and applied stress situation. All testing conditions should be documented.

6.3.7 Specify the Acceptance Criteria for each test method

It is the responsibility of the user to specify the acceptance criteria. Criteria are either specified in the Standard or by the user.

6.3.8 Report the Test Results

The user is responsible for reviewing the test results and for accepting material's qualification for the intended application. Keeping this documentation on file for future reference or audit is also the user's responsibility. These reports can also be used as the starting point for the inclusion of the tested material into the pre-qualified materials lists of NACE MR0175/ISO15156.

7 Other Issues

- Using older versions of MR0175

The maintenance Panel of NACE MR0175/ISO 15156 does not specifically stop users from referencing older versions however they strongly encourage users to reference the current version.

- CSA Z662 & other related Canadian references or regulatory requirements
- API 6A and NACE MR0175/ISO 15156 compliance

Class ZZ has been added to the API 6A list of material classification in order to accommodate the changes to the NACE/ISO standard.

8 References

- 1) "Introduction", NACE MR0175/ISO 15156-1 (2001), p. v.
- 2) "Changes to NACE Standard MR0175-2003",
www.nace.org/NACE/Content/technical/MR0175/MR0175Changes.pdf
- 3) "Introduction to ISO 15156 maintenance activities",
www.nace.org/nace/Content/technical/MR0175/MaintenanceActivities.pdf
- 4) NACE MR0175/ISO 15156 International Standard
- 5) www.iso.org/iso15156maintenance

9 Participants and Acknowledgements

The members of the CAPP Sour Materials Subcommittee include:

- Ray Goodfellow – Pangea Solutions
- Kevin Goerz – Shell Canada Limited
- Patricia Cameron – Talisman Energy Inc.
- Irina Ward – Master-Flo
- Dave Grzyb – Alberta Energy and Utilities Board
- Jerry Bauman - Cimarron Engineering
- Karol Szklarz - Shell Canada
- Jan Anderson- Husky Oil
- Phil Payne- Nuova Fima

- Jeff Fournell- Dresser Flow Control
- Vlad Sizov - Encana
- Alan Miller – Encana

The members of the CAPP SMS would like to express their gratitude and appreciation to:

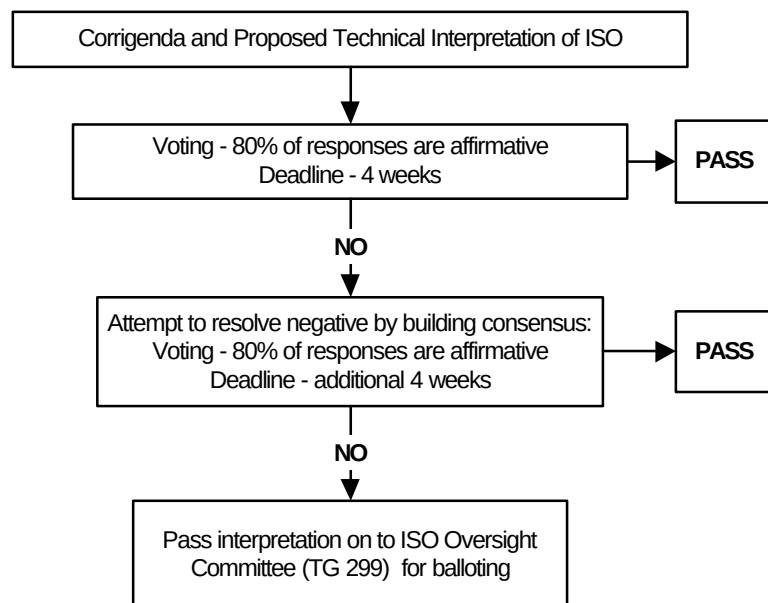
Jim Skogsberg – ChevronTexaco

10 Appendices

Appendix A: Voting Processes for ISO/TC 67 Interpretation and Maintenance

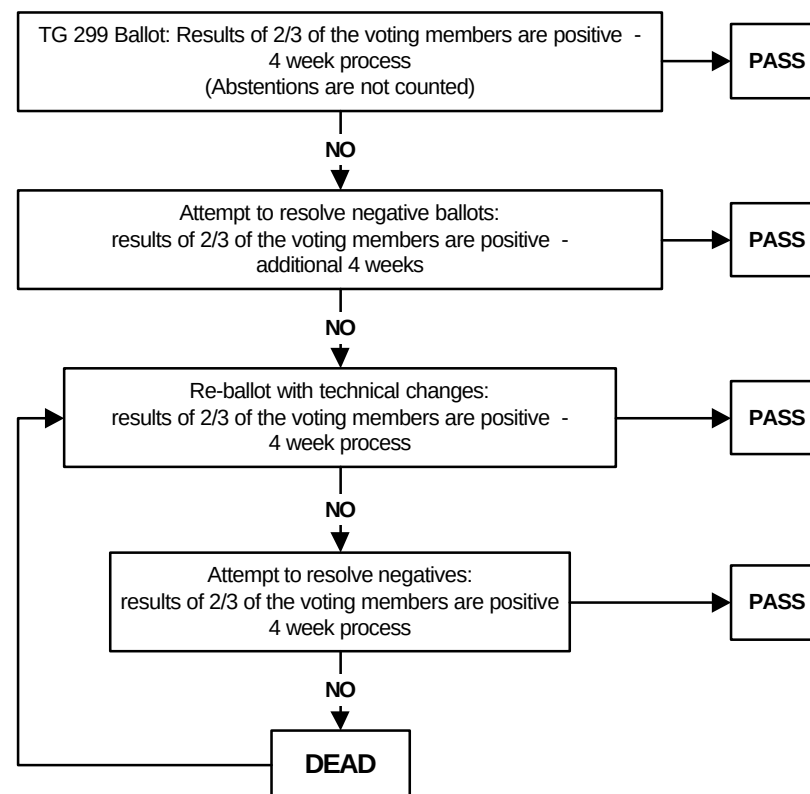
Maintenance Panel³ –

Process for Voting on Assigned Tasks
For Interpretation Amendments & Total Revisions



ISO Oversight Committee (TG 299)³ –

Process for Interpretations, Amendments & Total
Revisions of ISO 15156



Sample Ballot

Form 1-Ballot Item for NACE MR0175/ISO 15156
(latest edition)

SUBMITTING COMPANY:

SUBMITTED BY:

MAILING ADDRESS:

TELEPHONE NUMBER:

E-MAIL ADDRESS:

MATERIAL:

UNS NUMBER (IF KNOWN):

SUGGESTED ALTERNATIVE TO NACE MR0175/ISO 15156 (latest edition):

Notes for balloters:-

The proposal must show the existing test or table from the latest edition of NACE MR0175/ISO 15156 together with the revised text or table in which precise details of the proposed changes are highlighted.

If appropriate, these details shall include, for a given material, an environmental limits of application and any metallurgical limits related to materials chemistry, heat treatment, mechanical properties, hardness, etc. that governs its acceptability within those environmental limits.

MATERIAL DESCRIPTION

APPLICATION

SERVICE CONDITIONS

MECHANISM(S) OF CRACKING

FIELD EXPERIENCE

Sample Ballot *(Continued)*

FORM 1-BALLOT ITEM FOR NACE MR0175/ISO 15156
(latest edition)

LABORATORY DATA SUMMARY

MECHANISM(S) OF CRACKING

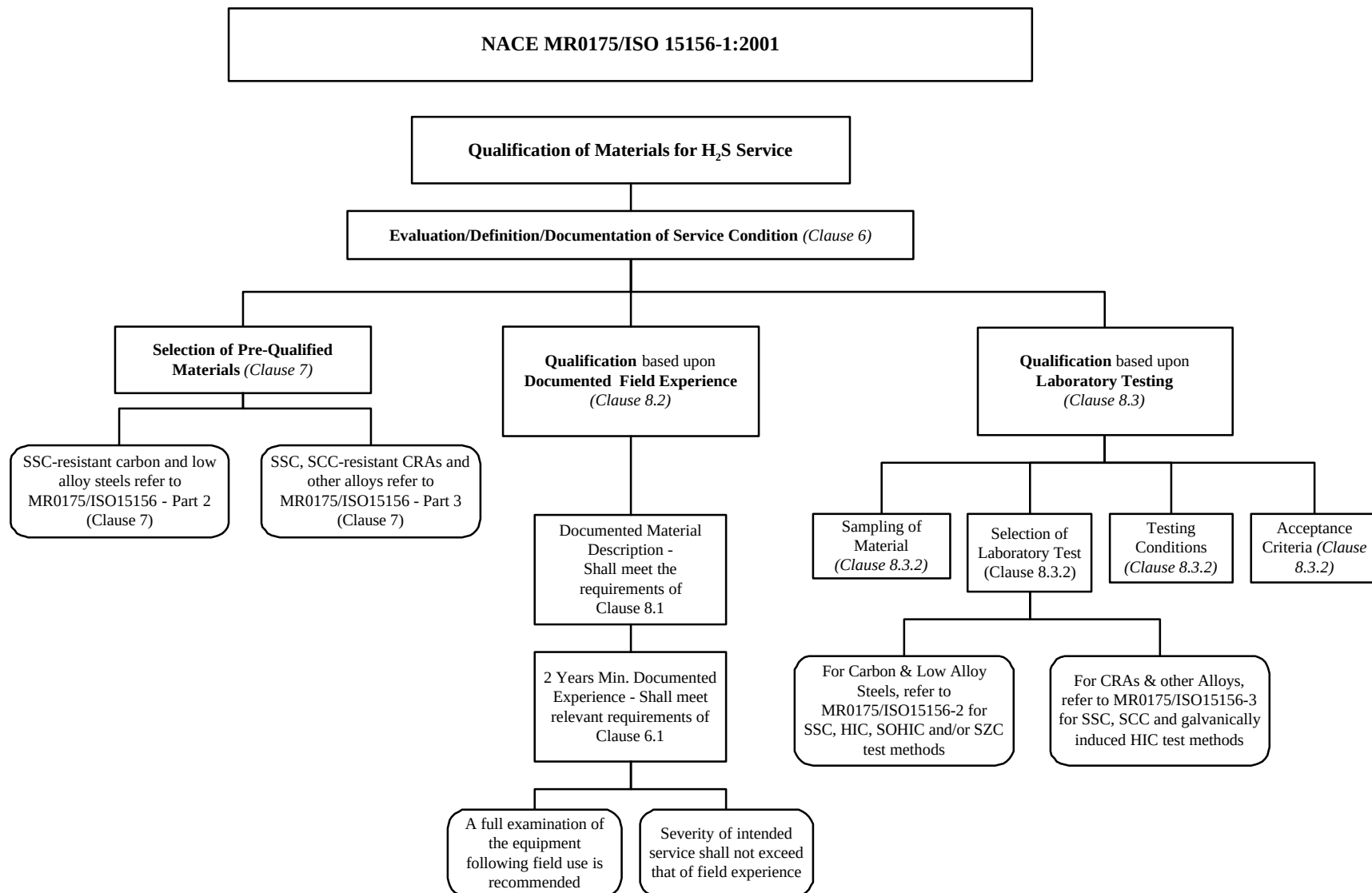
SELECTION, SAMPLING, AND PREPARATION OF TEST SPECIMENS

JUSTIFICATION OF THE TEST ENVIRONMENT AND PHYSICAL TEST CONDITIONS

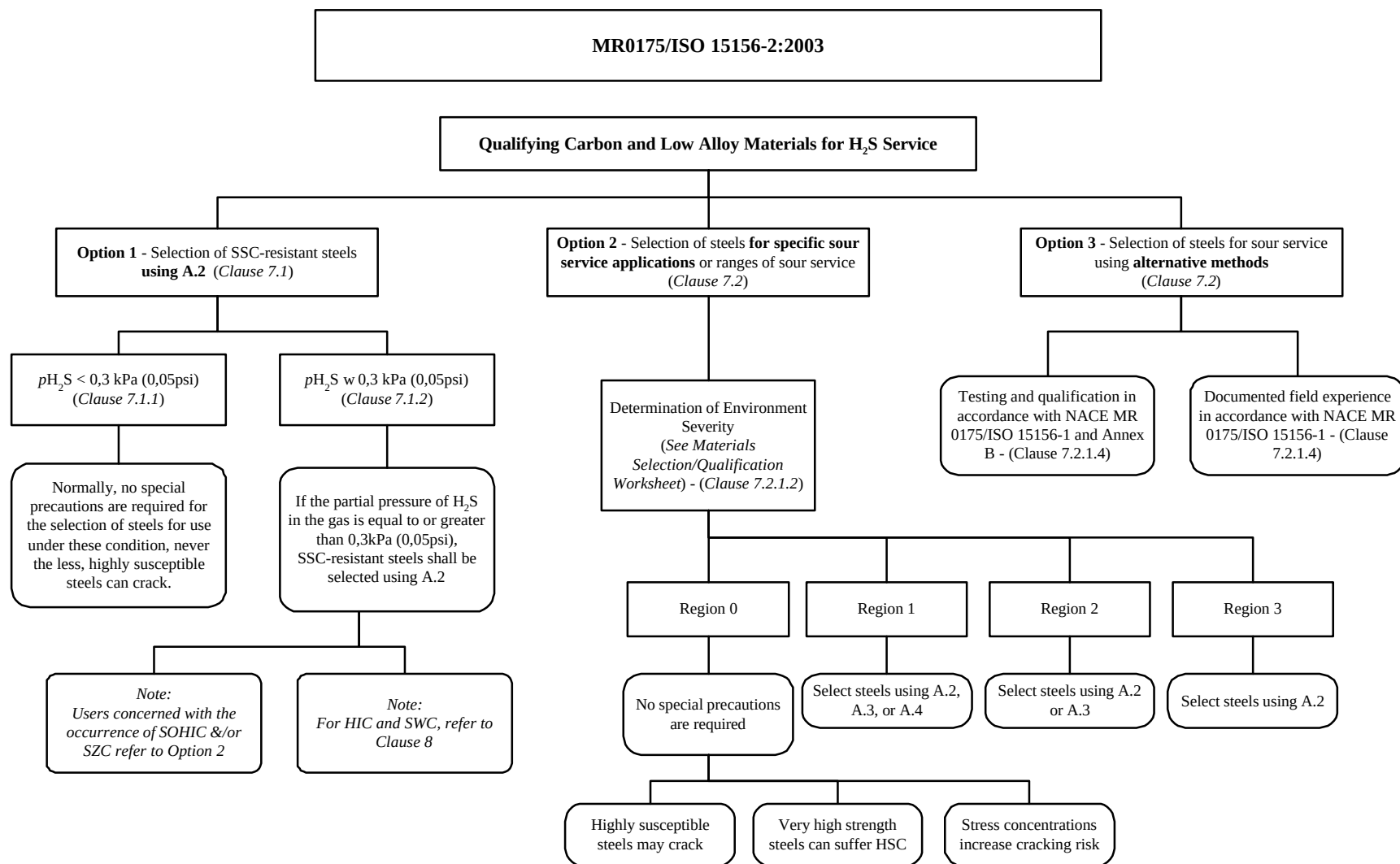
TEST RESULTS DEMONSTRATING COMPLIANCE WITH NACE MR0175/ISO 15156

Appendix B: Flow Charts- NACE MR0175/ISO15156 layout

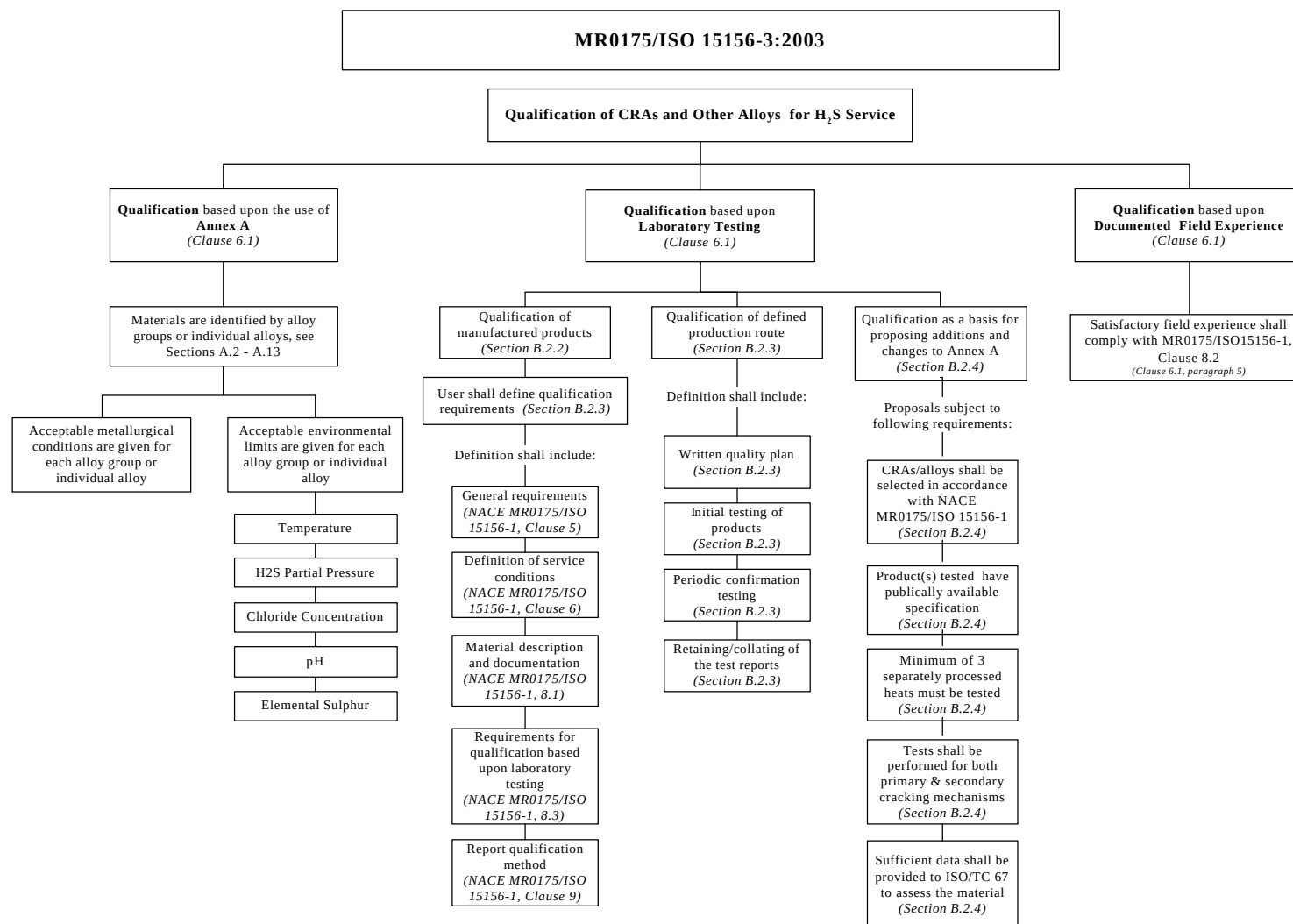
B.1. MR0175/ISO15156 – Part 1: 2001



B.2. MR0175/ISO15156 – Part 2: 2003

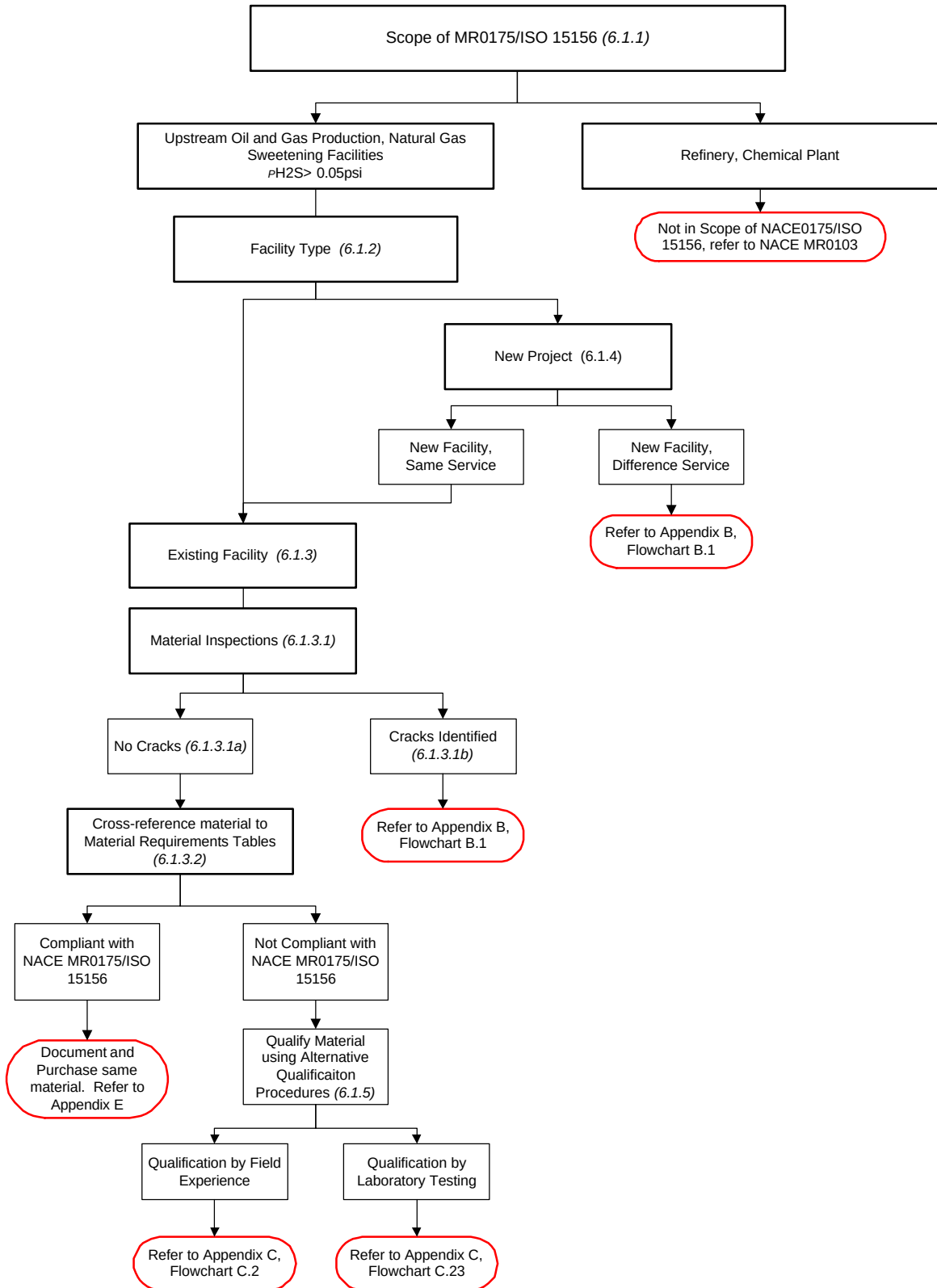


B.3. MR0175/ISO15156 – Part 3: 2003

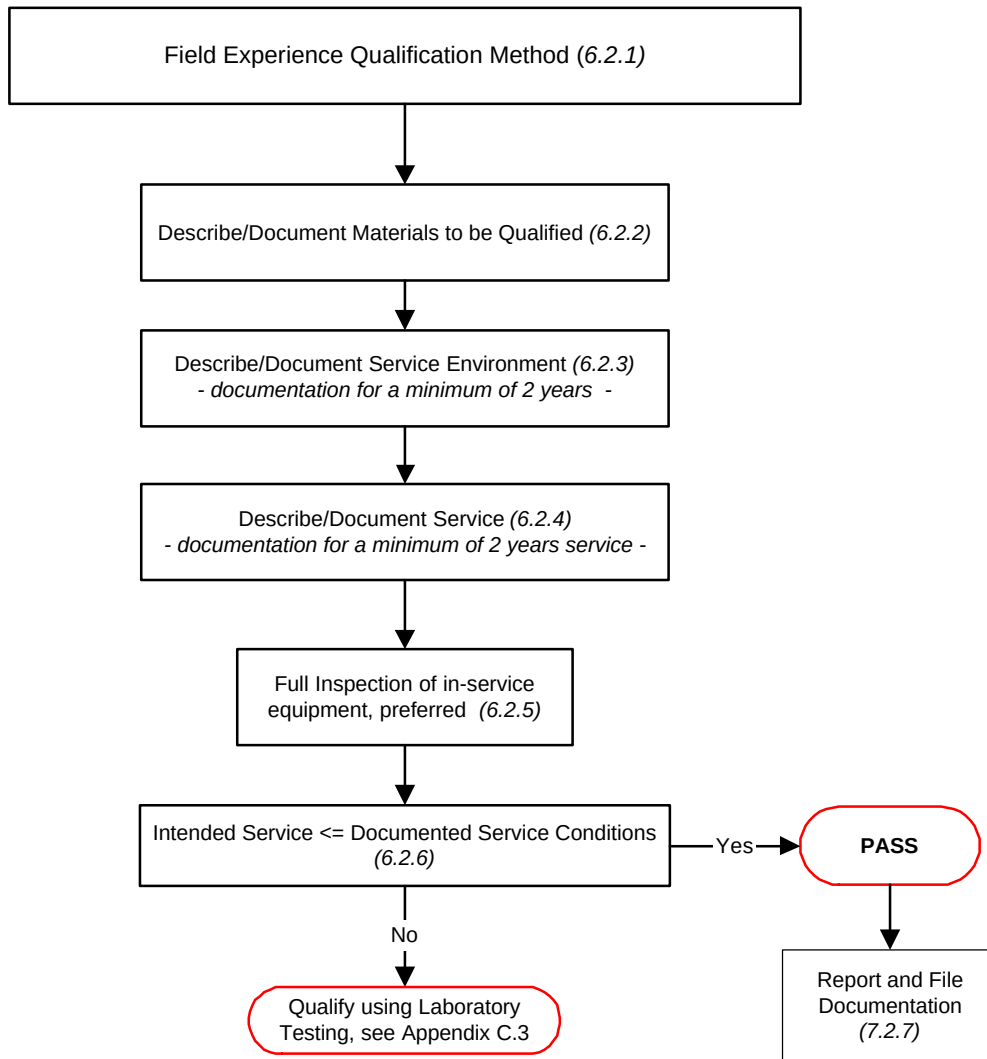


Appendix C: End User Decision Flow Charts

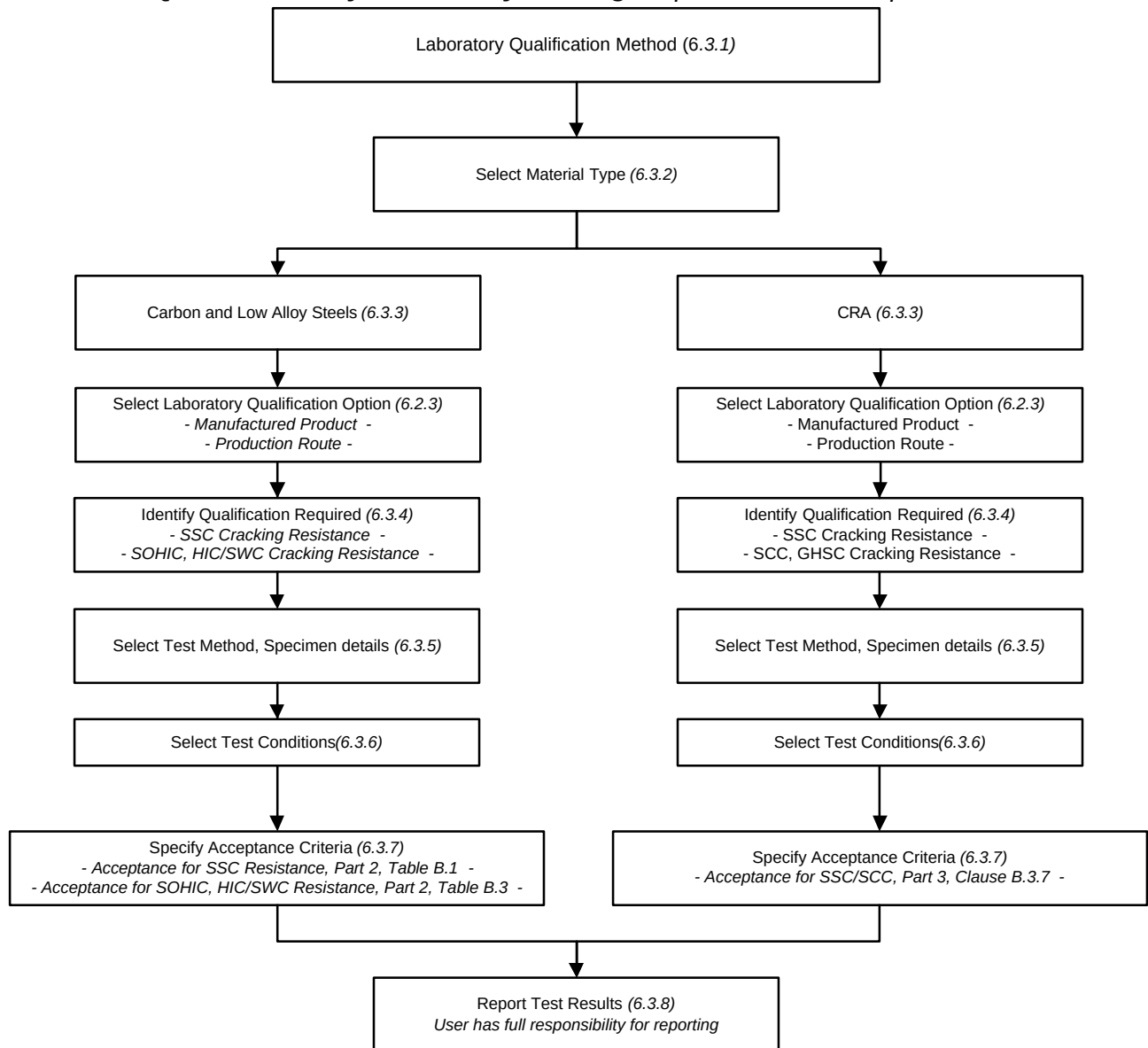
C.1. Select Qualification Method - *refer to Section 6.1 of this document*



C.2. Qualification by Field Experience - *refer to Section 6.2 of this document*



C.3. Qualification by Laboratory Testing - refer to Section 6.3 of this document



Appendix D: Data for Field Qualification

Table 1 Material Properties from Material Test Reports or Laboratory Testing

Component Description	Material	Heat Treatment	Hardness	Product Form	0.2% Yield Strength
	UNS No	Solution annealed, Q&T etc	HRC	Cast, Wrought Etc	MPa

Note: The UNS number will provide the reference to the chemical composition

Table 2: Data Obtained from Field Locations

Component Description	H ₂ S	CO ₂	Cl ⁻	HCO ₃	Pressure	Temp	Elemental Sulphur	Time in Service
	mole %	mole %	mg/l	mg/l	kPa	°C	Yes/No	Years

Note: Element sulphur could be obtained from solids sample analysis.

Table 3: Data obtained from Calculations and Failure Reports

Component Description	Partial Pressure of H ₂ S	Maximum applied Stress	In-situ pH	Failed or not	Failure description	Root Cause Analysis
				Yes/No		

Note: In Situ pH can be calculated using commercially available software

Appendix E: Sample Forms

10.1 MATERIAL SELECTION/QUALIFICATION WORKSHEET

Carbon and Low Alloy Steels (MR0175 / ISO15156)

DATE (yyyy-mm-dd):

11 Equipment/Pipeline Location			
DISTRICT	FIELD/AREA	FACILITY/PROPERTY	
LICENCE NO.			
EQUIPMENT #	SERIAL #	COMPANY ID #	
12 Material Selection/Qualification			
MATERIAL:	HARDNESS:	WALL THICKNESS:	STRENGTH : YS: min max TS:
CHEMISTRY: _____%C ____%Mn ____%Mo ____%Cr ____%P ____%S Other: _____			
13 Service Conditions			
H ₂ :	kPa (psi)	Cl ⁻ / Other Halides:	ppm (meq/l)
N ₂ :	kPa (psi)	Elemental Sulfur (S ⁰) :	present / absent
H ₂ S :	kPa (psi)	Others (document):	e.g. Acetic Acid
CO ₂ :	kPa (psi)		
System Pressure:	kPa		
Note: pH H₂S < 0.3kPa, no special precaution are required for selection of steels for use under these condition, highly susceptible steel can crack		Temperature : °C	
In Situ pH:		Environmental Severity:	
Prescribed Maximum Hardness: 22 HRC Note: provided they contain < 1% Ni and are not free machining steels and are used in the prescribed heat treated condition, see A.2.1.2.		Region 0 – no precautions Region 2 – use A.2 or A.3 Region 1 – use A.2, A.3 or A.4 Region 3 – use A.2 See MR-0175/ISO 15156 – Annex A (normative)	

13.1 Acceptability Bases for Selection for SSC/SCC Resistant Materials (CLAUSE 7:MR0175/ISO 15156-1)	
13.2	
13.3 Qualification Requirements/Testing Conditions	
PREFERRED MATERIAL/GRADE:	EQUIPMENT TYPE
NACE MR0175/ISO15156 REFERENCE:	

Note: UNOFFICIAL SAMPLE – User defined documentation.