

Qualification of non-metallic sealing materials and manufacturers

This NORSOK standard is developed by NTS with broad industry participation. Please note that whilst every effort has been made to ensure the accuracy of this standard, neither OLF nor TBL or any of their members will assume liability for any use thereof. NTS is responsible for the administration and publication of this standard.

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Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for existing and future petroleum industry developments.

The NORSOK standards are prepared to complement available international standards and fill the broad needs of the Norwegian petroleum industry. Where relevant NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

These standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001

The preparation and publication of the NORSOK standards is supported by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Manufacturing Industries). NORSOK standards are administered and issued by NTS (Norwegian Technology Centre).

Annex A, B and C are normative.

Introduction

This revision replaces NORSOK standard M-CR-710, rev. 1.

The intent of this NORSOK standard and the qualification process described herein is to assure that the non-metallic sealing material manufacturer has sufficient understanding and experience with the applicable materials to provide them with acceptable performance in the specified environment. Further that the manufacturer has sufficient insight and experience in the manufacture of such materials and that they are supplied with stable quality to meet given specifications.

The aim is that a successful qualification of a manufacturer and a specific material shall be valid for a majority of future development projects and for different operators.

The consideration of qualification of a manufacturer is at the discretion and determination of the Purchaser, normally on the basis of documentation provided by the manufacturer as required in this standard. A qualification by one Purchaser may also be accepted by subsequent Purchasers, provided the requirements in this standard are still complied with.

The Purchaser is responsible for ensuring if necessary with external competence that the manufacturers selected is qualified.

There does neither exist, nor are there currently plans to introduce a NTS/NORSOK qualification or approval scheme or a public listing of qualified manufacturers in this regard.

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1 Scope

This standard defines the requirements for critical non-metallic (polymer) sealing, seat and back up materials for permanent use subsea, including well completion, X-mas trees, control systems and valves. The standard also applies to topside valves in critical gas systems.

This standard covers the requirements and procedures for qualification of non-metallic (polymer) materials for use in such applications.

2 Normative references

The following standards include provisions, which through reference in this text constitute provisions of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognised standards may be used provided it can be shown that they meet or exceed the requirements of the standards referenced below.

STANDARDS		THERMO-PLASTICS	ELASTOMETERS
ASTM D 395	Standard Test Method for Rubber Property – Compression Set (method B).		X
ASTM D 638	Test Method for Tensile Properties of Plastics.	X	
ASMT D 695	Test Method for Compressive Properties of Rigid Plastics.	X	
ASTM D 746	Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.	X	X
ASTM D 790	Test method for Flexural Properties of Un-reinforced and Reinforced Plastics and Electrical Insulating Materials.	X	
ASTM D 792	Test Methods for Specific Gravity and Density of Plastics by Displacement.	X	X
ASTM D 1414	Methods of Testing Rubber O-rings.		X
ASTM D 1415	Standard Test Method for Rubber property – International hardness (IRHD).		X
ASTM D 1525	Test Method for Vicat Softening Point for Plastics.	X	
ASTM D 2240	Test Method for Rubber Property – Durometer Hardness (Shore A/ D).	X	X
ASTM D 2990	Test methods for Tensile, Compressive and Flexural Creep and Creep Rupture Test of Plastics.	X	
BS 1806	Standard Inch Sizes of O-rings.		X
BS 6442	Specification for limits of surface imperfections on elastomeric toroidal sealing rings (O-rings).		X
DIN 53453	Testing of Plastics, Impact Flexural Test.	X	
ISO 868	Determination of indentation hardness by means of a Durometer (Shore A/ D hardness).	X	X
ISO 1432	Rubber vulcanised – low temperature stiffening (Gehman test).		X
ISO 1817	Vulcanised rubbers – Resistance to liquids – methods of tests.		X
ISO D34	Tear resistance, method A.		X
ISO R 812	Method of test for temperature limit of brittleness for vulcanised rubbers.		X
Description of Arrhenius method: ASTM D 3032; Method of testing hook-up wire insulation.		X	X

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3 Definitions and abbreviations

3.1 Definitions

Accelerated test	A test at temperatures and selected pressure values chosen to accelerate seal degradation effects.
Compression Set, %	$100 \times [(\text{Original seal height} - \text{Post test seal height}) / \text{Interference}]$.
Elastomer	A material compounded from polymers and other constituents, then cured to form a rubbery material.
Fluid (or medium)	A medium which flows without recovery such as a gas, liquid, supercritical gas, or a mixture of these.
Interference	$[(\text{Original seal cross section}) - \text{height of spacer bar (seal fixture recess)}]$ each measured in same direction as direction of compression.
May	Verbal form used to indicate a course of action permissible within the limits of the standard.
Polymer	A high molecular weight organic compound, natural or synthetic, whose structure can be represented by a repeated small unit. Polymer includes thermoplastic and thermoset materials, of which elastomers are a sub-category.
Rapid Gas Decompression (RGD)	Rapid pressure drop in a gas containing system causes the fluid trapped inside an elastomer (polymer) to expand. The pressure drop rate must be faster than the diffusion rate of the fluid inside the polymer.
Room Temperature	20°C (+/- 2°C).
Seal cross-section	The free height of the seal at room temperature, measured normal to diameter in the direction of compression in the test. The measurement shall be taken at three circumferentially equidistributed positions.
Seal Type	A seal design of specified geometry, size and orientation.
Shall	Verbal form used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted, unless accepted by all involved parties.
Should	Verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.
Thermoplastic	A material capable of being repeatedly softened by an increase in temperature and hardened by a decrease in temperature. Applicable to those materials whose change upon heat is substantially physical rather than chemical and that in the softened stage can be shaped by flow into articles by moulding or extrusion

3.2 Abbreviations

COC:	Certificate of Conformance
DSC:	Differential Scanning Calorimeter
DTMA/ TMA:	Differential Thermo Mechanical Analysis/ Thermo Mechanical Analysis
RGD:	Rapid Gas Decompression
QC:	Quality Control

4 Functional requirements

Material selection shall be based on evaluation of compatibility with service environment, functionality under service and the design lifetime. The following shall be considered as appropriate to the seal requirements and evaluated when selecting the material:

- 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 behaviour
- Low temperature flexibility, ASTM D 746 and ASTM D 790

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.

It is the responsibility of the equipment purchaser to provide all necessary information about service conditions and environment.

5 Documentation requirements

Required documentation of material properties is given in Table 1 and 2 for thermoplastic and elastomeric materials respectively. The requirements are valid both for seal materials as well as back-up materials when they are an integral part of the seal assembly. Requirements for documentation of properties and quality control are given. Each seal material used shall be traceable to the producer and his quality control documentation as required in Table 1 and 2 respectively. Each batch of material shall be supplied with a certificate of conformance (COC) and traceability as a minimum.

Tables 1 and 2 in this clause defines also the required minimum amount of production and quality control tests during manufacturing of seal material and back-up materials. The final procedures, with respect to key parameters and tolerances, shall be defined based on results from qualification testing performed according to this Standard. The purchaser shall define the necessary requirements with tolerances in the purchase specification.

Table 1 – Required documentation of thermoplastic material properties

Guidelines on selection of standards are given in parentheses. Characteristics, which are not relevant for expected service conditions and/or material type, may be omitted.

PROPERTIES	Documentation	QC test
• Softening point (ASTM D 1525).	D	
• Specific gravity (ASTM D 792).	D	B
• Hardness (ISO 868/ASTM D 2240, Shore D).	D	B
• Tensile properties and elongation (ASTM D 638).	D	B
• Compression properties (ASTM D 695).	D	
• Impact strength (DIN 53453).	D	
• Measurement of glass transition temperature by DSC.	D	
• Resistance to creep under permanent tensile and compressive loads (ASTM D 2990).	D	
• Ageing characteristics (Annex C).	D	

Table 2 – Required documentation of elastomeric material properties

Guidelines on selection of standards are given in parentheses. Characteristics, which are not relevant for expected service conditions and/or material type, may be omitted.

PROPERTIES	Documentation	QC tests
• Specific gravity (ASTM D 792)	D	B
• Hardness (Shore A/IRHD) (ISO 868, ASTM D 2240/ASTM 1415).	D	B
• Tensile and elongation properties (ASTM D 1414).	D	B
• Compression set (ASTM D 395/ASTM D1414) at 100°C for 7 days in Nitrogen atmosphere.	D	
• Low temperature characteristics by DSC or DTMA.	D	
• Tear resistance (ISO D 34).	D	
• Gehman plot (ISO 1432) +20°C to -20°C.	D	
• Ageing/RGD characteristics (Annex A/B).	D	

LEGEND for Table 1 and 2:

- D: Properties to be documented for each supplier for each type of material.
Nominal values with tolerances shall be given (Data Sheet).
- B: Properties to be documented on a batch-wise basis, minimum 3 samples per test per batch.
The acceptance criteria shall be established prior to the test and based on qualification test results.

6 Requirements for qualification of manufacturers

6.1 General requirements

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 or rubber formulations 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 polymer and elastomer 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.

It will not be necessary to perform qualification testing, should well documented in-service experience with traceable production records and quality control documentation be available. Such documentation shall contain detailed information on service conditions such as time, temperature, pressure, fluid composition and chemicals added. An 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

The qualification shall apply for each specific seal material made of either polymer or elastomer materials 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.