Technical Paper

Subject Area: Car Seat Comfort – PU Foam Pad

Study of:

How to check Hardness of Car Seat PU Foam Pads

and

Relationship between Hardness checking Indentor size and Hardness

Conducted at:

Spack Automotives Pvt. Ltd, Greater Noida

Vania A Chopra

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1. Introduction to Seat Comfort

Polyurethane Foam has many uses, it is predominantly used for comfort and insulation, in the Automotive Industry it is mainly used to make PU Foam cushions for Seating.

PU Foam gives the shape, support, comfort and style to the occupant in a car seat, it absorbs the shocks and vibrations that are generated during the drive. PU Foam is has many properties, the most important for an occupant being hardness or the firmness, when we sit in a car seat, we either feel it is too soft or too hard, this property of Foam is called hardness. The hardness specification is decided by the car company and the seat design company, usually they use a comfort expert for this. Factors that are considered in deciding the hardness value is the vehicle type (Car – sedan, luxury, ultraluxury, SUV, pick up, sports, off road or on road) , the seating position, the thickness and density of the foam, the type of vehicle suspension, the vibrations that are transmitted from the vehicle floor to the seat and based on a study using a pressure map.

One of the properties which can determine comfort factor of foam is Hardness, hence it is the 1st parameter to be defined by seat designers. [1]

Hardness is measure of a materials resistance to surface deformation, penetration or indentation.

All Auto OEMs follow their own standards on achieving the Hardness. The method to derive the hardness value differs from one standard to another. Few examples are ISO (International Organization for Standardization) Standard, ASTM (American Society for Testing and Materials) Standard, JIS (Japanese Industrial Standards) Standard, Toyota Engineering Standard, etc.

Mostly, all the test methods, irrespective of the standard, go for indentor with 200 mm diameter (it is a circular metal part attached to the Hardness testing Machine, which makes physical contact with the foam pad to give the hardness value, which it does with the help of a load cell attached to it). However, depending on the shape & size of the foam pad, the indentor size may have to be

changed. An example of this is a Headrest Foam Pad where an indentor with 50 mm diameter is used.

In cases of some Seat PU Foam geometry a diameter 200m indentor is too large and does not sit flat on the surface of the foam to measure the hardness value as per the standard. In these cases the PU Foam moulding company and the Seat manufacturer are challenged as to how to check the PU Foam hardness value so as to achieve the hardness specified in the drawing. Getting a drawing modified is a long process and due to procedural requirements it can only be done thru and Engineering Change Note "ECN," which is a long process with many levels of approvals required.

To solve this problem, a smaller indentor can be used. This further causes problem where the designer is unable to give a new Hardness value related to the new indentor immediately but the development and production teams need the same to complete the development activity and start production.

This Technical Paper focuses on the relation and comparison between Hardness Value And Indentor Size, where using indentor with different size on a test piece as per JIS & ASTM standards leads to change in hardness value.

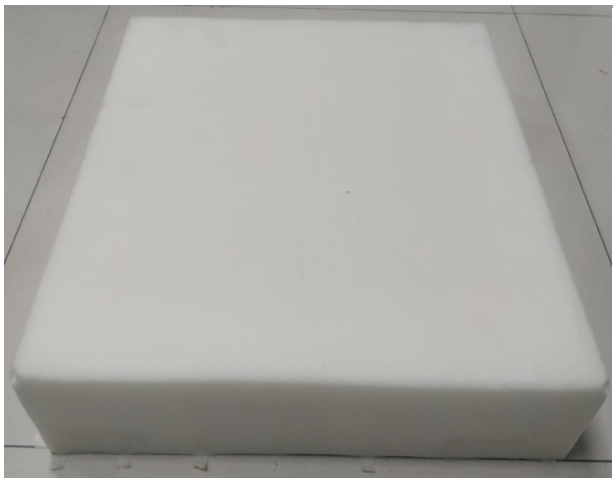
2. DEFINITIONS

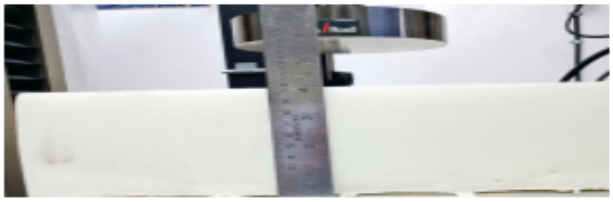
- **Core:** the internal portion of a molded part, free of skin. [2]
- **Molded foam**: a cellular product having the shape of the enclosed chamber in which it is produced by foaming, by mixing Isocyanate and Polyols. [2]
- **Skin**: the smooth outer surface layer of a molded foam product, formed by contact with the mold or surfaces. [2]
- **Slab**: a section of foam that is cut from the internal portion of a large bun. [2]
- **Urethane foam**: a flexible cellular product produced by the interaction of active hydrogen compounds, water, and isocyanates.[2]
- **Indentation Hardness**: The total force, in newtons, required to produce, under specified conditions, a specified indentation of a standard test piece with a standard apparatus using the test procedure specified. [3] This can also be specified in kilogram-force.
  Indentation tests are commonly used in production environment because they more accurately predict performance during use. [4]
- **Kilogram-force:** is a non-standard gravitational metric unit of force. It is equal to the magnitude of the force exerted on one kilogram of mass in a 9.806 m/s^2 gravitational field.
- **Density**: measure of mass per volume.
- **Foam Conditioning**: is the temperature & humidity conditions which must be met for a specific period of time before checking hardness of the foam.

3. REQUIREMENTS

The material and testing equipment requirements for both JIS & ASTM Standards are as follows:

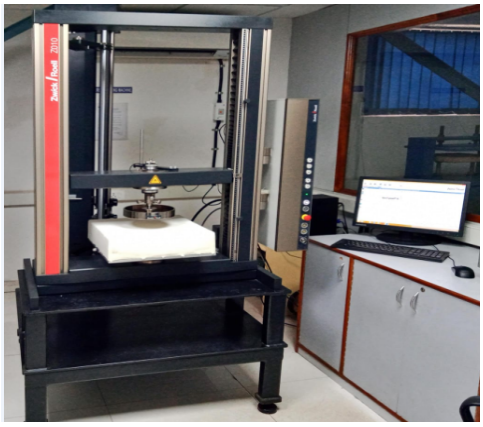
a) **Test Piece** – the size of 400 X 400 X 100 mm is used.





b) **Hardness Testing Machine**

Indian made Hardness Testing Machine



Zwick, Switzerland Hardness testing UTM

(Zwick Machine used for hardness testing)

c) **Supporting Surface** – a table with smooth & solid surface is used.

d) **Indentor** –

Indentor Diameter (mm)	Photo
200	
100	
80	
50	

4.a Japanese Industrial Standards: JIS

The standard used to check hardness is **JIS K 6400. : 1997**

Standard is produced below: [5]

Sampling method of test piece:

The test pieces are to be tested after elapse of 72 hrs. or longer from the production. However, for delivery test, the test can be done after 12 hrs. from production.

Conditioning of test piece:

This is done to condition the test piece to an ambient atmosphere, time period is 16 hrs. However for delivery test, it is 6 hrs.

a) 23±2°C temperature, 50±5% relative humidity – 16 hrs.

b) 23±5°C temperature, 50^{+20}_{-10}% relative humidity – 6 hrs.

Hardness Method:

We will follow Method A as is decided by & used for the Customer.

Method A:

The test piece is placed flatly on the center of table.

The initial thickness is measured when the indentor touches the upper surface of test piece with a load of 5^{0}_{-2} N.

Then, the indentor is pushed to (75±2.5) % of initial thickness at a speed of (100±20 mm/min.) & is immediately pulled up.

The indentor is immediately pushed to (25±1) % of initial thickness at the same speed & kept at that position for 20 seconds.

The hardness reading is measured after the end of 20 seconds & is taken as the final value of the Test Piece Hardness.

4.b American Society for Testing and Materials

ASTM STANDARD

The standard used to check hardness is **ASTM D 3574 – 08**

Standard is produced below: [6]

Sampling method of test piece:

The test pieces are to be tested after conditioning for at least 12 hrs. before the test.

Conditioning of test piece:

23±2°C temperature, 50±5% relative humidity – for at least 12 hrs. before the hardness test.

Hardness Method:

We will follow Method B1 as is decided by & used for the Customer.

Method B1:

The test piece is placed flatly on the center of table.

The initial thickness is measured when the indentor touches the upper surface of test piece with a load of 5^{0}_{-2} N.

Then, the indentor is pushed to (75±2.5) % of initial thickness at a speed of (250±20 mm/min.) & is allowed to rest at that position for 6±1 minutes. After this time period, indentor moves towards its initial position.

The indentor is then pushed to 50% (pre-decided with customer) of initial thickness at a speed of (50±5 mm/min.) & kept at that position for 60±3 seconds.

The hardness reading is measured after the end of time period & is taken as the final value of the Test Piece Hardness.

5. Relationship between Indentor size and Hardness

A test piece with the specified dimension was produced.

This was conditioned for 12 hrs. (Overnight) before the 1st hardness test was conducted on it using JIS Method with 200 mm diameter indentor.

Hardness test according to ASTM Method was conducted on a similar test piece with 200 mm diameter indentor.

The JIS & ASTM tests were done consequently on the respective test pieces after proper conditioning over the following days using indentor with different diameters.

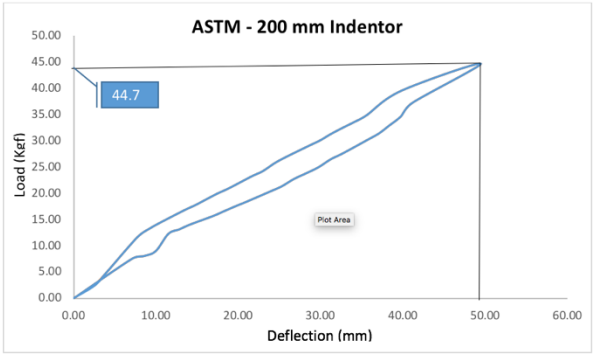
The result of the trial is depicted in below table.

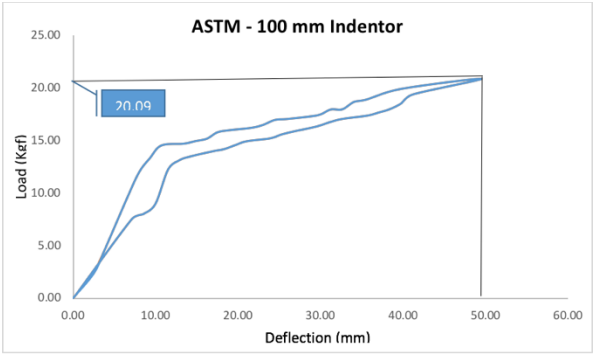
Hardness of Test Piece in Kgf				
Method	**Indentor – Ø200 mm**	**Indentor – Ø100 mm**	**Indentor – Ø80 mm**	**Indentor – Ø50 mm**
JIS @ 25% Compression	24.89 Kgf	9.31 Kgf	7.35 Kgf	4.96 Kgf
ASTM @ 50% Compression	44.7 Kgf	20.09 Kgf	16.46 Kgf	12.37 Kgf

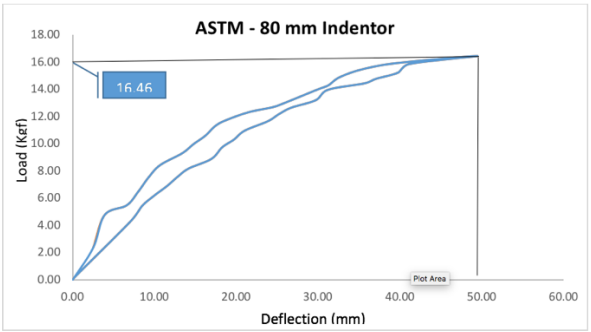
Load – Deflection Curve is made by the hardness checking machine software where it compares the deflection of the test piece with the corresponding deflection during the last & final compression at the end of which the hardness value of the foam pad is depicted. This is used to check the "Bottoming-out" effect, i.e., loss of comfort over a period of time. [7]

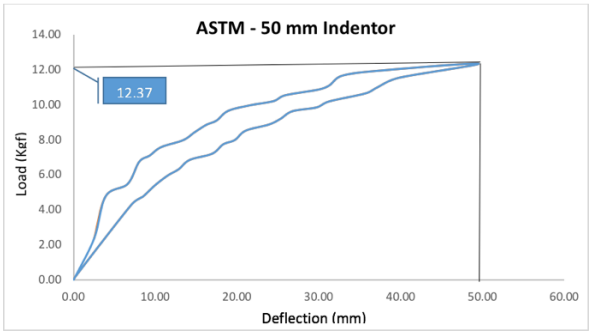
The following graphs are Load - Deflection Curves for the tests conducted during the trial.

Load Deflection Curve with Standard **ASTM D 3574 – 08**

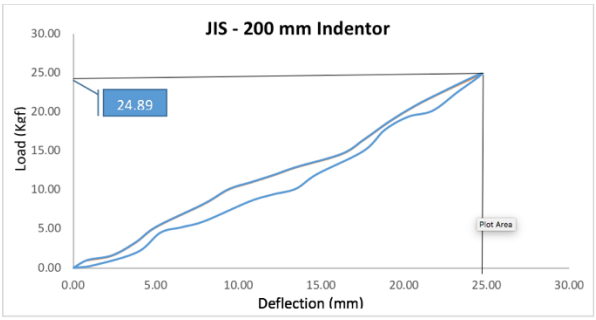


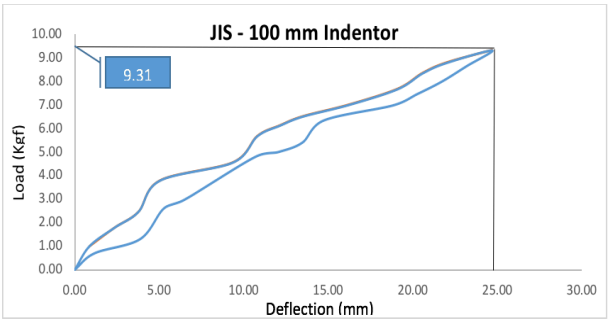


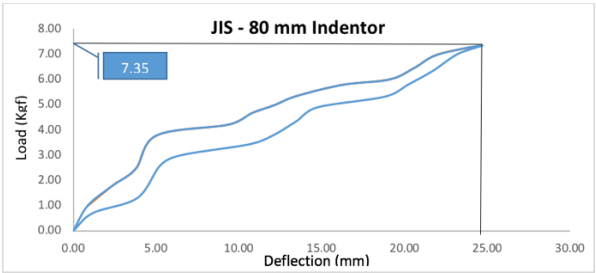


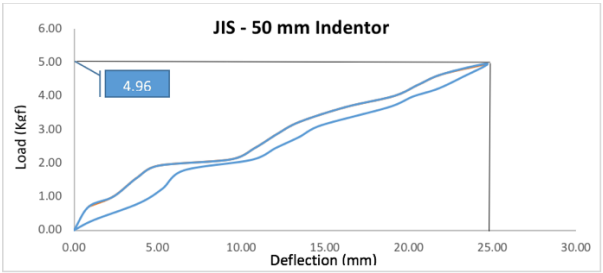


Load Deflection Curve with Standard **JIS K 6400 : 1994**









6. CONCLUSION

Hardness Value Change % from Ø 200 mm Indentor to Indentor of Ø 100mm ; Ø 80mm ; Ø 50mm			
Method	**Indentor – Ø100 mm**	**Indentor – Ø80 mm**	**Indentor – Ø50 mm**
JIS @ 25% Compression	63%	70%	80%
ASTM @ 50% Compression	55%	63%	72%

From the above exercise we conclude that hardness value changes to lower side in moulded PU Foam Pads in cases where we use indentor of diameter 100mm or 80mm or 50mm in comparison to an indentor diameter of 200mm.

REFERNCES

[1] The Polyurethanes Book – Wiley (2002), pg. 190
[2] ASTM D 3574 – 08, pg. 1
[3] EN ISO 2439 – February 2001, pg. 3
[4] The Polyurethanes Book – Wiley (2002), pg. 180
[5] JIS K 6400. : 1997, pg. 2, 4 & 5
[6] ASTM D 3574 – 08, pg. 2 & 3
[7] The Polyurethanes Book – Wiley (2002), pg. 184