

PS:3087-2017(1st Rev)

**PAKISTAN STANDARD SPECIFICATION
FOR
FLEXIBLE POLYURETHANE FOAM**



PAKISTAN STANDARDS AND QUALITY CONTROL AUTHORITY,
STANDARDS DEVELOPMENT CENTRE,
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SPECIFICATION FOR FLEXIBLE POLYURETHANE FOAM

0. FOREWORD

- 0.1 This Pakistan Standard was adopted by the Pakistan Standards & Quality Control Authority on 28th February 2017, and finalized by the Plastic and Plastic Products technical committee had been approved by National Standards Committee for Chemical.
- 0.2 This Pakistan Standard was first published in 1991. This revision has been prepared based on the Views/recommendations of consumers, manufacturers foam specialists, Chemists, Chemical Engineers, Scientists and other stakeholders have been given full consideration. The trade practice followed in the country has also been kept in view.
- 0.3 This standard has been formulated to ensure the production and supply of a satisfactory quality of flexible polyurethane foam manufactured in Pakistan and imported from other countries. The foam is a specially manufactured chemical compound and it should not contain impurities or harmful residues such as amines which are volatile and driven off by the heat generated in the formation of foam. A number of adhesives are used in the manufacture of foam mattresses. Any adhesive used should be either nitride or neoprene based. If neoprene based adhesives are used, it shall not have acidity more than pH 3.5. The adhesives should be able to withstand heat and moisture treatments as effectively as the foam itself.
- 0.4 Flexible polyurethane foams are manufactured by the simultaneous reactions of polyol(s) and water with an isocyanate, in the presence of various additives. During the reaction, gas bubbles are generated and trapped to form a cellular structure. Within minutes a liquid mixture is transformed into a low-density cellular solid. Foams of different structures, feel, and density can be manufactured. The isocyanate and polyol are completely reacted during manufacture and the foam, as supplied, contains no free isocyanate. The foam is sterile and at normal temperature presents no risk to health. Special protective clothing and equipment is not necessary when handling foam since it does not irritate the skin, eyes, or respiratory system except in those processes where foam dust is produced. Non-foaming applications normally do not contain blowing agents. Depending on the type of polyol and isocyanate used the generated foam exhibits different properties. By careful selection of the polyol and isocyanate, foam with varying properties can be generated. It could be soft and flexible with totally open cells, which are used in the furniture industry to very hard dense wood like closed cell rigid foam. The non-foam applications are generally in the coatings, adhesives, sealants and elastomers (CASE). The various categories are:-
- Flexible slab stock
 - Flexible cold cure moulded
 - Rigid foam
 - Footwear or micro-cellular
 - Coatings, adhesives, sealants and elastomeric applications
- 0.5 In the preparation of this standard assistance has been taken from Indian standards with reference to Polyurethane foam.
- 0.6 This standard contains clauses 3.3, 3.4, 3.6 and 4.1 which call for agreement between the supplier and the purchaser.
- 0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with PS: 103-1991(1st R) "Rules of rounding of numerical values". The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

- 1.1 This standard prescribes the requirements and the methods of sampling test for flexible polyurethane foam for domestic mattresses.

2.0 Normative References

The following referenced documents are indispensable for the application of this document. For dated

references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

1. ISO 5999:2013: Flexible cellular polymeric materials -- Polyurethane foam for load-bearing applications excluding carpet underlay -- Specification
2. ISO 6915:1991: Flexible cellular polymeric materials -- Polyurethane foam for laminate use -- Specification
3. IS: 7888 – 1976: Methods of Test for Flexible Polyurethane Foam.
4. IS: 7933 – 1975: Specification for Flexible Polyurethane Foam for Domestic Mattresses.
5. IS 9806: 2001:
6. ASTM D3574-03: Standard Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams.

3. TERMINOLOGY

- 3.1 For the purpose of this standard: definitions given in PS: 2778-1990 and PS: 2779-1990 shall apply.

4. REQUIREMENTS

- 4.1 **Constituents**—The mattress core shall be flexible polyurethane foam of polyether or polyester type which is defined as expanded cellular product produced by interaction of poly-hydroxyl compounds, water and isocyanates. The foam shall consist of cells of uniform characteristics which are essentially open and inter-connecting.

- The core may be of one, two or more inches of different densities and must comply with the specified requirements in terms of its gauge.
- Different constructional designs like full foam, laminated layers, profiled layers, etc, are also permitted.
- *Use of inorganic filler (e.g. Calcium Carbonate) is strictly prohibited in the product.*

- 4.2 **Condition**—The foam core shall be clean in appearance and free from any objectionable odour and any residual amines likely to be harmful to human tissues.

- 4.3 **Colour**— Colour of the polyurethane foam core shall be as agreed to between the purchaser and the supplier. *Different colors may be assigned to different densities.*

4.4 Dimensions and Tolerances

- 4.4.1 **Dimensions**—Dimensions shall be as specified by the purchaser provided they fall within the following limits: *dimensions cannot be specified for mattress, instead dimensions can be specified in inches (not in mm) in case of sofa seat. Below 1 inch, mm may be assigned.*

Length: variable in inches

Width: variable in inches

Thickness: 2,3,4,5,6 inches and onwards in inches in case of mattress, cushion, sofa seat. Slab sheets lesser than 25.4 mm will be used for industrial purpose.

4.4.1.1 Tolerances

The tolerances on length and width shall be as given below:

Length and Width(mm)	Tolerance (mm)
750 to 900	-0 } +10 }
901 to 1 350	-0 } +25 }
1351 to 2000	-0 } +40 }

Thickness	Tolerance
75 to 150mm	-0 } +5mm }

4.5 **Indentation Hardness Characteristic** —The load quotient determined as prescribed in Appendix “A” of this standard, with a sample of 380 X 380 X 100 mm shall not be less than 19: 1.

4.5.1 When the thickness of the specimen is not representative of the mattress core as a whole as in laminates or profiled construction the test shall be performed on the complete thickness of the core.

4.6 **Indentation Hardness Index**— Indentation hardness index is the load required to produce a deflection of 40 percent of initial thickness of the sample in accordance with the method described in A-3 of Appendix A of this standard. The value shall be as agreed to between the purchaser and the supplier. When the thickness of the test specimen is not representative of the core as in the case of laminates or profiled construction, the test shall be performed on the complete thickness of the core.

4.7 **Density**

Overall density of mattress core shall be not less than 22 kg/m³. Lowest density for mattress is 22±1 kg/m³ and above.

Density	Usage life	Color
1. 30±1 and above	12 years max	Only Black
2. 27±1	07 years max	Any Color except black
3. 25±1	05 years max	Any Color except black
4. 22±1	03 years max	Any Color except black
5. 18±1	For Industrial Use	Any Color
6. 12±1	For Industrial Use	Any Color

Industrial application: Minimum density for slab sheet is 12 kg/m³ and 18 kg/m³----any color.

Note: Sofa Sheets, Cushions, Slab Sheets, Mattress dimensions shall be measured only in inches and not in mm. under gauge is not allowed and will be treated as non conformance with the specifications.

4.8 **Tensile Strength** – Tensile strength of the foam shall be not less than 1 kgf/cm² (98 KN/m²) when tested as prescribed in Appendix B of this standard.

- 4.9 **Heat Ageing**—When the foam is subjected to the heat ageing test as prescribed in Appendix C of this standard, the tensile strength shall not be less than 70 percent of initial value as specified in 3.8.
- 4.10 **Compression Set** -When the foam is tested in accordance with the requirements as prescribed in Appendix D of this standard, the compression shall not be more than 10 percent.
- 4.11 **Durability** —When the foam sample is subjected to the fatigue test as described in Appendix E of this standard, The loss in 25 percent indentation hardness characteristics tested as specified in 3.6 shall not be more than 30 percent of the initial value and the reduction in thickness shall not be more than 10 percent of the initial value.

5. PACKING AND MARKING

- 5.1 **Packing**—the material shall be packed as agreed to between the purchaser and the supplier.

NOTE— To avoid deterioration of foam mattresses during storage, it shall be kept in well-ventilated rooms edgewise away from direct sunlight and not exposed to ultraviolet light.

- 5.2 **Marking:** The packages shall be marked with the following information by a non-staining ink:
- Name of the manufacturer and trade-mark, 3 any;
 -
 - Month of manufacture; and
 - Dimensions of the mattresses.
- Note: Size, thickness, length and width shall be considered for mattress and cushion and not for slab sheets.
- 5.2.1 The material may also be marked with the Pakistan Standard Mark.

NOTE— The use of Pakistan Standard Mark is governed by the provisions of the PSQCA act, VI of 1996 and the conformity assessment rules made there under.

The Standard Mark on products covered by Pakistan Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by PSQCA. Stand and marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a license for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the PSQCA.

6. SAMPLING

- 6.1 The sampling shall be done as prescribed in Pakistan Standard Methods.

APPENDIX A INDENTATION LOAD DEFLECTION TEST

- A.1 Apparatus** —Apparatus consists of a flat circular indenter foot of 323 cm² surface area, connected by means of a swivel joint to a load measuring device and mounted in such a manner that specimen can be deflected at a fixed speed of 2 to 3 mm per second. The indenter is moved up and down pneumatically. The load measuring device shall have accuracy of ± 1 percent or ± 0.1 kg whichever is greater. The apparatus shall be capable of measuring the sample thickness with an accuracy of ± 0.25 mm. The base of the apparatus shall be a horizontal plate with perforations for a rapid escape of air during the test.

- A.2 Test Specimen**— Cut the specimen from the slab which has been cured at room temperature for 48 hours. The dimensions of specimen shall be not less than 380 x 380 x 50 mm with thickness

in the direction of the rise of foam so that the stress placed is parallel to the direction of rise of foam. Condition the test specimen for 6 hours at $27 \pm 2^\circ\text{C}$ and 65 ± 5 percent relative humidity before testing. Samples of less than this standard thickness shall be plied together to reach as near the standard thickness as possible.

A.3 PROCEDURE

A.3.1 **Pre-flexing of Test Specimen** — Carry out pre-flexing of test specimen.

A.3.2 Place the specimen centrally under the indenter foot. Apply 1 kg load on the test area and measure the thickness (t_1). Compress the test piece by means of the indenter foot at the specified rate of 2 to 3 mm per second to produce an indentation of 70 percent of the thickness t_1 . Hold the deflection for 1 minute and raise the indenter rapidly until clear of the test piece.

Apply 1 kg load again after an interval of 45 seconds to the test area and maintain for 15 seconds. Measure the thickness (t_2) and apply the indenter immediately at the specified rate to produce an indentation of 25 percent of the thickness t_2 . Measure the load after the deflection has been maintained for 30 seconds. Increase the deflection to 65 percent of thickness t_2 and maintain for 30 seconds. Measure the load and then remove the load clear of the test piece.

A.3.3 When hardness number is to be determined at 40 or 50 percent, the following procedure shall be followed:

Apply a load of 1 kg on the selected area and measure the exact thickness (t). Compress the test piece by means of the indenter at specified rate to produce indentation of 70 percent of the thickness t_1 . Hold the indenter at this deflection for a period of one minute and raise the indenter rapidly until clear of the test piece. Again apply 1-kg load after an interval of 45 seconds and maintain for 15 seconds and measure the thickness (t_2). Then compress again at the specified rate under load to produce 40 or 50 percent deflection. Note the load, after maintaining at 40 or 50 percent deflection for 30 seconds. Raise the indenter clear of the test piece

A.4 Calculation and Reporting

Hardness number, 25 percent = Compressive stress at 25 percent deflection

$$= \frac{\text{Load at 25 percent deflection}}{323 \text{ cm}^2}$$

Hardness number, 65 percent = Compressive stress at 65 percent deflection

$$= \frac{\text{Load at 65 percent deflection}}{323 \text{ cm}^2}$$

Hardness number, 40 percent = Compressive stress at 40 percent deflection

$$= \frac{\text{Load at 40 percent deflection}}{323 \text{ cm}^2}$$

Hardness number, 50 percent = Compressive stress at 50 percent deflection

$$= \frac{\text{Load at 50 percent deflection}}{323 \text{ cm}^2}$$

$$\text{Load quotient} = \frac{\text{Hardness No., 65 percent}}{\text{Hardness No., 25 percent}}$$

NOTE - Hardness number 25 percent, 40 percent, 50 percent and 65 percent are also known as 25 percent, 40 percent, 50 percent and 65 percent indentation load deflection values respectively

APPENDIX B TENSION TEST

B.1 Apparatus-The apparatus consists of a power driven machine (medium load tensile tester) with the following provisions:

- a) Sensitive dial indicator which remain at the point of maximum load after rupture of the specimen and measures the tension at the point,
- b) Suitable grips for holding the specimen,
- c) Rate of travel of power actuated grip shall be 500 ± 50 mm per minute and uniform at all times, and
- d) The total capacity of the tester is such that the ultimate load is at least one-fifth of the total capacity of the machine.

B.2 Test Specimen - Punch the specimen in the shape of a dumb-bell shown in Fig. 1 by means of a sharp die out of a foam sheet of 10 or 20 mm thickness. The foam sheet shall be cut vertically in the direction of the rise of the foam with the help of a splitting machine, from the foam slab cured at room temperature for 48 hours. Condition the test specimen at $27 \pm 2^\circ\text{C}$ and 65 ± 5 percent relative humidity for 6 hours before testing.

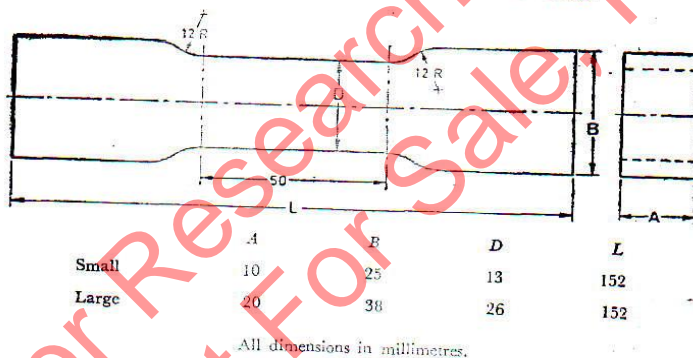


FIG-1 DUMB-BELL Test Piece

B.3 Number of Specimens - Three specimens shall be tested.

B.4 Procedure

- B.4.1 Determine the thickness and width of the specimen accurately by means of a vernier caliper or soft material thickness gauge as described in 3. Make two gauge marks 50 mm apart as shown in Fig. 1.
- B.4.2 Clamp the specimen in the grips. The minimum separation between the grips shall be 65 mm. Adjust the specimen symmetrically between the grips for uniform distribution of the tension applied over the cross-section.
- B.4.3 Start the machine and note continuously the distance between the two gauge marks and record the distance at rupture. Note the load indicated on the dial.

B.5 Calculation and Reporting

$$\text{B.5.1 Tensile strength (B), kg f/cm}^2 = \frac{F_{\max}}{A}$$

Where

F_{\max} = force at failure of the specimen in kg f, and
 A = original cross-sectional area in cm^2 .

B.5.2 Tensile Stress

$$\text{Tensile stress } (\sigma_t), \text{ kgf/cm}^2 = \frac{f_t}{A}$$

Where, F_t = Force at specified elongation in kgf, and
 A = Original cross-sectional area in cm^2 .

B.5.3 Ultimate Elongation (Elongation at Break)

$$\text{Ultimate elongation } E_b, \text{ percent} = \frac{L_b - L_0}{L_0} \times 100$$

Where, L_b = length between the gauge marks in mm at the time of failure, and

L_0 = original length between the gauge marks in mm.

B.5.4 Report the averages of the three specimens tested.

APPENDIX C AGEING TEST

C.A HUMIDITY AGEING TEST:

C.A.1 **General**-The test specimen is subjected to low pressure steam and the effect on the physical properties observed.

C.A.2 **Test Specimen** - The number, size and shape of test specimens shall be appropriate to the property being examined and shall be prepared before the test.

C.A.3 **Procedure**---The specimens shall be tested not less than 48 hours after manufacture. They shall be conditioned immediately before testing for not less than 6 hours at 27 ± 2 °C and 65 ± 5 percent relative humidity. Place the specimen in a steam pressure vessel and add just sufficient distilled water avoiding wetting the specimen. Heat the vessel to 105 °C. Expel the air from inside by leaving the safety valve open until the steam blows out of the opening. Close the valve and maintain the temperature for 3 hours. After the expiry of the test period, open the pressure vessel and remove the specimen. Dry at 70 ± 1 °C in an air-circulating oven at the rate of 3 hours per 25 mm of thickness, subject to a minimum of 3 hours. Condition the specimen after removal from oven for at least 2 hours and not more than 24 hours at room temperature and 65 ± 5 percent relative humidity. Test the conditioned specimen for the particular physical property and express the result as the change from those of un-aged specimen.

C.B HEAT AGEING TEST:

C.B.1 **General**-The test consists of subjecting the test specimen to dry heat and observing the effect on its physical properties.

C.B.2 **Test Specimens** - same as above

C.B.3 **Procedure** - The test specimens shall be tested not less than 48 hours after manufacture. Condition the specimen immediately before testing for a period of not less than 6 hours at 27 ± 2 °C and

65 ± 5 percent relative humidity. Place the specimen in a thermostatically controlled oven with air circulation and maintain the temperature at 140±1 °C for 16 hours. After the expiry of the test period remove the specimen from the oven and condition it at room temperature for at least 2 hours but not more than 24 hours at 65±5 percent relative humidity. Test the conditioned specimen for the particular property and express the result as the change from those of un-aged specimens.

APPENDIX D COMPRESSION SET TEST:

D.1 General - The test consists of maintaining the foam specimen under specified conditions of temperature and observing the degree of recovery within a specified time after release.

D.2 Apparatus - The apparatus consists of two flat plates of 200 x 200 mm, with appropriate spacers and clamps to keep the plates parallel to each other when clamped with specimen between the plates.

D.3 Test Specimen - Cut the test specimen from a foam slab which has been cured for 48 hours at room temperature in such a way that the load is applied in the direction of the rise of the foam to get specimen of 50 x 50 x 25 mm. Test specimens shall be free from any contamination and skin on the vertical sides. When thin materials are to be tested, sufficient specimens of 50 x 50 mm shall be taken so that the sum of their thickness before compression is at least 25 mm. The specimens shall be plied together and interleaved with photographic glass-mounting slides where the number of plies is greater than two, and the complete assembly shall be treated during the test as a single thick specimen.

D.4 Condition the test specimens at 27±2°C and 65±5 percent relative humidity for 6 hours before testing. A minimum of 3 specimens shall be tested for 50 or 75 percent compression of its thickness. In special cases + compression of 90 percent may be agreed upon.

D.5 Procedure - A soft material dial thickness gauge is used for measuring the thickness of the specimen. In case of thin material calculate the thickness of the foam by deducting the aggregate thickness of the glass slides from the measured total thickness of the assembly. The specimen shall then be put between the plates and with the help of spacers subjected to 50 percent deflection. The whole assembly is then stored under standard atmospheric conditions for 70 hours or at 70±2°C for 22 hours. After this duration, the plates are removed and the specimen is allowed to recover for at least 30 minutes under standard testing conditions. The thickness is measured again with the soft material dial thickness gauge. The same procedure is followed for 75 or 90 percent deflection.

D.6 Calculation and Reporting:

Compression set at the rate of 50 percent deflection = $h_0 - h_{50}/h_0 * 100$,

Compression set at the rate of 75 percent deflection = $h_0 - h_{75}/h_0 * 100$

Compression set at the rate of 90 percent deflection = $h_0 - h_{90}/h_0 * 100$

Where h_0 = original height of the specimen in mm,

h_{50} = final height of the specimen in mm after 50 percent deflection test,

h_{75} = final height of the specimen in mm after 75 percent deflection test, and

h_{90} = final height of the specimen in mm after 90 percent deflection test.

Average of the values obtained from the three samples tested shall be reported.

APPENDIX E SHEAR FATIGUE TEST

E.1 Apparatus – The apparatus consists of the following:

- a) A perforated moving platform (perforated base platen) with 6 mm diameter holes at 19 mm centre distance;
- b) Provision for movement of the above platform at the rate of 28 cycles per minute and stroke length of 330 mm;

c) A stationary roller 460 mm long and 75 mm in diameter mounted in an off-set position (15") with suitable mesas for adjustment for: 1) loading the test piece so that a specified deflection is maintained: and 2) deflecting the test specimen so that a specified load is maintained.

E.2 Test Specimen - Cut a test specimen of 380 x 380 mm and of desired thickness (preferably 50 mm) from a foam slab with thickness in the direction of rise of foam so that the stress applied is parallel to the direction of rise of foam. Condition the test specimen at 27 & 2°C and 65 & 5 percent relative humidity for 6 hours before testing.

E.3 Procedure. (a) Test Under Constant Deflection Condition - Subject the specimen to indentation load deflection test and note the reading. Place the specimen centrally on the perforated base platen and secure it by means of double sided adhesive tape. Bring down the roller on to the specimen and then adjust for a constant deflection of 65 percent of its original thickness. Switch on the machine and keep the specimen under the above conditions for 20,000 cycles (40,000 flex) at the specified frequency of the movement of the table and stroke length.

(b) Test Under Constant Load Condition - Subject the specimen to indentation load deflection test and note the readings. Then place the specimen centrally on the perforated base platen and secure it by means of double sided adhesive tape. Bring down the roller on the specimen by the application of necessary load so as to achieve test under constant load condition. Switch on the machine and keep the specimen under above conditions for 20,000 cycles (40,000 flex) at the specified frequency of the movement of the table and stroke length.

(c) In both the above conditions of test, allow a recovery period of 30±10 minutes after 20,000 cycles and perform the indentation load deflection test as described and note the readings.

E.4 Calculation and Reporting: Percentage loss in load deflection (F1) = $L_0 - L_f/L_0 * 100$

Where L_0 = Original load deflection value, and
 L_f = Final load deflection value.

Percentage loss in thickness (Ft) = $t_0 - t_f/t_0 * 100$

Where t_0 = original specimen thickness in mm, and

t_f = final specimen thickness in mm.

Check the specimen for physical breakdown of cellular structure by visual examination and compare with the un-flexed specimen.

NOTE - Percentage loss of load deflection is to be reported only if the percentage loss in thickness is less than 10 percent.