## Technical Specification

**Title:** Polymeric Material for Critical Gas Systems  
**NP:** NP-1  
**Area:** DP&T-SUP  

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### Information

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1 OBJECTIVE

This technical Specification is based on NORSOK M-710: with the amendments and deletions mentioned below and, also, on ISO/DIS 23936-2.

This Technical Specification does not intend to list every test necessary to qualify a given polymeric sealing material - within the equipment to be purchased by PETROBRAS - related to applications where there is a supercritical fluid with high CO₂ levels. The valve or seal supplier must guarantee its own quality procedure in order to manufacture its equipment, assuring its suitability for the service application described by PETROBRAS (the purchaser): i.e., considering compatibility with service environment, functionality under service and the design lifetime.

The tests described in this Technical Specification intend to cover some qualification tests, considered as pre-screening tests, in order to select a polymeric seal that is suitable for applications related to high levels of CO₂ and high pressures.

Modifications and additions to NORSOK M-710 item 1:

1.1. This Technical Specification describes general principles and gives requirements and recommendations for the selection and qualification of non-metallic materials for critical gas systems service in oil and gas production environments.

1.1.1. By critical gas systems, it comprises:

- CO₂ compression / injection systems with pressures higher than 900 psi or supercritical CO₂ environment;
- Valves and instruments which subjected to high pressures gas (higher than 900 psi) or supercritical CO₂ environment;
- Equipments subjected to high pressures gas (higher than 900 psi) or supercritical CO₂ environment.

1.2. This Technical Specification does not deal with coating systems or linings, which are related to other specific technical specifications. The goal of this Technical Specification is the requirements for critical non-metallic (polymer) sealing, seat and back up materials for permanent topside applications.
2 STANDARDS AND REFERENCE DOCUMENTS

2.1 NORSOK STANDARD

2.1.1. NORSOK M-710: 2014 - Qualification of non-metallic materials and manufacturers – Polymers

2.2 ISO STANDARDS

2.2.1 ISO 2859: 2014 - Sampling procedures for inspection by attributes. Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection

2.2.2 ISO 11346: 2014 - Rubber, vulcanized or thermoplastic -- Estimation of life-time and maximum temperature of use

2.2.3 ISO 17025 - General requirements for the competence of testing and calibration laboratories

2.2.4 ISO/DIS 23936-2 - Petroleum, petrochemical and natural gas industries. - Non-metallic materials in contact with media related to oil and gas production. Part 2: Elastomers

2.2.5 ISO 3601-3 - Fluid power systems - O-rings - Part 3: Quality acceptance criteria

2.3 PETROBRAS STANDARD

2.3.1 I-ET-3010.1M-1200-200-P4X-001 - PIPING SPECIFICATION FOR TOPSIDE

2.4 ASTM STANDARDS

2.4.1 ASTM D 3032: 2016 - Standard Test Methods for Hookup Wire Insulation


3 REQUIREMENTS AND RECOMMENDATIONS

Replace the definitions shall, should and may on NORSOK M-710 item 3.1 by those as follow:

3.1. Whenever used the term “Shall” in this technical document, it is intended that what follows is an absolute requirement. Non-compliance to shall requirements shall be formally accepted by PETROBRAS.
3.2. Whenever used the term “Should” in this technical document, it is intended that what follows is a recommendation. Alternative solutions having the same functionality and quality are acceptable provided that alternative solution had been submitted to PETROBRAS and receive its approval.

3.3. Whenever used the term “May” in this technical document, it is intended that what follows indicate a course of action permissible within the limits of this technical specification.

4 DEFINITIONS AND ABBREVIATIONS

Modifications and additions to NORSOK M-710 item 3.1:

4.1. DEFINITIONS

4.1.1. Lining: Lining means a coating or layer of sheet metal adhered to or in intimate contact with the interior surface of a base metal. Its function is to meet requirements such as corrosion resistance or abrasion at different working temperatures.

4.1.2. Coating System: The complete number and types of coats applied to a substrate in a predetermined order.

4.1.3. Accelerated test: a test undertaken at conditions designed to speed material deterioration; this is usually accomplished by increasing temperature, to raise chemical reaction rates, but fluid concentration and stress are variables which can also be manipulated.

4.1.4. Elastomer: an amorphous material mechanically mixed with other constituents to form a rubber compound which is then shaped by flow into articles by the manufacturing processes of moulding or extrusion and (invariably) chemically cured at elevated temperature to form an elastic insoluble material. Alternative name, rubber.

4.1.5. Seal type: a seal design of specified geometry, size and orientation; for example, an O-ring.

4.1.6. (Compound) Manufacturer: Producer of the polymer material or semi-finished products made from polymeric materials.

4.1.7. Equipment Purchaser: Part responsible for procuring the polymeric material or component which will be part of the goods (valves, instruments, pressure vessels, compressors, pumps, etc…) delivered during the project.

4.1.8. “Equipment Manufacturer” is defined as the responsible by fabrication of equipment or components internal to the Package.

4.1.9. “Package Unit” or “Package” is defined as an assembly of equipment supplied interconnected, tested and operating, requiring only the available utilities from the Unit for the Package operation.
4.1.10. “Packager” is defined as the responsible for project, assembly, construction, fabrication, test and furnishing of the Package.

4.1.11. “Module” is defined as the metallic structure suitable for lift and transport, where Packages and equipment will be installed, being supplied completely mounted and pre-commissioned.

4.1.12. “Module Supplier” is defined as the responsible for project, assembly, erection, construction, fabrication, test and furnishing of the Module.

4.1.13. “Bidder” is defined as the responsible for the lift, hook up, installation and integration of all Modules on the Unit Hull.

4.1.14. “Purchaser” means the legal entity which is in charge of do or supplies something. For the purpose of this Technical Specification CONTRACTOR can mean different meanings according his responsibilities. This term can be interpreted as:

a) “Purchaser” = Packager;
b) “Purchaser” = Module supplier;
c) “Purchaser” = Bidder;
d) “Purchaser” = Equipment Manufacturer.

4.2. ABBREVIATIONS

Modifications and additions to NORSOK M-710 item 3.2:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUT</td>
<td>Continuous Use Temperature</td>
</tr>
<tr>
<td>ID</td>
<td>Internal Diameter</td>
</tr>
<tr>
<td>OD</td>
<td>Outer Diameter</td>
</tr>
<tr>
<td>RGD</td>
<td>Rapid Gas Decompression</td>
</tr>
<tr>
<td>CSD</td>
<td>Cross Section Diameter</td>
</tr>
</tbody>
</table>

5 FUNCTIONAL REQUIREMENTS

Replace the text of NORSOK M-710 item 4 by:

Material selection shall be based on evaluation of compatibility with service environment, functionality under service and the design lifetime. The material selection for piping systems is based on PIPING SPECIFICATION FOR TOPSIDE, issued during the Design. For other equipment the equipment purchaser shall be based on project’s information about service conditions and environment, and items below shall be considered during the material selection process:

- Adequate physical and mechanical properties (hardness, tensile strength, elongation at break, modulus of elasticity, compression set, tear resistance, etc.);
- Resistance to high pressure extrusion or creep;
- Resistance to thermal cycling, and dynamic movement;
• Resistance against rapid gas decompression;
• Long term behavior;
• Low temperature flexibility, ASTM D 746 and ASTM D 790 (in any case of minimum design temperature lower than zero degree centigrade).

Clause 2 gives references to relevant standards for polymers, mainly thermoplastic materials and elastomeric materials. The standards describe test methodology for performing the tests. The test conditions and duration's shall be as described in this NORSOK standard in those cases where the NORSOK standard deviate from the referenced standards. The polymers used shall be sourced from the same material manufacturers that performed the seal material qualification, using the same manufacturing route and procedures.

6 REQUIREMENTS FOR QUALIFICATION OF MANUFACTURERS

6.1. GENERAL REQUIREMENTS

Modifications and additions to NORSOK M-710 item 6.1:

In order to be qualified, the manufacturer shall document that he has manufactured materials and performed the testing required and that the material has met the relevant requirements in this standard.

The testing shall be performed on articles produced from specific polymer (thermoplastics or rubber) formulation and production procedures, made according to the normal production route and with regular production equipment.

This standard specifies the required minimum numbers of tests that must be performed in order to document the material suitability and compatibility with those test fluids specified in this standard, applicable to the intended seal application. The qualification testing shall apply for the polymeric (thermoplastics or rubber) materials on a one-off basis and the results shall be valid as long as the requirements stated in clause 6.2 are satisfied. For later supplies of identical material from the same manufacturer, a quality control of each batch of material shall be sufficient using an accepted quality limit previous agreed with PETROBRAS from ISO 2859: 2014 - Sampling procedures for inspection by attributes. Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection.

Well documented in-service experience with traceable production records and quality control documentation available shall replace qualification tests only with prior approval of PETROBRAS. Such documentation shall contain detailed information on service conditions such as time, temperature, pressure, fluid composition and chemicals added. The operating company can for example provide the documentation of flawless service. The service temperature must be in the same range as for the new application (maximum 10°C below) and the service life shall be minimum 50% of design life.
6.2. VALIDITY OF QUALIFICATION

Modifications and additions to NORSOK M-710 item 6.2:

The qualification shall apply for each specific seal material made of either thermoplastic or elastomeric materials (polymers) and each specific manufacturer. The qualification shall be repeated if any changes have been made to the formulation of the product or the production route. This applies also for changes in raw materials or of sub suppliers.

If production is carried out at different plants/locations, a separate qualification is required for each plant.

7 QUALIFICATION OF ELASTOMERIC SEALING MATERIALS

7.1. GENERAL

Modifications and additions to NORSOK M-710 item 7.1:

The technical requirements for testing of elastomeric seals are divided into two sections. The first section defines the ageing test requirements (ANNEX A) and the second (ANNEX B) defines the requirements for rapid gas decompression testing.

Rapid gas decompression testing is required for any pressure system with pressures higher than 900 psi.

7.2. REQUIREMENTS FOR AGEING TESTS

7.2.1. General

Modifications to NORSOK M-710 item 7.2.1 (Requirements for ageing tests - General):

This standard defines test procedures for the prediction of the progressive degradation of elastomeric seals exposed to fluids with high CO₂ and recommended pressure over an extended period of time. It is applicable where it is required to predict service life in a specific application or for the comparison of the performance of different seal materials. The prediction shall be based on tests performed at three different temperatures, following Arrhenius' methodology (ISO 11346 and ASTM D 3032).

If it is not feasible to use Arrhenius' methodology, a compatibility/ageing test shall be performed at the maximum design temperature. Regarding the minimum design temperature, when below 0°C, evaluate the low temperature flexibility according to ASTM D 746 and ASTM D 790. This test will not give the lifetime of the rubber compound, but will reprove rubbers’ grades not suitable for a given application.

An initial pre-check test shall be performed, if no previous knowledge about the behavior of a seal material in a certain fluid exists. The test duration shall be sufficient to reach saturation of the fluid in the material at the test temperature. If no immediate changes in volume or weight occur, then the ageing test can start.

The supplier shall, during accelerated test for obtaining results for extrapolation to service life, limit the test temperature so it can be ensured that the same chemical and/or physical processes will occur as during service.
The seal shall be tested in a constrained mode. The standard constraint shall be a flange or spigot/sleeve test arrangement whereby the seal is compressed by 20% of its original cross section. The flange or spigot/sleeve arrangement shall be submerged in the test fluid. No pressure difference over the seal is required. A standard O-ring seal shall be used; reference is made to ANNEX A, clause A.1.3.

When extrapolating data from the present procedures appropriate statistical techniques shall be applied. For example, if progressive degradation is dependent on a single chemical ageing process, a method based on Arrhenius equation/method may be used as described in ASTM D 3032 and ISO 11346. Test media, conditions, equipment, procedures and test report requirements are described in detail in ANNEX A.

8 QUALIFICATION OF THERMOPLASTIC MATERIALS

Modifications to NORSOK M-710 item 8.2.1 (Requirements for ageing tests - General):

8.1. REQUIREMENTS FOR AGEING TESTS

8.1.1. General

This standard defines test procedures for the prediction of the progressive degradation of thermoplastic seals and back-up materials exposed to fluids at elevated pressure and temperature over an extended period of time. It is applicable where it is required to predict service life in a specific application or for the comparison of the performance of different materials. This shall be achieved by testing at three different temperatures, following Arrhenius’ methodology (ISO 11346 and ASTM D 3032).

If it is not feasible to use Arrhenius’ methodology, a compatibility/ageing test shall be performed at the maximum design temperature. Regarding the minimum design temperature, when below 0ºC, evaluate the low temperature flexibility according to ASTM D 746 and ASTM D 790.

An initial pre-check test shall be performed if no previous knowledge about the behavior of a thermoplastic material in a certain fluid exists. The test duration shall be sufficient to reach saturation of the fluid in the material at the test temperature. If no immediate changes in volume or weight occur, then the ageing test can start.

The supplier shall, during accelerated test for obtaining results for extrapolation to service life, limit the test temperature so that it can be ensured that the same chemical and/or physical processes will occur as during service.

When extrapolating data from the present procedures appropriate statistical techniques shall be applied. For example, if progressive degradation is dependent on a single chemical ageing process, a method based on Arrhenius equation/method may be used as described in ASTM D 3032 and ISO 11346.

Test media, conditions, equipment, procedures and test report requirements are described in detail in ANNEX C.
9  NORSOK M-710 / ANNEX A - AMENDMENTS

ANNEX A: Test media, conditions, equipment and procedures for ageing of elastomeric materials

Replace TABLE A.2 for:

Case 1 - Case for environment’s for CO₂ content up to 10%: 10% CO₂ - 90%CH₄.

Case 2 - Case for environment’s for CO₂ content close to 100%: 100% CO₂.

Replace clauses in A.1.2 per: the temperatures for the immersion (ageing test) shall be the maximum and minimum design temperature. The pressure must be as close as possible to the operational pressure described in the design data. Attention must be paid in relation to the state of the mixture CO₂ - CH₄: supercritical or gaseous depending on the pressure and temperature, because this must be reproduced in the immersion test. Regarding the exposure period (A.1.2.3):

The exposure period for lifetime predictions shall account the time to reach saturation of the test samples (soak) and be sufficiently long as to allow for reliable extrapolation according to requirements for methods such as Arrhenius plot (ASTM D3032).

If the supplier did not manage to use Arrhenius’ methodology due to not reaching failure criteria at accelerating temperatures or not observing any properties variation among the 3 different accelerated temperatures, just the above short term immersion test must be performed and the polymer’s lifetime in this application will not be able to be predicted. This short term immersion test at the maximum design temperature shall include enough samples to be retrieved at intervals of 1, 7, 14, 30 and 60 days. The mechanical tests and mass/volume and compression set described at NORSOK M-710 must be addressed after each sampling from the immersion test.

The failure criteria are described in NORSOK M-710.

10  NORSOK M-710 / ANNEX B - AMENDMENTS

ANNEX B: Test media, conditions, equipment and procedures for rapid gas decompression testing of elastomeric materials.

IMPORTANT: This clause is only applicable for design pressure > 900 psi (62 bar).

Replace TABLE B.1 for:

Case 1 - Case for environment’s CO₂ content up to 10%: 10% CO₂ - 90%CH₄.

Case 2 - Case for environment’s CO₂ content close to 100%: 100% CO₂.

B.1.1.3 Test temperature:

The test must be conducted at the maximum design temperature. Temperature shall be recorded during the test with calibrated temperature measurement equipment, preferably linked to a PC running data acquisition software.

The thermocouple should be located in the centre of the test vessel. The temperature-time log shall be included in the test report.
When performing the RGD test, the temperature shall be increased to the test level and be steady for at least 15 minutes before the gas pressure is applied. The temperature shall be maintained during the depressurization stages of the test as far as possible, although slight (and transient) reductions are unavoidable during de-pressurization events. After the final de-pressurization, the test vessel must be allowed to stand at test temperature with ports open for at least 12 hours, before cooling.

B.1.1.4 Test pressure:

The test must be conducted at the maximum design pressure. Pressure shall be measured with calibrated pressure measurement equipment, and recorded during the test. The sampling rate shall be reduced for the de-pressurization stages of the test; an interval of 30 seconds is recommended. The pressure-time log shall be included in the test report, as well as transducer/transmitter calibration details.

When performing the RGD test, the vessel shall be pressurized only after it has been stable at test temperature for at least 15 minutes. After the final de-pressurization, the vessel shall be allowed to stand at test temperature with ports open for at least 12 hours, to allow the test seals to degas, before cooling.

B.1.1.5 Exposure periods and number of cycles

The initial exposure period (first cycle) shall be a minimum of 68 continuous hours at test pressure and test temperature. The total number of pressure cycles shall be eight.

Each cycle of the RGD test shall consist of the following operations:

(i) increase pressure to the test level;
(ii) maintain pressure for the required time period;
(iii) reduce pressure at the rate specified in B.1.1.6;
(iv) hold at ambient pressure for 1 hour (+10/-0 minutes).

After the eighth de-pressurization, the vessel should be cooled according to NORSOK M-710’s clause B.1.1.3.

The eighth cycle RGD test is designed to be completed within a one week period. There is no provision in the standard test procedure for intermediate sampling.

B.1.1.6 Decompression rate:

The rate of test cell de-pressurization shall be one of the following:

a) (20 ± 2) bar per minute;

b) Bespoke, with agreement between interested parties; includes multiple rates.

As far as possible the gas pressure shall be released continuously via the valve attached to the test cell. The de-pressurization rates shall be calculated from the pressure log and the mean value included in the test report.
B.1.2 RGD test specimen

The standard test specimen shall be an O-ring seal having (nominal) CSD (Cross Section Diameter) of 5.33 mm. A minimum of four replicate O-ring seals shall be tested. There is no limit to the number of replicate seals that can be included in a RGD test; however, all of the tested seals shall meet the acceptance criterion (clause 7.3.2 in NORSOK M-710) in order the compound can be considered suitable for this application.

The smallest allowable O-ring size is 312. There is no upper size limit, but practical considerations mean that O-rings larger than size 329 are unlikely to be employed as test pieces. All seals shall conform to ISO 3601-3, class N.

It has been found that if a 5.33 mm section O-ring passes the RGD test under a given set of conditions, then smaller section O-rings (e.g., 3.53 mm, 2.62 mm) of the same compound shall be considered to pass providing all else being equal (i.e., method of seal manufacture, housing geometry). Extrapolation of RGD performance from a small section seal to a larger section diameter seal is not permitted. If the standard RGD test is applied successfully to O-ring seals having a CSD of 3.53 mm (for example), then 5.33 mm O-rings of the same compound would also have to be successfully tested in order to obtain valid certification for O-rings having this CSD.

B.1.3 Test seal housing details

RGD testing shall be performed using replicate whole O-ring seals, constrained radially in appropriate metallic grooves which allow gas to access both sides of every seal. Performance information obtained from the testing of free-standing seals or housed seal sections is not acceptable.

Groove dimensions must be measured and reported, along with the radial cross section diameter of each test O-ring. The level of groove fill, calculated on a sectional area basis using the measured CSD, must be reported. The percent deflection (or squeeze) imposed by the assembled housing on the O-ring must be reported, using the measured CSD and groove dimensions.

The choice of groove geometry for the O-ring test seals is open and the source must be given in the test report; for example, international standard; corporate specification, etc.

Experience has shown that in order to increase the chance of an O-ring seal resisting RGD events, it should not be excessively deflected (or under-deflected) in its groove and the level of groove fill should be relatively high. Hence, the arrangement that shall be tested is one in which the O-ring seal:

(i) is deflected radially by (14.5 ± 3) % of its nominal CSD, and

(ii) occupies 80 % to 85% of groove volume.

Alternative deflections and groove fill parameters can be used if agreed between the parties. It is convenient to test O-rings in metallic fixtures designed to house two or four seals.
B.3 Test Procedure:
The procedure for the standard dry gas RGD test is as follows:
(a) Measure the CSD of each replicate test seal in the radial direction at three circumferentially equidistributed positions. Measure each test fixture groove ID, OD and width;
(b) Install the test seals in the test fixtures; light lubrication to aid installation is permitted;
(c) Place the fixtures in the test vessel and close it;
(d) Charge the vessel with nitrogen to 10 bar minimum and check for leaks. Release the nitrogen;
(e) Heat the vessel to test temperature;
(f) Once temperature has been stabilized at the test level for at least 15 minutes, charge the vessel with the test gas mixture to the test pressure. Temperature and pressure shall be recorded continuously; a sampling interval of 10 minutes is recommended; this shall be reduced to 30 seconds for depressurization operations;
(g) Maintain test pressure and temperature for a minimum period of 68 hours. [Cycle 1];
(h) De-pressurize the vessel at the required rate and hold at ambient pressure and test temperature for 60 +10/-0 minutes;
(i) Re-pressurize the vessel to test pressure and hold for a minimum of 6 hours. [Cycle 2];
(j) Repeat step (h);
(k) Re-pressurize the vessel to test pressure and hold for a minimum of 12 hours. [Cycle 3];
(l) Repeat step (h);
(m) Repeat step (i). [Cycle 4];
(n) Repeat step (h);
(o) Repeat step (k). [Cycle 5];
(p) Repeat step (h);
(q) Repeat step (i). [Cycle 6];
(r) Repeat step (h);
(s) Repeat step (k). [Cycle 7];
(t) Repeat step (h);
(u) Repeat step (i). [Cycle 8];
(v) De-pressurize the vessel at the required rate and hold at ambient pressure and test temperature for a minimum period of 12 hours, with port/valve open;
(w) Cool the vessel to room temperature;
(x) Open the vessel and retrieve the test fixtures;
(y) Remove the test seals from the fixtures. Describe the appearance of each test seal within 30 minutes; photograph relevant features;
(z) Section and rate each test seals according to the procedures given in clause B.4.

B.4 RGD Damage rating system

In order to evaluate the extent of RGD - induced damage in the O-ring test seals, each shall be sectioned and rated according to the number and length of cracks present. The number of sections is linked to seal size; the larger the seal, the greater the number of cuts required for characterization; see the TABLE B.4 below for O-rings having a CSD of 5.33 mm.

**TABLE B.4 - RELATIONSHIP BETWEEN O-RING SIZE AND NUMBER OF CUTS FOR RATING PURPOSES**

<table>
<thead>
<tr>
<th>O-ring size</th>
<th>Number of cuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>312-316</td>
<td>4</td>
</tr>
<tr>
<td>317-324</td>
<td>6</td>
</tr>
<tr>
<td>325-329</td>
<td>8</td>
</tr>
<tr>
<td>330-333</td>
<td>10</td>
</tr>
</tbody>
</table>

Sections shall be made with a sharp blade, e.g. a new scalpel, razorblade; the latter is recommended for high hardness seals. The blade can be wetted with soapy water to facilitate cutting and improve exposed surface quality. The first cut should be made through the centre of the largest visible damage feature (e.g., a blister or crack). The second cut should be made through the next most obvious unrelated feature. The remaining cuts should then be made at approximately equal intervals in the intervening regions. If there is no damage visible on the seal, the initial cut can be made anywhere, with the remaining cuts distributed in a symmetric pattern around the seal.

B.4.1 Crack type and measurement

Examine each cut section surface using a loupe (or other optical device) which gives a magnification of at least 10x. For the purposes of rating, three crack types have been defined - internal, external and split; these are illustrated schematically in the figure below:

a) Internal Cracks  b) External cracks  c) Splits
Crack length is defined as a percentage of the nominal seal CSD. For example, the CSD of series 3XX O-rings is 5.33 mm; hence this value is used as the reference point; the use of the actual sectional dimensions is forbidden. Experience has shown that most exposed seal sections can be rated easily by inspection, with crack measurements only required in those cases where the rating could be a 3 (pass) or a 4 (fail).

The majority of RGD cracks are expected to be linear, or near linear. Accordingly, the preferred measurement method is direct end-to-end: for fractures with some curvature, length can be measured along the crack path. Crack orientation and location are not relevant factors. Projection of a crack onto a plane for measurement purposes is not permitted.

B.4.2 RGD damage rating system

Each seal section shall be rated according to the system given in the modified Table B.4.1 below. The single digit represents the number, length and type of cracks present in the exposed section.

**NEW TABLE B.4.1 - RATING NUMBER SYSTEM FOR EXPOSED O-RING SEAL SECTION SURFACES.**

<table>
<thead>
<tr>
<th>RGD damage features</th>
<th>Rating</th>
<th>Pass/ Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cracks, holes and blisters are permitted.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>- The exposed surface shall be intact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any number of cracks, each &lt;25% CSD: total crack length shall not exceed CSD</td>
<td>1</td>
<td>PASS</td>
</tr>
<tr>
<td>- External cracks shall be &lt; 10% CSD; no splits are permitted.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 5 cracks, each &lt; 50% CSD: total crack length shall not exceed 2x CSD.</td>
<td>2</td>
<td>PASS</td>
</tr>
<tr>
<td>- External cracks shall be &lt; 25% CSD; no splits permitted.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 8 cracks of which 2 internal cracks can have length 50% to 80% CSD: total crack length shall not exceed 3x CSD.</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>- External cracks shall be &lt; 50% CSD; no splits permitted.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Nine (9) or more cracks having the total length greater than 3x CSD or;</td>
<td>4</td>
<td>FAIL</td>
</tr>
<tr>
<td>- At least one (1) internal crack &gt; 80% CSD or;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Three (3) or more internal cracks each 50% CSD or;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Any external crack &gt; 50% CSD.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- No split permitted.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any split, regardless of location and length.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>- No exception permitted.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Photographic examples for the above rating system

Rating 1

Rating 2

Rating 3
For each tested O-ring the ratings should be listed in descending order, with the four highest values defining the RGD performance of the seal.
B.5 RGD Test Report

The test report shall include the following information:

a) reference to this Standard;

b) date of test;

c) test seal CSD (radial); fixture groove ID and OD; % deflection (squeeze) and % groove fill;

d) seal reference information: compound manufacturer, compound name/number, batch/lot number, elastomer type, manufacturer, seal manufacturing method, date of cure;

e) test fluid composition, temperature, pressure;

f) the temperature/pressure vs. time logs in graphical form;

g) average de-pressurization rate;

h) seal ratings according to new (modified) TABLE B.4.1;

i) representative seal section photographs;

j) other pertinent information; for example, any deviation from the test procedure.

11 NORSOK M-710 / ANNEX C - AMENDMENTS

ANNEX C: Test media, conditions, equipment and procedures for ageing of thermoplastic materials

Clause C.1.1 Ageing Test Media: replace TABLES for 100% CO₂.

The test methodology shall be according to NORSOK M-710 standard.

12 EQUIPMENT PURCHASER OBLIGATIONS

12.1. The EQUIPMENT PURCHASER is responsible for the compliance with the requirements of the applicable International Codes, Statutory Regulations and the PETROBRAS Specification(s).

12.2. Any deviation from this Specification or any of the documents listed below can be accepted only after gaining approval from the PETROBRAS.

12.3. CERTIFICATION REQUIREMENTS

12.3.1. EQUIPMENT PURCHASER shall be responsible for obtaining all necessary certification.

12.3.2. All tests must be conducted by independent third party.

12.3.3. Only test laboratories which have a quality system in compliance with ISO 17025 or equivalent shall be used.
12.3.4. The test reports shall show at minimum:

- Identification of the polymeric material tested;
- Batch lot identification;
- Identification of the entity responsible for conducting tests;
- Responsible for conducting the tests;
- Test results according this Technical Specification;
- Conclusion;
- Standards used during tests.