DIVINYCELL HT SERIES
FOAM CORE FOR
AEROSPACE APPLICATIONS

Introduction

Divinycell HT Series Foam is an expanded plastic based on a highly modified alloy of linear vinyl and crosslinked urea-amide polymers, known as an IPN or Interpenetrating Polymer Network. Divinycell HT Series Foam reflects designed properties and performance especially associated with aircraft applications. It functions structurally in continuous temperatures ranging from –330º F. to +195ºF. while maintaining the properties of high strength, light weight, thermal insulation and exceptional resistance to aging. This combination of properties and function are the key to the versatility of design and performance of Divinycell Series Foam.

DIAB advocates that Divinycell HT Series Foam be applied to multi-functional design and application. Design should reflect the ultimate in efficiency with regard to thermal insulation, acoustical and weight reductions, fire resistance (FAR 25.853, Para a1I a1ii)* and structural stability. Divinycell Foam Core applications are limited only by the designers imagination. It combines the design versatility of a vacuum formed thermoplastic with the stability and high modulus of sandwich structure.

DIAB invites you to review the information presented herein. If you have any questions or suggestions regarding Divinycell HT Series Foam, do not hesitate to contact DIAB for technical assistance.

*HT50 certified to Para a1i for thickness of 6mm (¼") and more. Thickness below 6mm (¼") and more than the 3mm (⅛") are certified to Para a1ii.

TECHNICAL BULLETIN

TABLE OF CONTENTS

TECHNICAL BULLETIN

SECTION I
PHYSICAL & ELECTRICAL PROPERTIES

Divinycell HT Physical Properties

Divinycell HT polyvinyl foam is an alloy linear vinyl and is crosslinked urea-amide polymers meet the 250º temperature requirements of the modern day Aerospace industry. This core material has been formulated make for dimensional stability with little change after 15 hours at 160º F.

Divinycell HT is highly anisotropic in respect of shear. These features make it most suitable for use as a sandwich core material in composite structures. Divinycell HT and Divinycell H250 have been used extensively for honeycomb panel edge fill.

Divinycell HT retains its rigidity at much higher temperatures than ordinary polyvinyl foam core. This fact makes it suitable for adhesive processes at higher temperatures under pressure.

Divinycell HT exhibits lower smoke and toxicity than previously produced foam cores and will meet FAR 25.853 vertical burn requirements.

Sheet Size & Maximum Thickness & Standard Tolerances

	HT 50	**HT 70**	**HT 90**	**HT 110**
Sheet Size	44.5 x 86.6	36.5 x 78.0	36.6 x 74.4	30.3 x 71.0
Maximum Thickness	1.8”	2”	1.8”	2”

Thickness Tolerance: ± .01”
Sheet Size Tolerance: ± 1/8”
Density Tolerance: ± 10%

Strength v. Temperature

Residual Compressive Strength at (Fº)
70º _____ 100%
160º _____ 75%
212º _____ 50%

Minimum Heat Forming Temperature = 260ºF

*See Operating v. Processing v. Maximum Temperature section later in this guide.

Average Physical Properties

Quality		HT 50	HT 70	HT 90	HT 110	HT 130
Density	kg/m^3	50	70	90	110	130
ASTM D 1622	lb/ft^3	3.1	4.4	5.6	6.9	8.1
Compressive Strength	Mpa (+22°C)	0.7	1.15	1.6	2.1	2.55
ASTM D 1621	psi (+72°F)	101.5	166.8	232.1	304.6	369.8
Compressive Modulus	Mpa (+22°C)	75	100	125	150	200
ASTM D 1621	psi (+72°F)	10877	14503	18129	21755	29000
Tensile Strength	Mpa (+22°C)	1.5	2.1	2.7	3.3	3.9
ASTM D 1623	psi (+72°F)	217.5	304.6	391.6	478.6	565.5
Tensile Modulus	Mpa (+22°C)	95	125	150	175	200
ASTM D 1623	psi (+72°F)	13778	18129	21755	25381	29000
Shear Strength	Mpa (+22°C)	0.55	0.9	1.25	1.6	2.05
ASTM C 273	psi (+72°F)	79.8	130.5	181.3	232.1	297.3
Shear Modulus	Mpa (+22°C)	19	26	33	40	47
ASTM C 273	psi (+72°F)	2756	3771	4786	5801	6815
Dielectric Constant		1.07	1.09	1.12	1.14	1.16
ASTM D2520						
Water Absorption	kg/m^2	0.1	0.06	0.047	0.04	0.04
ASTM C 272	lb/ft^2	0.0205	0.0123	0.0096	0.0082	0.008
Water Permeability	$m^2/s \times 10^{-8}$	2.5	1.3	1.2	1.0	0.9
ASTM E96	$ft^2/s \times 10^{-8}$	0.23	0.12	0.11	0.09	0.08
Continuous Operating	°C	-200 - +90	-200 - +90	-200 - +90	-200 - +90	-200 - +90
Temperature Range	°F	-325 - +195	-325 - +195	-325 - +195	-325 - +195	-325 - +195

Maximum continuous operating temperatures will vary due to core thickness, density, and skins used. Should be determined by in house testing.

Fastener Retention Data

The following information includes the results of shear and tensile tests performed on potted fasteners in Divinycell rigid polyvinyl foam panels.

Core Material	Divinycell HT70-4.4-P.C.F. ½" (12mm) thick
Skin Material	1 Ply Each Side of Newport Adhesives Inc. Style NB1106-7781
Potting Adhesive	SLE 3009 – Dalco Industries, California
Fastener	SHUR-LOK SL607-3-7S

Seven panels were tested. Each had 2 fasteners potted in, one was pulled in shear and the other in tension. The panels were held by a metal frame and placed in a TINUS-OLSEN testing machine which measured ultimate load in PSI.

The results follow:

	SHEAR LOAD	TENSION LOAD
PANEL #1	306 PSI	148 PSI
PANEL #2	230 PSI	110 PSI
PANEL #3	304 PSI	125 PSI
PANEL #4	270 PSI	90 PSI
PANEL #5	306 PSI	100 PSI
PANEL #6	254 PSI	100 PSI
PANEL #7	290 PSI	90 PSI
AVERAGE	280 PSI	109 PSI

In the shear tests, in several cases the adhesive partially broke away from the fastener and stayed attached to the core. It was presumed that a practice of cleaning the fasteners in a good solvent prior to use might improve the bond. The tension pulls were not made equal, but on one side only, which tends to twist the fastener. A direct pull may result in slightly higher loading capacity.

Divinycell Dielectric And Loss Tangent Properties

Test Report

Account with **Barracuda Technologies** 315 Seahawk Drive DeSoto, Texas 75115	Date 6/24/82	Page 1 of 2 Pages
	W.O. No. T 19801	P.O. No. Letter 5/18/82
	Identification: As Noted	Shipped

IDENTIFICATION: Three (3) specimens identified by customer as the following were submitted for testing:

1. Divinycell HT50 (3.1 p.c.f.) 42.1" x 60" x 12.7mm
2. Divinycell HT50 (3.1 p.c.f.) 42.1" x 60" x 3.175mm
3. Divinycell HT110 (7.0 p.c.f.) 31.6" x 60" x 12.7mm

REFERENCE: A letter from Richard L. Lang, dated 5/18/1982.

TESTING: Dielectric Constant and Dissipation Factor at 1K Hz; Dielectric Constant and Loss Tangent at X-Brand.

Dielectric Constant And Dissipation Factor

Tested as Received at Room Temperature

TEST METHOD: ASTM D-150

SPECIMAN	THICKNESS INCHES	FREQUENCY HZ	DISSIPATION FACTOR	DIELECTRIC CONSTANT
HT50	0.126	1K	0.0023	1.07

Dieletric Constant And Loss Tangent At X-Band

Tested By The Shorted Line Method

TEST FREQUENCY: 9.375 GHZ
TEST METHOD: ARTC-4

SPECIMAN	THICKNESS (INCHES)	WAVELENGTH COEFFICIENT	DIELECTRIC CONSTANT	LOSS TANGENT
SAMPLE CONDITIONING: TESTED AS RECEIVED AT ROOM TEMPERATURE				
IDENTIFICATION: HT50				
'FORWARD'	1.1970	0.7216	1.067	0.0022
'REVERSE'	1.1970	0.7209	1.066	0.0016
		AVERAGE	1.067	0.0019
INDENTIFICATION: HT110				
'FORWARD'	1.2040	0.7698	1.139	0.0019
'REVERSE'	1.2040	0.7711	1.141	0.0019
		AVERAGE	1.140	0.0019

SECTION II
FLAME SPREAD, SMOKE & TOXICITY

Flame Spread

Test Report

Account with **Barracuda Technologies** 315 Seahawk Drive DeSoto, Texas 75115	Date 4/21/82	Page 1 of 2 Pages
	W.O. No. T 19666	P.O. No. Letter 4/5/82
	Identification: As Noted	Shipped None

IDENTIFICATION: Divinycell Foam HT50, H60, H80
SPECIFICATION: FAR 25.853 (a)

60 SECOND VERTICAL IGNITION

60 SECOND VERTICAL IGNITION

Tested at Room Temperature

METHOD: Appendix F
PRE CONDITIONING: C:24/23/50

SPECIMAN	NOMINAL WIDTH	NOMINAL THICKNESS	NOMINAL LENGTH	FLAME TIME	BURN LENGTH	FLAME TIME OF DRIPPINGS	CLASSIFICATION
	INCHES	INCHES	INCHES	SECONDS	INCHES	SECONDS	
HT50							
1	3	0.25	12	0.5	5.2	ND	1
2	3	0.25	12	0.4	5.6	ND	1
3	3	0.25	12	0.3	5.7	ND	1
			AVERAGE:	0.4	5.5	ND	1
H60							
1	3	0.24	12	0.6	5.8	ND	1
2	3	0.24	12	0.5	5.9	ND	1
3	3	0.24	12	0.6	5.7	ND	1
			AVERAGE:	0.6	5.8	ND	1

60 SECOND VERTICAL IGNITION (Continued)

SPECIMAN	NOMINAL WIDTH	NOMINAL THICKNESS	NOMINAL LENGTH	FLAME TIME	BURN LENGTH	FLAME TIME OF DRIPPINGS	CLASSIFICATION
	INCHES	INCHES	INCHES	SECONDS	INCHES	SECONDS	
H80							
1	3	0.22	12	0.4	4.7	ND	1
2	3	0.22	12	0.5	5.6	ND	1
3	3	0.22	12	0.5	5.4	ND	1
			AVERAGE:	0.5	5.2	ND	1
			Minimum requirements:	5	6	3	

ND = No Drippings
1 = Self-extinguishing by this test.
2 = Burning by this test.

Test Report

Account with	Date	Page 1 of 2 Pages
Barracuda Technologies 315 Seahawk Drive DeSoto, Texas 75115	3/23/82	
	W.O. No. T 19603	P.O. No. 1125
	Identification: As Noted	Shipped [ ] None

IDENTIFICATION: Divinycell HT50, HT70
SPECIFICATION: Boeing Company Document No. D6 T 10861-1

60 SECOND VERTICAL IGNITION

TEST METHOD: FAR 25.853 (a), Appendix F and BSS 7230

PRE CONDITIONING: C:24/23/50

TEST TEMPERATURE: 73º +/- 5ºf

IGNITION SOURCE: Matheson Manufactured Gas Type “B”

FLAME TEMPERATURE: 1800º +/- 50º C

SPECIMEN CONFIGURATION: Nominal 3.0” W x 12.0” L x 0.13” T.

SAMPLE NO.	EXTINGUISHING TIME (SECONDS)	BURNED LENGTH (INCHES)	DRIP EXTINGUISHING TIME (SECONDS)	MATERIAL CLASSIFICATION
HT50 Divinycell Rigid PVC Foam				
1	0.6	6.6	ND	2
2	0.7	6.9	ND	2
3	0.6	7.2	ND	2
AVERAGE:	0.6	6.9	ND	2

TECHNICAL BULLETIN

60 SECOND VERTICAL IGNITION (Continued)

SAMPLE NO.	EXTINGUISHING TIME (SECONDS)	BURNED LENGTH (INCHES)	DRIP EXTINGUISHING TIME (SECONDS)	MATERIAL CLASSIFICATION
HT 70 – Divinycell Rigid PVC Foam				
1	1.1	5.8	ND	1
2	0.9	5.6	ND	1
3	0.7	5.8	ND	1
AVERAGE:	0.9	5.7	ND	1
MAXIMUM REQUIREMENT:	15	6	3	

ND = No Drippings
1 = Self-extinguishing by this test.
2 = Burning by this test.

Test Report

Account with **Barracuda Technologies** 315 Seahawk Drive DeSoto, Texas 75115	Date 2/28/82	Page 1 of 2 Pages
	W.O. No. T 19481A	P.O. No. Letter 1/29/82
	Identification: As Noted	Shipped ☐ None

IDENTIFICATION: Divinycell HT 50 (3.1 p.c.f.)

SPECIFICATION: Boeing Company Document No. D6 T 10861-1

12 SECOND VERTICAL IGNITION

TEST METHOD: FAR 25.853 (b) and BSS 7230

PRE CONDITIONING: C: 24/23/50

TEST TEMPERATURE: 73º +/- 5ºF

IGNITION SOURCE: Matheson Manufactured Gas Type “B”

FLAME TEMPERATURE: 1800º +/- 50ºC

SPECIMEN CONFIGURATION: Nominal 3.0” W x 12.0” L x 0.13” T.

SAMPLE NO.	EXTINGUISHING TIME (SECONDS)	BURNED LENGTH (INCHES)	DRIP EXTINGUISHING TIME (SECONDS)	MATERIAL CLASSIFICATION
1	0.4	6.6	ND	A
2	0.7	6.3	ND	A
3	0.6	7.6	ND	A
AVERAGE:	0.6	6.8	ND	A
MAXIMUM ALLOWED:	15	8	5	

12 SECOND VERTICAL IGNITION (Continued)

MATERIAL CLASSIFICATION

A – Self-extinguishing by this test.
B – Burning by this test.

ND – No drippings.

Test Report

Account with	Date	Page 1 of 2 Pages
Barracuda Technologies 315 Seahawk Drive DeSoto, Texas 75115	2/28/82	
	W.O. No. T 19481D	P.O. No. Letter 1/29/82
	Identification: As Noted	Shipped ☐ None

IDENTIFICATION: Divinycell HT 70 (4.3 p.c.f.)

SPECIFICATION: Boeing Company Document No. D6 T 10861-1

12 SECOND VERTICAL IGNITION

TEST METHOD: FAR 25.853 (b) and BSS 7230

PRE CONDITIONING: C: 24/23/50

TEST TEMPERATURE: 75º +/- 5ºF

IGNITION SOURCE: Matheson Manufactured Gas Type “B”

FLAME TEMPERATURE: 1800º +/- 50ºC

SPECIMEN CONFIGURATION: Nominal 3.0” W x 12.0” L x 0.13” T.

SAMPLE NO.	EXTINGUISHING TIME (SECONDS)	BURNED LENGTH (INCHES)	DRIP EXTINGUISHING TIME (SECONDS)	MATERIAL CLASSIFICATION
1	0.8	5.8	ND	A
2	0.8	5.9	ND	A
3	1.0	5.2	ND	A
AVERAGE:	0.9	5.6	ND	A
MAXIMUM ALLOWED:	15	8	5	

12 SECOND VERTICAL IGNITION (Continued)

MATERIAL CLASSIFICATION

A – Self-extinguishing by this test.
B – Burning by this test.

ND – No drippings.

Smoke

Test Report

Account with **Barracuda Technologies** 315 Seahawk Drive DeSoto, Texas 75115	Date 2/28/82	Page 1 of 2 Pages
	W.O. No. T 19481D	P.O. No. Letter 1/29/82
	Identification: As Noted	Shipped ☐ None

IDENTIFICATION: Divinycell HT 50 (3.1 p.c.f.)

SPECIFICATION: Boeing Company Document No. D6 T 10861-1

Smoke Generation By Materials On Combustion

TEST METHOD: BSS 7238

TEST TEMPERATURE: 73º +/- 5ºF

PRE CONDITIONING: C: 24/23/50

SPECIMEN	THICKNESS (INCH)	90 SECONDS MLT(%)	90 SECONDS DS	4 MINUTES MLT(%)	4 MINUTES DS	MINIMUM MLT(%)	MINIMUM Dm	MINIMUM Dm (MINUTES)	Dc	Dm(corr.)
Non-flaming Exposure:										
1	0.132	66	23.8	55	34.3	51	38.6	8	1	37.6
2	0.130	72	18.8	61	28.3	51	38.6	12	1	37.6
3	0.131	70	20.4	58	31.2	51	38.6	10	1	37.6
		AVERAGE:	21.0		31.3					37.6
		STANDARD DEVIATION:	2.6		3.0					0.0

SMOKE GENERATION BY MATERIALS ON COMBUSTION (Continued)

SPECIMEN	THICKNESS (INCH)	90 SECONDS MLT(%)	90 SECONDS DS	4 MINUTES MLT(%)	4 MINUTES DS	MINIMUM MLT(%)	MINIMUM Dm	MINIMUM Dm (MINUTES)	Dc	Dm(corr.)
Flaming Exposure:										
1	0.133	42	49.7	37	57.0	36	58.6	6	2	56.6
2	0.130	48	42.1	43	48.4	42	49.7	5	1	48.7
3	0.132	45	45.8	39	54.0	38	55.5	5	1	54.5
4	0.131	47	43.3	42	49.7	41	51.1	6	1	50.1
5	0.132	43	48.4	39	54.0	38	55.5	5	1	54.5
	AVERAGE:		45.9		52.6					52.9
	STANDARD DEVIATION:		3.2		3.5					3.3
	REQUIRED PER D6 T 10861-1:				50, maximum					

TECHNICAL BULLETIN

Test Report

Account with	Date	Page 1 of 2 Pages
Barracuda Technologies 315 Seahawk Drive DeSoto, Texas 75115	2/28/82	
	W.O. No. T 19481E	P.O. No. Letter 1/29/82
	Identification: As Noted	Shipped None

IDENTIFICATION: Divinycell HT 70 (4.3 p.c.f.)

SPECIFICATION: Boeing Company Document No. D6 T 10861-1

Smoke Generation By Materials On Combustion

TEST METHOD: BSS 7238

TEST TEMPERATURE: 73º +/- 5ºF

PRE CONDITIONING: C: 24/23/50

SPECIMEN	THICKNESS (INCH)	90 SECONDS MLT(%)	90 SECONDS DS	4 MINUTES MLT(%)	4 MINUTES DS	MINIMUM MLT(%)	MINIMUM Dm	MINIMUM Dm (MINUTES)	Dc	Dm(corr.)
Non-flaming Exposure:										
1	0.130	66	23.8	51	38.6	41	51.1	11	1	50.1
2	0.128	57	32.2	48	42.1	45	45.8	7	1	44.8
3	0.128	68	22.1	55	34.3	44	47.1	11	1	45.1
4	0.132	60	29.3	40	52.5	37	57.0	8	2	55.0
		AVERAGE:	26.9		41.9					48.8
		STANDARD DEVIATION:	4.7		7.8					4.8

SMOKE GENERATION BY MATERIALS ON COMBUSTION (Continued)

SPECIMEN	THICKNESS (INCH)	90 SECONDS MLT(%)	90 SECONDS DS	4 MINUTES MLT(%)	4 MINUTES DS	MINIMUM MLT(%)	MINIMUM Dm	MINIMUM Dm (MINUTES)	Dc	Dm(corr.)
Flaming Exposure:										
1	0.132	42	49.7	34	61.8	33	63.6	6	2	61.6
2	0.132	42	49.7	34	61.8	33	63.6	5	2	61.6
3	0.128	43	48.4	36	58.6	35	60.2	6	1	59.2
4	0.134	40	52.5	30	69.0	29	71.0	6	2	69.0
5	0.130	44	47.1	35	60.2	34	61.8	6	1	60.8
	AVERAGE:		49.5		62.3					62.4
	STANDARD DEVIATION:		2.0		4.0					3.8
	REQUIRED PER D6 T 10861-1:				50, maximum					

Test Report

Account with	Date	Page 1 of 2 Pages
Barracuda Technologies 315 Seahawk Drive DeSoto, Texas 75115	4/13/88	
	W.O. No.	P.O. No. Letter
	Identification: As Noted	Shipped ☐ None

IDENTIFICATION: Divinycell HT 70 with Compolet Skins

SPECIFICATION: O.S.U. Heat Release Test

TEST METHOD: ASTM-E-906

TEST TEMPERATURE:

PRE CONDITIONING: C: 24/23/50

Material HT70 0.5”	HEAT RELEASE 2 MINUTES KW-MIN/M2	PEAK RATE KW/M2	SMOKE DENSITY 2 MINUTES SMK/M2	PEAK RATE SMK/MIN-M2
1	59	46	28	55
2	66	49	45	76
3	53	40	73	95
Average	59	45	49	76

COMPOLET pre-preg is moulding blank, mouldable both in flat and in complex shaped form. It is composed of a phenolic resin reinforced with random oriented glass fibre.

Toxicity

Test Report

Account with	Date	Page 1 of 1 Pages
Barracuda Technologies 315 Seahawk Drive DeSoto, Texas 75115	2/28/82	
	W.O. No. T19481C	P.O. No. Letter 1/29/82
	Identification: As Noted	Shipped None

IDENTIFICATION: Divinycell HT 50 (3.1 p.c.f.)

SPECIFICATION: Boeing Company Document No. D6 T10861-1

TOXIC GAS GENERATION BY MATERIALS ON COMBUSION
USING DRAGER TUBE ANALYSIS

TEST METHOD: BSS 7239

TEST TEMPERATURE: 73º +/- 5º F

TEST CONDITIONINS: Materials were tested simultaneously with Smoke Generation by Materials on Combustion, BSS 7238, using the flaming mode only. Gas sampling, in all cases, was initiated four (4) minutes after the start of testing to BSS 7238.

SPECIMEN	CO (ppm)	$S0_2$ (ppm)	HC1 (ppm)	NO_X (ppm)	HCN (ppm)	HF (ppm)
1	8	0	18	2	8	0
2	6	0	19	3	6	0
3	5	0	25	2	7	0
4	-	-	26	-	-	-
AVERAGE:	6	0	22	2	7	0
STANDARD DEVIATION:	1.5	0	4.1	0.6	1.0	0
MAXIMUM ALLOWED:	3500	100	500	100	150	50

TECHNICAL BULLETIN

Test Report

Account with	Date	Page 1 of 1 Pages
Barracuda Technologies 315 Seahawk Drive DeSoto, Texas 75115	2/28/82	
	W.O. No. T19481C	P.O. No. Letter 1/29/82
	Identification: As Noted	Shipped ☐ None

IDENTIFICATION: Divinycell HT 70 (4.3 p.c.f.)

SPECIFICATION: Boeing Company Document No. D6 T10861-1

TOXIC GAS GENERATION BY MATERIALS ON COMBUSION
USING DRAGER TUBE ANALYSIS

TEST METHOD: BSS 7239

TEST TEMPERATURE: 73º +/- 5º F

TEST CONDITIONINS: Materials were tested simultaneously with Smoke Generation by Materials on Combustion, BSS 7238, using the flaming mode only. Gas sampling, in all cases, was initiated four (4) minutes after the start of testing to BSS 7238.

SPECIMEN	CO (ppm)	$S0_2$ (ppm)	HC1 (ppm)	NO_x (ppm)	HCN (ppm)	HF (ppm)
1	15	0	60	10	9	0
2	12	0	70	6	7	0
3	18	0	45	7	6	0
4	-	-	-	5	-	-
AVERAGE:	15	0	58	7	7	0
STANDARD DEVIATION:	3.0	0	12.6	2.2	1.5	0
MAXIMUM ALLOWED:	3500	100	500	100	150	50

E-84 Tunnel Test

I. Introduction

This report presents the results of a flame spread tunnel test on a polyvinyl chloride foam, submitted for evaluation for Barracuda Technologies, Incorporated of DeSoto, Texas. This Report contains a description of the material tested, the preparation and conditioning of the specimen, the test procedure, and finally the test results. Note that the results only apply to the specimen tested, in the manner tested, and not to the entire production of this or similar materials, nor to this material's performance when used in combination with other materials. All test data are on file and are available for review by authorized persons.

The test was conducted in accordance with the provisions of ASTM Designation E84-80, "Standard Method of Test for Surface Burning Characteristics of Building Materials." This test method is similar to the test method specified in ANSI No. 2.5, NFPA No. 255, UL No. 723, UBC No. 42-1, and ASTM E84-75; however, two improvements have been incorporated in the current E84-80 procedure, i.e., the stack pressure control tap has been relocated to a position forward of the burners and the formulae used to calculate the flame spread have been modified – resulting in slightly lower values.

The purpose of the test was to evaluate performance of the test specimen in relation to that of mineral-fiber-cement board and red oak flooring under similar fire exposure. The results are expressed in terms of flame spread, fuel contribution, and smoke development during a 10-minute exposure and recorded as a ratio with mineral-fiber-cement board 0 and red oak flooring 100.

II. Description Of Materials

On April 25, 1983, the test material was received from the Sponsor. It is described in Table 1:

Table 1. Description

Type:	Polyvinyl chloride foam core
Code No.:	Type 30
Trade Name:	Divinycell™
Thickness:	1.0 in. (25.4 mm)
Unit Weight:	0.202 lb/ft^2 (0.99 kg/m^2)
Total Weight:	9.80 lb (4.45 kg)
Density:	2.43 lb/ft^3 (38.86 kg/m^3)
Size Received:	3 pieces, 21¼ x 109½ in. (0.54 x 2.78m)

III. Preparation And Conditioning Of Test Specimen

The 21 in. x 25 ft. (0.53 x 7.63 m) specimen was prepared using two of the 21 ¼ x 109 ½ in. (0.54 x 2.78 m) sections and one piece cut to 81 in. (2.06 m). They were placed end-to-end in the tunnel with no additional support.

The specimen was conditioned for 7 days in an atmosphere maintained between 68º and 78º F (20º and 26º C) temperature and 45 to 55 percent relative humidity.

IV. Test Procedure

The test was conducted on May 3, 1983. Reference data were obtained and furnace operation checked by conducting a 10-minute test with mineral-fiber-cement board on the day of the test and by periodic test with red oak flooring. These tested provided the 0 and 100 references for flame spread, fuel contribution, and smoke density. Ignition over the burners was noted 46 seconds after the start of the test in the most recent calibration with red oak flooring. Each specimen to be evaluated was tested in accordance with the standard procedure.

V. Test Results

The test results were calculated on the basis of observed flame travel and the measurements of areas under the recorder curves of furnace temperature and smoke density (see Table 2). To allow for possible variations in results due to limitations of the test method, the numerical results were adjusted to the nearest figure divisible by 5.

Recorded data for flame spread, fuel contribution, and smoke density of the specimen are shown in the figures at the end of this report as a solid line on each graph.

Table 2. Classification

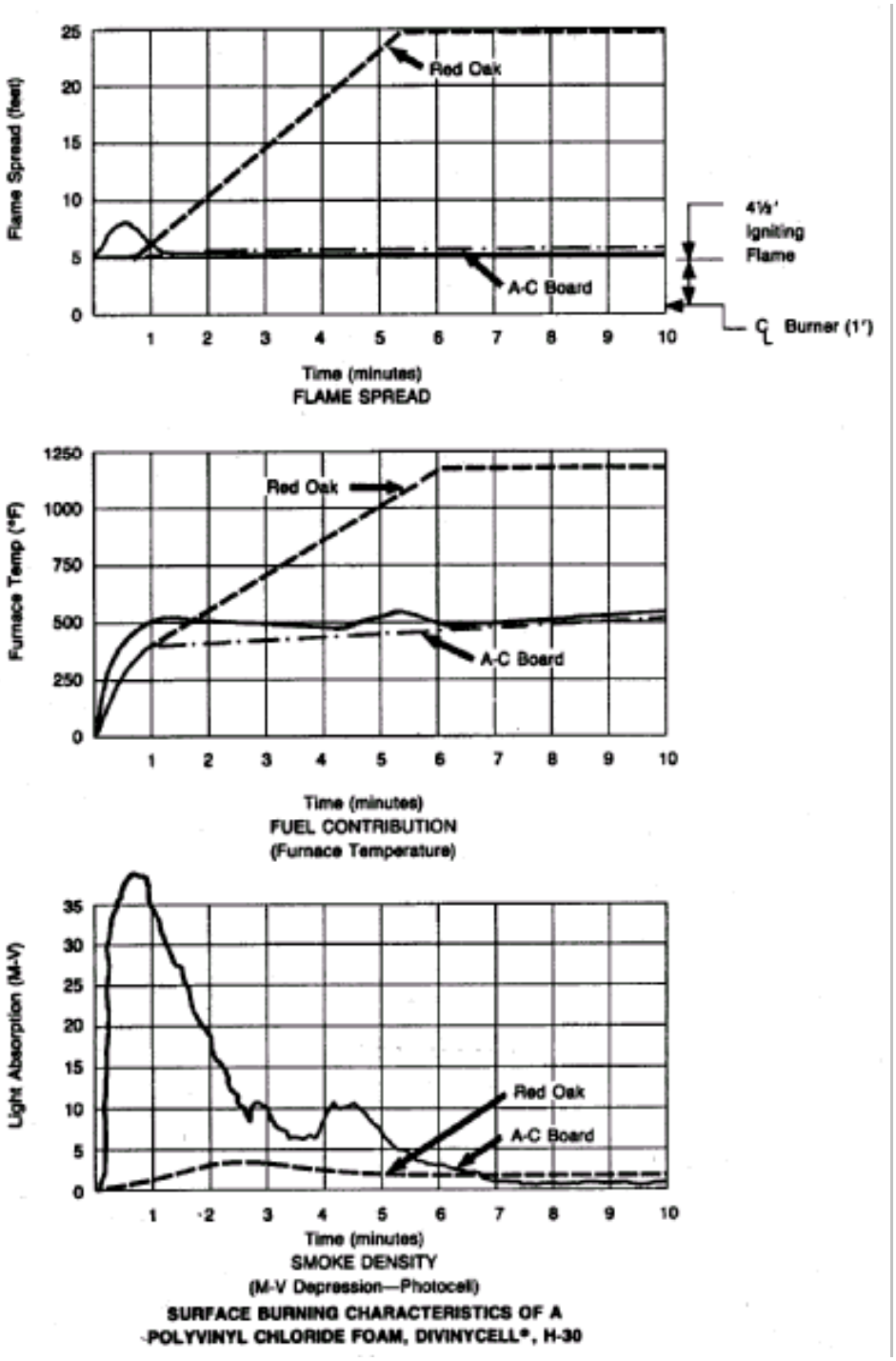
Test Specimen	Flame Spread Index E84-80	Fuel Contribution	Smoke Density
Mineral-Fiber-Cement Board	0	0	0
Red Oak Flooring	100	100	100
Polyvinyl Chloride Foam, Divinycell™, H-30	15	0	445

VI. Observations During And After Test

The observations made during and after the test are summarized as follows: Ignition of the foam occurred at 2 seconds with pieces of char falling at 40 seconds. At 1 minute 45

seconds, material on the floor was burning. The maximum flame advance to 8½ ft. (2.59 m) occurred at 30 seconds at sample level. On the floor of the tunnel, the material burned to 15 ft (4.57 m). There was no afterflame.

The foam was melted away to 20 ft (6.10 m) with face melt to 25 ft. (7.63m).



SURFACE BURNING CHARACTERISTICS OF A POLYVINYL CHLORIDE FOAM, DIVINYCELL®, H-30

Section III
Thermoformed And Flat Panel
Process Specifications

Divinycell Ht Process Specs For Thermoformed Composite Panels Utilizing 250º F. Curing Prepreg Resin Systems

General:

DIAB Inc. presents the information herein for the express purpose of fabricating Divinycell HT Foam Core composite structures. Information herein shall be regarded as a general guide for establishment of processing and fabrication of Divinycell HT Foam Core structures. Each fabricator or user should determine what specific process variables are required for successful adaptation of this Divinycell HT Foam Core process.

DIAB Inc. advocates that this dynamic structural system be multi-functionally designed. Design should reflect the ultimate in efficiency with regard to thermal insulation, sound deadening, weight reduction, fire resistance (FAR 25) and structural stability. Divinycell HT Foam Core applications are limited only by a designers imagination. It combines the design versatility of vacuum formed plastic with the stability and high modulus of sandwich structure.

If you have any questions or suggestions regarding the information herein, do not hesitate to contact DIAB Inc. for technical assistance.

REVISION LETTER	DATE	DESCRIPTION
A	May 31, 1983	First Draft
B	April 15, 1988	Added O.S.U. Heat Release Test

Table Of Contents

Divinycell HT Process Specification For
Thermoformed Composite Panels Utilizing 250º F
Cure Resin-Fabric Systems (Pre-Preg)

I. Scope:

This specification covers the equipment, material and process required to fabricate foam core composite interior panels.

II. General Equipment Requirements:

1.0 One convection type oven capable of maintaining 250º degrees F to 275º degrees F +/- 5º degrees throughout with a vacuum source or manifold inside the oven. Oven should have a temperature tracking and recording system (thermocouples) that allow oven temperature and part temperature monitoring.

2.0 One vacuum pump with surge tank and capacity to maintain a minimum of 24 to 29 inches Hg (mercury) on a continuous basis.

3.0 General shop saws and related equipment for part trimming.

III. Material Requirements:

1.0 Tool Construction
- 1.1.0 Tooling epoxy
- 1.2.0 Reinforcement fabrics
- 1.3.0 Sheet wax
- 1.4.0 Mold release
- 1.5.0 Silicone seal

2.0 Part Construction
- 2.1.0 Divinycell HT Structural Foam Core
- 2.2.0 Pre-preg reinforcement fabrics
- 2.3.0 Peel ply, release fabrics
- 2.4.0 Bleeder fabrics
- 2.5.0 Mold release
- 2.6.0 Joint or filler compounds
- 2.7.0 Bagging film

IV. General Process Procedure – Tooling:

1.0 Tooling Requirements for Fabrication of Matched Mold Concept
- 1.1.0 Obtain or fabricate mold (mold may be male or female depending on size, shape or complexity of part to be fabricated).
- 1.2.0 Clean and check mold surface for any defects. Apply 3 coats of a non-transferable mold release or as recommended by release manufacturer. This will facilitate easy removal of sheet wax applied in 1.3.0.
- 1.3.0 Apply the sheet wax in the required thickness to achieve the desired over-all panel thickness. I.e. 1/8” thick final part thickness requires a 1/8” thick wax sheet.

1.4.0 Layup a laminate approximately 3/16 inch thick over the top of the sheet wax using a suitable tooling resin system, either a room temperature curing system capable of extended use at 275º degrees F. If a heat cure system is utilized, use caution not to exceed the melting temperature of the wax.

1.5.0 After laminate has cured and cooled to room temperature, remove it from the mold and clean all sheet wax from its surfaces. From this point on, the 3/16 inch thick laminate made over the sheet wax will be referred to as the tool lid or top. The lid or bottom tool may be fitted with guide pins to position these parts properly during part loading.

1.6.0 A vacuum fitting(s) should be attached either to the old base or the tool lid. The over-all size of the tool will determine the number of fittings required. The location of each fitting is determined by the complexity of the part to be produced.

1.7.0 The outer edge of the tool base should now be fitted with a silicone rubber seal, set to the inside of the guide pins (if so equipped). The seal should rest within a channel which will eliminate its tendency to pull away during vacuum clamping.

2.0 Tool Lid Within A Vacuum Bag

2.1.0 One alternate method to utilize the tool lid is to trim it back around the edges leaving approximately 3" of base tool accessible for bag sealing.

2.2.0 Utilizing vacuum bag sealing tape on edge of base tool place part with tool lid in position, place bagging film and bleeder cloth over the top of the lid, seal bag film to seal tape and apply vacuum.

V. Part Fabrication – Matched Tool Process:

1.0 Hot Forming Foam Core

1.1.0 Preheat oven to 260º F. Apply a mold release to tool base and lid. Ensure both surfaces are clean before application.

1.2.0 Trim foam core to fit inside of silicone seal (any excess core will be trimmed off later). The core may be taped in position to insure its proper centering within the tool cavity.

1.3.0 Set tool lid in place, but do not clamp shut. The weight of the tool lid is necessary to help work the foam core into shape during the heat soak cycle.

1.4.0 Place tool in oven at 240º F for HT50 core or continue 260º F oven setting when utilizing HT70, HT90 or HT110 core. Allow core within the tool to heat soak for a minimum of 45 minutes. Actual heat soak time may be accurately determined via the use of thermocouple tracking of actual foam temperature depending on thickness of the core and complexity of the part being formed. The heat soak time may have to be extended as required.**

1.5.0 At the end of the heat soak, remove tool from oven, attach and apply full vacuum. Push lid down to obtain seal (clamping may be necessary). If the shape is complex – return tool to oven (under

vacuum) for 30-45 minutes. Allow foam temperature to cool down to at least 140º F before removing the now formed core.

2.0 Fabric Layup of Formed Foam Core

2.1.0 Use tool base or lid to support formed core during layup. Apply pre-preg to both surfaces of the formed core.

2.2.0 Apply peel ply to front and back of part after pre-preg. Peel ply may be omitted from tool side or inside of panel surface depending on desired finish.

2.3.0 Apply bleeder to peel ply covered surfaces. Be sure bleeder does not come in contact with pre-preg. If peel ply is not used, do not use bleeder on pre-preg surface.

2.4.0 Place part in tool and close lid. Apply full vacuum and work lid down until a good seal is obtained (clamping may be necessary).

2.5.0 Cure part within oven according to pre-preg data sheet. Do not exceed 240º F for HT50 or 260º F for HT70, HT90 or HT110 cores (part temps.)**

2.6.0 When part has cured, remove tool from oven and allow tools to cool down under vacuum to 140º F part temperature. Use shop fans to speed cooling process.

2.7.0 Discontinue vacuum and carefully remove part from mold. Bleeder and peel ply may now be removed.

2.8.0 Inspect part for bond continuity and wrinkles. When acceptable, establish trim lines and trim part as required.

VI. Process And Tooling Requirements For Fabrication Utilizing Single Tool Process:

1.0 Obtain mold. Mold may be male or female depending on size, shape and complexity of the part to be fabricated. When choosing tool, consideration should be given as to which side of part will be upholstered. Generally, the tool side will be upholstered.

2.0 Clean and check surface of mold for any defects that may show up in the surface of you part. At this point, apply a non-transferring release agent per product data sheet.

3.0 Develop templates of metal or other suitable material to use as an outline to cut foam core material into pieces to fit tool cavity. Allow suitable space between pieces of core, especially in any sharp angles or corners. These spaces will be filled with a suitable filler compound.

4.0 Layup of Template Cut Core Material

4.1.0 Apply pre-preg to tool surface.

4.2.0 Place pre-cut pieces of core on top of pre-preg applied to tool. Use a heat gun as necessary to get core to stick down to pre-preg and tool.

4.3.0 Apply filler material between gaps in corners as required. Recommend filler material applied via SEMCO Tube.

4.4.0 Apply pre-preg over top of core material. Use a heat gun to stick pre-preg onto core material, if necessary.

4.5.0 Apply peel play to exposed pre-preg surface. Make sure the peel ply does not bridge any angles, corners or radii.

4.6.0 Apply bleeder cloth on top of peel ply covered surface. Be sure bleeder cloth is not contacting pre-preg.
4.7.0 Apply vacuum bag sealing tape around edge of tool. Seal bagging film and apply vacuum while checking for leaks and any bidging of bag film.
4.8.0 Place tool in pre-heated oven set at proper curing temperature.
4.9.0 When part has achieved cure, remove from oven and allow to cool to at least 140º F temperature.
4.10.0 Remove bag film, bleeder and peel ply and carefully demold part from tool.
4.11.0 Inspect part and when acceptable, establish trim lines on part and trim as required.

VII. Operating Temperature:

It is recommended that foam core interior panels fabricated in accordance with this specification not be used in an environment that will expose them to temperatures in excess of 225º F for excessive periods of time. Foam core structures will operate successfully in a continuous temperature environment ranging from –67º to 225º F. For exposure to temperatures in excess of 225º F, contact DIAB Inc. for technical recommendations or assistance.

**… Critical limitation or procedure

VIII. Maximum Process Temperature

Maximum process temperature has historically been the temperature at which Divinycell HT can be processed without causing more than a 1% change in dimensional stability. Some material discoloration is normal up to a dark brown.

Grade	Maximum Process Temperature	
HT70	250° F	121° C
HT90	250° F	121° C
HT110	250° F – 265° F	121° C – 130° C
HT130	250° F – 265° F	121° C – 130° C

Exceeding a maximum process temp will result in a 4-5% shrinkage of the core up to 280F, and up to 10% shrinkage up to 300F.

IX. Not to Exceed Temperature

Not to exceed temperature is the temperature at which Divinycell HT experiences degradation of the physical properties.

Grade	Maximum Process Temperature	
All	300° F	149° C

Visually this is characterized by the material turning black (not brown or dark brown), a simple pH test can be done to confirm visual observations. Add about 1-gr. suspect material grindings to 20 gr. of distilled water. Stir and allow to soak for 60 minutes. pH test with litmus paper or electronic pH meter. pH value will be 4.5 or less indicating degradation. Further it should be explained that this degradation is time dependent on the order of 25-45 minutes. Short cycles on the order of 6 minutes @ 325°F are currently being used with Divinycell HT 110 with successful results.

Divinycell HT Process Specifications For Flat Panels Using A Heated Platten Press

I. Equipment

Single or multiple opening heated platten press, capable of maintaining even pressure across the faces. Plattens should heat and cool evenly and maintain + or –5ºF. during the cure cycle. A temperature tracking system is recommended for maintaining accuracy.

II. General Information

Divinycell HT grades are formulated to be stable for one hour at 250º F*. Pre-preg reinforcement fabrics or adhesives should match this cycle as closely as possible. The proper core density should be selected based on load requirements. Compressive and shear strengths, and impact potentials should be analyzed to determine core density. These requirements should also be considered when choosing the appropriate skin thickness and type. Tolerance on core thickness is + or - .010” (inches). Then calculating core thickness, .010” to .020” should be added to allow for some compression at laminating temperature; I.e.: if a finished panel of .500” is required, with a .20 skin on each side (total skins .040”), a core of .480” thick would be ordered (not .460”). The press would then be loaded at .520” and stops set at .500” to assure uniformity of final panel thickness. Divinycell HT has a smooth even surface to provide good bonding. However, if very high peel strengths are required, we can texturize the surface to enable greater resin penetration. This style of material is specified at HT-RS. General if HT-RS is used with a pre-preg reinforcement, the resin % of the pre-preg should be increased slightly or a film adhesive placed between the laminate and the core. The additional resin will penetrate the roughened surface, resulting in higher skin peel values.

* HT50 is formulated for 1 hr. at 240º F.

III. Preparation

Divinycell HT core is closed cell and will not absorb moisture. However, in humid climates some moisture may accumulate in the cut surface cells. It is recommended if this problem exists, each sheet be dried for 15 to 20 minutes at 150ºF. prior to bonding. All surfaces should be cleaned of dust and dirt before lamination begins.

IV. Pressing

Press stops must always be used, as mentioned in section II, to assure proper panel thickness tolerance. For best results, presses should be loaded at medium temperatures (ie: 140ºF), brought up to curing levels for the desired time, and then cooled before opening. This will assure the best consistency. However, with Divinycell HT it is possible to load the press at near cure temperature. Even though we do not recommend opening the press before a cooling cycle, if production levels require it, the panels should be immediately placed between two sheets of ½” plywood to allow an even cool-down. Some formulations of adhesives may off-gas slightly as they begin to cure. This could cause voids between the laminate and core. Procedure to avoid this problem would be to

"bump" or "burp" the press a few minutes into the cycle (5 to 7 minutes is most common). The use of breather fabrics may also help to solve off-gassing problems.

VI. Finishing

Surface finishes can be applied at the same time as the laminates if all materials and adhesives are compatible. In most instances, finish layers are post applied in separate bonding cycle to assure their appearance. Painting panels is becoming more popular to save weight and expense. To improve the laminate surface for painting, a layer of filler or surface prep may be applied during bonding. This helps to fill skin porosity and enhance painted surfaces.

Appendix A

Materials / Vendor List

MATERIAL	USAGE	VENDOR
Divinycell Rigid Foam Core HT50 (3.1 p.c.f.) HT70 (4.4 p.c.f.) HT90 (5.6 p.c.f.) HT110 (7.0 p.c.f.)	 Core Material Core Material Core Material Core Material	DIAB Inc. 315 Seahawk Drive DeSoto, TX 75115 Tel. 972-228-7600 Fax 972-228-2667 www.diabgroup.com

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