

PRODUCTS FOR SOUR OILFIELD APPLICATIONS (NACE MR0175:2021) AND SOUR PETROLEUM REFINING OPERATIONS (NACE MR0103 - 2015)

PIP #: ASH-PI-60

Applicable to:
Pressure Gauges,
Diaphragm Seals,
Switches, Transducers
And Thermowells

Introduction

Many metals and alloys are susceptible to corrosion and stress corrosion cracking when used in environments containing hydrogen sulfide (H₂S). To prevent equipment failures and increase safety in “sour” applications, NACE International issues several standards regarding materials selection for applications exposed to hydrogen sulfide. Using materials selected in accordance with NACE standards MR0175/ISO 15156 and/or MR0103/ISO 17945 reduces the likelihood of failure due to stress corrosion cracking in sour environments. A comprehensive list of NACE compliant Ashcroft products can be found at the end of this document.

The Standards

MR0175:2021/ISO 15156:2020: *“Materials for Use in H₂S Containing Environments in Oil and Gas Production”*

This document has been adopted as a worldwide standard by NACE, ANSI, and ISO. This comprehensive standard is divided into three sections, separately addressing general requirements, ferrous alloys, and corrosion resistant alloys as used in sour oil and gas field applications. The standard defines acceptable operating limits for metallic materials based on composition and metallurgical condition (temper and hardness) of the material and the chemistry and temperature of the process fluid.

MR0103/ISO 17945:2015: *“Metallic Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments”*

This document addresses the selection of materials in oil and gas refineries. Refinery environments are typically less severe than production environments, due to lower chloride concentrations, higher pH levels, and the use of corrosion inhibitors. As a result, MR0103 tends to be less stringent than MR0175. It doesn’t place restrictions on temperature or composition of the process fluid, but instead focuses on hardness of the metal as the primary driver of resistance to stress cracking.

Scope of the Standards

MR0175 and MR0103 provide materials selection guidance to mitigate the risk of stress cracking in production and refining applications exposed to hydrogen sulfide (H₂S). The standards do not consider general or localized corrosion or the use of non-metallic materials such as polymers and elastomers.

Additionally, MR0175 restricts the usage of many alloys by limiting the temperature, pH, and/or composition at which these alloys may be used. It is the responsibility of the customer to select an appropriate instrument based on these factors.

Using the Standards

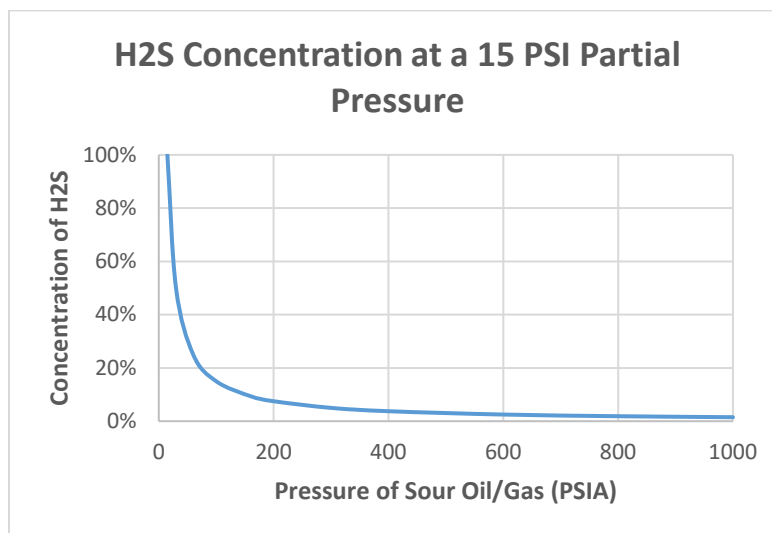
MR0103 is straight forward, there are no restrictions to temperature, chemistry, etc. An alloy only needs to meet the metallurgical requirements (material compositions and hardness).

MR0175 requires a bit more effort to apply. In addition to material composition and hardness, process temperature and composition must be considered.

Temperature: Corrosion and stress cracking are driven by chemical kinetics. The probability of stress cracking (and the rate at which it occurs) is directly proportional to temperature.

H₂S Concentration: MR0175 covers both sour oil and gas production. In oil, H₂S is gas dissolved in the oil. In natural gas, H₂S gas is mixed in with the natural gas. Furthermore, oil and gas wells typically produce some amount of water which may also contain dissolved H₂S. To simplify the application of the standard across these different scenarios (H₂S dissolved in oil/water, mixed with natural gas, or even mixture of oil/gas), the NACE standard specifies concentration of H₂S as a “partial pressure”. This also allows us to account for the compressibility of gas (pressure in gas is analogous to concentration).

For example, MR0175:2021 Table A.2 limits austenitic stainless steel used at 140°F (60°C) with no limits on chlorides or pH to 15 psi partial pressure of H₂S. This equates to 15% H₂S at a working pressure of 100 psi, or 1.5% H₂S at 1000 psi.



Chloride Concentration: Chlorides are an anion of salt molecules (sodium, calcium, magnesium chloride) that are naturally present in many wells. Chlorides are well documented stress cracking agents in stainless steels and contribute to pitting and crevice corrosion as well. The presence of chlorides will increase the probability of stress cracking in sour environments and as such, MR0175 limits the acceptable chloride concentration for some materials that are less resistant to stress cracking.

pH: pH is a measure of acidity in an aqueous medium (i.e. water produced from the oil/gas well). A low pH (less than 7) indicates an acidic environment, with lower pH indicating more acidity. In addition to increasing the susceptibility to stress cracking, a low pH and can result in accelerated corrosion rates and a risk of hydrogen embrittlement.

Elemental Sulfur: In some sour wells, elemental sulfur may be present in the crude or gas stream. Many alloys are susceptible to severe corrosion and stress cracking when in contact with sulfur. MR0175 classifies alloys as resistant, not resistant, or “no data submitted”.

Pressure Gauges for Use in Sour Service

Bourdon Tube Gauges for Sour Service

Ashcroft offers process style pressure gauges suitable for sour service in two materials, 316L stainless steel and Monel[®], a nickel/copper alloy. Gauges with Monel[®] wetted parts are suitable for all MR0103 and MR0175 applications, with the exception of the 1082 Test Gauge which uses a hardened tube that exceeds the 35HRC hardness limit.

The NACE standard requires austenitic stainless steels, like 316L, to be in the fully annealed condition and free of cold work with a maximum hardness of 22 HRC. These requirements are very difficult to achieve when designing a high reliability pressure gauge. A bourdon tube is essentially a spring, and some cold work is needed to develop a strong, repeatable spring rate with minimal hysteresis. As such, Ashcroft qualifies stainless steel pressure gauges for sour service by laboratory testing.

Laboratory Testing of Stainless Steel Pressure Gauges

An independent laboratory was commissioned to assess the suitability of Ashcroft stainless steel bourdon tube gauges in sour environments. The gauges were pressurized to 80% of scale at a temperature of 158°F (70°C) with a sour media as specified in MR0175/ISO 15156, table E.1, Level V. The media consisted of an aqueous solution of H₂S at a partial pressure of 100 psi (0.7 mPa), CO₂ at a partial pressure of 200 psi (1.4 MPa), and a chloride concentration of 91 g/L (in the form of sodium chloride). The media was replenished weekly. After 30 days of exposure, there was no evidence of stress corrosion cracking or other damage. After exposure to the test media, the gauges were tested for cycle life by pressure cycling from 20% to 80% of scale at a rate of 0.3 to 0.6 Hertz (ASME B40.1 paragraph A-2.8). The performance of the exposed gauges was equivalent to baseline tests.

Certification

All products listed are compliant with the NACE standards. If a certificate of compliance with MR0175 / ISO 15156 or MR0103 / ISO 17945 is required, order option CD5.

Precautions

Pressure gauges shall be used in accordance with ASME B40.100 and all Ashcroft recommendations. All restrictions on temperature, pH, and chemistry imposed by MR0175 / ISO 15156 must be observed. It is the responsibility of the customer to determine the appropriate materials of construction based on their process variables and operational requirements.

ASHCROFT NACE COMPLIANT PRESSURE GAUGES

Product	Specification	
	Oilfields (Production) MR0175/ISO 15156	Refineries MR0103
All pressure gauges with Monel [®] wetted parts (except for type 1082 Test Gauges)	Compliant	Compliant
Types 1009 (4 1/2" and 6" only), 1109, 1209, 1259, 1279, 1377, 1379, 2464, T5500, T6500, 1010, 1017, 1020, 1127, 1128, and 1220 with 316L wetted components	Compliant	Compliant
Type 5503 Differential Pressure Gauge with Hastelloy [®] C-276 diaphragm and housing and Teflon [®] or FFKM gaskets	Compliant	Compliant

Diaphragm Seals for Use in Sour Service

Many of Ashcroft's pressure gauges are suitable for direct contact with sour media, but a diaphragm seal is desirable in many applications. For example, double containment may be beneficial when measuring flammable gasses, the overall corrosion rate may be too great, or the risk of stress cracking or pitting may be too high to use stainless steel or Monel. In these situations, a diaphragm seal will provide an additional layer of protection without the cost of custom engineering a pressure measurement instrument using exotic alloys.

Ashcroft offers a wide range of NACE compliant materials, allowing the user to customize a solution for their particular set of process conditions. Available materials include:

316L stainless steel

Duplex stainless steels (2205, 2207)

Super Austenitic Stainless Steel (Carpenter 20, 904L)

Nickel Alloys (Monel[®], Inconel 625, Hastelloy C276 and C22)

Ashcroft diaphragm seals are designed to meet all NACE requirements including material composition and metallurgical condition (hardness) which eliminates the need to qualify the product by laboratory trials or field experience.

Help with Material Selection

Some alloys may be better suited to certain applications. A good rule is to use 316L stainless steel diaphragm seals at low temperatures (<140°F / 60°C) with low chloride content (<50 mg/L or 50 ppm) and use Hastelloy C-276 at high temperature or when chloride is present. The table below gives some general guidance on materials selection in sour environments.

Materials Selection for Sour Processes		
Application	Problem	Solution
Oil/Gas Production	Uncontrolled Chemistry, difficult to perform maintenance	Hastelloy C276 to ensure high reliability
Desalting	Elevated Chloride content	Hastelloy C276 or Super duplex to avoid SCC or pitting/crevice corrosion
Distillation, Cracking	High temperature	Hastelloy C276 or C22, nickel alloys have superior strength and metallurgical stability at temperature
Hydrotreating	Hydrogen embrittlement	316L SS has superior hydrogen compatibility
Acid Treating, pH adjustment, waste treatment	Upset Conditions (Acid and Base exposure)	Hastelloy C22, performs well under changing conditions
Caustic Treating	Caustic/Bases/Sodium Hydroxide	Carpenter 20, Monel®, and Hastelloy C22 provides superior resistance to caustic environments (High pH)
Amine Treating	High H ₂ S content, amines	316L SS or Hastelloy C276
Sulfur Recovery	Elemental sulfur, high H ₂ S content	Hastelloy C276 or C22 for resistance to elemental sulfur

Limits on Temperature or Chemistry

MR0175 places temperature and process fluid chemistry limits on some alloys, including the commonly used 316L stainless steel. The customer should review their process conditions to make sure the selected material will be used within the process windows established by the MR0175 document.

In addition to the limits established by the standards, Ashcroft limits the use of 304L, 316L, and Carpenter 20 diaphragms to 140°F (60°C). Above this temperature, the diaphragm, which is quite thin, may experience localized corrosion in the presence of chlorides.

Best Practices

Instruments attached to diaphragm seals should have stainless steel or Monel® wetted components to minimize corrosion in the event of a diaphragm failure.

Consider the effect of galvanic corrosion when specifying a diaphragm seal. Diaphragm seal lower housings should use a material similar to the piping system. Stainless steel and nickel alloys should not be mixed with copper bearing alloys (Monel®, brass/bronze, Carpenter 20). A diaphragm should match the lower housing or be made from a similar but more corrosion resistant material. For example, if an all Hastelloy C276 diaphragm seal isn't justified from a cost standpoint, consider using a 316L lower housing with a Hastelloy C276 diaphragm. Conversely, avoid using a 316L diaphragm with Hastelloy C276 lower housing because this could accelerate corrosion of the diaphragm.

Certification

All products listed are compliant with the NACE standards. If a certificate of compliance with MR0175 / ISO 15156 or MR0103 / ISO 17945 is required, order option CD5.

Precautions

Diaphragm seals shall be used in accordance with ASME B40.100 and all Ashcroft recommendations. All restrictions on temperature, pH, and chemistry imposed by MR0175 / ISO 15156 must be observed. It is the responsibility of the customer to determine the appropriate materials of construction based on their process variables and operational requirements.

ASHCROFT NACE COMPLIANT DIAPHRAGM SEALS

Instrument	Specification	
	Oilfields (Production) MR0175/ISO 15156	Refineries MR0103
Type 100 & 200 Series, and 702/740 with 304L, 316L, or Carpenter 20 Cb-3 [®] wetted (140°F/60°C max.)	Compliant	Compliant
Types 400 & 500 Series with 316L wetted parts (140°F/60°C max.)	Compliant	Compliant
Types 100 & 200 Series, and 702/740 with Monel [®] , Hastelloy [®] C-22 or C-276 wetted parts	Compliant	Compliant
Types 400 & 500 Series with Hastelloy [®] C-22 or C-276 wetted parts	Compliant	Compliant
Types 100 & 200 Series with duplex/super duplex or 904L wetted parts	Compliant	Compliant
Type 100 & 200 Series, and 702/740 with Tantalum wetted parts	Compliant	Not Compliant
Type 311/312 with all 316L wetted parts (140°F / 60°C max.)	Compliant	Compliant
Type 310/315, 400/500, 510/511 with all Monel [®] construction	Compliant	Compliant
Type 510/511 with all Hastelloy [®] C-276 construction	Compliant	Compliant

Pressure Switches, Transducers and Thermowells for Use in Sour Service

Pressure Switches

Ashcroft offers two types of pressure switch actuators for direct exposure to H₂S containing process fluids. A-series pressure switches are available with a 316L stainless process connection and actuator piston sealed with an HNBR (hydrogenated nitrile butadiene rubber) actuator seal. Elastomers, like HNBR, are outside the scope of the NACE standards, but this material is known to perform well in moderately sour environments.

Ashcroft B, L, G, and P series pressure switch are available with Monel[®] process connections and actuator diaphragms. The all-welded design eliminates wetted elastomers resulting in maximum durability.

Transducers

Ashcroft type A2, A2X, and A4 transducers with all 316L stainless steel wetted parts are suitable for direct contact with sour process fluids. The chemistry and temperature restrictions imposed by the MR0175/ISO 15156 should be observed.

Use caution at temperatures in excess of 140°F (60°C) if chloride is present, localized corrosion (pitting) could occur. Explosion proof or intrinsically safe products should be used with flammable process fluids.

Thermowells

Thermowells have more section thickness than bourdon tubes or diaphragms, and are less susceptible to general corrosion and pitting. As such, Ashcroft does not place any additional restrictions on these products outside the requirement of MR0175/ISO 15156.

The most commonly used NACE compliant materials are 316L stainless steel (with option XMA to ensure the hardness is less than 22 HRC), Monel[®], and Hastelloy C276.

Products Compliant with NACE Standards

A summary of NACE compliant products is listed in the table on page 4.

Certification

All products listed are compliant with the NACE standards. If a certificate of compliance with MR0175 / ISO 15156 or MR0103 is required, order option CD5.

Precautions

All products shall be used in accordance with the Installation & Maintenance Manual and all Ashcroft recommendations. All restrictions on temperature, pH, and chemistry imposed by MR0175 / ISO 15156 must be observed. It is the responsibility of the customer to determine the appropriate materials of construction based on their process variables and operational requirements.

ASHCROFT NACE COMPLIANT PRESSURE SWITCHES, TRANSDUCERS, AND ACCESSORIES.

	Specification	
	Oilfields (Production) MR0175/ISO 15156	Refineries MR0103
Switches		
A Series Pressure switches with 316L Process Connection and HNBR (N) actuator seal	Compliant	Compliant
Type B400, B700, G, L, and P series with all welded Monel [®] construction (Specify XMA option)	Compliant	Compliant
Transducers		
Type A2, A2X, and A4 with 316L wetted parts (140°F/60°C max.)	Compliant	Compliant
Thermowells		
316 (specify XMA option), Monel [™] , or Hastelloy [™] C-276	Compliant	Compliant