

Benecor

Honeycomb Core

SPECIFICATION NO.:
LCS - 100

REVISION NO.:
9

DATE:
11/19/08

LASER SPECIFICATION

REVISIONS

REV. 0	Original Issue	4-Apr-96
REV. 1	General revision	29-May-96
REV. 2	General revision	1-Jul-96
REV. 3	General revision	20-May-97
REV. 4	General revision	27-Jul-99
REV. 5	General revision	17-Jul-01
REV. 6	General revision	18-Jul-03
REV. 7	Added Weld Strength Option	15-Feb-08
REV. 8	Revised Thickness Tolerance, General Rev.	7-Mar-08
REV. 9	Added cell size criteria and core condition	11-Nov-08

APPROVALS

ENGINEERING

DATE

QUALITY ASSURANCE

DATE

1.0 SCOPE

This specification establishes the requirements and acceptance criteria for laser welded honeycomb core prior to any subsequent operations.

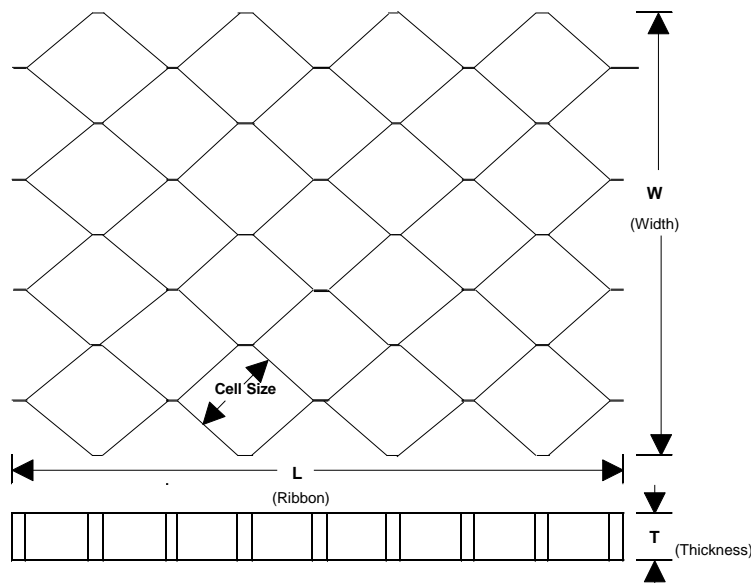
2.0 DOCUMENT PRIORITY

In the event of conflict between the requirements of applicable documents, the following precedence shall apply:

- 2.1 Purchase agreement or contract.
- 2.2 Engineering Drawings.
- 2.3 This Specification.
- 2.4 Other applicable documents.

3.0 DEFINITIONS

- 3.1 Blanket: Laser welded assembly of expanded foil forming the honeycomb core structure.
- 3.2 Cell Size: Distance between two parallel cell walls.
- 3.3 Foil: Sheet or strip as received from the mill.
- 3.4 Length (L): Measurement in direction of the foil (ribbon direction, Figure 1).
- 3.5 Node: Weldment area between foils.
- 3.6 Thickness (T): Height of core (Depth).
- 3.7 Width (W): Measurement perpendicular to the direction of the foil (Figure 1).



**DIMENSION INTERPRETATION
FIGURE 1**

6.0 CORE REQUIREMENTS

6.1 Length and Width Dimensions

Unless otherwise specified in the purchase order, the following tolerances on dimensions of the core blanket shall apply:

- L - parallel to foil direction: -0", +1"
- W - perpendicular to foil direction: -0", +1"

6.2 Thickness Tolerance

Thickness tolerance of the core blanket shall be as specified in Table 1.

NOMINAL CUT THICKNESS, INCHES	TOLERANCE, INCHES
Finish Surfaces (F)	± 0.003
Standard Surfaces (S)	± 0.010
Rough Surfaces (R)	± 0.030

**TABLE 1
CORE THICKNESS TOLERANCES**

- 1/ Localized surface steps exceeding 0.003 inch are not permitted on finished core surfaces.
- 2/ The rough surface core face will contain no slits, tears, craters, burns, or other defects that cannot be removed by subsequent machining to the nominal thickness dimension defined by the purchase order.

6.3 Flatness

Core shall conform to a flat surface plate within the tolerance of the surface finish under hold-down pressure of not more than 5 psi.

7.0 CELL GEOMETRY

7.1 Cell Size

Typically, the bi-directional (Figure 3) 10-cell average, where n equals 10, shall be within ± 10 percent of nominal cell size measured as follows.

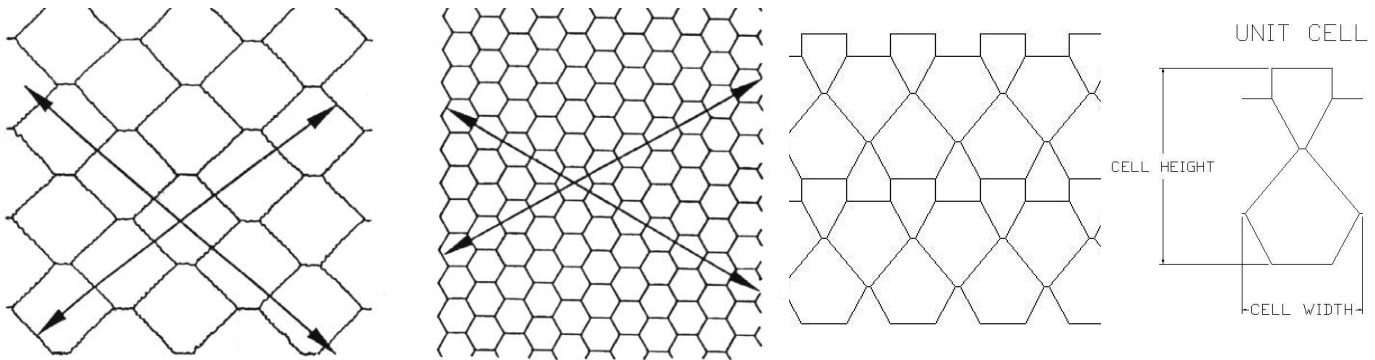
$$\text{Cell Size Measurement Square Cell} = (n \times C_s) + [(n+1) \times t_f]$$

- bi-directional
n = Number of Cells
- C_s = Cell Size
- t_f = Foil Thickness

Cell Size Measurement Beneflex Cell Height= $[n \times (C_s \times 2.163)] + [(nx4) \times t_f]$
n = Number of Cells
C_s = Cell Size
t_f = Foil Thickness

Cell Size Measurement Beneflex Cell Width= $n \times (C_s \times 1.333)$
n = Number of Cells
C_s = Cell Size

No single cell shall vary from the nominal cell size by more than 15% except that spliced cells may be up to 30% smaller than the nominal size.



**CELL SIZE MEASUREMENT
FIGURE 3**

7.2 Hexagonal Cell Construction

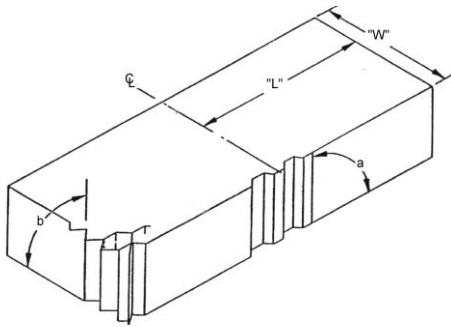
Hexagonal cell honeycomb core is constructed by performing a double weld pass at each node creating the appropriate node dimension for an hexagonal configuration.

7.3 Beneflex Cell Construction

Beneflex cell honeycomb core is constructed by welding a square cell pattern followed by a pattern with double welds at each node to create the appropriate node dimensions for a Beneflex configuration.

7.4 Core Cell Angles

Cell angles for core shall meet the requirements shown in Figure 4.



ANGLE 90°	CORE SIZE	
	2-20	2-30 and larger
a	± 1°	± 2°
b	± 2°	± 2°

**CORE CELL ANGLES
FIGURE 4**

7.5 Density

The Density of the finished blanket shall be specified as nominal. Typical density values are given in Appendix 3, Appendix 4 and Appendix 5.

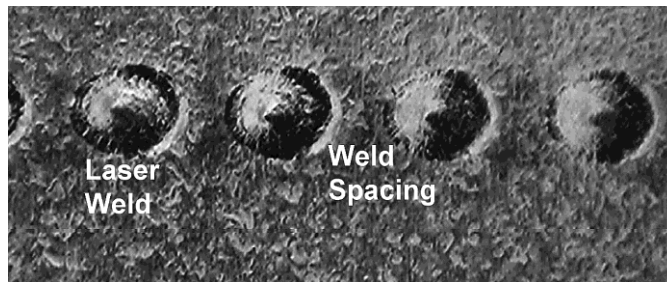
7.6 Out of Square

The angle between two adjacent cell walls within a cell shall not deviate from 90 degrees by more than 10 degrees. This only applies to square cell sizes of 0.125" and greater.

8.0 WELD CHARACTERISTICS

8.1 Node Welds

Welds shall be approximately equally spaced along the node length (core thickness). The number of welds and weld spacing shall be adequate to assure welds meet the Node Shear Strength requirements of Appendix 6, when tested per Section 12.2.



**Picture 1
Typical Weld Pattern and Spacing**

8.2 Node Shear Strength

Node shear weld tests shall be performed every eight hours of laser welding. The node shear weld test shall consist of a single node weld across two overlapping foil sheets (Figure 7). Foil material base line testing shall be performed in the same manner.

8.2.1 When required by customer requirement or contract, higher node shear strengths than in Appendix 6 can be achieved. Node shear strengths as high as 95% of base metal strength can be achieved on various alloys.

8.2.2 Node shear weld tests shall be performed at the following intervals:

8.2.2.1 Beginning of each new job

8.2.2.2 Shift changes

8.3 Weld Quality

The allowable weld defects for node laser welds are as follows:

- Burnthrough holes Maximum of eight holes per inch of core thickness per square foot.
- Edge burnout None
- Side expulsion Side expulsion shall not occur on more than 2 percent of the total nodes or more than 4 adjacent nodes in any direction.

8.4 Welding Schedules

A certified laser welding schedule (Appendix 1) shall be established for each material type and thickness. Resistance welding schedules (Appendix 2) shall be established for splicing and repair welding.

9.0 WORKMANSHIP

9.1 Splicing and Repairs

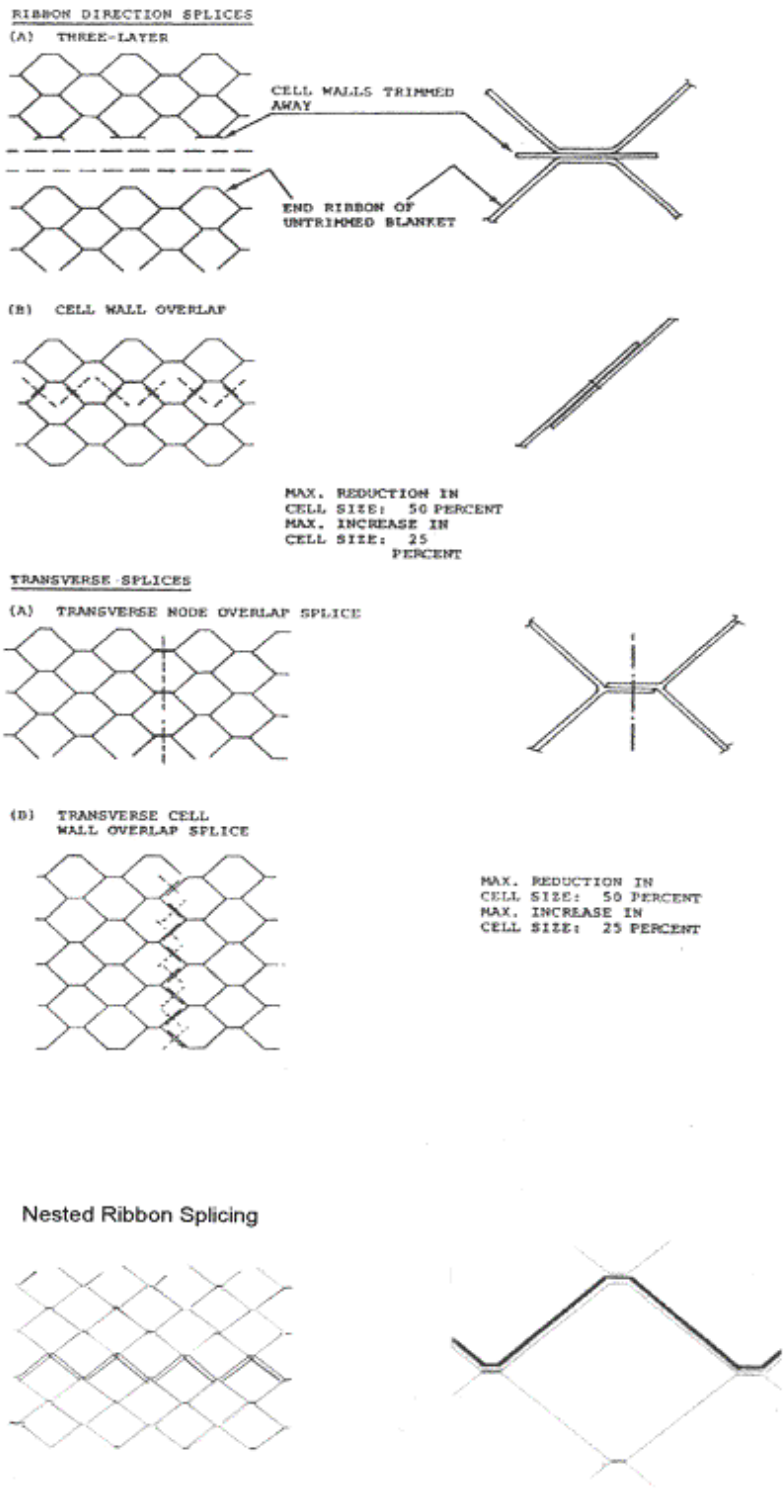
9.1.1 Splices and repairs shall be made by resistance spot welding at nodes and /or at cell walls. The weld joint shall be made along the full thickness of the core with the minimum number of welds per node as specified in Table 2.

9.1.2 Requirements of core splicing and repair methods are shown in Figure 5 and Figure 6 with dimensional tolerances.

9.1.3 The minimum node shear strengths for resistance welds shall meet the requirements of Appendix 6.

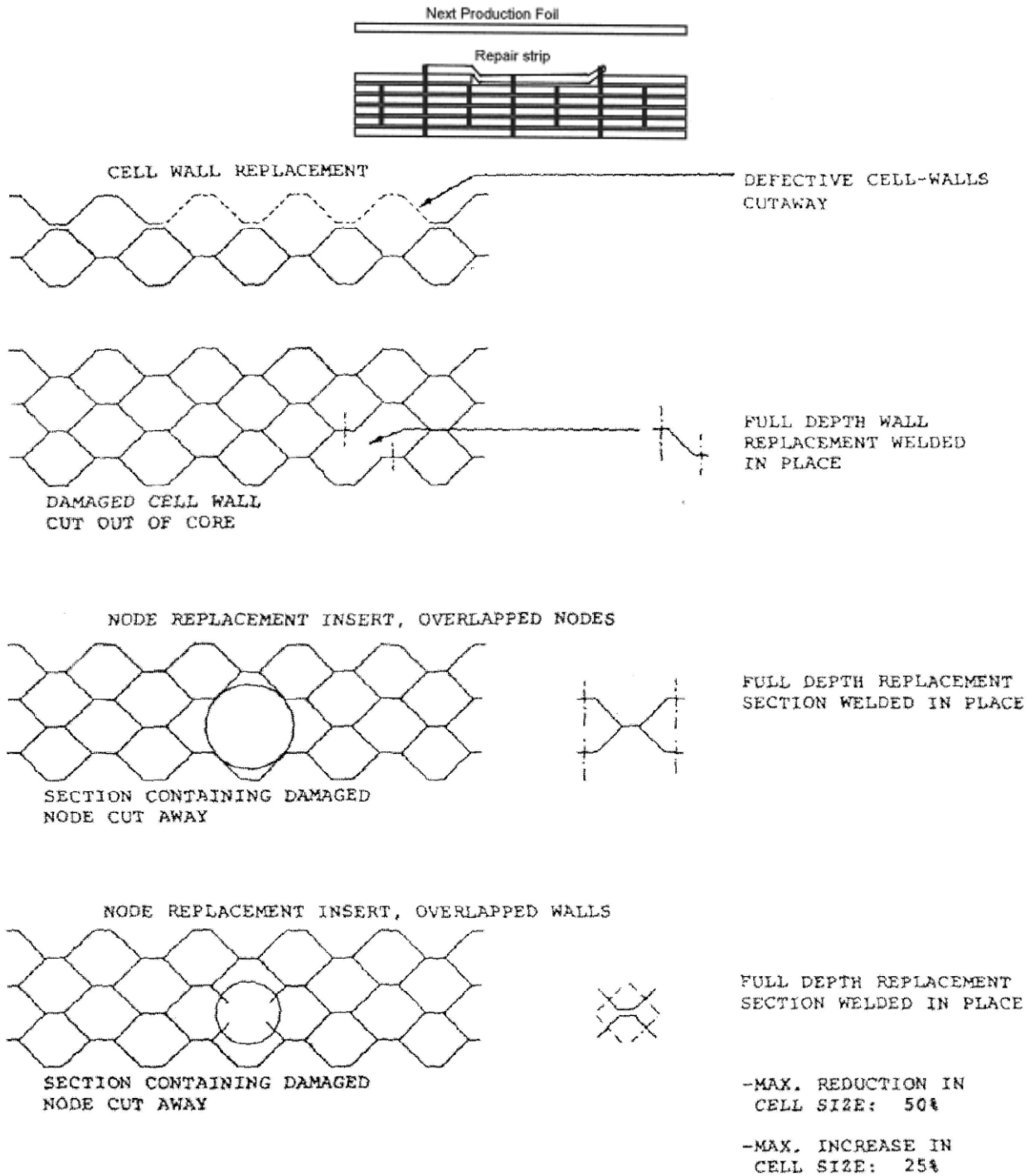
Core Thickness		Minimum Number of Welds
up to	0.250	4 per node
0.251	0.500	6 per node
0.501	1.000	8 per node
greater than	1.000	10 per node

**MINIMUM NUMBER OF NODE WELDS
TABLE 2**



**FIGURE 5
CORE SPLICES**

Inprocess Repairs



**CORE BLANKET REPAIRS
FIGURE 6**

9.2 Cell Shape

- 9.2.1 For square cell each core cell shall be approximately square in shape; the influence of node width on cell shape shall be discounted.
- 9.2.2 For hexagonal cell each core cell shall be approximately hexagonal in shape; the influence of node width on cell shape shall be discounted.
- 9.2.3 For Beneflex cell each core cell shall be approximately pentagonal in shape; the influence of node width on cell shape shall be discounted.
- 9.2.4 Localized deviation from the general cell shape is permitted provided the cell size tolerances of Section 7 and Figure 3 are met.

10.0 CORE BLANKET CONDITION

- 10.1 Contact with lead or mercury is prohibited. Use of lead-base alloy tools or zinc, tin, or cadmium-plated tools or fixtures is prohibited.
- 10.2 Acceptable defect limits are listed in Table 3.

TYPES OF DEFECTS	MAXIMUM NUMBER OF DEFECTS PER SQUARE FOOT CELL SIZE IN INCHES					
	1/8	3/16	1/4	3/8	1/2	3/4
1. Node Separation [1]	2	2	1	1	1	1
2. Splits or Tears [3]	0	0	0	0	0	0
3. Buckling of Nodes [4]	0	0	0	0	0	0

- [1] Node separation shall have at least three acceptable adjacent nodes on each side when located on the same ribbon. A node shall be considered separate if a 0.005 inch shim can be inserted to a depth 1/2 the core thickness.
- [2] Splits or tears starting at the ribbon edge and extending 0.02 inch or less are acceptable. All other tear defects in the cell wall are not acceptable.
- [3] Buckling of nodes is not acceptable as determined visually. Buckling of the cell walls shall not be cause for rejection.

TABLE 3

11.0 QUALITY CONTROL

- 11.1 Any core procured to this specification shall be subject to both supplier and purchaser inspection by authorized inspectors to determine compliance with the requirements of this specification.
- 11.2 Complete records shall be maintained of all raw materials testing and other tests

required by this specification, and shall be made available to authorized customer representatives upon request.

11.3 Shipments of material shall be accompanied by a statement that the core material has been tested to, and meets the requirements of this specification and any material specifications contained in the purchase order.

11.4 The Benecor Quality Department shall review all supplier test data submitted with shipments and perform any additional inspection or testing necessary to assure that the production material meets all requirements specified herein.

11.5 The core blanket shall be uniform in quality and condition.

12.0 MATERIAL TEST METHODS

12.1 Core Density

12.1.1 The core density shall be determined on blankets by dividing the weight in pounds by the volume in cubic feet.

12.2 Node Shear Strength

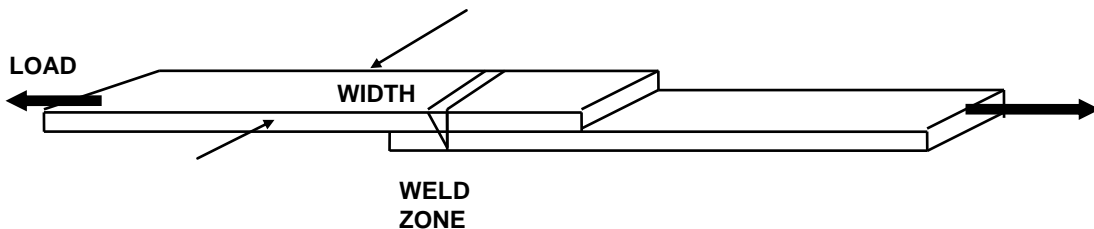
12.2.1 Node shear specimens shall be pulled in tension at a rate to produce failure in 1 to 3 minutes.

$$\text{Node Shear Strength} = \frac{\text{Ultimate Load (lb.)}}{\text{Width of Test Specimen (in.)}} = \text{LB./IN.}$$

Weld Coupon

$$\text{Foil Material Strength} = \frac{\text{Ultimate Load (lb.)}}{\text{Width of Test Specimen (in.)}} = \text{LB./IN.}$$

Material Coupon



**LAP SHEAR STRENGTH
FIGURE 7**

13.0 MATERIAL IDENTIFICATION

Honeycomb core within the scope of this specification shall be identified per customer requirement.

14.0 PACKAGING AND MARKING

14.1 Packaging

14.1.1 Packaging shall be accomplished in such a manner as to assure prompt delivery with the core materials retaining the properties required in this specification. Furthermore, all core materials shall be protected from contaminating substances such as moisture, dirt, dust, oil, grease, paint, etc.,

14.1.2 All shipping containers shall be sufficiently strong to prevent core damage during shipment.

14.1.3 Protective material such as cardboard shall be placed between blankets of core if two or more blankets are shipped in the same container.

14.2 Marking

Shipping containers shall be legibly marked and core material pieces shall be suitably tagged.

15.0 COMMERCIAL GRADE

For commercial grade core, only paragraphs 1, 2, 3, 4, 5, 6, 7.1 and 7.2 apply.

APPENDIX 1

CERTIFIED LASER WELDING SCHEDULE

MATERIAL DATA		SCHEDULE NO.: <input style="width: 80px;" type="text"/>	
ALLOY TYPE			
FOIL THICKNESS			
<p>LASER PARAMETERS AND MACHINE SETTINGS ARE PROPRIETARY AND CONFIDENTIAL.</p> <p>THE BENECOR QUALITY DEPARTMENT MAINTAINS CONTROLLED COPIES AND VERIFIES CORRECTNESS OF SETTINGS FOR QUALIFICATION PURPOSES.</p>			
VISUAL INSPECTION			
WELD PENETRATION			
% WELD OVERLAP			
WELD PROFILE			
ROOT WELD			
NODE SHEAR TEST REPORT		Material Strength =	
TEST No. X+ #/in.	TEST No. X- #/in.	TEST AVERAGE	% OF BASE METAL
COMMENTS:			
APPROVAL:			
_____ ENGINEERING DATE			
_____ QUALITY DATE ASSURANCE			

APPENDIX 2

Benecor

Honeycomb Core

RESISTANCE WELDING SCHEDULE

SCHEDULE NO.:	
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MATERIAL DATA
ALLOY TYPE
FOIL THICKNESS
HEAT NUMBER

MACHINE SETTINGS
MON. CURR.
MON. MODE 1
MON. MODE 2
MAX. CURR.
TRANS RATIO
MODE 1
WELD SCHD.
STEP NO.
STEP %

WELD PARAMETERS
CURR 1
CURR 2
PULSATION
VALVE#
MAIN AIR PRESSURE
WELD CLAMP PRESSURE

VISUAL INSPECTION	
WELD PENETRATION	
WELDS PER INCH	
WELD CROWN	
WELD ROOT	

NODE SHEAR TEST DATA	
TEST # 1	
TEST # 2	
AVE. STRENGTH	

APPROVALS:			
ENGINEERING	DATE	QUALITY	DATE

APPENDIX 3

**NOMINAL DENSITY
Square Cell Configuration**

CELL SIZE	FOIL THICKNESS	SQUARE CELL TITANIUM	SQUARE CELL NICKEL ALLOY	SQUARE CELL STAINLESS STEEL
	(inch)	(lbs./cu.ft.)+/- 10%	(lbs./cu.ft.)+/-10%	(lbs./cu.ft.)+/-10%
1/8	0.0020	9.6	18.0	17.1
	0.0025	12.0	22.6	21.4
	0.0030	14.3	27.0	25.7
3/16	0.0020	6.2	11.7	11.1
	0.0025	7.8	14.7	13.9
	0.0030	9.3	17.6	16.7
1/4	0.0020	4.6	8.7	8.3
	0.0025	5.8	10.9	10.3
	0.0030	6.9	13.0	12.4
	0.0040	9.2	17.4	16.5
	0.0050	11.5	21.8	20.6
3/8	0.0020	3.0	5.7	5.4
	0.0025	3.8	7.2	6.8
	0.0030	4.6	8.6	8.2
	0.0040	6.0	11.5	10.9
	0.0050	7.6	14.4	13.6

APPENDIX 4**NOMINAL DENSITY
Hexagonal Cell Configuration**

CELL SIZE	FOIL THICKNESS (inch)	Hexagonal Titanium (lbs./cu.ft.)+/- 10%	Hexagonal SS (lbs./cu.ft.)+/- 10%
1/8	0.001	6.0	10.7
	0.002	11.9	21.4
3/16	0.001	4.0	7.1
	0.002	8.0	14.2
	0.003	11.9	21.3
1/4	0.002	6.0	10.7
	0.003	9.0	16
3/8	0.002	4.0	7.1
	0.003	6.0	10.7

APPENDIX 5**NOMINAL DENSITY
Beneflex Core Configuration**

CELL SIZE	FOIL THICKNESS (inch)	BENEFLEX TITANIUM (lbs./cu.ft.) +/- 10%	BENEFLEX SS (lbs./cu.ft.) +/- 10%
BX150	0.001	5.35	9.58
	0.002	10.71	19.17
BX200	0.001	3.95	7.06
	0.002	7.89	14.13
	0.003	11.84	21.19
BX300	0.002	5.17	9.26
	0.003	7.76	13.9
BX400	0.002	3.85	6.89
	0.003	5.77	10.34

APPENDIX 6

MINIMUM NODE SHEAR STRENGTH

TITANIUM ALLOYS

Foil Thickness	CP-Ti Minimum Strength lb/in.	Ti3Al2.5V Minimum Strength lb/in.	Beta 21S Minimum Strength lb/in.
0.0010	30	40	
0.0015	50	60	
0.0020	55	80	
0.0025	70	100	
0.0030	80	115	
0.0035	110	140	147
0.0040	120	145	160
0.0045	125	165	180
0.0050	130	175	190
0.0060	155	200	220

STAINLESS STEEL AND NICKEL BASED ALLOYS

Foil Thickness	Minimum Strength lb/in.
0.0010	45
0.0015	70
0.0020	90
0.0025	115
0.0030	135
0.0035	150
Thicker foils available on request	