Stellchem Polymer – Rhino Wood Repair (RWR) Mechanical Properties Testing Report

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***Abstract:* In this report the results of the mechanical properties (tensile strength, flexural strength and hardness) of Stellchem's polymer; Rhino Wood Repair (RWR) is discussed. The tests were done based on the ASTM standards for wood based materials. ASTM D3500 – Tensile strength test, ASTM D3043 – Flexural strength and ASTM D143 – Hardness testing. The values evaluated from the tests are compared with commonly used softwoods and hardwoods.**

I. Introduction

The product under study, Stellchem's polymer Rhino Wood Repair (RWR) is an affordable permanent wood repair solution and has far superior uses to replace damaged or rotten wood. It could be used on any damaged rotten wood components, it is perfect for beams, posts, structural applications, furniture, antiques, floors, etc. The further advantages of this polymer are that it can be drilled, molded to required shape, sculpted, painted, stained and even texturized like the regular wood material. The RWR material has been tested for various mechanical properties based on the ASTM standards and compared with some of the commonly used wood. The results of these tests are presented in sections II – VI. Further details are given in Appendices 1 – 3.

II. Tensile Strength (ASTM D3500)

Tensile testing is a procedure where a sample is subjected to a controlled tension until failure. This test is used to predict how the material will react under force. It depicts the property ultimate tensile strength of a material.

The Specimens were prepared based on the ASTM D3500 standards. The pictures of the sample templates and the load deformation graphs are shown in Appendix 1. ADMET Expert 2 Tensile test equipment was used to perform the testing. All the procedures used for testing are given in Appendix 3.

The data sheet (Table 1) shows the results from five different samples. The data submitted has a standard deviation of 1390 psi. This is an acceptable range given the measurements are in thousands psi. The obtained values of tensile stress are compared with the tensile stress values of some commonly used wood materials and the comparison is shown Table 2.

Table 1: Tensile stress [1]

RWR Sample	Maximum Load (N)	Tensile Stress (Psi)
Sample 1 (T1)	256.8	19550
Sample 2 (T2)	212.20	16157
Sample 3 (T3)	249.10	18966
Sample 4 (T4)	239.10	18207
Sample 5 (T5)	255.00	19415
Average:		**18459**

Table 2: Comparison with commonly used wood material [2]

Material	Tensile Stress (Psi)	RWR strength
Douglas fir	15600	18.32% stronger
Pine	10600	74.14% stronger
Maple	15700	17.57% stronger
Oak	11300	63.35% stronger

As can be seen from Table 2 and Figure 1, Stellchem's polymer (RWR) exceeds Tensile strength of commonly used softwoods like

Douglas fir, Pine and hardwoods like Maple and Oak.

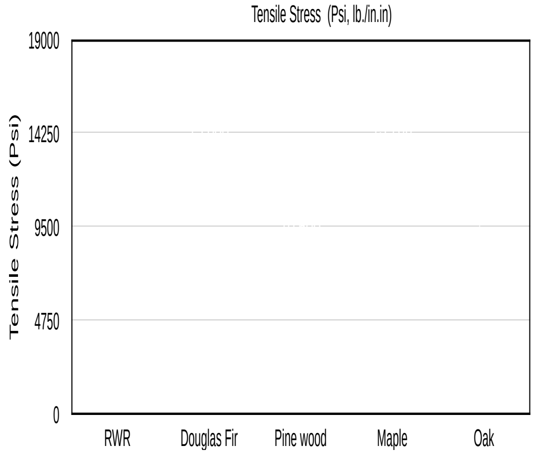


Figure 1: Comparison of Tensile Stress

III. Flexural Test (ASTM D3043)

Flexural testing is a mechanical test method used to measure the mechanical behavior to unified bending loads. It is used to define the structural integrity of materials being tested.

The Specimens were prepared based on the ASTM D3043 standards. The pictures of the samples, sample specifications and the load deflection curves are given in Appendix 2. ADMET Expert 2 Flexure test equipment was used to perform the testing. The data sheet shows the results from five different samples tested. The data presented here has a standard deviation of 14.36.

Table 3: Flexural Strength [3]

RWR Sample	Maximum Load (N)	Modulus of Rupture (MPa)
Sample 1 (F1)	59.20	833.508
Sample 2 (F2)	43.79	873.40
Sample 3 (F3)	55.90	847.37
Sample 4 (F4)	42.67	849.61
Sample 5 (F5)	45.61	852.38
Average		**851.25**

The obtained values of Modulus of Rupture are compared with the Modulus of Rupture values of some commonly used wood materials and the comparisons are shown in Table 4 and Figure 2 below.

Table 4: Comparison of modulus of rupture [2]

Material	Modulus of Rupture(MPa)	RWR strength
Douglas fir	85	901.1% stronger
Pine	32	2560.2% stronger
Maple	109	680.9% stronger
Oak	55	1447.7% stronger

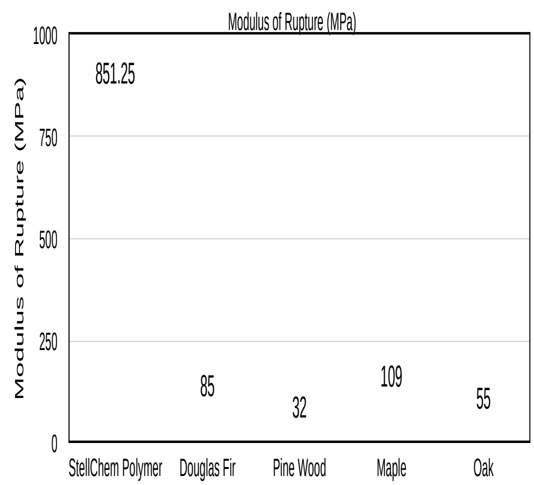


Figure 2: Comparison of modulus of rupture

- Stellchem's polymer (RWR) is at least 680% stronger than maple.
- Stellchem's polymer (RWR) can take at least seven times more load than the most commonly used softwoods like Douglas fir, Pine and hardwoods like Maple and Oak.

IV. Hardness Test (ASTM D143)

Hardness testing is a physical test method that directly relates to the resistance of the specimens indentation. The Specimens were prepared based on the ASTM D143 standards. The pictures of the sample templates are shown in Appendix 2. ADMET Expert 2 Hardness equipment was used to perform the testing. The data sheet (Table 5) shows the results from two different samples and at two different sides. The data has a standard deviation of 10.07.

The obtained values of Hardness are compared with the Hardness values of some commonly used wood materials and the comparison Table and chart are shown below (Table 6 and Figure 3, respectively). Stellchem's polymer (RWR) is very close to the hardness values of the commonly used softwoods like Douglas fir and Pine. This test does not, however, define the ultimate load or weight the material can bear.

Table 5: Hardness test [4]

RWR Sample	Tangential Surface (lb)	Radial Surface (lb.)	End Surface (lb.)
Sample 1 - Side 1	454.42	442.27	459.081
Sample 1 - Side 2	453.55	425.17	464.60
Sample 2 - Side 1	424.63	406.35	423.17
Sample 2 - Side 2	425.16	421.41	419.47
Average	**439.44**	**423.80**	**441.58**

Table 6: Comparison of Hardness [2]

Material	Hardness (lb.)	RWR strength
Douglas fir	500	13 % softer
Pine	420	3.56 % harder
Maple	970	55% softer
Oak	960	55.7 % softer

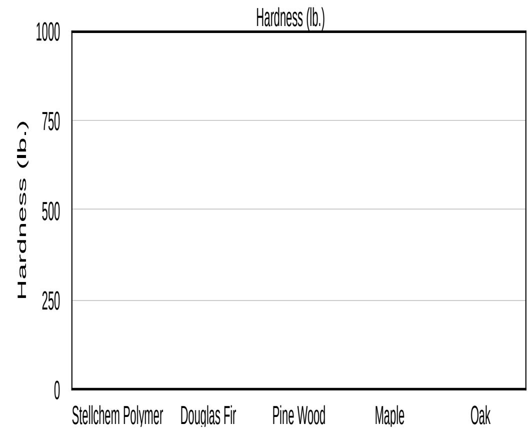


Figure 3: Comparison of Hardness

V. Conclusion

Stellchem's polymer, Rhino Wood Repair putty, proved to be superior in strength to softwoods and hardwoods under force. RWR putty is 25 times stronger in load strength than Pine and 7 times stronger in load strength than Maple. Hardness of RWR was found to be slightly greater than Pine. The mechanical properties of RWR make it versatile and easy to use for the contractor/renovator. The superior strength and unique hardness makes it very easy to use. Although, RWR is structurally stronger than many softwoods and hardwoods, its balance of strength and hardness makes it easy to sand, paint, stain, nail, screw, cut and saw.

VI. References

[1] ASTM D 3500 – 90 "*Standard test methods for structural panels in tension*" 2009.

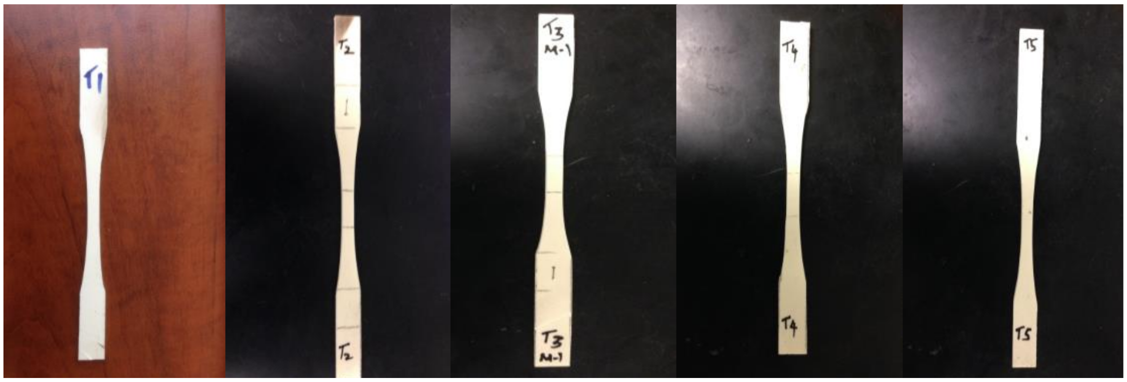
[2] "*Wood handbook – Wood as an engineering material*" ch-4, pp. 4.4-4.24, 2010

[3] ASTM D 3043 – 00 "*Standard test method for structural panels in flexure*" 2011

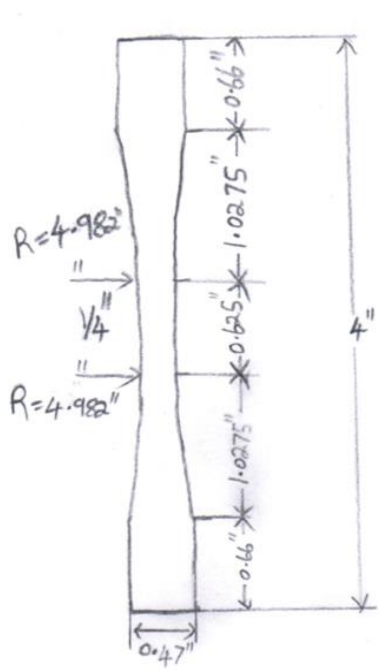
[4] ASTM D 143 – 09, "*Standard test methods for clean specimens of timer*"

Appendix 1:

Tensile Sample Pictures:

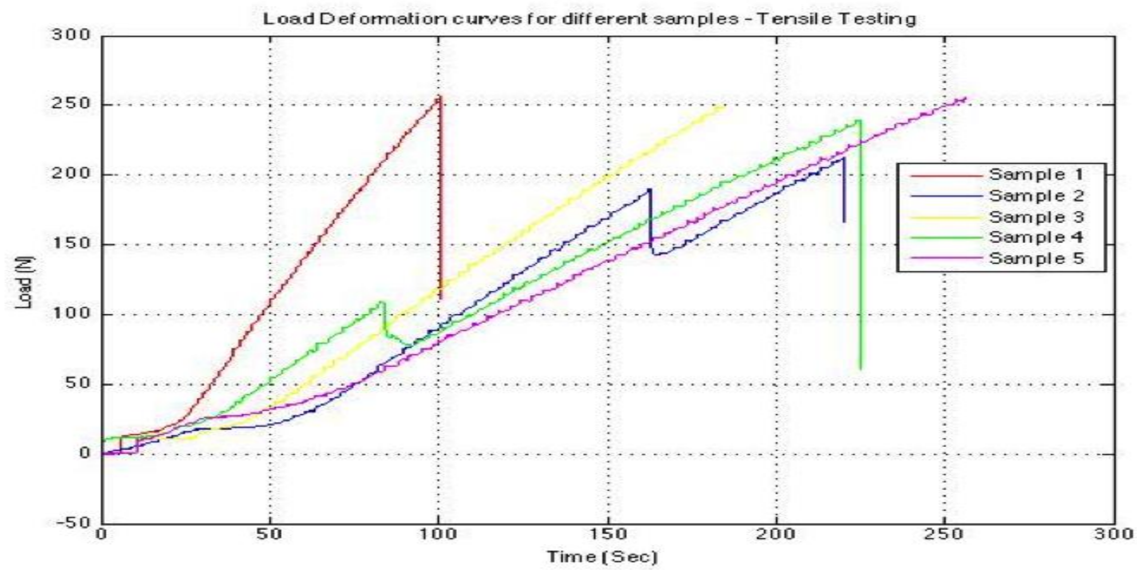


Tensile Sample Template:

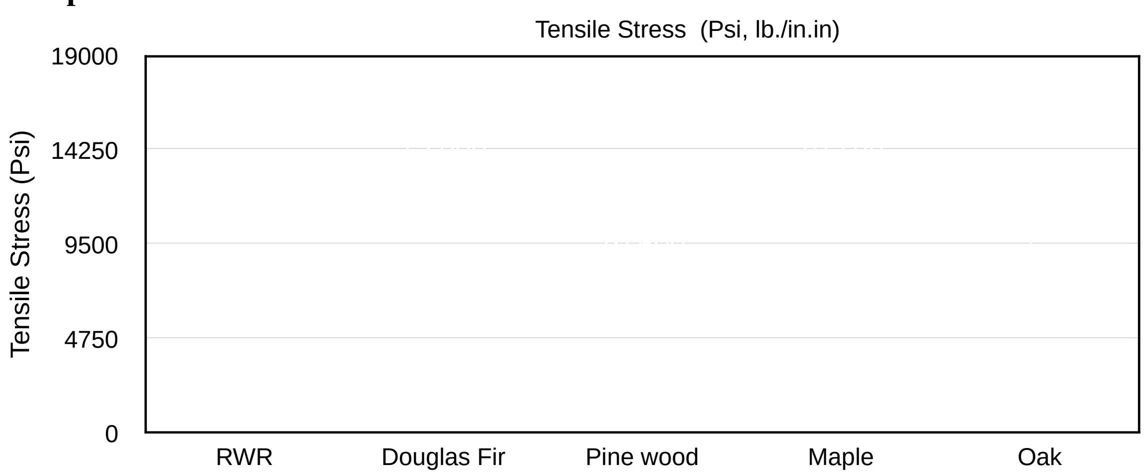


Appendix 1 Con’t:

Load Deformation Curves for the Samples:

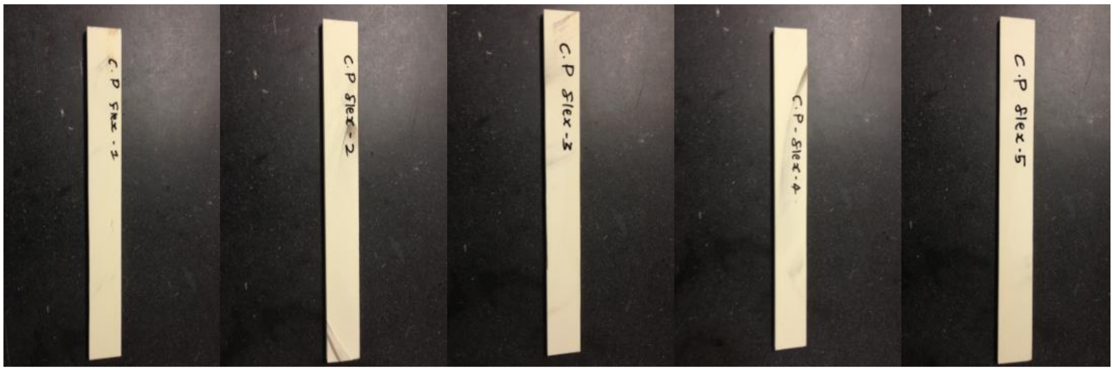


Comparison of the tensile Stress:

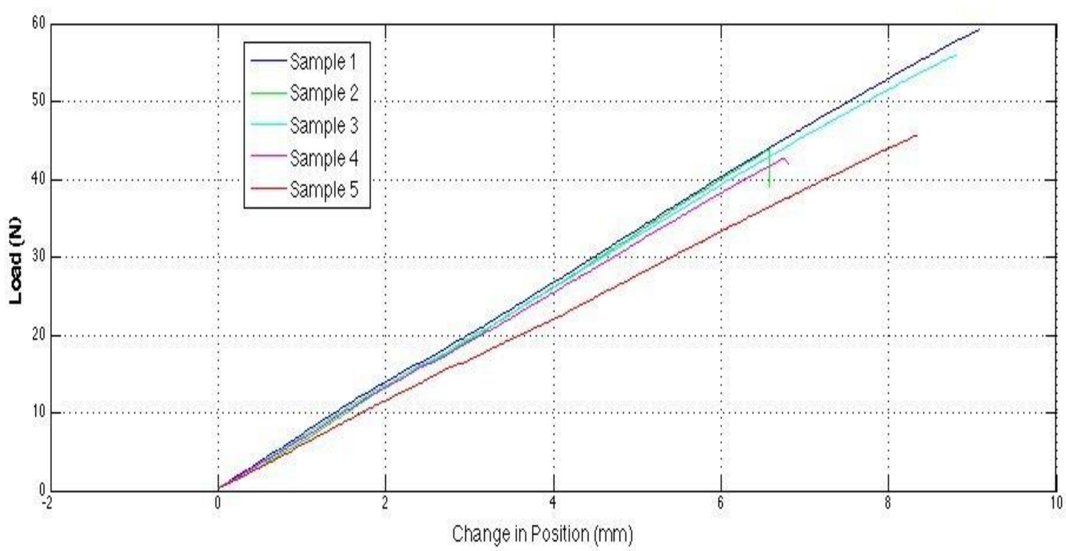


Appendix 2:

Flexural Test Samples:

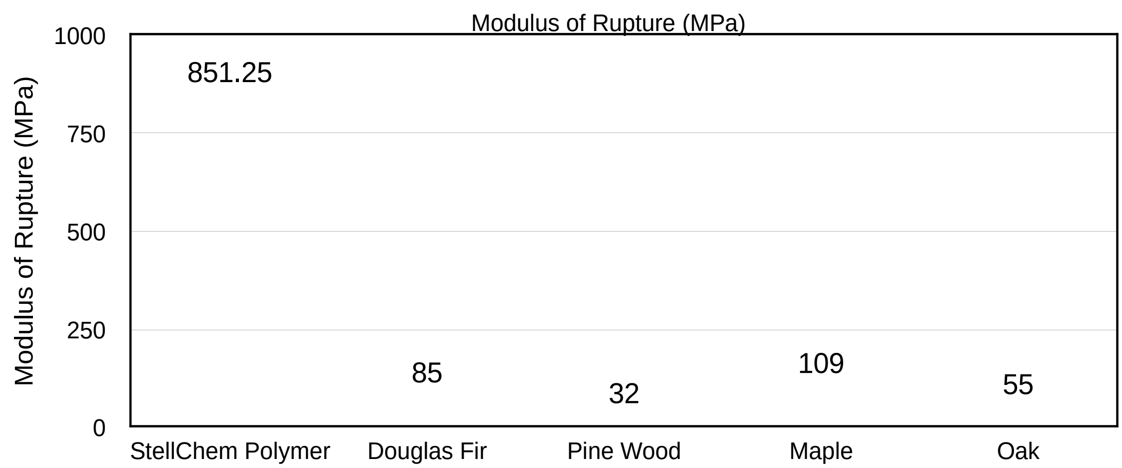


Load Deflection Curves:



Appendix 2 Con’t:

Comparison of Modulus of Rupture:



Comparison of Hardness:

Appendix 3:

- ***Tensile Test***

Test Specimens (section 6 - D3500):

Specimens are of Type C as shown in the figure.

When the evaluation of elastic properties as well as ultimate tensile strength is required, the size and shape of the test specimen shall be selected on the basis of the construction and thickness of the material. For other structural panels, and plywood or composites with the grain of the individual veneer plies or laminations making grain angles of individual veneer lamina of 0 or 90°, Type A shall be used for material over 1⁄4 in. (6 mm) in thickness and Type B for material 1⁄4 in. (6 mm) or less in thickness. For plywood with an angle other than 0 or 90° between the length of the specimens and the grain orientation, Type C shall be used regardless of the thickness of the material. The specimens shall have a thickness equal to that of the material. The thickness and the width of each specimen at the critical section shall be measured to an accuracy of not less than +/- 0.3 % or 0.001 in. (0.02 mm) whichever is larger.

The test specimens shall be properly shaped, using a template in conjunction with a vertical-spindle woodworking shaper or any other method that will give equally satisfactory results.

Loading Procedure (Section 7 – D3500):

Hold the specimen in wedge-type self-tightening and self-aligning grips. Rate of crosshead motion shall be constant throughout the test such that the specimen breaks within 3 to 10 min after initiation of loading. A crosshead motion rate of 0.035 in./min (0.9 mm/min) is usually satisfactory. If failure does not occur within the desired 3 to 10-min time span, adjust the loading rate.
Measure the elapsed time from initiation of loading to maximum load and record to the nearest 1⁄2 min.

Load-Deformation Curves:

Take data for load-deformation curves to determine the modulus of elasticity and the proportional limit. Choose increments of load so that not less than 12 and preferably 15 or more readings of load and deformation are taken to the proportional limit. Attach the deformation apparatus at the center of the specimen's length and width. Take deformation readings to the nearest 0.0001 in. (0.002 mm).

2. ***Flexure Test***

Test Specimen (Section 5 - D3043):

The test specimen shall be rectangular in cross section. The depth of the specimen shall be equal to the thickness of material, and the width shall be 1 in. (25 mm) for depths less than 1⁄4 in. (6 mm) and 2 in. (50 mm) for greater depths (Note 1). When the principal direction of the face plies, laminations, strands, or wafers is parallel to the span, the length of the specimen (Note 2) shall be not less than 48 times the depth plus 2 in.; when the principal direction of the face plies, laminations, strands, or wafers is perpendicular to the span, the specimen length shall be not less than 24 times the depth plus 2 in. (Note 3).

Measurements:

Measure specimen thickness at mid- span at two points near each edge and record the average. Measure to the nearest 0.001 in. (0.02 mm) or 0.3 %. Measure width at mid-span to the nearest 0.3 %.
When needed for interpretation of test results for plywood, veneer composites, and laminates measure thickness of each layer to the nearest 0.001 in. (0.02 mm) at mid-span at each edge and record the average.

Appendix 3 Con’t:

Span:

The span shall be at least 48 times the nominal depth when the principal direction of the face plies, laminations, strands, or wafers of the test specimen is parallel to the span and at least 24 times the nominal depth when the principal direction of the face plies, laminations, strands, or wafers is perpendicular to the span (Note 3).

End supports:

Reaction points shall be capable of freely compensating for warp of the test specimen by turning laterally in a plane perpendicular to the specimen length so as to apply load uniformly across its width. Design of end supports shall place the centre of rotation near the neutral axis of the specimen of average thickness. Bearing points shall be rounded where they contact the specimen. Use of bearing plates is generally recommended and is required wherever significant local deformation may occur.

Use of roller bearings or plates and rollers to preclude friction forces between end support and specimen is recommended in addition to the requirement of lateral compensation. The use of a large ball bearing to provide lateral compensation for warp is also illustrated. This method is particularly recommended for thin specimens and small loads.
As the specimen deflects during test, loads no longer act in the direction assumed in formulas for calculating properties.

Loading Block:

A loading block having a radius of curvature of approximately one and one-half times the depth of the test specimen for a chord length of not less than twice the depth of the specimen shall be used. In cases where excessive local deformation may occur, suitable bearing plates shall be used. Radius of curvature of bearing plate or block shall not be so large as to cause bridging as the specimen bends.

Loading Procedure:

Apply the load with a continuous motion of the movable head throughout the test. The rate of load application shall be such that the maximum fibre strain rate is equal to 0.0015 in./in. (mm/mm) per min within a permissible variation of +/- 25 percent. Load shall be measured to an accuracy of +/-1 % of indicated value, or 0.4 percent of full scale, whichever is larger.

Measurement of Deflection:

Take data for load- deflection curves to determine the modulus of elasticity, proportional limit, work to proportional limit, work to maxi- mum load, and total work. Take deflections measurements and the readings to the nearest 0.001 in. (0.02 mm). Choose increments of load so that not less than 12 and preferably 15 or more readings of load and deflection are taken to the proportional limit.

Deflections also may be measured with transducer type gages and plotted simultaneously against load. In this case, record deflection to an accuracy of at least 1.5 % of deformation at proportional limit and the recorded trace below the proportional limit shall be at least 2½ in. (64 mm) long or ¼ of full scale measured on the deformation axis, whichever is larger. Similar requirements apply to the load axis.

Appendix 3 Con’t:

3. Hardness

Test Specimens (Section 13 - D143):

The hardness tests shall be made on 2 by 2 by 6 in. (50 by 50 by 150 mm) specimens. The actual Cross-sectional dimensions and length shall be measured.

Test procedure:

Use the modified ball test with a “ball” 0.444 in. (11.3 mm) in diameter for determining hardness. The projected area of the ball on the test specimen is 1 cm^2. Record the load at which the ball has penetrated to one half its diameter, as determined by an electric circuit indicator or by the tightening of the collar against the specimen.

Two penetrations shall be made on a tangential surface, two on a radial surface, and one on each end. The choice between the two radial and between the two tangential surfaces shall be such as to give a fair average of the piece. The penetrations shall be far enough from the edge to prevent splitting or chipping.

Speed of testing:

The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.25 in. (6 mm/min).

Notes:

NOTE 1: In certain specific instances, it may be necessary or desirable to test specimens having a width greater than 1 or 2 in. (25 or 50 mm). To eliminate plate action when wider specimens are tested, the specimen width shall not exceed one third of the span length and precaution shall be taken to ensure uniform bearing across the entire width of the specimen at the load and reaction points.

NOTE 2—In cutting specimens to meet the length requirement, it is not intended that the length be changed for small variations in thickness. Rather, it is intended that the nominal thickness of the material under test should be used for determining the specimen length.

NOTE 3: Establishment of a span-depth ratio is required to allow an accurate comparison of test values for materials of different thicknesses. It should be noted that the span is based on the nominal thickness of the material and it is not intended that the spans be changed for small variations in thickness.