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TITLE:

GASKETS FOR PLATE HEAT EXCHANGERS – EPDM, NBR AND HNBR TYPES

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1 INTRODUCTION

This technical specification establishes the requirements for Plate Heat Exchanger gasket supplying (EPDM, NBR and HNBR types).

The purpose of this technical specification is to establish tests (and acceptance criteria) for gasket evaluation, regardless of the PHE model.

The requirements for gasket supplying according to this Technical Specification are intended for internal applications to the Petrobras System. Petrobras is not responsible for the use, outside the Petrobras System, of equipment qualified under this document.

This technical specification was elaborated to be applied mainly in large Plate heat Exchangers.

Plate Heat Exchangers (PHE) are classified as large when nozzle diameter exceeds 200 mm (including).

Smaller sized Plate Heat Exchangers (PHE) may have different technical requirements for gaskets evaluation. For these cases, Petrobras must be consulted to verify the need to meet the requirements of this technical specification.

2 REFERENCE DOCUMENTS

- ISO-23936-2** Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production.
- ISO-34** Rubber, vulcanized or thermoplastic — Determination of tear strength Part 1: Trouser, angle and crescent test pieces.
- ISO-37** Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties.
- ISO-48** Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD).
- ISO-815** Rubber, vulcanized or thermoplastic — Determination of compression set
- ISO-1817** Rubber, vulcanized or thermoplastic — Determination of the effect of liquids;

3 ABBREVIATIONS

- PHE Plate Heat Exchanger
- ISO International Organization for Standardization
- NBR Nitrile Butadiene Rubber
- EPDM Ethylene Propylene Diene Methylene Rubber
- HNBR Hydrogenated Nitrile Butadiene Rubber

4 TECHNICAL REQUIREMENTS

The technical requirements presented in this technical specification are only applicable to the EPDM, NBR and HNBR gaskets and to any gasket geometry, referring to any model of Plate Heat Exchanger.

The technical requirements described in this document refer to documentary tests or tests.

The gaskets must meet the General Requirements (provided in item 4.1) and the Specific Requirements (item 4.2). In addition, the manufacturer must issue an inspection report of the gaskets to be supplied, meeting the requirements of item 4.3 (Inspection of gaskets).

The report to prove compliance with the requirements indicated in 4.1 and 4.2 must be submitted together with the Technical Proposal. The report indicated in 4.3 must be submitted together with the gaskets provided.

Petrobras informs that at any time after the conclusion of the process of purchase of gaskets (when they are already under the responsibility of Petrobras), it may carry out inspections and/or evaluations on the product delivered by the Manufacturer. If there is any defect or deviation from the requirements set forth in this technical specification, the Manufacturer will be subject to the sanctions provided in the contract.

4.1 GENERAL REQUIREMENTS

- 4.1.1 Each gasket shall be a single piece (except the initial/final plate and where indicated by Petrobras) and with compatible and suitable geometry for the plate model in which it will be installed.
- 4.1.2 The gaskets shall be manufactured so that cross-contamination leakage cannot occur without first showing evidence of external leakage.
- 4.1.3 It will not be accepted to supply already used or reconditioned gaskets. The gaskets supplied must be new.
- 4.1.4 The gaskets must be completely clean and free of any surface defects and/or imperfections (tears, marks, deformations, and other anomalies) along their length.
- 4.1.5 The gasket shall be supplied without the presence of any kind of porosity along its length.
- 4.1.6 Gaskets of NBR and HNBR types that have been manufactured using the sulfur cure process will not be accepted. For NBR and HNBR gaskets, only peroxide cure is accepted.
- 4.1.7 It is prohibited to supply gaskets with a manufacturing date prior to one year from the date of approval of the purchase order.
- 4.1.8 The gaskets provided must be packed in such a way as to ensure that they do not deteriorate during transport and storage.
- 4.1.9 The batch of supplied gaskets must have a numbering that allows to associate the quality control associated with the lot. It is not necessary for the gaskets to be identified with the numbering of the batch recorded on the gaskets, but some documentation must exist, when the gaskets are delivered, to trace all the information requested. The supplier must enter the identification code used, and this code must be entered on the material certificate.
- 4.1.10 The manufacturer shall ensure that the gaskets provided in EPDM or HNBR material withstand continuous operation at a temperature of 160 °C without failure of deterioration of the gaskets for a period of at least one year.
- 4.1.11 The manufacturer shall ensure that the gaskets supplied with NBR material withstand continuous operation at a temperature of 140°C without failure of deterioration of the gaskets for a period of at least one year.

4.2 SPECIFIC REQUIREMENTS:

4.2.1 SPECIFIC PERFORMANCE REQUIREMENTS:

To meet the performance specific requirements the manufacturer shall prove that your gasket has been approved in all listed tests of Section 5 (Gasket Evaluation Tests). If the gasket manufacturer is also the original manufacturer of that PHE model so gasket evaluation tests of Section 5 is not required.

The evidence that a specific gasket was approved in all tests listed in Section 5 shall be done through a report containing test results and a laboratory identification.

All tests must be performed by third party companies. The reports must have identification of the laboratory and must be signed by responsible technical professionals, attesting compliance with the specified normative test methods, as well as the requirements of this technical specification.

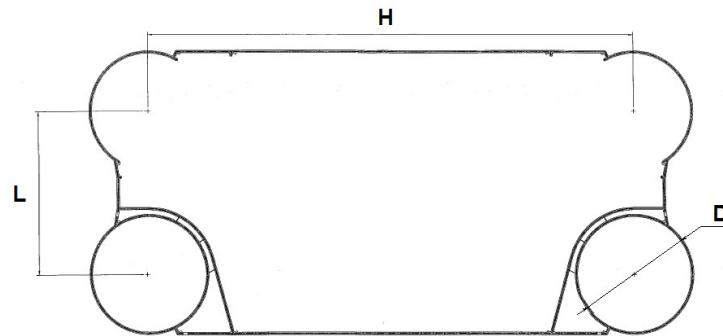
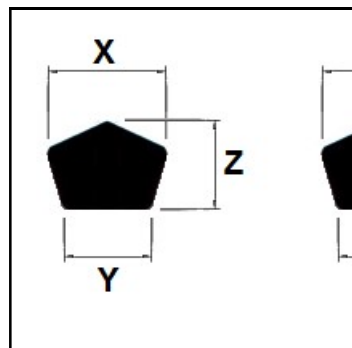
Reports presented in a language other than Portuguese or English must be accompanied by a translation into Portuguese or English.

4.2.2 SPECIFIC GEOMETRY REQUIREMENTS:

All gaskets provided should fit perfectly on the plates pertaining to that gasket model, without being observed (along the length of the gasket) any displacement of the gasket relative to the base of the groove.

Figure 1 shows the general main dimensions of a gasket. Figure 2 shows cross-sectional dimensions of different gasket designs.

To meet specific geometry requirements, Manufacturer must complete Table 1 with nominal values and manufacturing tolerances for the gasket model to be supplied to Petrobras. If the gasket manufacturer is also the original manufacturer of that PHE model so the nominal values and manufacturing tolerance are not required.


Figure 1 - Gasket main dimensions.

Figure 2 - Cross-section dimensions of different gasket models.
Tabela 1 - Gasket Dimensions (Nominal value and manufacturing tolerance).

Dimension			Description
L	nominal	mm	Horizontal distance between hole centers.
	tolerance	± mm	
H	nominal	mm	Vertical distance between hole centers.
	tolerance	± mm	
D	nominal	mm	Hole diameter (measured from the outside gasket side).
	tolerance	± mm	
X	nominal	mm	Maximum gasket width.
	tolerance	± mm	
Y	nominal	mm	Gasket base width.
	tolerance	± mm	
Z	nominal	mm	Gasket height.
	tolerance	± mm	

The Manufacturer must state in the report the nominal values and manufacturing tolerance of the dimensional values shown in Table 1.

NOTA: If there is any change in the geometry of the gasket along the length of the plate, the Manufacturer must state the dimensions of the gasket for all variations found.

4.3 GASKET INSPECTION:

For the supplied gaskets, the manufacturer must select 5% or 10 gaskets (whichever has the highest value) and carry out the hardness measurements.

For hardness measurement, for each selected gasket, the manufacturer shall measure the property by at least five points in different positions along the length of the gasket. All hardness measurements for the selected gasket shall be in accordance with the requirements of this ET and recorded in the inspection report.

The Manufacturer shall issue a gasket supply inspection report, indicating table 2 filled in.

Table 2 – Gasket Hardness

Sample (5% ou 10)	Parameter	Measuring Points					Average
		1	2	3	4	5	
1	Hardness						
2	Hardness						
3	Hardness						
4	Hardness						
5	Hardness						
6	Hardness						
7	Hardness						
8	Hardness						
9	Hardness						
10	Hardness						
...	Hardness						
...	Hardness						
...	Hardness						

5 GASKET EVALUATION TESTS

This section presents the gasket evaluation tests, which are part of the Specific Requirement for the supply of gaskets for Plate Heat Exchangers (item 4.2). The required tests are:

- 5.1 - HARDNESS TEST
- 5.2 - TENSILE STRENGTH AND ELONGATION TEST
- 5.3 - COMPRESSION SET TEST
- 5.4 - TEAR STRENGTH TEST
- 5.5 - DETERMINATION OF THE EFFECT OF LIQUIDS TEST

The performance of a particular gasket in tests of its physical-chemical properties is strongly influenced by the conditions under which these tests are performed (e.g., temperature, type of fluid in contact with gasket, etc.). Therefore, it was defined an operational condition for the test of each type of gasket (EPDM, NBR and HNBR), as being the most critical for the application of that type of gasket in the PHEs used by Petrobras.

The tests shall be performed on samples of gaskets identical to those that will be provided, i.e., the same geometry, same material, same formulation, and same manufacturing process (unless otherwise indicated by this technical specification).

The batch of gaskets supplied to PETROBRAS (already glued to the plates or separated) must have a numbering that allows associating the quality control tests associated with the lot. It is not necessary for the gaskets to be identified with the numbering of the batch recorded on the gaskets, but some documentation must exist, when the gaskets are delivered, to trace all the information requested.

The supplier must inform the identification code used, and this code must appear on the material certificate.

5.1 HARDNESS TEST:

The hardness shall be measured according to the method set forth in ISO-48 (except where indicated in that specification).

The approval criteria for the hardness of the gasket are shown in Table 3. The result presented must be an average of at least three test specimens tested.

Table 3 - Acceptable criteria for hardness

Material	Acceptable hardness range (ISO-48)
EPDM	75 – 85 IRHD
NBR	72 – 85 IRHD
HNBR	75 – 85 IRHD



5.2 TENSILE STRENGTH AND ELONGATION TEST

ISO-37 establishes a procedure for tensile properties evaluation in vulcanized or thermoplastic rubbers. The properties that can be determined are tensile strength, elongation at break, strain at a specific elongation, and elongation at a specific stress.

The configuration of the specimen used must conform to type 1A as specified by ISO-37. The result presented must be an average of at least three specimens tested.

For tensile / elongation tests, the acceptance criterion must be that the tensile strength value is greater than 15 MPa and that the elongation at break is greater than 170%.

Alternatively, to the dumbbell test (ISO-37 standard), the tensile test can be performed with the gasket molded into the final geometry.

5.3 COMPRESSION SET TEST

The compression set test shall be performed in accordance with ISO-815 (except as indicated in this technical specification). The standard covers the testing of rubbers that will be subjected to compression efforts in a liquid or gaseous medium in their application. In this test, the residual deformation of the specimen is measured after the removal of the specimen from the compression device in which it was placed during a specific time undergoing a constant deformation.

The compression applied on the specimen should always be 25% even in cases where the hardness of the elastomer is greater than 80 IRHD.

The test shall be performed at a temperature of 150° C (for HNBR and EPDM gaskets) and at a temperature of 120° C (for NBR gaskets), with a range of $\pm 2^{\circ}\text{C}$ in temperature. The relative humidity should be between 40-60%.

The tests should be performed with a 10 mm stretch of the molded gasket in the final geometry. The result presented must be an average of at least three specimens tested.

For the 72h and 336h times, the samples should stand for 24 hours at room temperature before the tightening is removed.

The compression set values must be measured in the following periods: 24h, 72h and 336h. After taking the measurements on a test body, it should be discarded, and not return to the compression device again for measurements in subsequent periods.

For Compression Set Tests, the acceptance criterion for Qualification Tests is that the values are never higher than: 25% (in 24 hours), 50% (in 72 hours) and 60% (in 336 hours). In addition, the hardness values should also be measured in the 24h, 72h and 336h periods, and the variation with respect to the hardness measurement at room temperature should not exceed 10 IRHD.



5.4 TEAR STRENGTH TEST

ISO-34 should be used as the basis for conducting tear resistance tests on vulcanized elastomers. The tearing of an elastomer is a mechanical rupture process initiated and propagated in a region of high stress concentration, caused by a tear, defect or localized deformation.

Only method C (shown in ISO-34) should be used. The carpet used to make the test piece should have a thickness of $2 \text{ mm} \pm 0.2 \text{ mm}$ and the notch should have a depth of $1 \text{ mm} \pm 0,2 \text{ mm}$ (according to ISO-34 - Method C).

The test shall be performed at the standard laboratory temperature (23°C).

For tear strength, the acceptance criterion shall be that which is greater than 25 kN / m .

5.5 EFFECT OF LIQUIDS TEST

ISO-1817 describes the methods of evaluating the resistance of elastomers to the action of liquids by measuring their properties before and after immersion in test liquids. This standard should be used as the basis for the immersion tests, except at the points indicated by PETROBRAS in this technical specification.

The specimen must be immersed with all its surfaces in contact with the fluid.

The immersion apparatus shall be so designed as to have at least 15 times the volume of the specimen. The apparatus should also avoid evaporation of the test fluid and the ingress of air. A more detailed description is found in ISO-1817.

The specimens shall be of the molded gasket itself, with a length of 10 mm of an already shaped gasket.

Two immersion tests, one with standard oil ASTM IRM-903 and one with distilled water, both at a temperature of 100 ° C, shall be performed. When the gasket to be evaluated is of the EPDM type, only the distilled water test should be performed.

Hardness and volume should be measured before and after immersion in the test liquid. The test approval criteria for the two properties are presented in Table 4, regardless of the gasket geometry used in the test.

Table 4 - Acceptance criteria for effect of liquid test.

Property	Acceptance criteria	
	IRM-903 oil immersion	Distilled water immersion
Hardness	+ 0/-12 units	+ 3/-3 units
Volume	+18 % / -0 %	+3 % / -3 %

Measurement of properties should occur within 72 hours of the start of the test. The result presented must be an average of at least three specimens tested.

After measuring the properties in a test specimen, it should not be immersed again for measurement of properties in subsequent periods, it should be discarded.