PLASCORE DEFORMABLE BARRIER

US (FEDERAL) SIDE IMPACT
FMVSS 214

PLASCORE®

Table Of Contents

1. Introduction

1.1 Performance requirements

The National Highway Traffic Safety Administration (NHTSA) developed a Moving Deformable Barrier (MDB) for use in full-system crash testing. This included the development of a crushable face to simulate the stiffness of the front end of a striking vehicle. The main core of this barrier face assembly is to be constructed from aluminum honeycomb having crush strength of 310 ± 17 kPa (45 ± 2.5 psi). Although, in engineering terms, strength signifies a load, since the term crush strength is commonly used by aluminum honeycomb manufacturers to signify a load per unit area, units of this measure will be kilopascal (kPa) (pounds per square inch (psi) in the document).

Several companies could potentially manufacture this honeycomb material, each having their own method for testing the crush strength of the material. In order to assure equivalence between the MDB faces of the various manufacturers, a standard procedure for certifying the crush strength of the aluminum honeycomb has been established.

The MDB face assembly includes a bumper constructed of honeycomb 1690 ± 103 kPa (245 ± 15 psi) sandwiched between 3.2 mm (0.125") thick aluminum plates. The bumper is a flexion member and develops flexion strength based on the material properties of these front and back plates. Since the crush strength of this honeycomb is therefore not critical, the manufacturer's standard method of certifying crush strength will suffice for the bumper honeycomb.

1.2 Documentation

The test contractors will obtain a copy of the certification data and procedure that the barrier face manufacturer uses to certify that the bumper honeycomb barrier meets the required crush strength of 1690 ± 103 kPa (245 ± 15 psi).

The test contractor must obtain a copy of the certification data and procedure used by the honeycomb face manufacturer to certify that the honeycomb barrier meets the 310 ± 17 kPa (45 ± 2.5 psi).

When barriers are delivered, the test contractor must obtain eight (8) samples that have the following dimensions (152mm x 152mm x 25mm) (6" x 6" x 1") per block from which the barrier faces were manufactured which will enable verification of the certification data supplied by barrier face manufacturer. This verification entails that the contractor possess the necessary test equipment to conduct barrier face certification testing as outlined in the certification procedure later in this brochure.

Plascore's Barrier meets all the performance requirements set forth above. Also Plascore does provide all the certification and the documentation mentioned

1.3 Test Facility's responsibility:

The test facility has the responsibility of procuring certified aluminum honeycomb barrier face units from the honeycomb manufacture which meet the crush strength specifications required by the standard. Each honeycomb barrier will be used for only one test, thus the test facility shall procure one barrier face for each vehicle being tested plus one extra barrier face in case something unexpectedly happens to a barrier face. The test facility shall conduct detailed inspection of the honeycomb barrier for shipping damage.

The test facility shall retain a copy of the barrier manufacturers test data used to certify the barrier face and make it available for review by the COTR. This shall consist of certification information for the 310 and 1690 kPa barrier face portions. The test facility shall have the equipment or access to equipment that will allow them to test honeycomb samples.

2. Industry Requirements (Refer to attached Drawing Number P01-01-00)

The side impactor will be made up of two assemblies –

- **Face Assembly and**
- **Bumper Assembly**

2.1 Face Assembly –

The face assembly is comprised of the face honeycomb, a backing plate and a face sheet.

The face honeycomb will have the following specifications:

- 1.6-density 3/8" cell size 5052 material aluminum honeycomb.
- Crush Strength - 45 ± 2.5 psi.
- Dimensions – 15 ± 0.25 T x 66 ± 0.25 W x 22 ± 0.25 L
- Weight 65 Pounds

The face honeycomb will be bonded to a backing plate (part # 2) and a face sheet (part # 4) with Narmco 117 Bonding Film or equivalent.

2.2 Bumper Assembly

The bumper assembly is made up of the bumper honeycomb, a back plate and a face plate.

The bumper honeycomb will have the following specifications:

- 5.2 density ¼" cell size 3003 material aluminum honeycomb.
- Crush Strength 245 ±15 psi.
- Dimensions – 3.75 T x 65.75 W x 6.00L.

The bumper honeycomb will be bonded to a back plate (part # 6) and a face plate (part # 8) with Narmco 117 Bonding Film or equivalent.

The two assemblies will be bonded together with Narmco 117 or equivalent.

3. PLASCORE'S ALUMINUM HONEYCOMB CRUSH STRENGTH CERTIFICATION PROCEDURE

This procedure is intended to apply to aluminum honeycomb having nominal crush strength of 310 kPa (45 psi) as well as 1690 kPa (245 psi).

3.1 Hardware Specifications

The hardware used for certifying aluminum honeycomb must be capable of applying a sufficient load (about 13.3 kN (3,000 lb), over at least 17 mm (0.65") stroke. The crush rate must be constant and known. To ensure that the load is applied to the entire sample, the top and bottom crush plates must be no smaller than 165 mm by 165 mm (6.5" x 6.5"). The engaging surfaces of the crush plates must also have a roughness approximately equivalent to 60 grit sandpaper. The bottom crush plate should be marked to ensure that the applied load is centered on the sample.

Due to the construction of the aluminum honeycomb, its resistance to crush is inherently uniaxial. Off-axis loading can cause the cells to "fold-over" during certification, reducing the sample's resistance to crush, and thus its apparent crush strength. To minimize this occurrence, it is necessary that the hardware used in the certification testing be properly oriented and sufficiently rigid. Therefore, under no load, the top and bottom crush plates must be parallel, within 0.127 mm (0.005"). Also, the average angular rigidity of the crush plate assemblies (about axes normal to the direction of crush), over the range of 0 to 203 N.m (0 to 150ft-lb) applied torque, must be at least 1017 N.m/deg (750 ft-lb/deg).

3.2 Sample Size

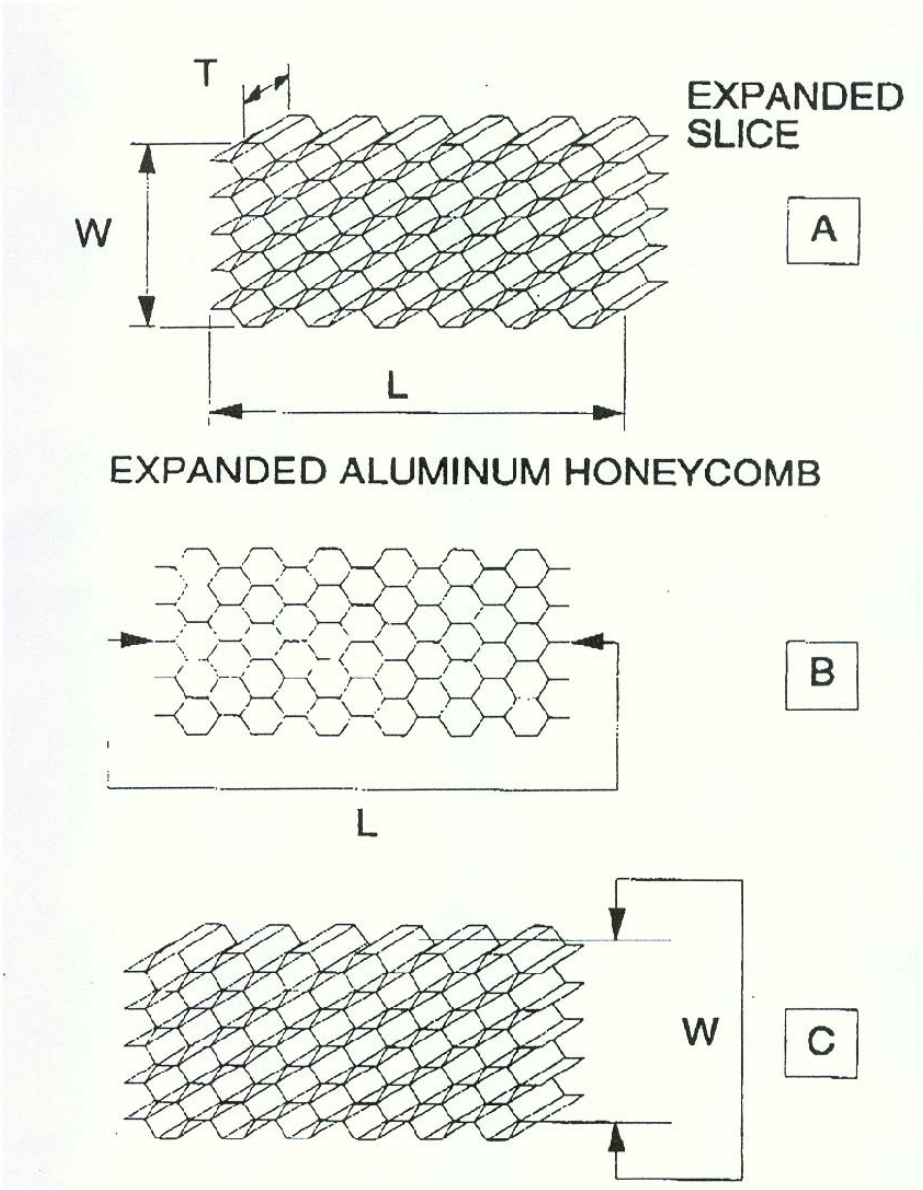
Much of the honeycomb's strength comes from the structure of the cells that make up the material. When these cells are cut, as is the case in preparing test samples, much of the crush strength is lost, but not all. Due to these "fringe" effects, the effective crush area is not the measured area. The percentage error between these two areas reduces as the measured area increases. It is therefore desirable to test a sample large enough such that the fringe effects do not cause large variations in crush strength but not so large as to be awkward for testing. Square pieces, 152 mm x 152 mm (6" x 6"), were found to satisfy both conditions.

Samples of various thickness were also tested. It was found that as the thickness increased, the likelihood of the sample to buckle increased. When this occurred, the measured crush force dropped off quickly. When samples of one inch thickness were used, no noticeable buckling occurred, while allowing ample stroke for determining crush strength. Therefore, a sample thickness of one inch was selected.

Unstabilized honeycomb is to be used for these samples, and since this is difficult to cut to precise dimensions, a tolerance of + 6mm (+0.25") is allowed on both the length and the width, while a tolerance of + 1.6mm (+0.0625") is allowed on the thickness as shown in Figure A on the next page. The relatively loose tolerances make it necessary to

accurately measure the actual crush area of a sample. Three length measurements are taken, fringe to fringe, and recorded as L1, L2 and L3. These are to be located one-half of an inch from each end and at the middle of each sample. If these locations fall between the fringes, the measurements are to be taken from lines projected between the adjacent fringes, as shown in Figure B. This procedure is then repeated for the width. All length and width measurements are to be taken at the centerline plane of the thickness, as shown in Figure C. The crush area is then calculated as follows:

$$A = \frac{(L1 + L2 + L3)}{3} + \frac{(W1 + W2 + W3)}{3}$$



3.3 Crush Rate and Distance

The measured crush strength of aluminum honeycomb is sensitive to the crush rate used in testing. It is therefore necessary to specify a crush rate to be used in certifying crush strength. Previous testing has shown that the variation in crush strength between samples increases with increased crush rate, even if the samples are from the same block of core material.

Six samples of honeycomb were cut from the same block of core material. Three of these were crushed at a rate of 5mm per minute (mpm) (0.2 inch per minute (ipm) while the other three were tested at 13 mpm (0.5 ipm). Each force deflection curve was divided into three sections, giving a total of nine crush strengths for each set of samples. The standard deviation for the samples tested at 5mpm was 2.4 kPa (0.35 psi), while it was 10.8 kPa (1.55 psi) for those done at 13 mpm (0.5 ipm).

If three times the standard deviation is to be no greater than 4.7 kPa (2.5 psi, the allowable tolerance on crush strength), then linear interpolation of the above results indicates that the crush rate should not exceed 7.6 mpm (0.3 ipm). From this, a crush rate range from 5 mpm to 7.6 mpm (0.2 ipm to 0.3 ipm) was established for this certification procedure.

Another characteristic of the MDB aluminum honeycomb is that the useable crush distance is 70 percent of the initial sample thickness. Beyond this, the crush force rises quickly. To assure validity of the data, even on the thinnest sample allowed by this procedure, data from crush distances greater than 16.5 mm (0.65 inches) will not be used. To obtain the maximum quantity of data, the minimum crush distance was specified as 16.5 mm (0.65 inches).

3.4 Data Collection

Force versus deflection data are to be recorded for each certification test. These data may be recorded in either digital or analog form, but since digital data is required for determining the crush strengths, a means of converting analog data to digital data must be available. The rated tolerance on the load cell used to obtain this data must not be more than +0.5 percent, while that of the displacement transducer used not to exceed + 1 percent. The calibration interval for each of these must be less than six months and the standard must be NBS traceable. One of the goals of this certification procedure was to assure uniformity in the estimation of crush forces. Uniformity can be achieved by requiring the use of digital data for the force estimations. This in turn makes it necessary to specify a digital sampling rate for these data. It was judged that a rate of 5 Hz (5 points per second) was high enough to accurately describe a continuous force/deflection curve, but not so high as to produce an unreasonably large number of data points. Therefore, the minimum sampling rate for digital data used in this certification procedure was specified to be 5 Hz.

3.5 Data Analysis

As outlined previously, digital force versus deflection data that have been collected at a minimum sampling rate of 5 Hz must be available for analysis. The data must include that part of the curve from zero to 16.5 mm (0.65") of crush.

When honeycomb is crushed, the compressive force first reaches a peak (ultimate strength) and then comes down to a fairly constant level as shown in the figure. The ultimate strength is of little interest in MDB testing since it occurs in a small interval of deflection and was not measured in MDB to load cell tests. Therefore, any data prior to 6mm (0.25") of crush will not be used in this analysis.

This post peak data, 6mm to 16.5mm (0.2 inch to 0.65 inch) of crush, will be divided into three sections or displacement intervals. The first will contain data from 6mm to 9.6 mm (0.25 to 0.38 inches) of crush, inclusive. The second is to span from 9.6mm to 13.2mm (0.38 inch to 0.52) inches of crush, exclusive, while the last includes data from 13.2mm to 16.5mm (0.52" to 0.65") inclusive. An average force, F (n), will then be calculated over each of these ranges of crush as follows:

$$F(n) = \frac{(F(n)_1 + F(n)_2 + ... + F(N)_I}{I}; n = 1,2,3$$

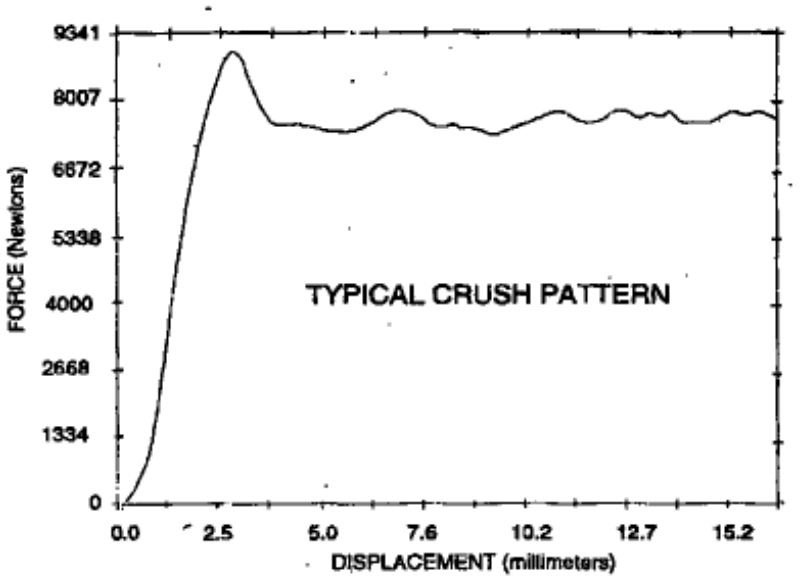
In this equation, *I* represents the number of data points measured in each of the three intervals. Using the area, A, measured as described in Section 3.2, the average crush strength of each segment can then be calculated as follows:

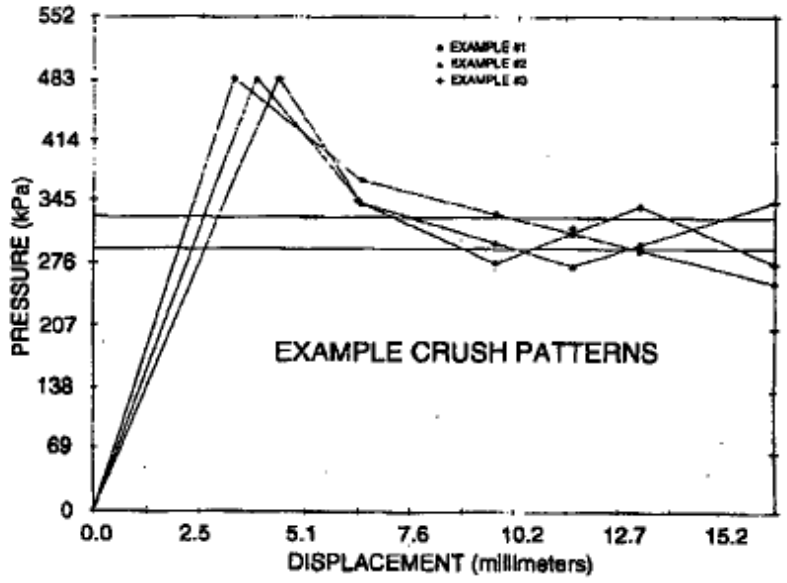
$$S(n) = \frac{F(N)}{A}; n = 1,2,3$$

If a honeycomb sample is to pass this certification, all three of the crush strengths calculated must meet the following specifications:

$$293kPa \le S(n) \le 327kPa (42.5psi \le S(n) \le 47.5psi)$$

The figure shown illustrates the need for dividing the constant crush portion of the curve into multiple segments. If a sample produced a crush pattern similar to that of example #1, it would not be acceptable since it does not crush at a nearly constant force. Yet if single crush strength were calculated based on the entire range of 6mm to 16.5mm (0.25 to 0.65 inches), this sample would pass the certification. A similar argument could be given for a sample, which produced a crush pattern such as that of example #2. In this case, if the curve were divided into one or two segments, the sample would pass certification even though it does not display a nearly constant crush.



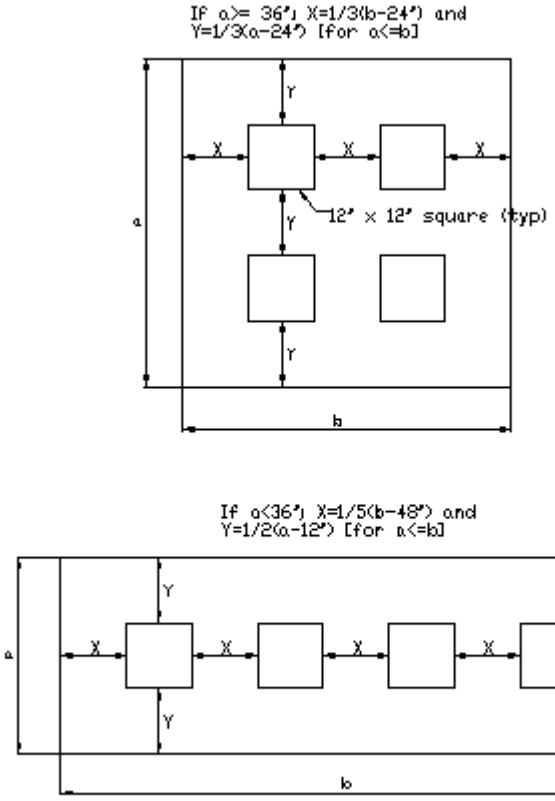


3.6 Block Certification Specification

The previous discussion outlines the procedures and specifications for certifying a single sample of aluminum honeycomb. A 152mm x 152mm (6 inch by 6 inch) sample represents only a very small portion of the entire block of honeycomb used to construct the Moving Deformable Barrier (MDB) faces. Therefore, to determine if a block has uniform properties across its entire area, 8 samples will be tested from 4 locations, evenly spaced across the block. For a block to pass certification, 7 of the 8 samples must meet the crush strength specifications outlined in the previous section.

The location of the samples depends on the size ofthe honeycomb block. First, four samples, each measuring 304mm x 304mm x 25mm(12”x12”x1”) should be cut from the block of barrier face material. Each of these larger samples are cut into certification size

samples 152mm x 152mm x 25mm (6”x6”x1”). The honeycomb manufacturer should certify his product based on testing two of the certification samples from each of the four locations. The other two should be made available to the customer, upon request.



3.7 Attachments

Examples of typical test reports, graphs, and certifications, which will be supplied with the barrier, have been provided for review.

REV.	DATE	DESCRIPTION	SIGNATURE
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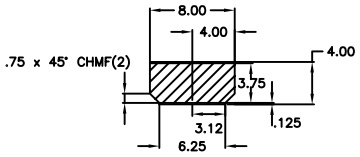
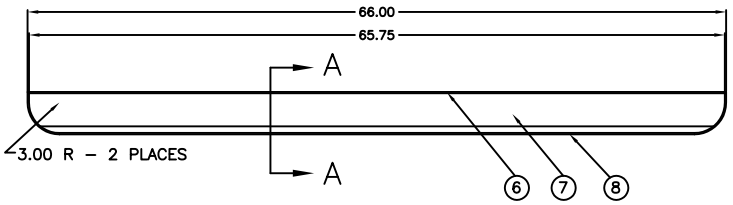
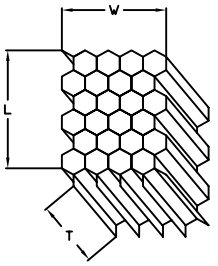
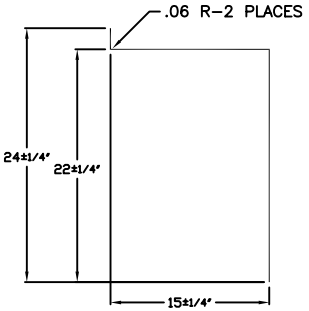


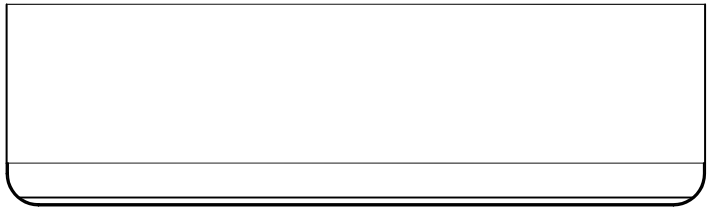
SECTION A–A



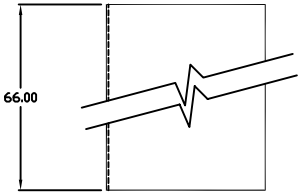
(5) BUMPER ASSEMBLY
SHARP EDGES .02 R.
DIMENSIONS AND TOLERANCES PER ANSI Y14.5–1973
BOND WITH NARMCO 117 BONDING FILM OR EQUIVALENT.
DEVELOPED LENGTH OF DSL–1285–8 IS 71.12"
MATERIAL FOR ITEM 7 IS ALUMINUM HONEYCOMB
ACG–1/4–003 245 ±15 PSI CRUSH STRENGTH
3.75 T X 65.75 W X 8.00 L

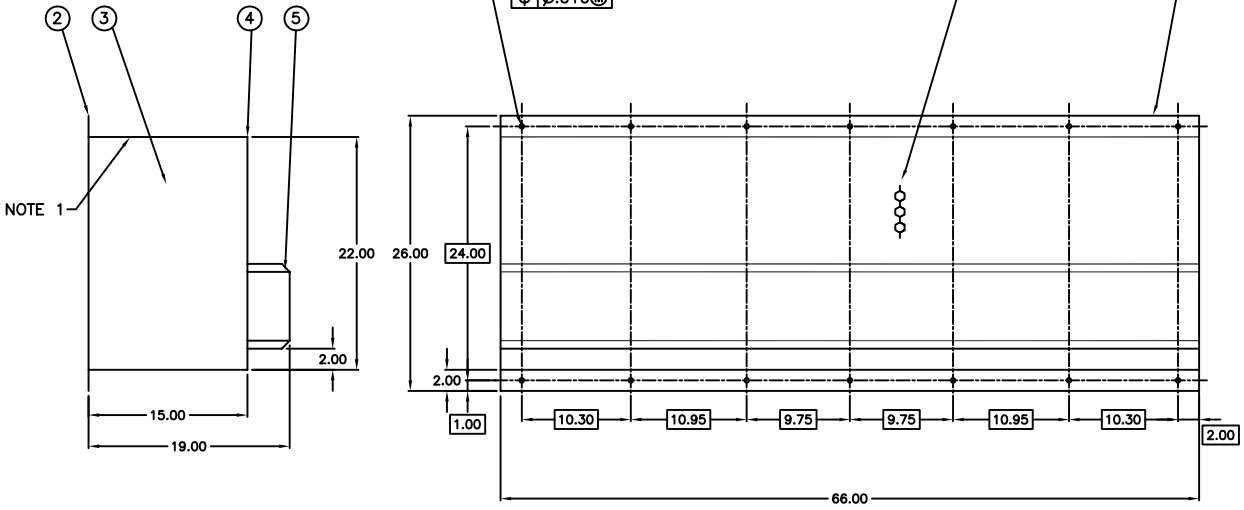






GRAIN DIRECTION DETAIL
USE TO ESTABLISH HONEYCOMB ORIENTATION





(4) FACE SHEET
SHARP EDGES .02 R.
DIMENSIONS AND TOLERANCES PER ANSI Y14.5–1973
MAT'L. 5052–H34 AL. .032 X 39.00 X 66.00

Rev A – Original Drawing # DSL–1285 drawn on 12–10–98 has been renumbered only

No.	Qty	Item No.	Description	Finish
8	1	DSL–1285–8	FACE PLATE	–
7	1	–7	BUMPER HONEYCOMB	–
6	1	–6	BACK PLATE	–
5	1	–5	BUMPER ASSEMBLY	–
4	1	–4	FACE SHEET	–
3	1	–3	FACE HONEYCOMB	–
2	1	–2	BACKING PLATE	–
1	1	DSL–1285–1	ENERGY ABSORBING FACE ASS'Y	–

NOTES: 1.) DO NOT BEND THIS SURFACE
2.) BOND ALL SURFACES EXCEPT AS NOTED WITH NARMCO 117 BONDING FILM OR EQUIVALENT.

(1) ENERGY ABSORBING FACE ASSEMBLY
SHARP EDGES .02 R.
DIMENSIONS AND TOLERANCES PER ANSI Y14.5–1973
MATERIAL FOR ITEM 3 IS ALUMINUM HONEYCOMB 3/8–5052 .001N–1.6
45±2.5 PSI CRUSH STRENGTH 15±1/4 T X 66±1/4 W X 22±1/4 L.
WEIGHT IS 65 POUNDS

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND TOLERANCES ON:
XXXXX = CRITICAL DIM LEVEL 2
XXXXX³ = CRITICAL DIM LEVEL 3
FRACTIONS: = ± 1/16
DECIMALS: X=±0.1
.X=±0.06
.XX=±0.03
.XXX=±0.01
ANGLES: = ± 2°

PLASCORE
615 N. FAIRVIEW STREET
ZEELAND, MICHIGAN 49464
(616) 772–1220

DWG TITLE:
NHTSA SIDE IMPACTOR–ENERGY ABSORBING FACE ASSEMBLY

SIZE	FSCM	DWG NUMBER:	REV
A	39212	P01–01–00	A

DRAWN BY: J.BUTCHER	DATE: 11–20–01
ENGRG: –	SCALE: NTS
CAD#: DSL–1285	QC APP.:
	SHEET: 1 OF 1

PLASCORE®

SIDE IMPACTOR BARRIER CERTIFICATION

Date: February 28, 2002

To:

PURCHASE ORDER INFORMATION

Customer P.O. Number:	689268
Work Order Number:	12314
Quantity:	1 piece

CORE INFORMATION

Core Type:	PAMG-1.6-3/8-001-P-5052
Cell Size:	0.375 inches
Density:	1.6 pcf

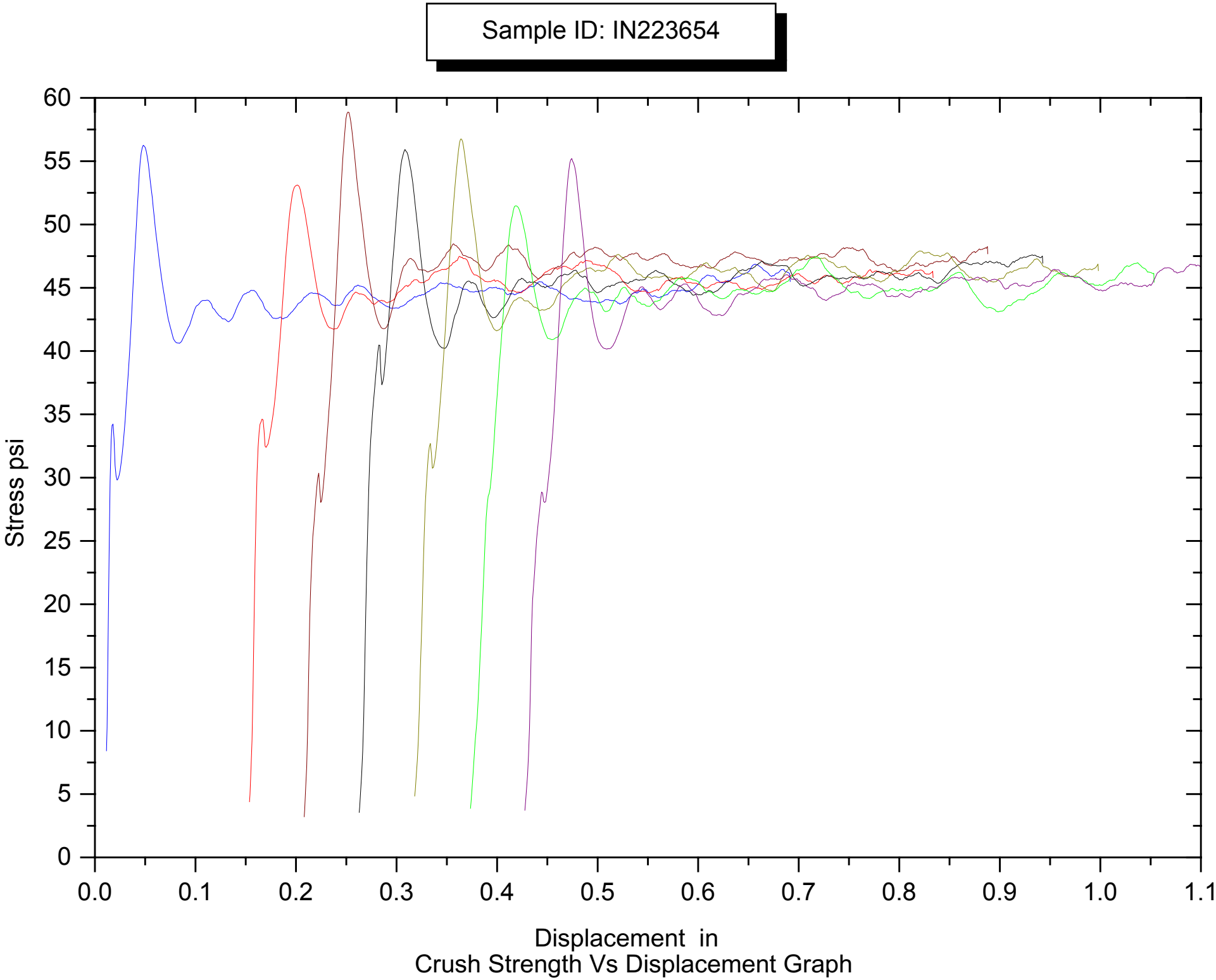
Unit Number: 091C0102

This is to certify that the aluminum honeycomb core supplied, under the unit number provided, meets the crush requirements of 45 psi +/- 2.5 psi per DWG # DSL 1285 / P01-01-00.

_____

Quality Control Representative

PLASCORE, INC. • 615 N. FAIRVIEW ST. • P.O. BOX 170 • ZEELAND, MI 49464-0170 • PHONE (616) 772-1220 • FAX (616) 772-1289


Sample ID: IN223654
Stress psi
60
55
50
45
40
35
30
25
20
15
10
5
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
Displacement in
Crush Strength Vs Displacement Graph

Plascore Inc.
615 N. Fairview St.
Zeeland, MI USA 49464

NHTSA-Crush Test

Test type: Compression
Operator name: JIM
Sample Identification: IN223654
Interface Type: 4200

Instron Corporation
Series IX Automated Materials Testing System 7.51.00
Test Date: Wednesday, February 06, 2002

Sample Rate (pts/secs): 5.0000
Crosshead Speed: 0.3000 in/min
2nd Crosshead Speed: 0.0000 in/min

Full Scale Load Range: 30000.000 lbf

Humidity (%): 50
Temperature: 73 F

Block Number 107B0102

Core Type 3/8-1.6-P-5052

NHSTA 42.5 - 47.5 PSI

WG11 N/A

BOTH N/A

Sample comments:

	Load at Max.Load (lbf)	Stress at Max.Load (psi)	Stress Between Limits 1 (psi)	Stress Between Limits 2 (psi)	Stress Between Limits 3 (psi)	Width (in)	Thickness (in)
1 .339	2025	56	44.51	44.48	45.23	6.10	5.90
2 .333	1881	53	46.01	45.18	45.82	6.00	5.90
3 .328	2086	59	47.44	47.19	47.16	5.90	6.00
4 .349	1979	56	45.38	46.08	46.36	6.10	5.80
5 .343	1994	57	46.02	46.76	46.39	6.00	5.85
6 .359	1823	52	45.47	44.79	45.07	6.10	5.80
7 .353	1938	55	44.93	45.34	45.62	6.00	5.85
Mean	1961	55	45.68	45.69	45.95	6.03	5.87
S.D.	89	2	0.95	1.02	0.74	0.08	0.07
C.V.	5	4	2.08	2.22	1.60	1.25	1.19
Minimum	1823	52	44.51	44.48	45.07	5.90	5.80
Maximum	2086	59	47.44	47.19	47.16	6.10	6.00

Crush Test Report

PLASCORE®

SIDE IMPACTOR BARRIER CERTIFICATION

Date: February 28, 2002

To:

PURCHASE ORDER INFORMATION

Customer P.O. Number:	689268
Work Order Number:	12314
Quantity:	1 piece

CORE INFORMATION

Core Type:	PCGA-5.2-1/4-P-3003
Cell Size:	0.250 inches
Density:	5.2 pcf

Unit Number: 081A1001

This is to certify that the aluminum honeycomb core supplied, under the unit number provided, meets the crush requirements of 232 – 250 psi per DWG # DSL 1285 / P01-01-00.

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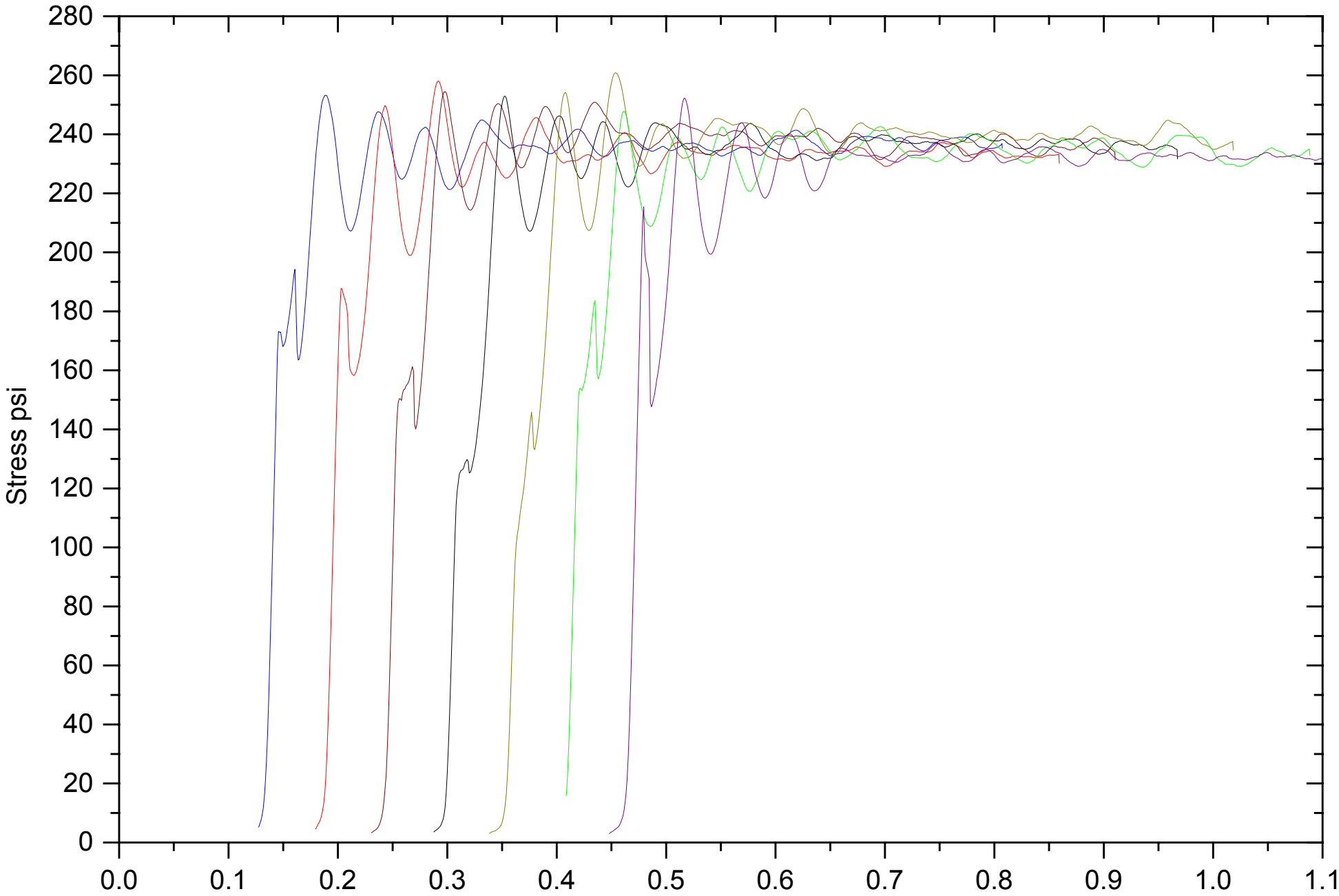
Quality Control Representative

PLASCORE, INC. • 615 N. FAIRVIEW ST. • P.O. BOX 170 • ZEELAND, MI 49464-0170 • PHONE (616) 772-1220 • FAX (616) 772-1289

Sample ID: IN223563



Crush Strength Vs Displacement Graph

Plascore Inc.
615 N. Fairview St.
Zeeland, MI USA 49464

NHTSA-Crush Test

Test type: Compression
Operator name: JIM
Sample Identification: IN223563
Interface Type: 4200

Instron Corporation
Series IX Automated Materials Testing System 7.51.00
Test Date: Tuesday, January 29, 2002

Sample Rate (pts/secs): 5.0000
Crosshead Speed: 0.3000 in/min
2nd Crosshead Speed: 0.0000 in/min

Full Scale Load Range: 30000.000 lbf

Humidity (%): 50
Temperature: 73 F

Block Number 071C0102

Core Type 1/4-5.2-P-3003

NHSTA 232-250 PSI

WG11 223.3-248.1 PSI

BOTH 232-248.1 PSI

Sample comments:

	Load at Max.Load (lbf)	Stress at Max.Load (psi)	Stress Between Limits 1 (psi)	Stress Between Limits 2 (psi)	Stress Between Limits 3 (psi)	Width (in)	Thickness (in)
1 .240	8742	253	236.03	236.01	237.42	6.00	5.75
2 .239	9209	258	234.19	233.31	233.83	6.10	5.85
3 .225	8778	254	240.00	237.85	235.67	5.75	6.00
4 .244	9028	253	235.89	237.83	236.30	6.10	5.85
5 .232	9153	261	240.79	239.14	239.67	5.80	6.05
6 .254	8996	248	235.86	234.96	233.94	6.10	5.95
7 .250	9233	252	233.16	232.66	232.12	6.00	6.10
Mean	9020	254	236.56	235.97	235.56	5.98	5.94
S.D.	198	4	2.83	2.45	2.53	0.15	0.12
C.V.	2	2	1.20	1.04	1.07	2.46	2.10
Minimum	8742	248	233.16	232.66	232.12	5.75	5.75
Maximum	9233	261	240.79	239.14	239.67	6.10	6.10

Crush Test Report

Main Office and Production Facility

Deborah Brents
Plascore Inc.
615 N. Fairview Street, Zeeland, MI 49464
Tel (616) 748-2252
Fax (616) 772-5508
Email deborah.brents@plascore.com

East Coast U.S.A and Eastern Canada

Nick Ogrizovich
Plascore Inc.
14 Fox Hollow Road, New Fairfield, CT 06812
Tel (203) 746-4569
Fax (203) 746-4589
Email nick.ogrizovich@plascore.com

Southeast U.S.A

David Holmes
Plascore Inc.
PO Box 85, Nokomis, FL 34274
Tel (941) 486-8830
Fax (941) 486-8831
Email david.holmes@plascore.com

West Coast U.S.A

George Kania
Plascore Inc.
415 N. Oakhurst Drive #203, Beverly Hills, CA 90210
Tel (310) 273-8895
Fax (310) 273-1932
Email george.kania@plascore.com

Europe

Thomas Pluch
Plascore GMBH+Co.KG
Feldborn 6, DE 55444 Waldlaubersheim, Germany
Tel 49-6707-9143-00
Fax 49-6707-9143-40
Email thomas.pluch@plascore.com