Contents

Stave and Barrel Design and FEA Analysis

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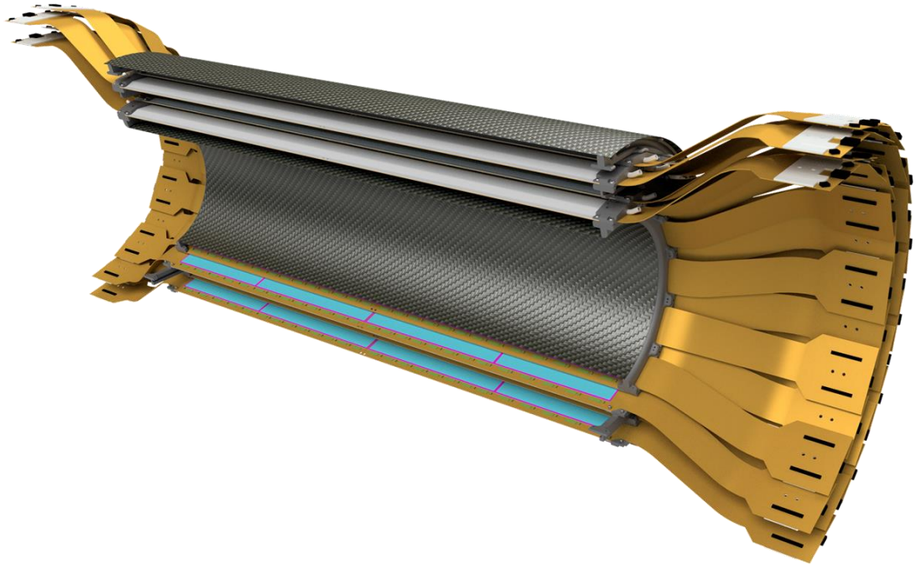
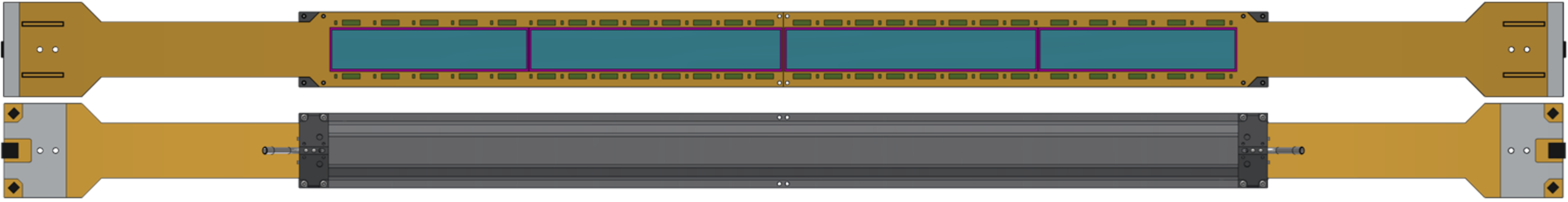
Brookhaven National Laboratory



Motivation

- Stave
  - The stave design was based on HDI geometry.
  - The HDI needs rigidity and cooling (3W).
  - The stave supports two HDIs (4 sensors and 52 chips).
- Barrel
  - The barrels supports 56 staves (L1: 24 and L2: 32) (224 sensors and 2912 chips).
  - The barrel design was based on stave design and requirements.
- Both
  - The stave needs sufficient clearances between adjacent staves.
  - The stave needs to accommodate the MVTX (cone).



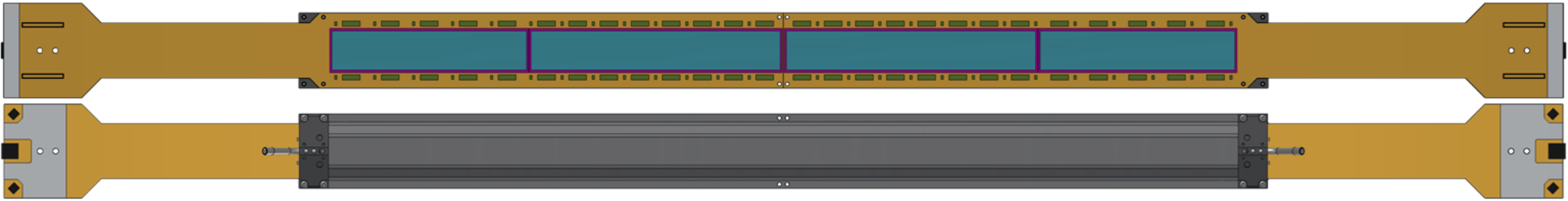
Requirements

Physics

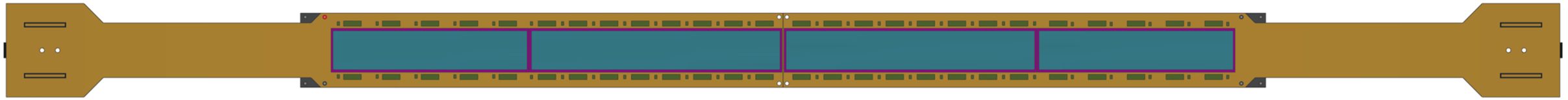
- $|\eta| \geq 1.0$ @ $|Z_{vertex}| = 10$ cm
- 100% ϕ coverage
- $X/X_{\circ} \leq 1.25\%$ per ladder

Mechanics

- $15°C \leq T \leq 22°C$
- $\delta \leq 0.005$”
- $\omega \geq 100Hz$



Ladder

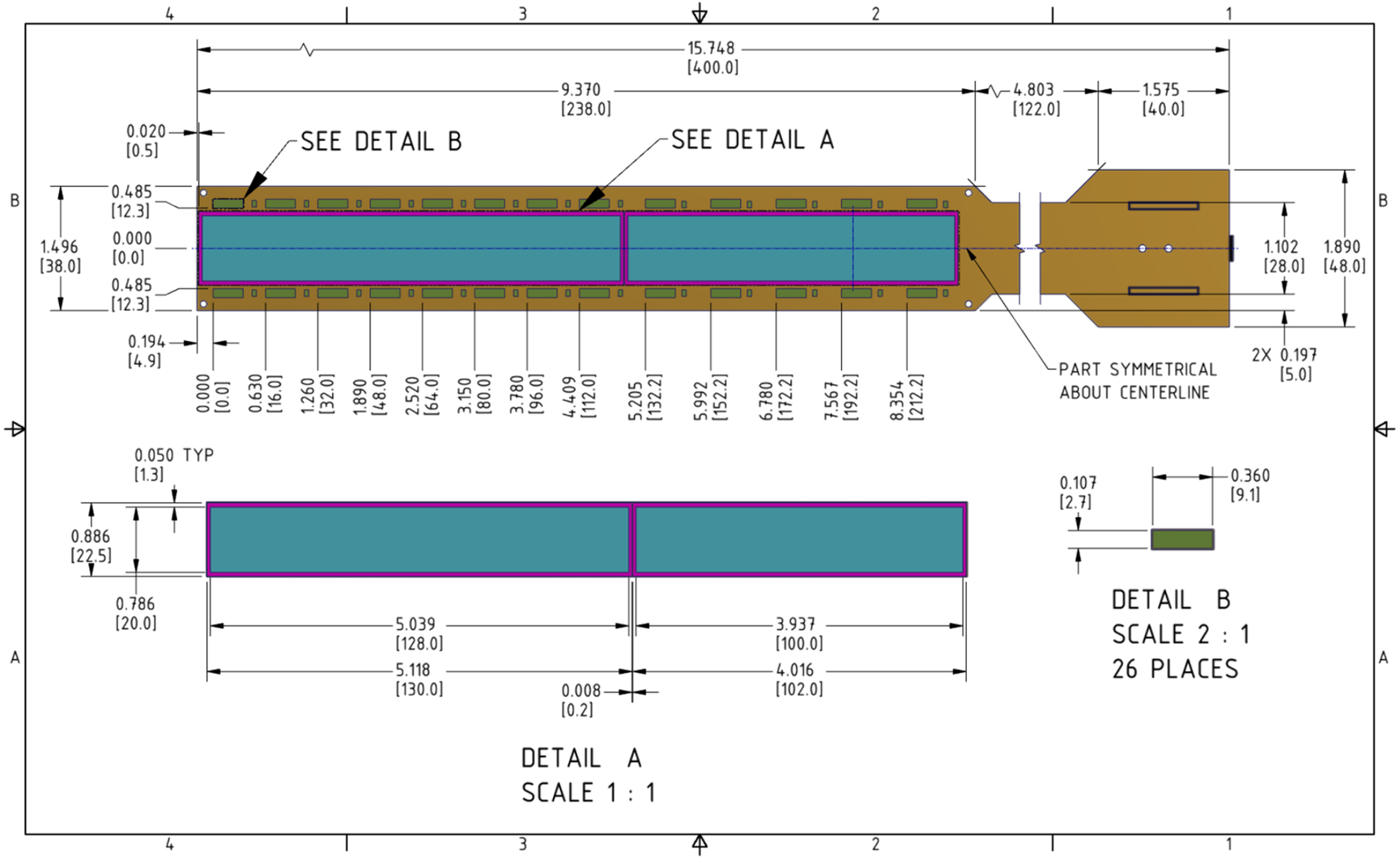


HDI – Design and Radiation Length

HDI Thickness: 473 um
Width: 38.0 mm
z-length total: 400 mm
Sensor thickness: 320 um
FPHX chip thickness: 320 um

HDI Material	Thickness [µm]	X/X_0
Copper	38	0.26%
Polyimide	380	0.14%
	Total	0.40%

The HDI is composed of 7 copper layers. 4 solid ground or power layers and 3 signal line layers.



Stave – Average Radiation Length

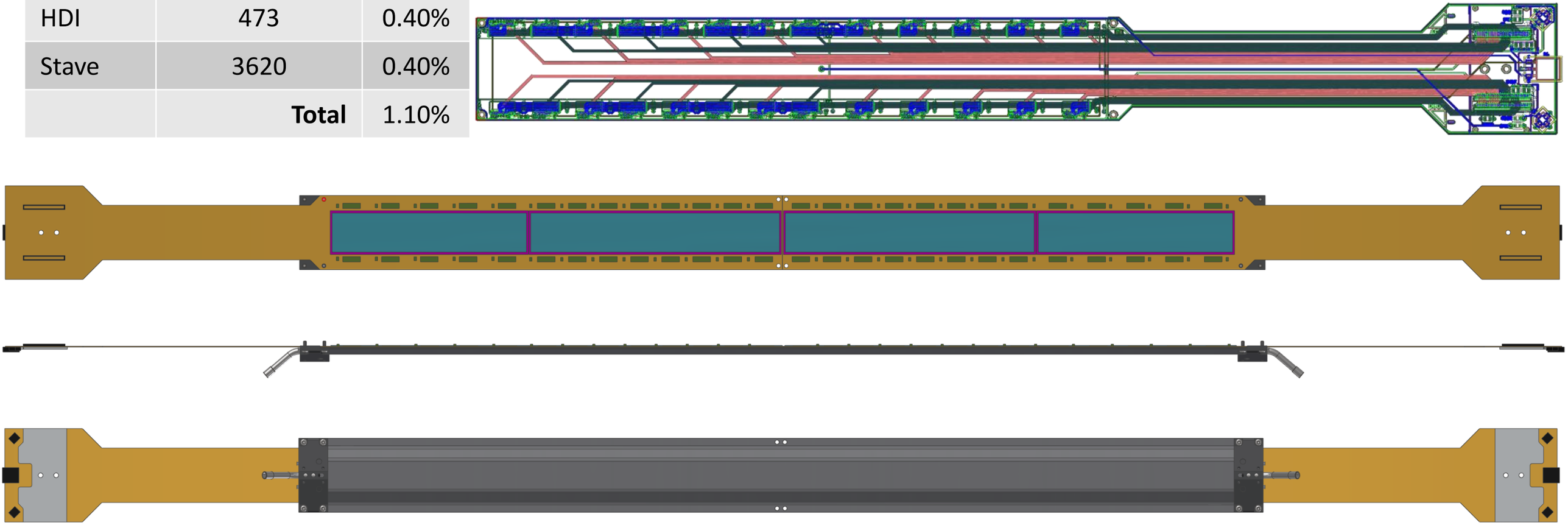
Material	**Thickness [µm]**	Radiation Length (mm)	$\mathbf{X/X_0}$
CFC Flat	0.3300	256.4122	0.1287
CFC Formed	0.3411	256.4122	0.1330
CFC Tube	0.1033	282.2909	0.0366
Foam	1.4740	3771.3741	0.0391
Epoxy	0.1016	298.7463	0.0340
Water	0.0826	356.7854	0.0231
		Total	0.3946

Material	Fraction	Radiation Length (mm)
CFC	0.6	194.0909
Epoxy	0.4	349.8941
	Total	256.4122
Water	0.7	360.8000
Glycol	0.3	349.2849
	Total	356.7854

Ladder – Stave + Two HDIs and Radiation Length

Material	Thickness [µm]	X/X_0
Silicon	320	0.30%
HDI	473	0.40%
Stave	3620	0.40%
	Total	1.10%

All components are averaged over the area of the stave in the active region.



Estimated Weight: 0.1lb. (0.445N)

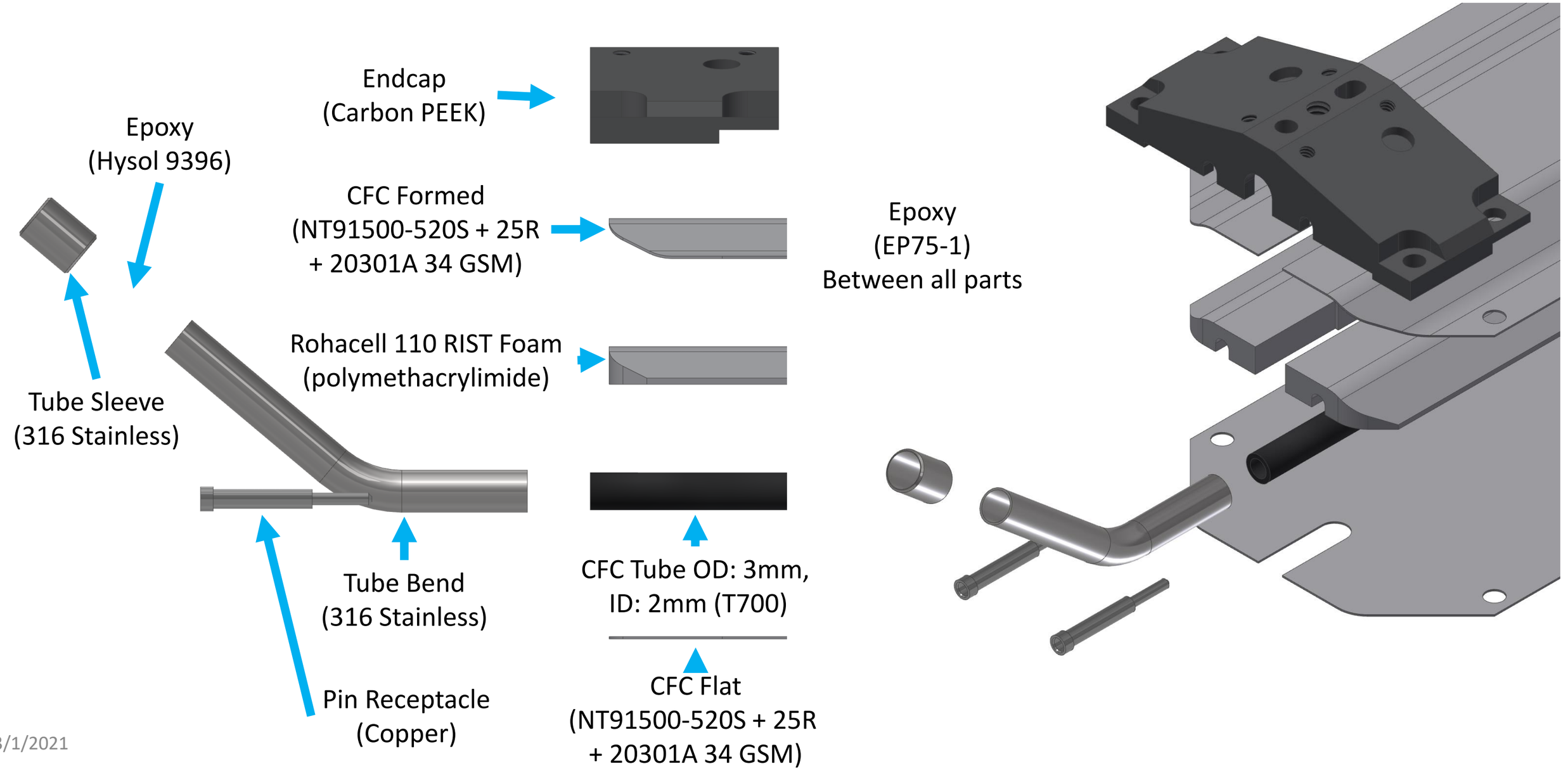
Stave Design

Stave Design – Assembly

Thickness: 0.76 mm
Height: 3.76 mm
Width: 38.00 mm
Length: 497 mm

Material: Carbon Fiber, Polymethacrylimide (PMI), Stainless Steel and Epoxy (radiation length = 0.40%)

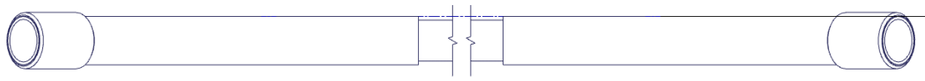
Stave Design – Parts

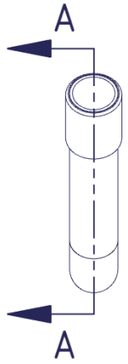


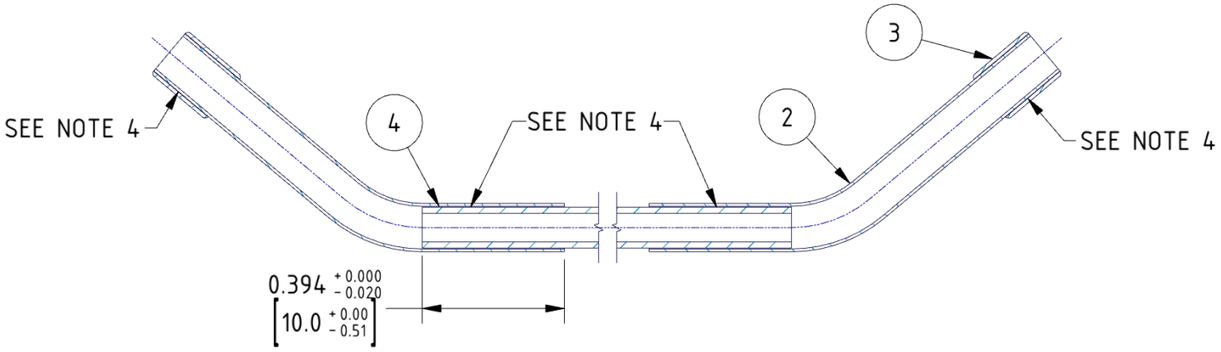
Stave Tube – Assembly Drawing

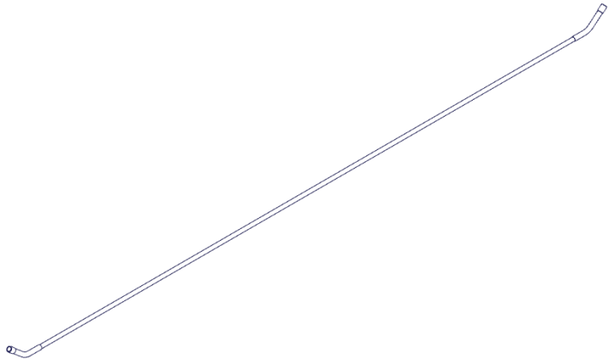
NOTES:
1. DIMENSIONS & TOLERANCES IN BRACKETS ARE FOR REFERENCE ONLY.
2. DRAWING MAY BE USED WITH MODEL "205-0310-0105 - REV B - INTT - Stave Tube Assembly.stp".
3. PARTS TO BE THOROUGHLY CLEANED TO REMOVE ALL LOOSE PARTICULATES.
4. PARTS TO BE EPOXIED TOGETHER. DO NOT FILL TUBE.
5. ASSEMBLY BURST TEST AT 60psi FOR 1 HOUR.
6. ASSEMBLY TO BE AIR AND WATER TIGHT TO 0.2 ml-mbar/min.
7. ASSEMBLY PRESSURE DROP TO BE 1.125 ± 0.056psi AT 200ccm OF WATER WHEN LEVEL.

REVISION HISTORY					
REV	ECN NUMBER	ZONE	DESCRIPTION	DATE	APPROVED
A			INITIAL RELEASE	10/7/2019	rfeder
B			NOTE 5 - 1 HOUR WAS 1 MIN., NOTE 6 - 0.2 ml-mbar/min was 0.01 ml-mbar/sec., ADDED NOTE 7	11/30/2020	rfeder









BILL OF MATERIALS			
ITEM	QTY	PART NUMBER	DESCRIPTION
4	AR	HYSOL 9396 OR EQUIV	Epoxy
3	2	205-0310-0108	Stave Tube Bend Sleeve
2	2	205-0310-0107	Stave Tube Bend
1	1	205-0310-0106	Stave Tube

THIRD ANGLE PROJECTION

INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.5-2009
UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES [mm]
DECIMAL TOLERANCES
X.X ± 0.05
X.XX ± 0.01
X.XXX ± 0.005
ANGLES ± 0.5

FINISH: 0 ✓
BREAK EDGES: MIN.: 0 MAX.: 0

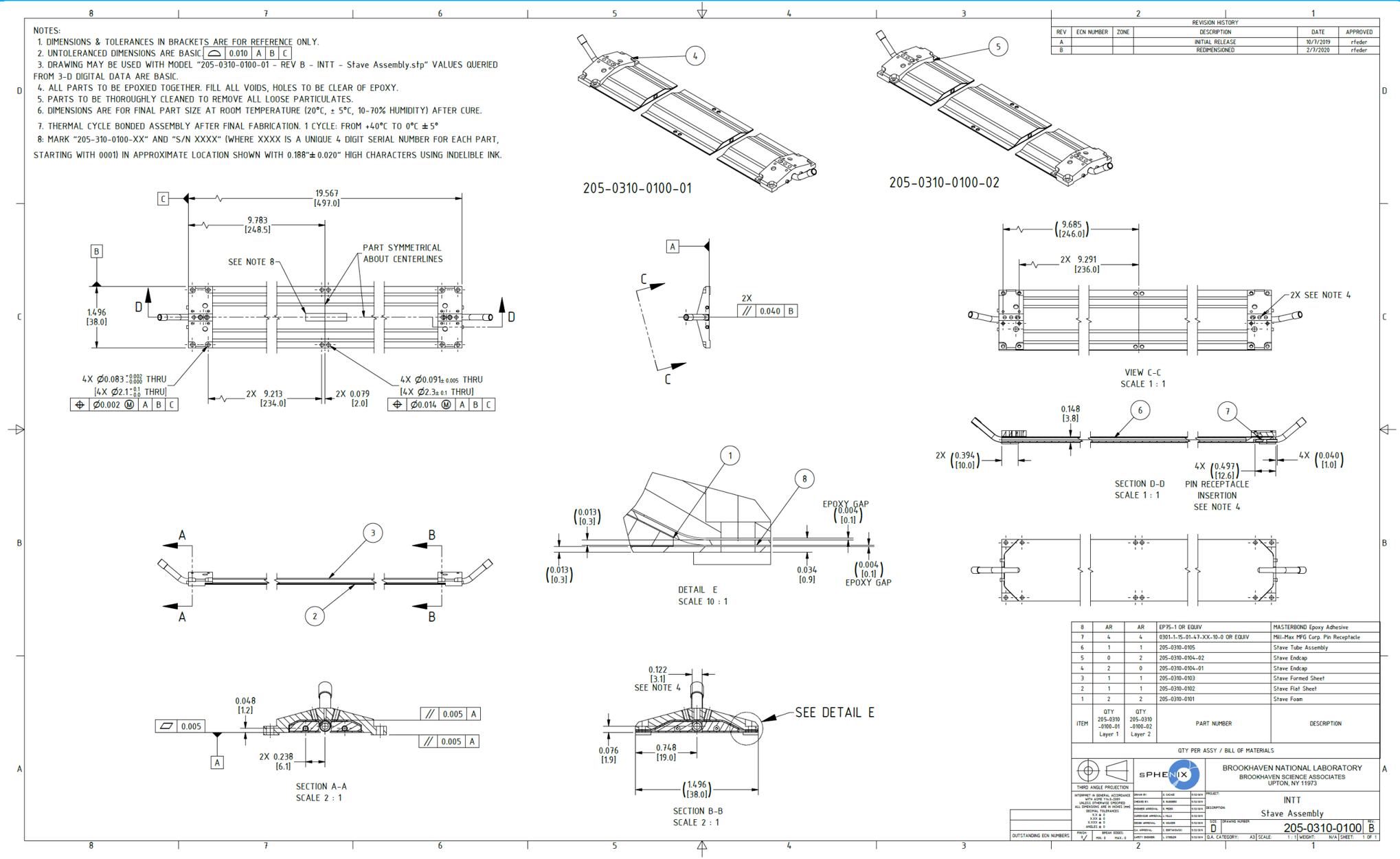
OUTSTANDING ECN NUMBERS

DRAWN BY:	B. CACACE	5/22/2019
CHECKED BY:	R. RUGGIERO	5/22/2019
ENGINEER APPROVAL:	R. FEDER	5/22/2019
SUPERVISOR APPROVAL:	J. MILLS	5/22/2019
DESIGN APPROVAL:	R. NOLICER	5/22/2019
Q.A. APPROVAL:	C. GORTAKOWSKI	5/22/2019
SAFETY ENGINEER:	L. STIEGLER	5/22/2019

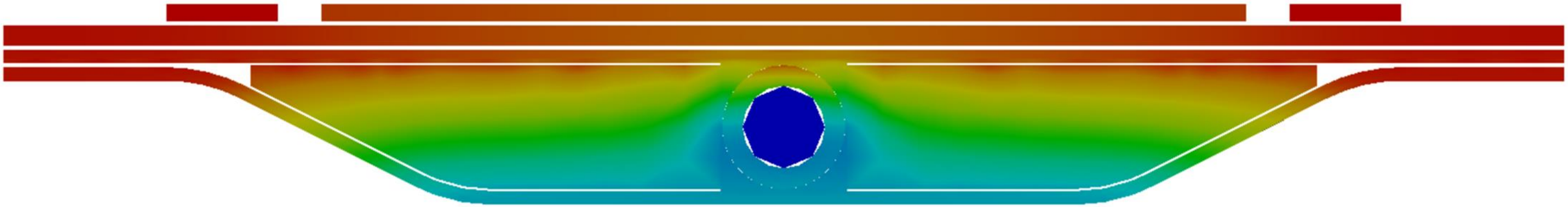
BROOKHAVEN NATIONAL LABORATORY
BROOKHAVEN SCIENCE ASSOCIATES
UPTON, NY 11973

PROJECT: INTT
DESCRIPTION: Stave Tube Assembly
SIZE: B | DRAWING NUMBER: 205-0310-0105 | REV.: B
Q.A. CATEGORY: A3 | SCALE: 3 : 1 | WEIGHT: 0 lbmass | SHEET: 1 OF 1

Stave – Assembly Drawing

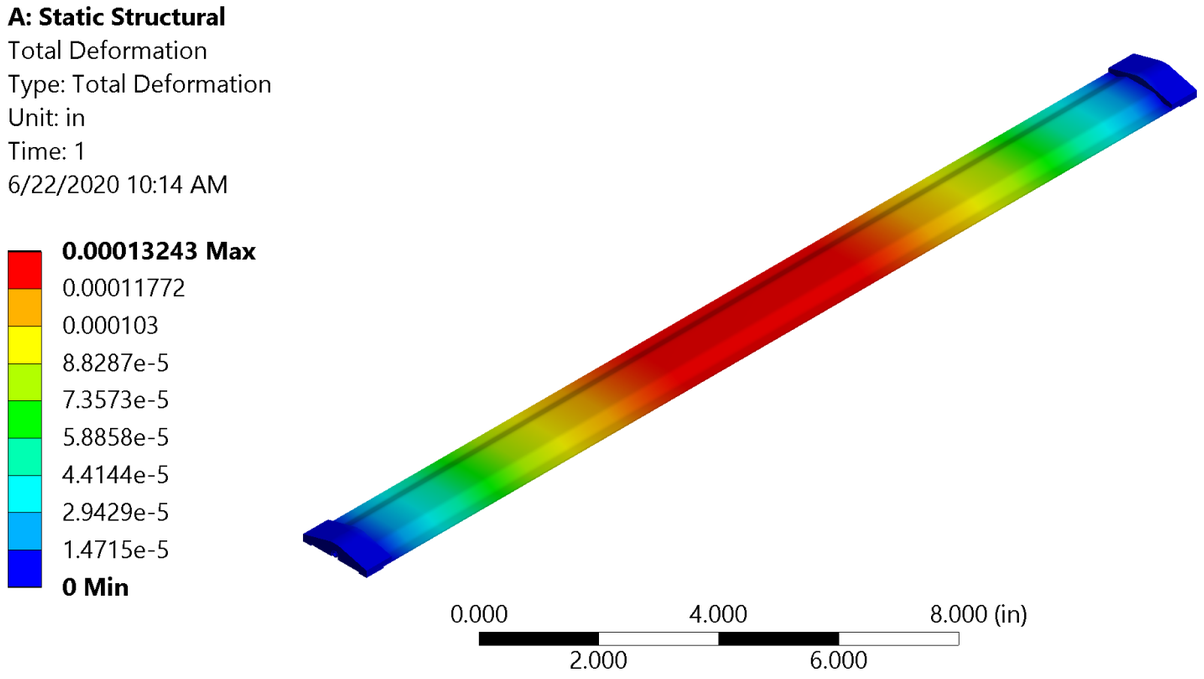


Stave FEA Analysis

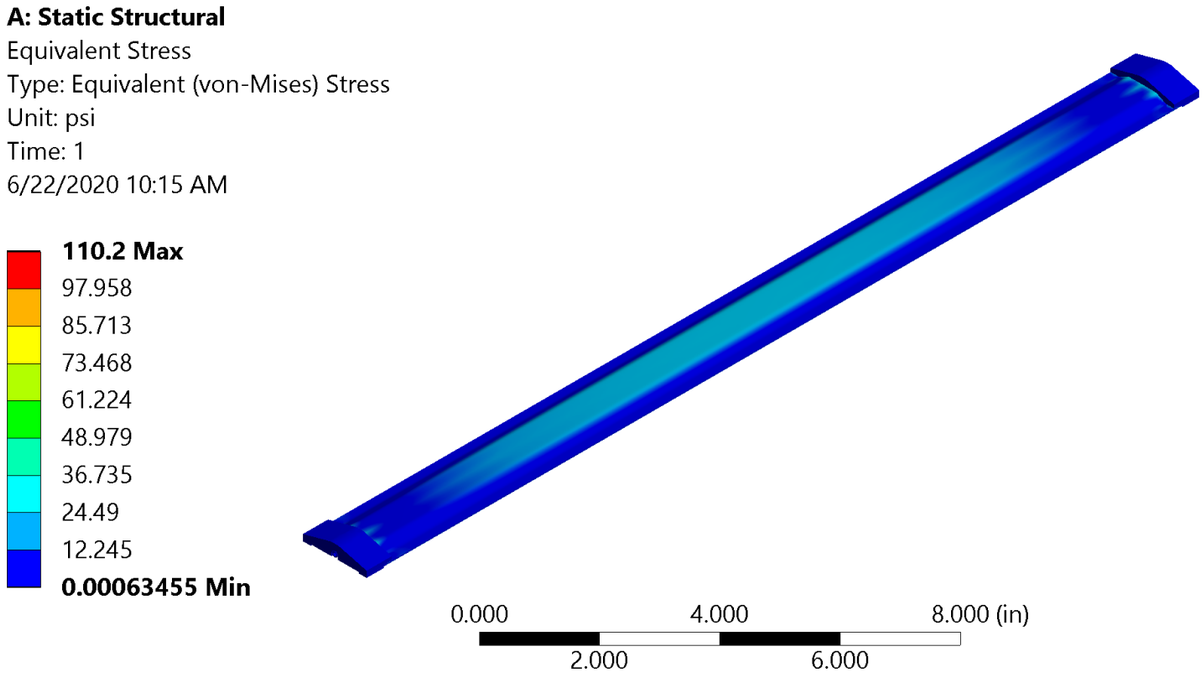


Structural – Under its Own Weight

Deflection – MAX: 0.0001 in (2.5 um)



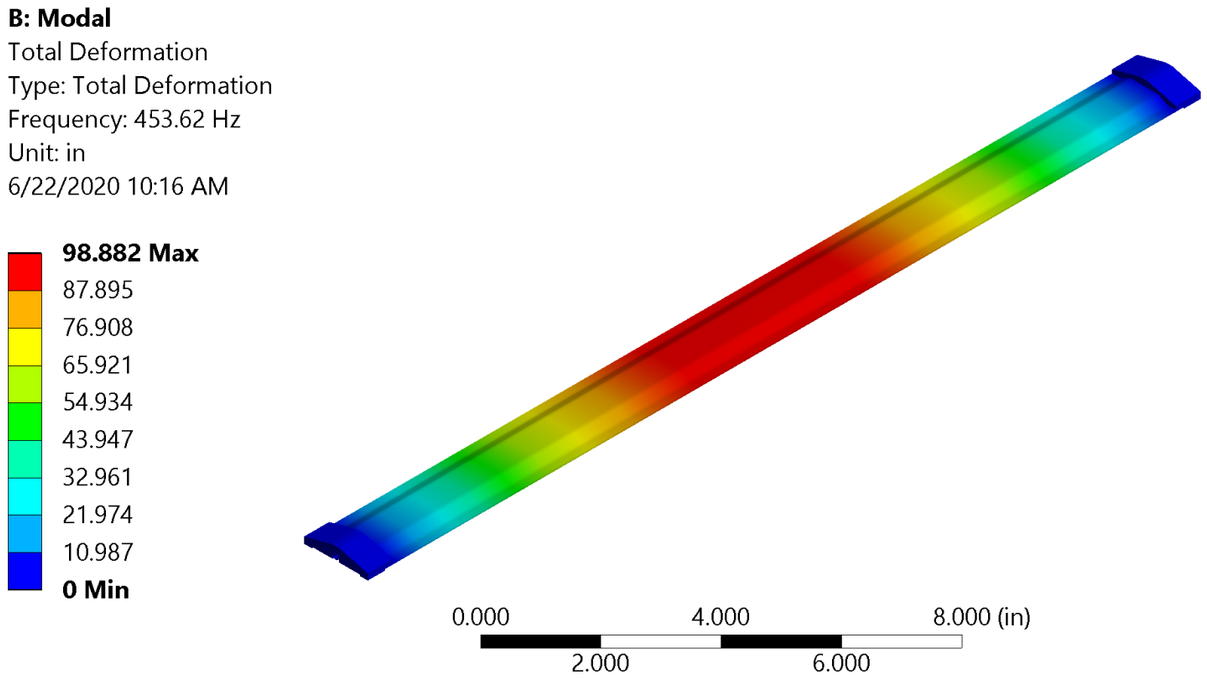
Stress – MAX: 110 psi (0.6 MPa)



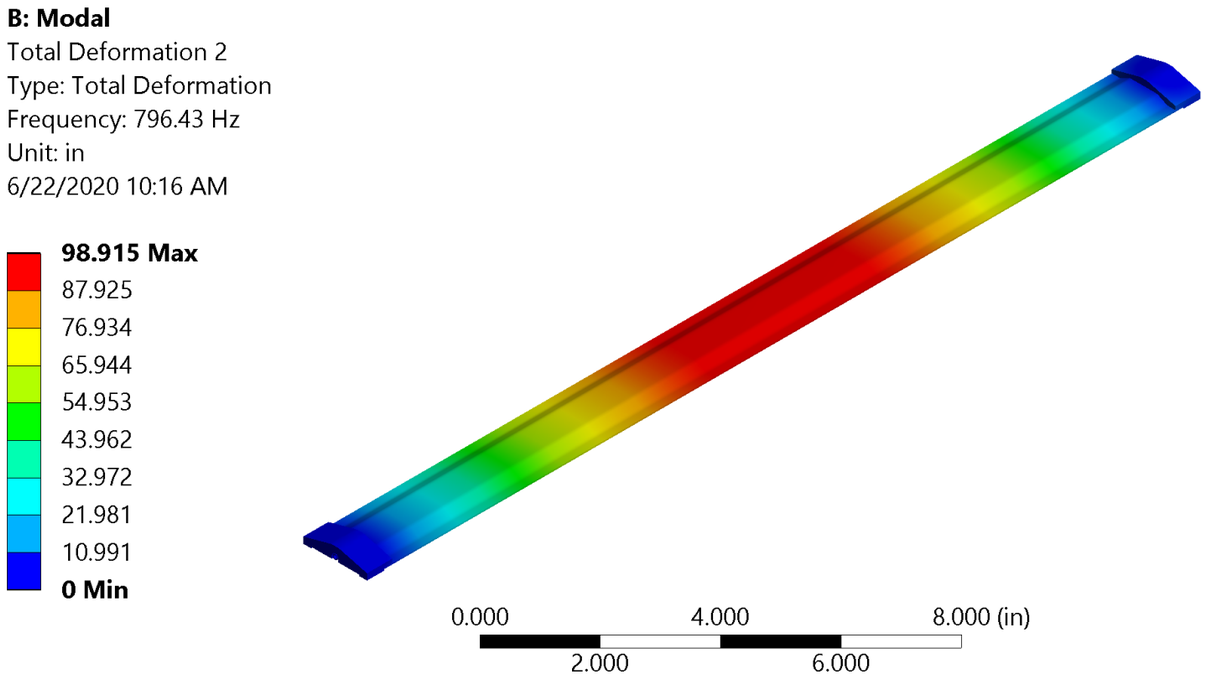
Boundary Conditions: Endcaps simply supported, HDI weight added

Vibration – Natural Frequencies

First Mode – 453 Hz



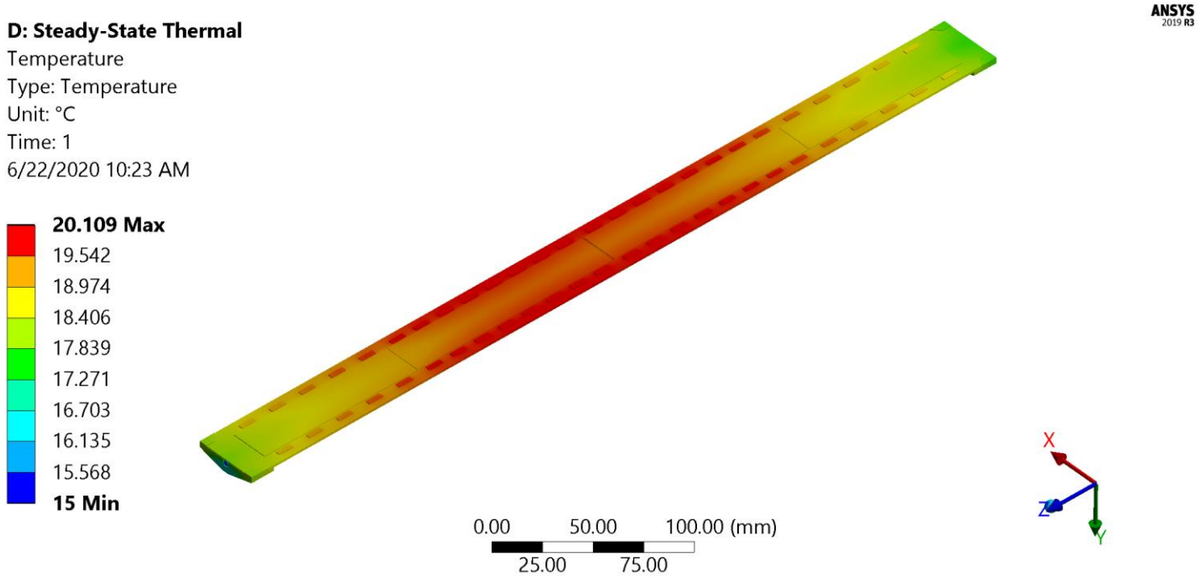
Second Mode – 796 Hz



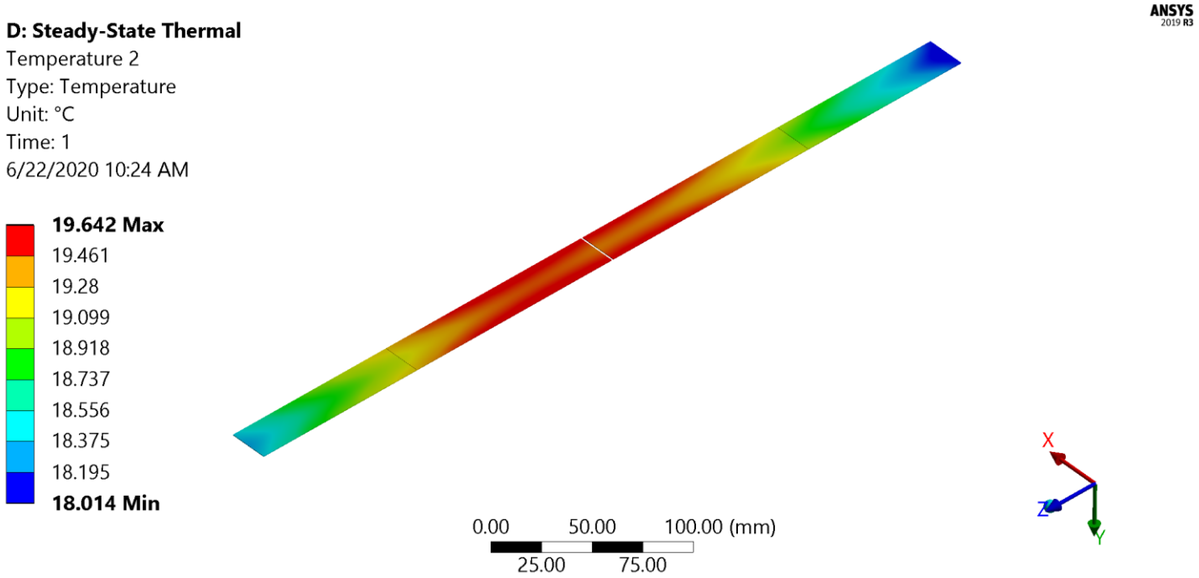
Boundary Conditions: Endcaps simply supported

Thermal – Temperatures

Stave ΔT – 5.1 °C (9.2 °F)



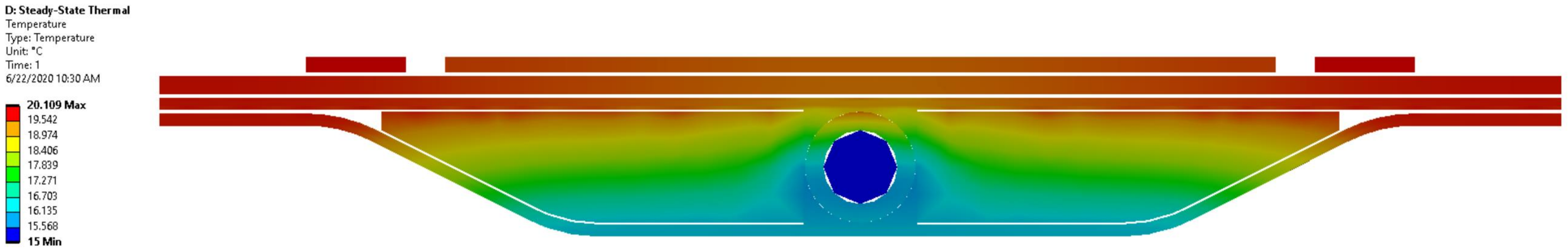
Sensors ΔT – 1.6 °C (2.9 °F)



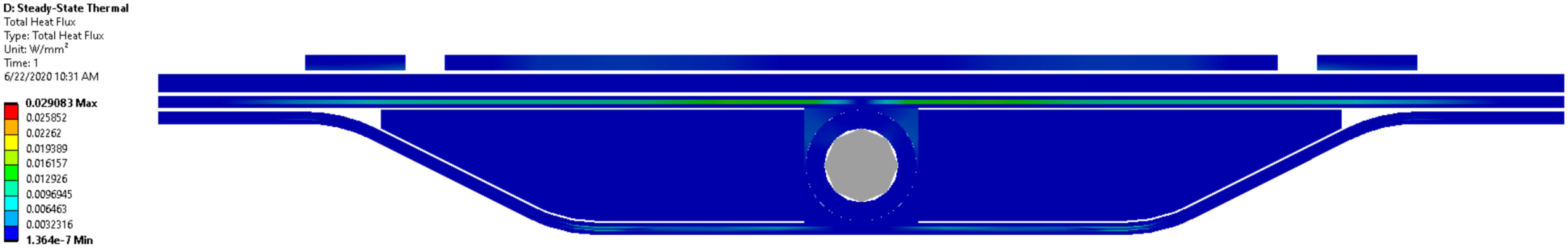
Boundary Conditions: Inlet temp 15C, flow rate 0.12l/m, natural convection, chips dissipate 3W total

Thermal – Midplane Cross Section

Temperature

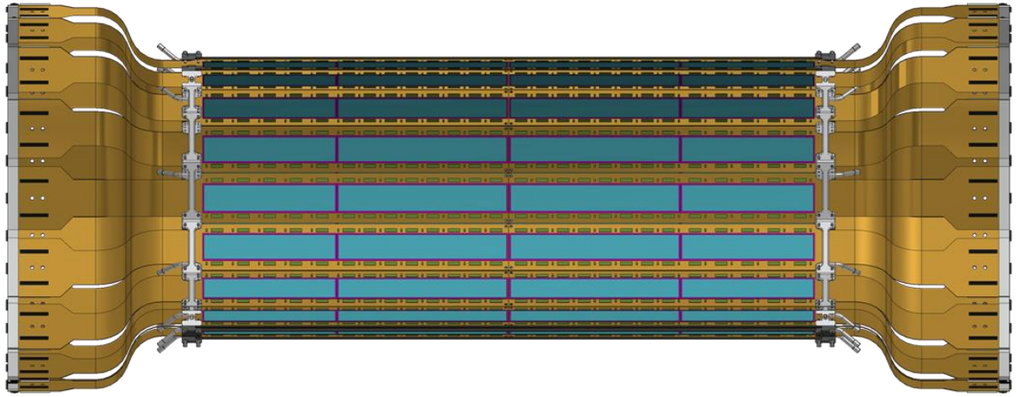


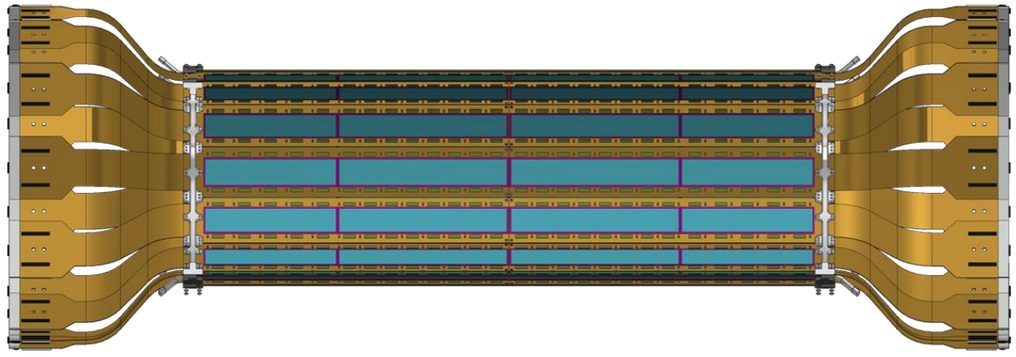
Heat Flux



Boundary Conditions: Inlet temp 15C, flow rate 0.12l/m, natural convection, chips dissipate 3W total

Barrel Configuration

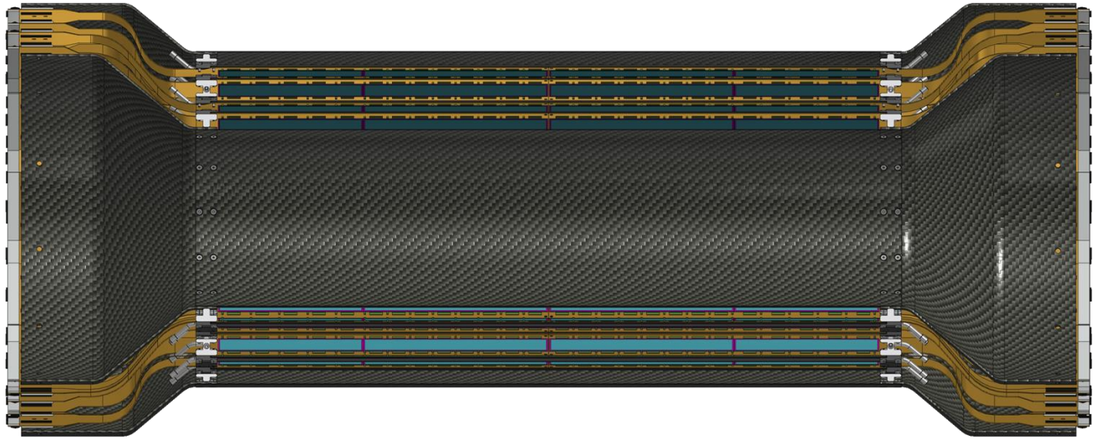




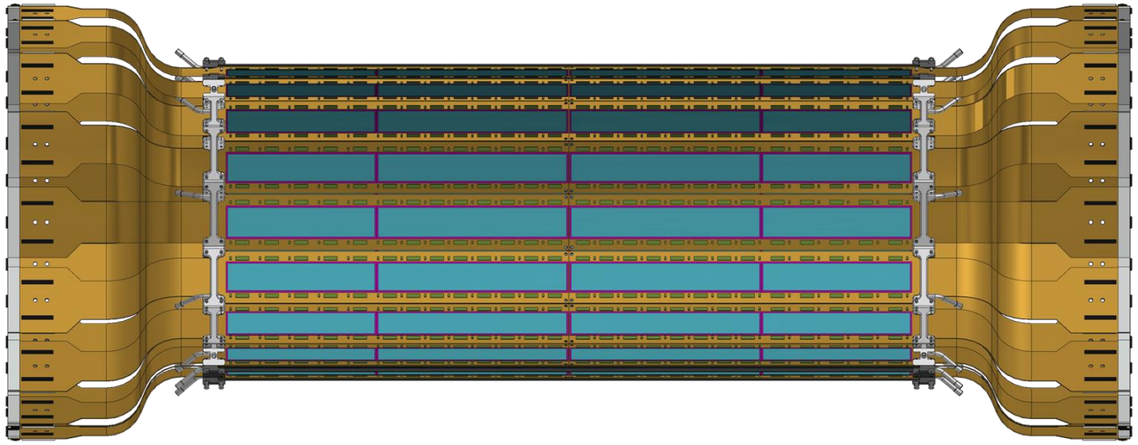
Barrel – Two Layers

Full Detector

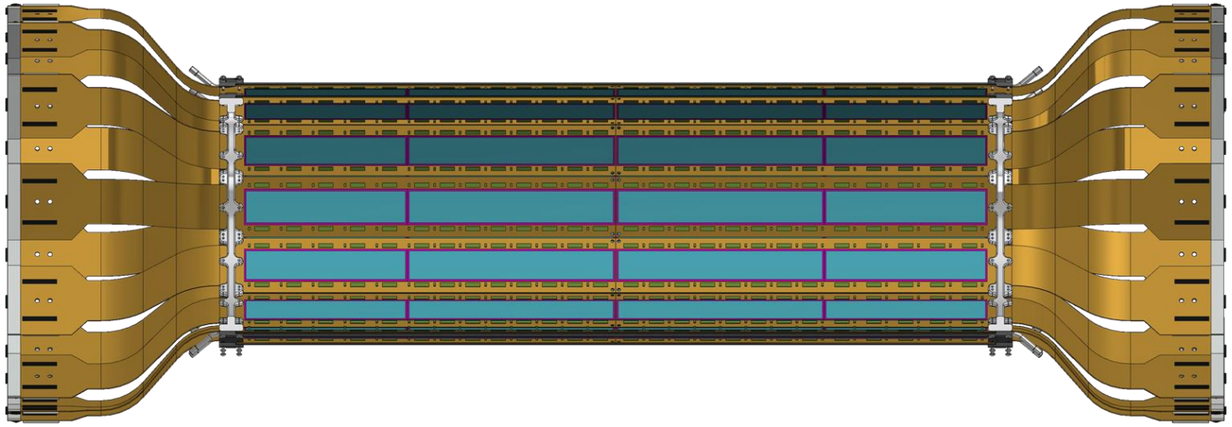
Half Barrel



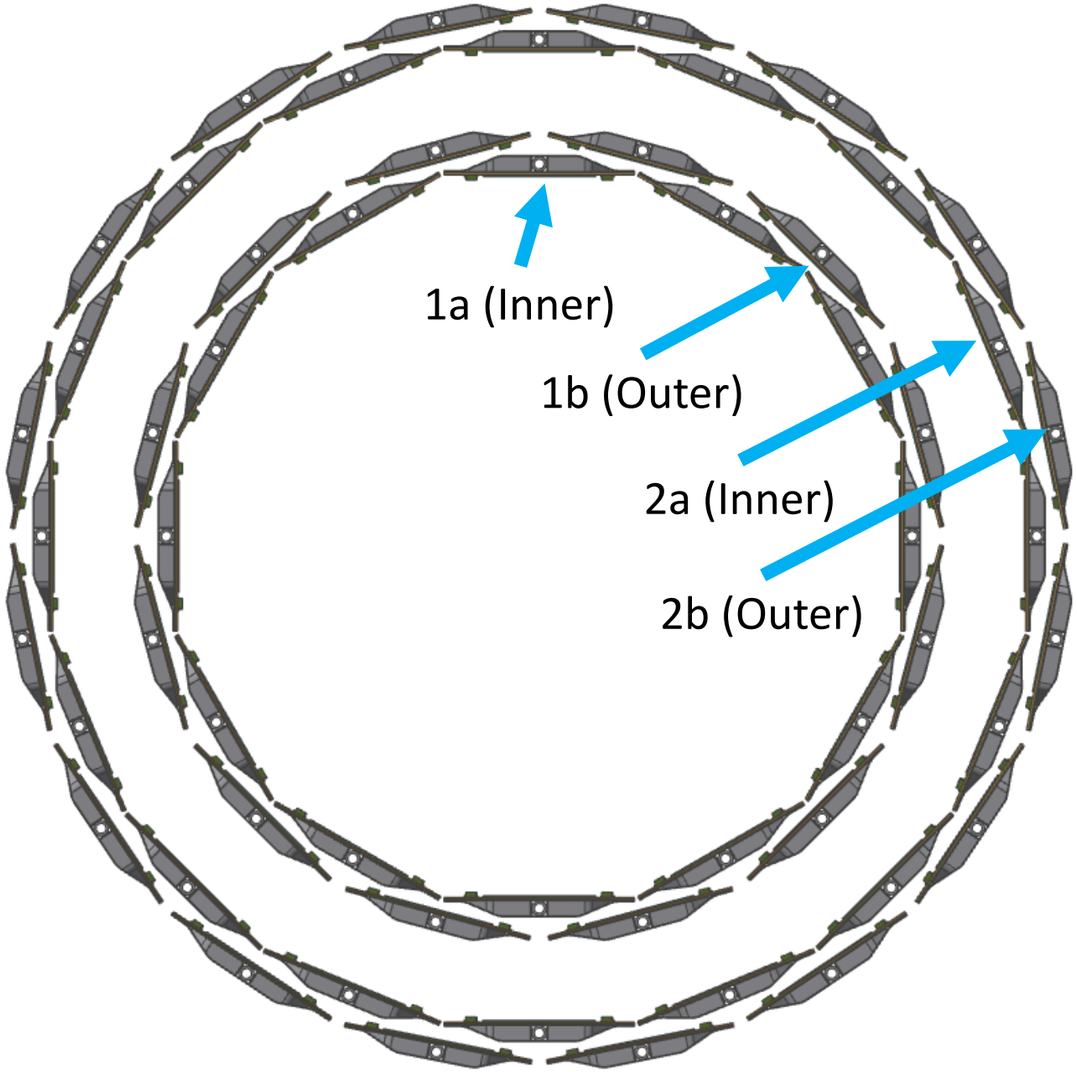
Outer Layer

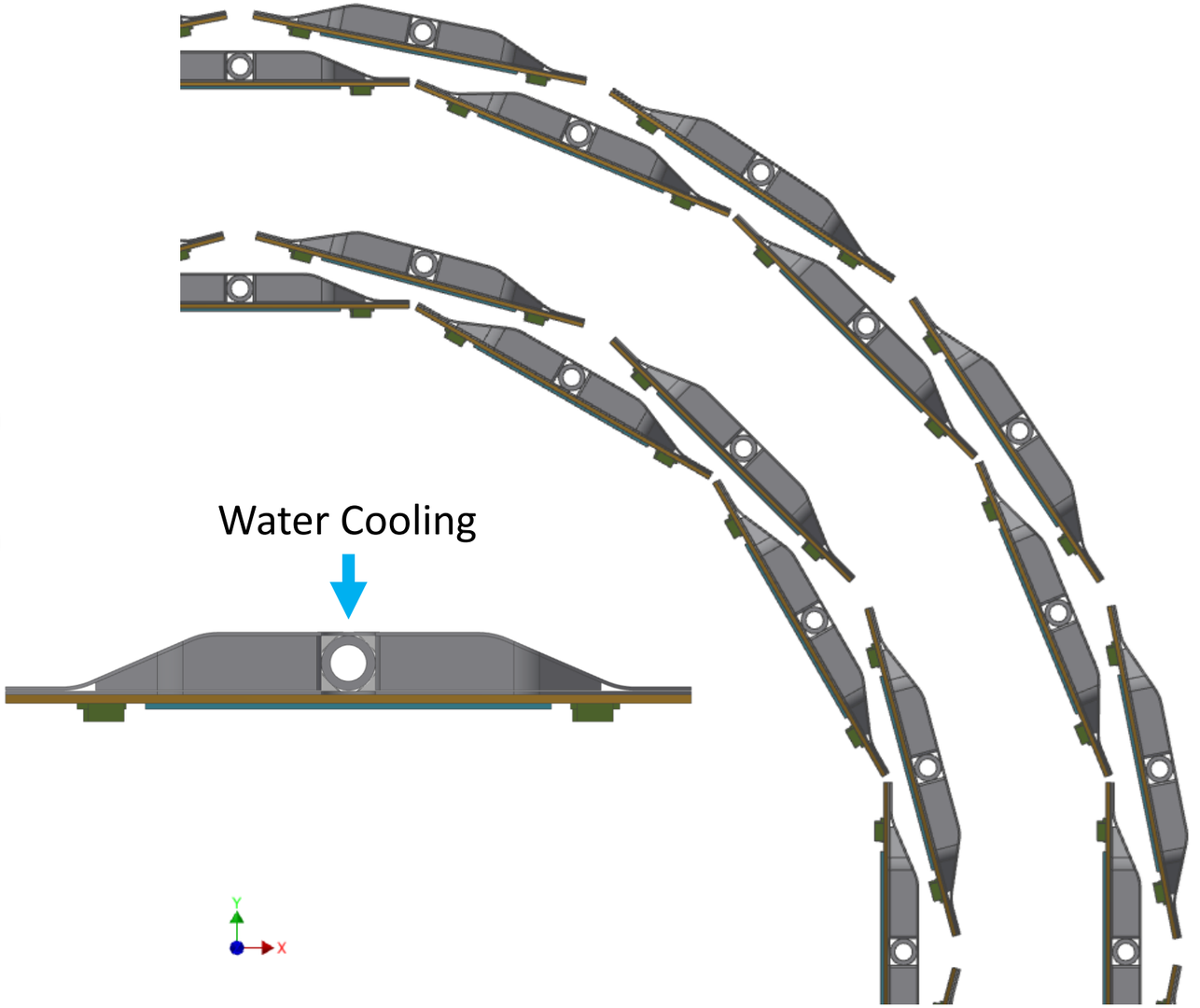


Inner Layer

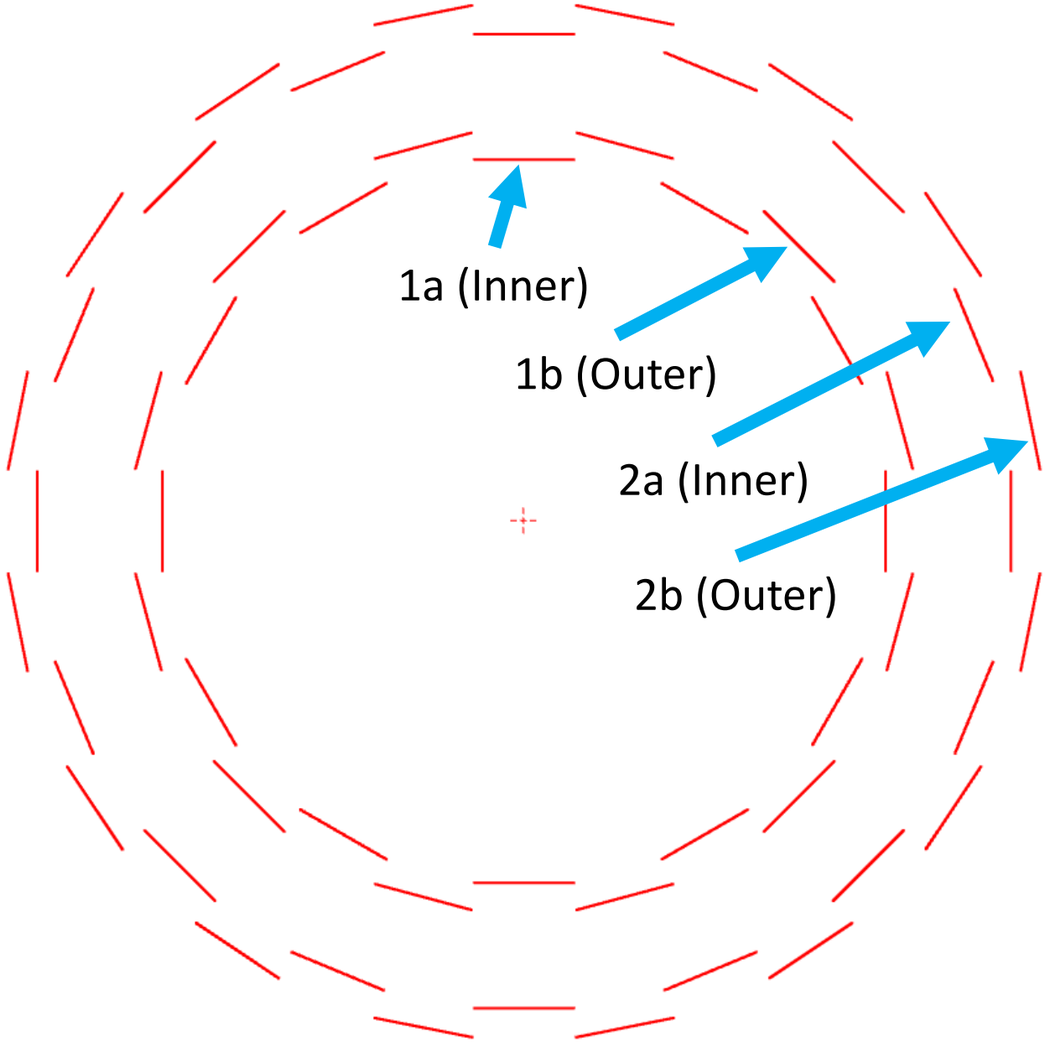


Barrel – Two Layer Configuration Staves

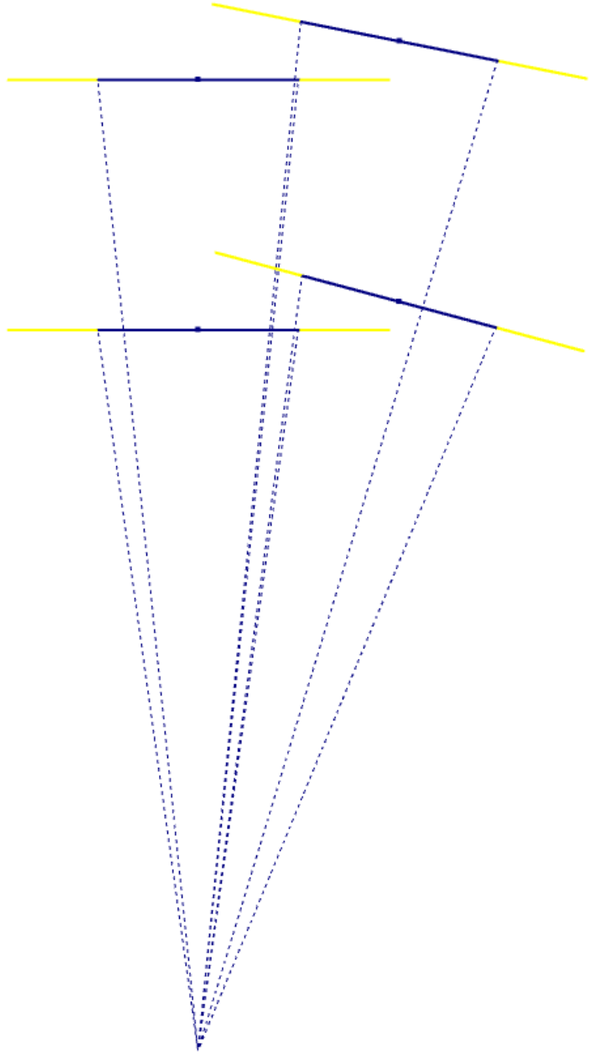




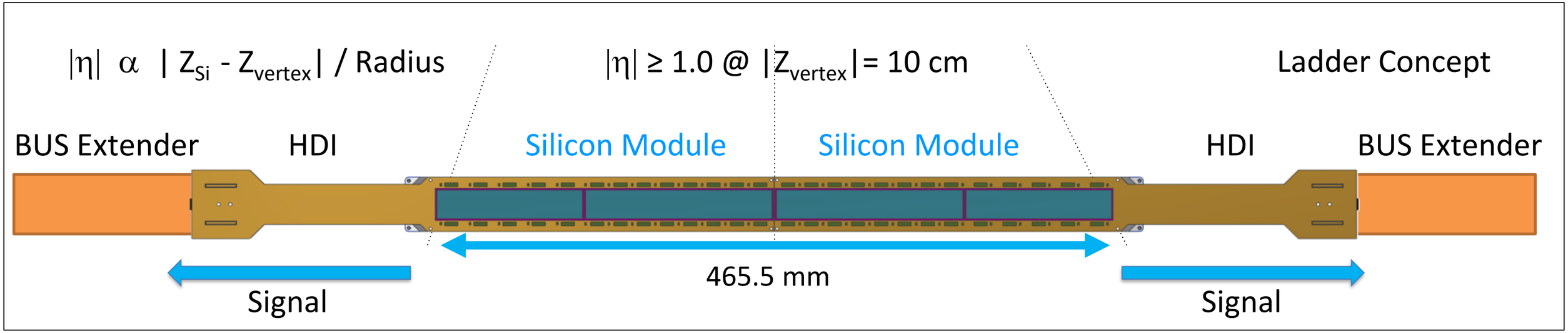
Barrel – Two Layer Configuration Active Area



The width of the active area is 52.6% of the total width of the ladder. In order to have overlap for full PHI coverage and have a reasonable stave thickness, the ladders were stager radially with no tilt.

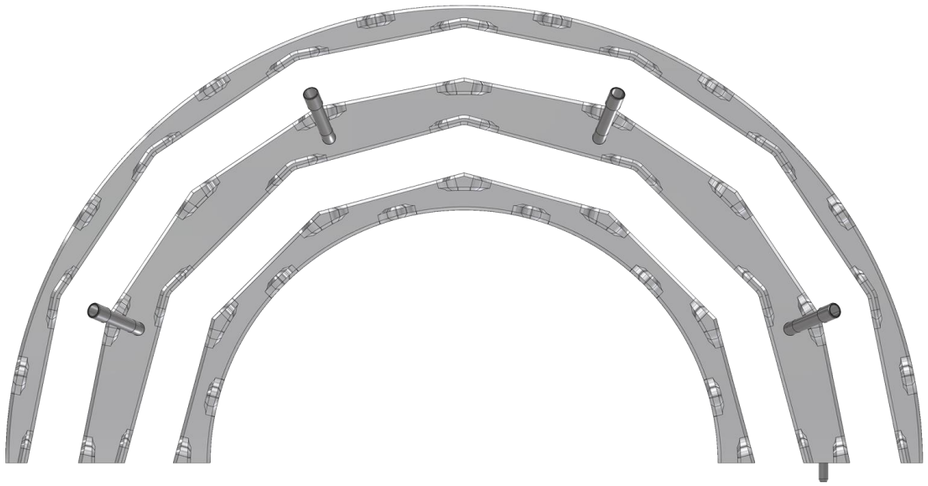


Barrel – Two Layer Configuration Numbers

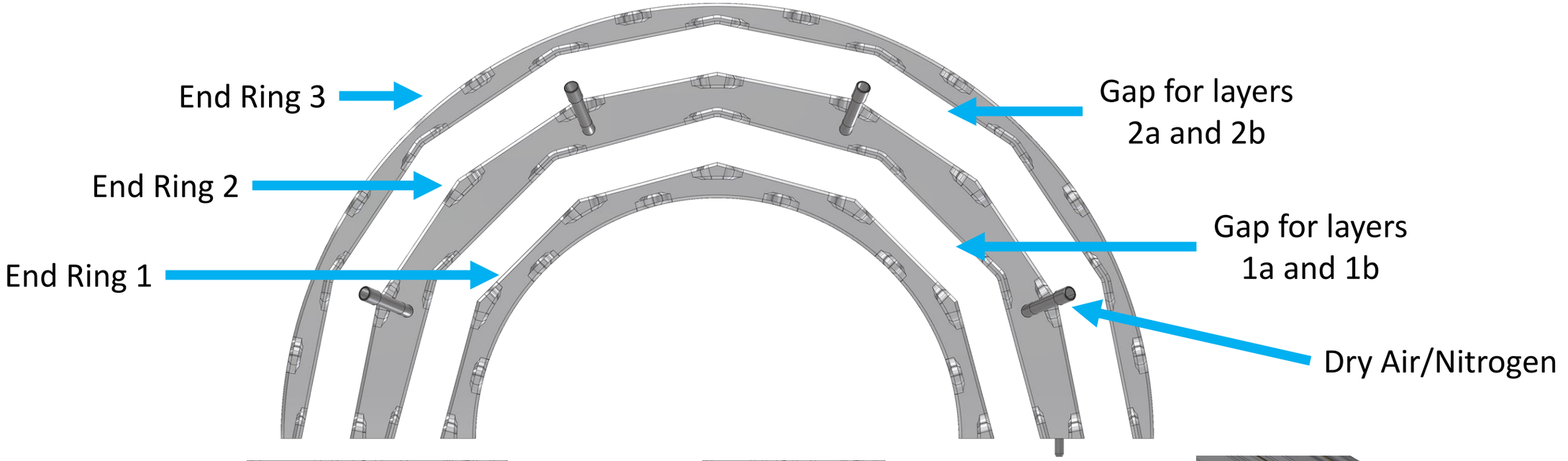


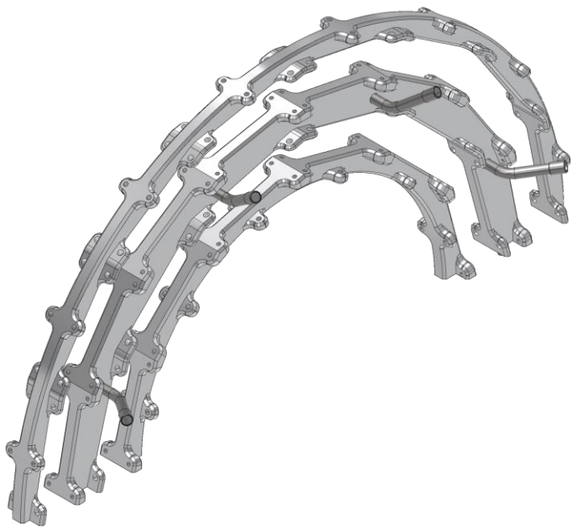
Barrel	Center of Sensor Tangent Radius (mm)	Pseudo rapidity	QTY of Ladders	Angle (deg)	Coverage (PHI) (%)	Overlap (%)	Clearance (mm)	Chip Power Dissipation (W)	Stave Rad Length (%)	Barrel Rad Length (%)
1	-	-	24	-	100	2	2.00	62.30	0.80	2.20
1a (Inner)	71.88	1.37	12	0	53	0	0.60	31.15	0.40	1.10
1b (Outer)	77.32	1.31	12	0	49	0	3.80	31.15	0.40	1.10
2	-	-	32	-	100	2	2.22	83.07	0.80	2.20
2a (Inner)	96.80	1.12	16	0	53	0	0.60	41.53	0.40	1.10
2b (Outer)	102.62	1.07	16	0	49	0	3.12	41.53	0.40	1.10
Total	-	-	56	-	-	100	11.22	145.37	1.60	4.40

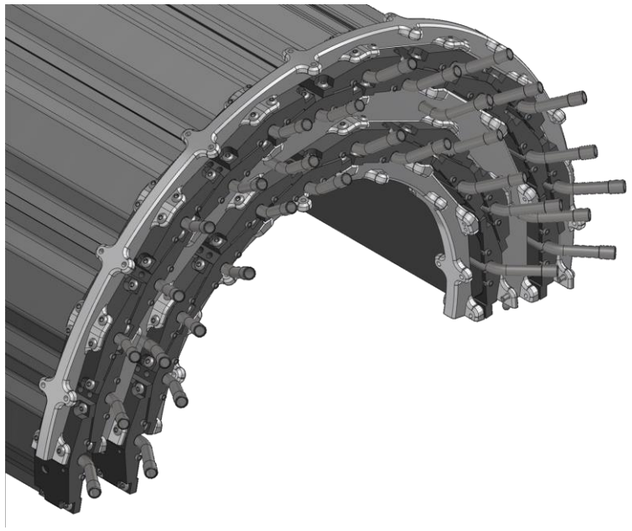
Barrel Design

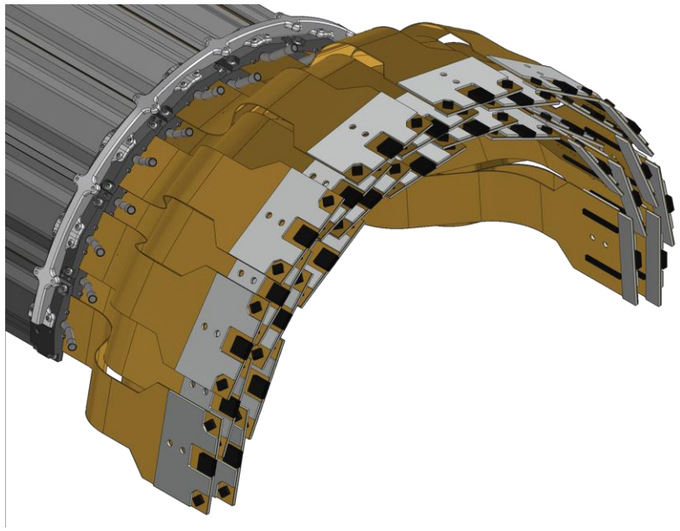


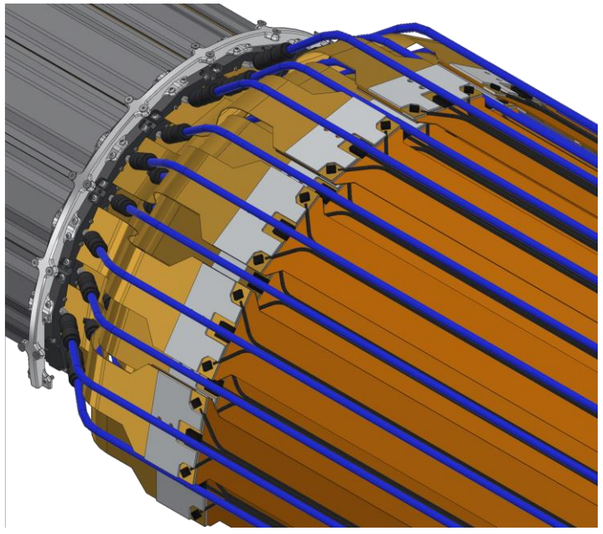
End Rings - Half Barrel, One Side





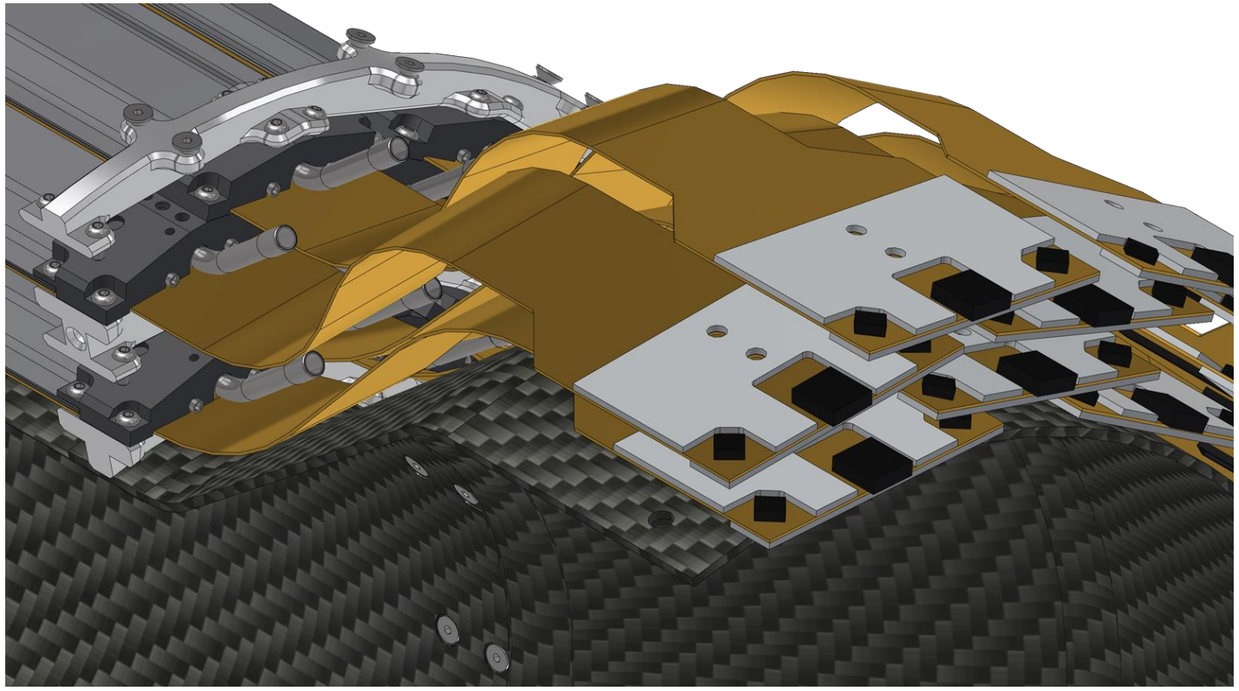




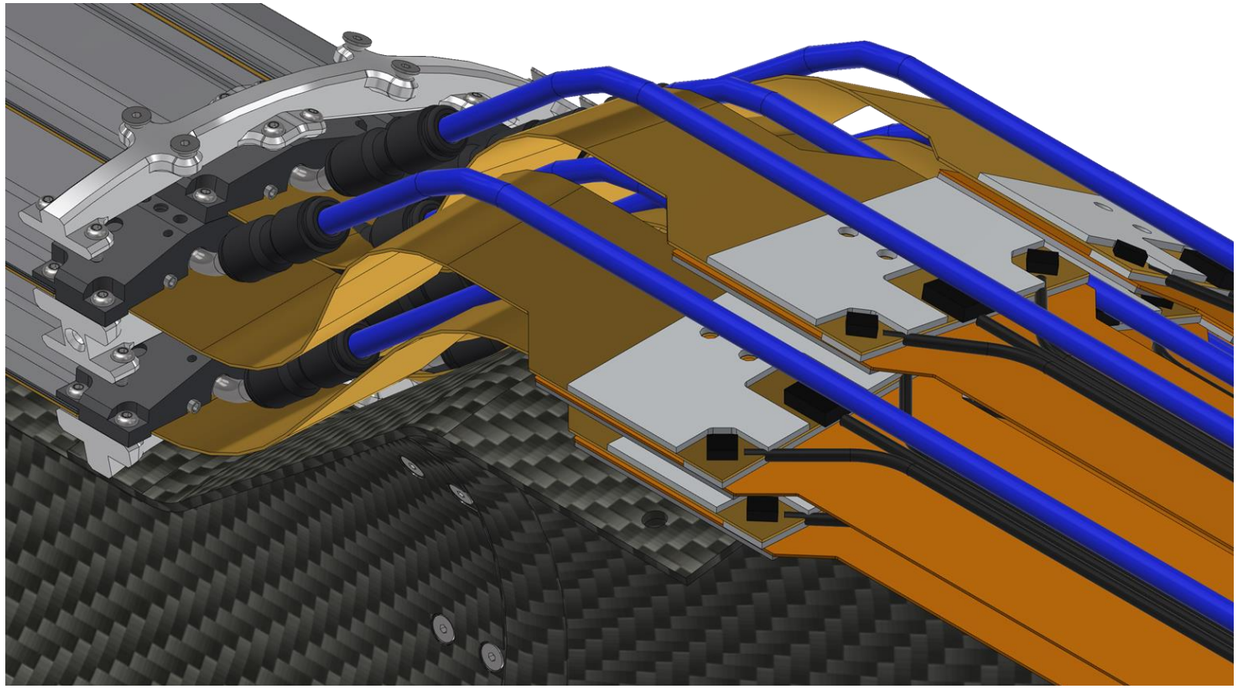


Barrel – Cooling and Extension Connection

Ladders – No Connections

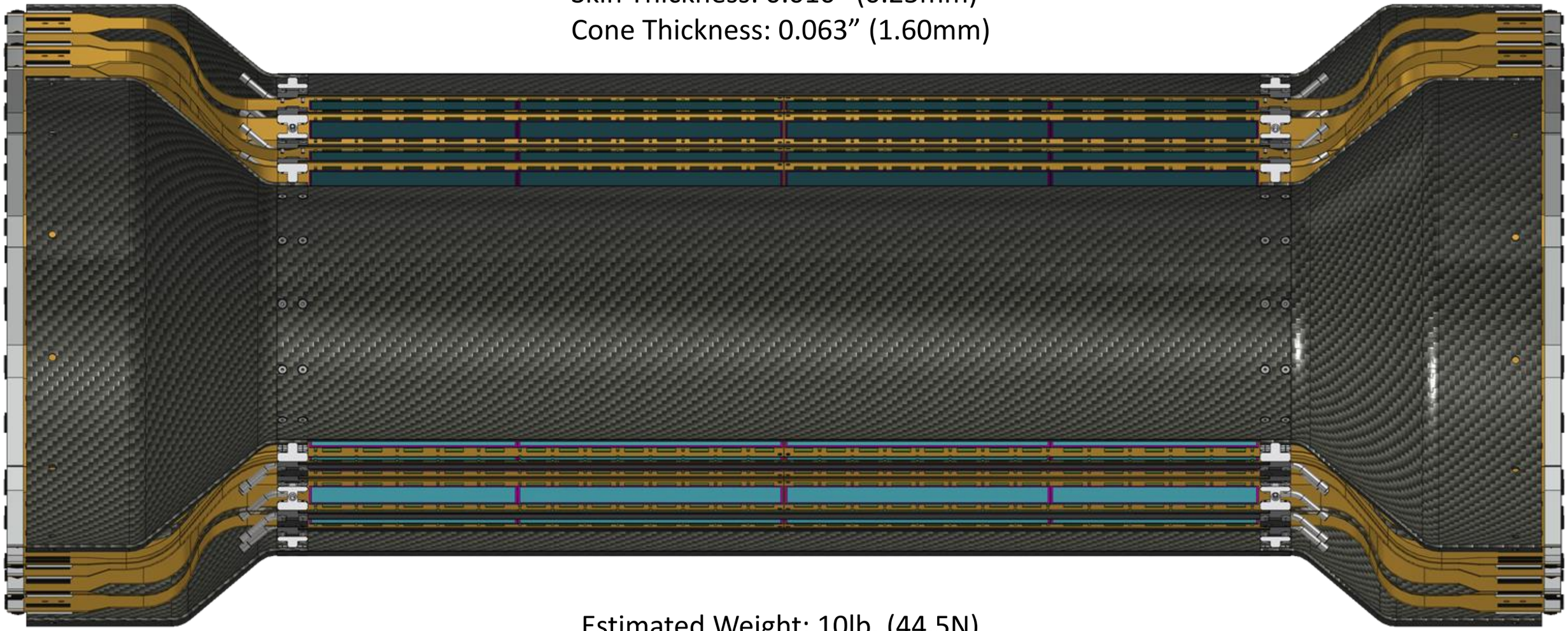


Ladders – Both Connections



Barrel – Carbon Fiber Skins and Cones

Skin Thickness: 0.010” (0.25mm)
Cone Thickness: 0.063” (1.60mm)



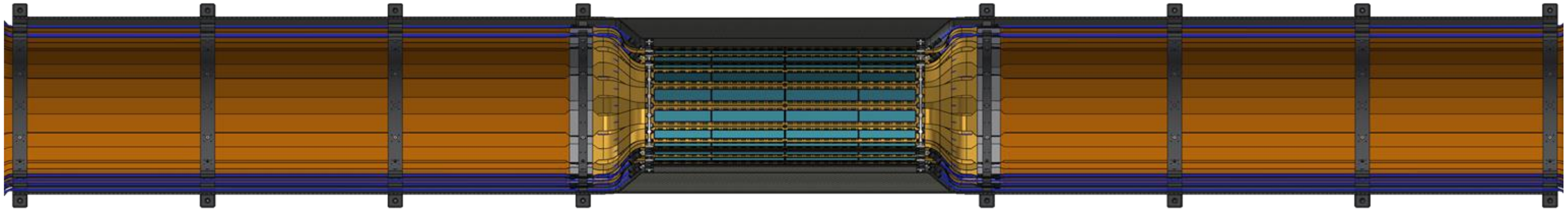
Estimated Weight: 10lb. (44.5N)
Both Sides Total: 20lb. (89N)

Barrel - Assembly

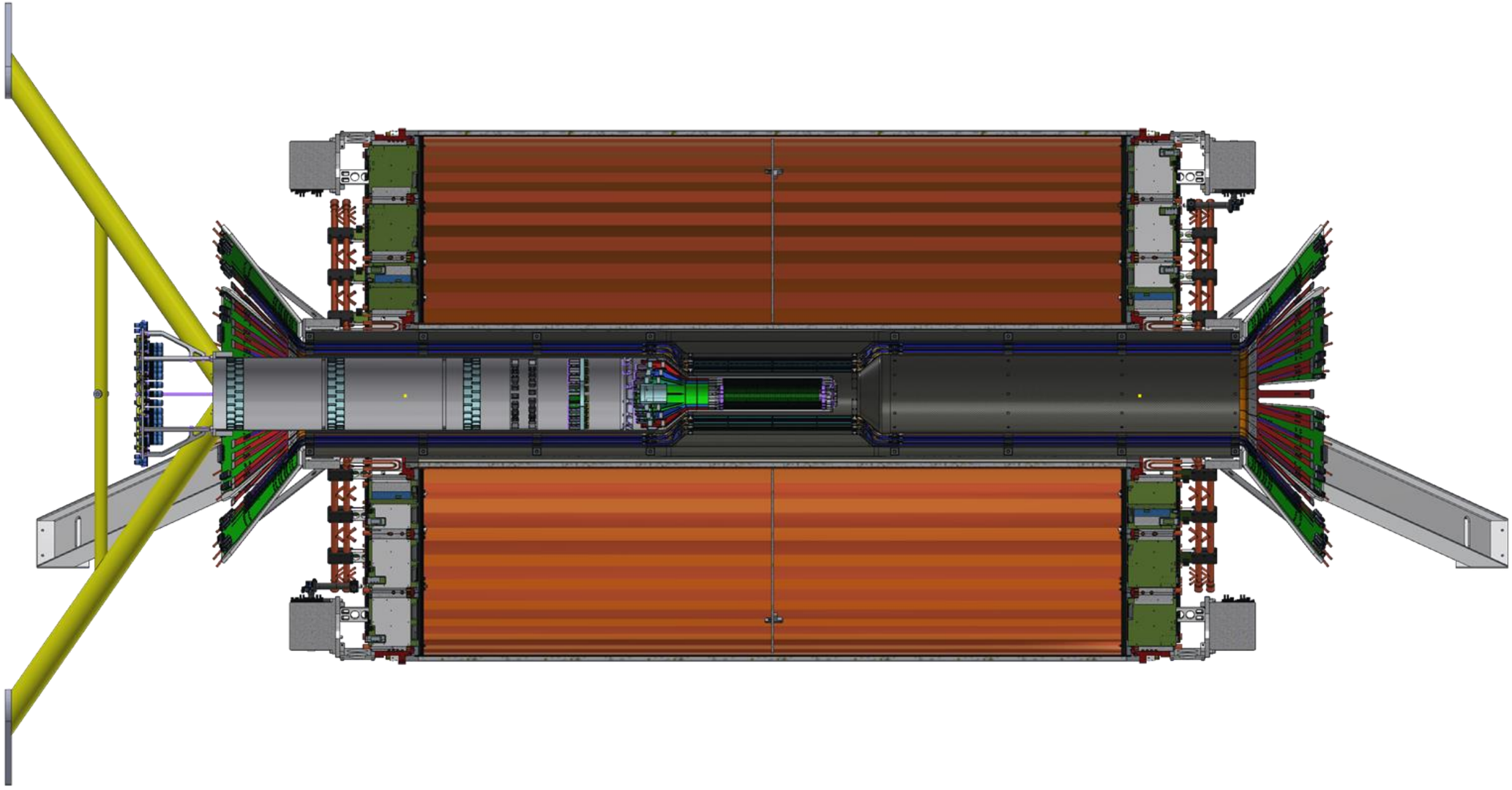
Barrel - Services

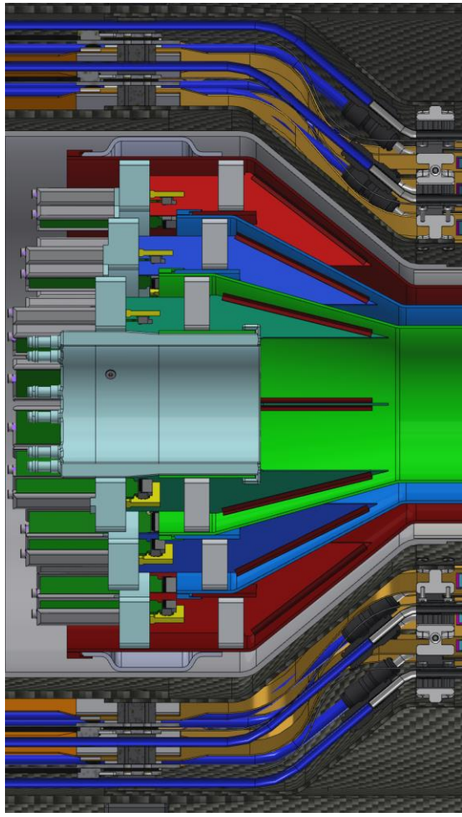
With Inner Carbon Fiber

Without Inner Carbon Fiber

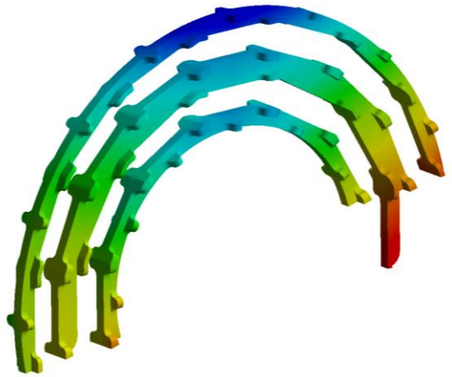


Barrel - Integration



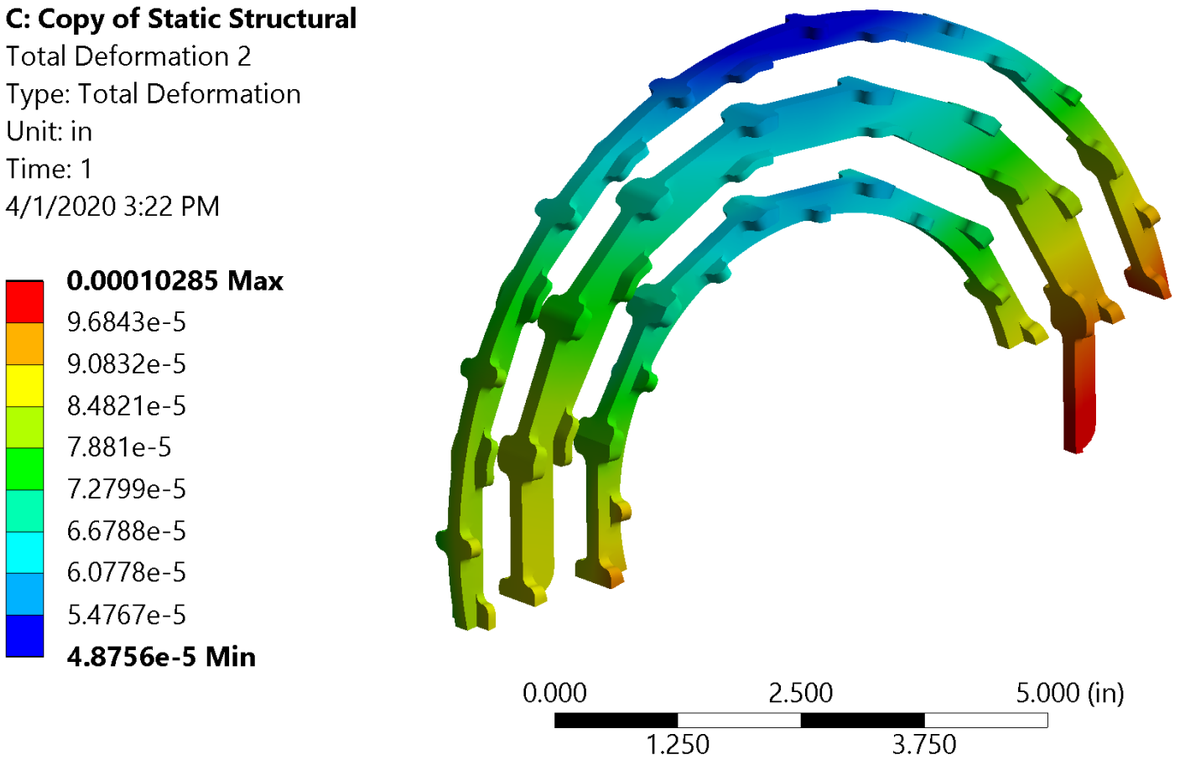


Barrel FEA Analysis

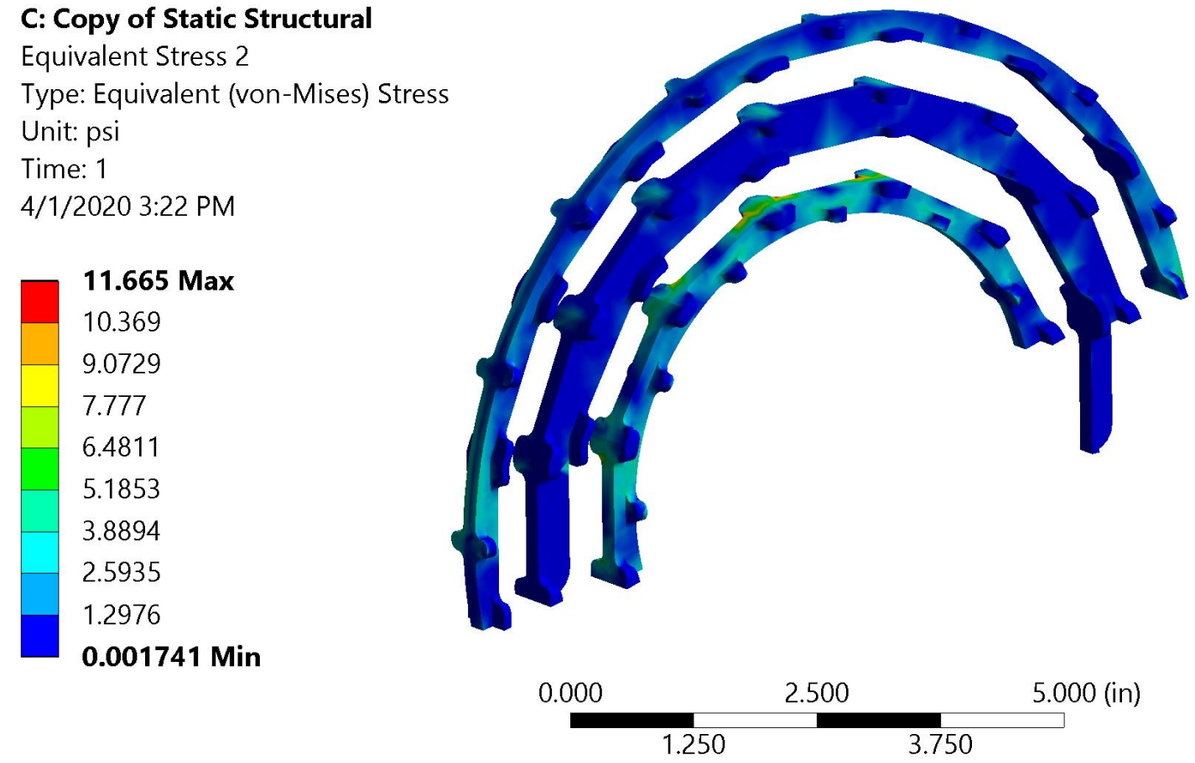


Structural – Under its Own Weight

Deflection – MAX: 0.0002 in (5 um)



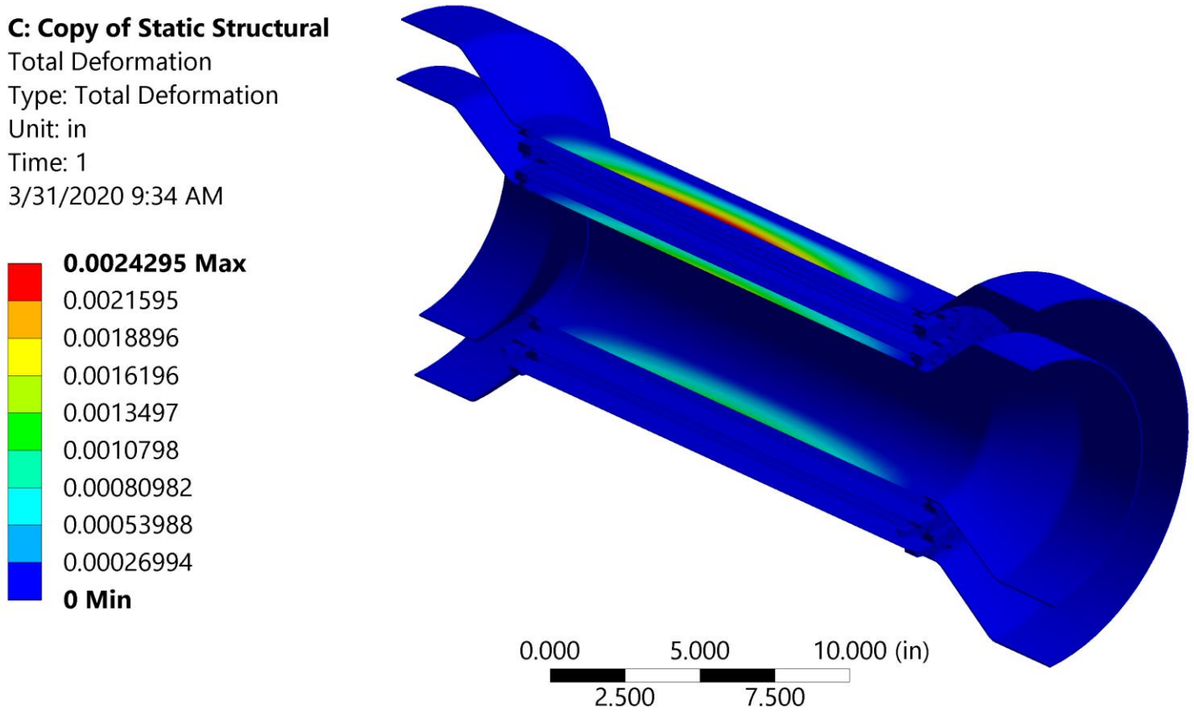
Stress – MAX: 12 psi (0.08 MPa)



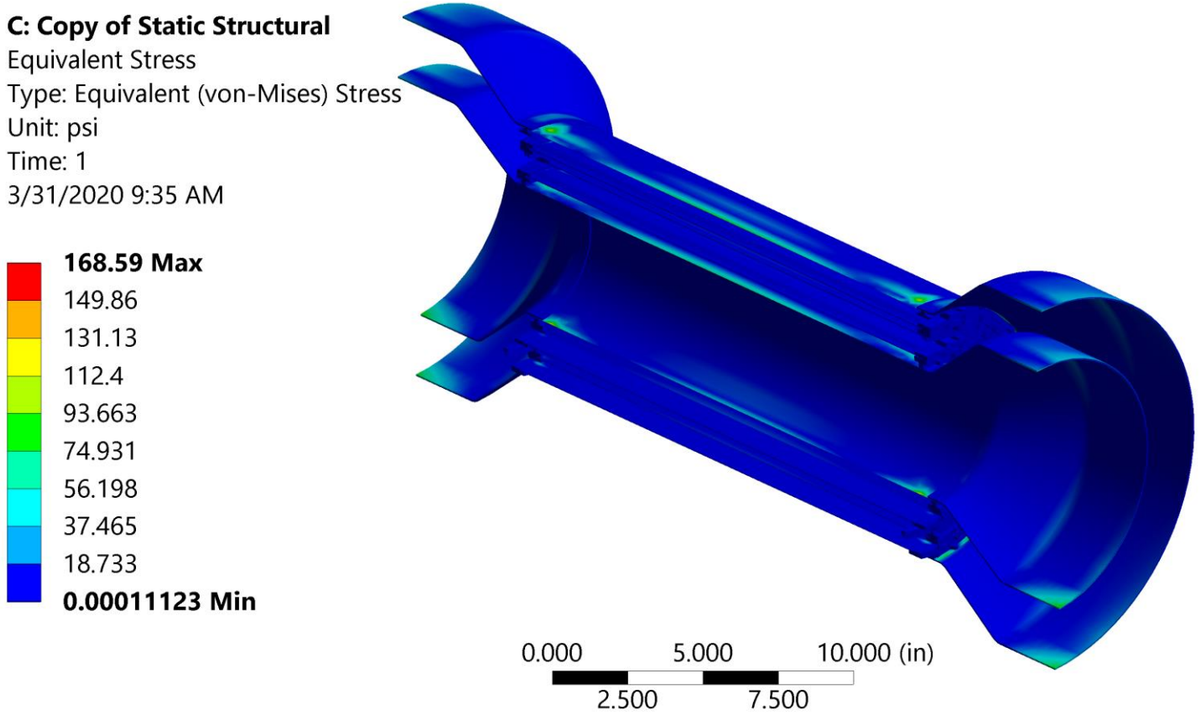
Boundary Conditions: Carbon fiber cones fixed-fixed, HDI weight added

Structural – Under its Own Weight

Deflection – MAX: 0.0025 in (63.5 um)



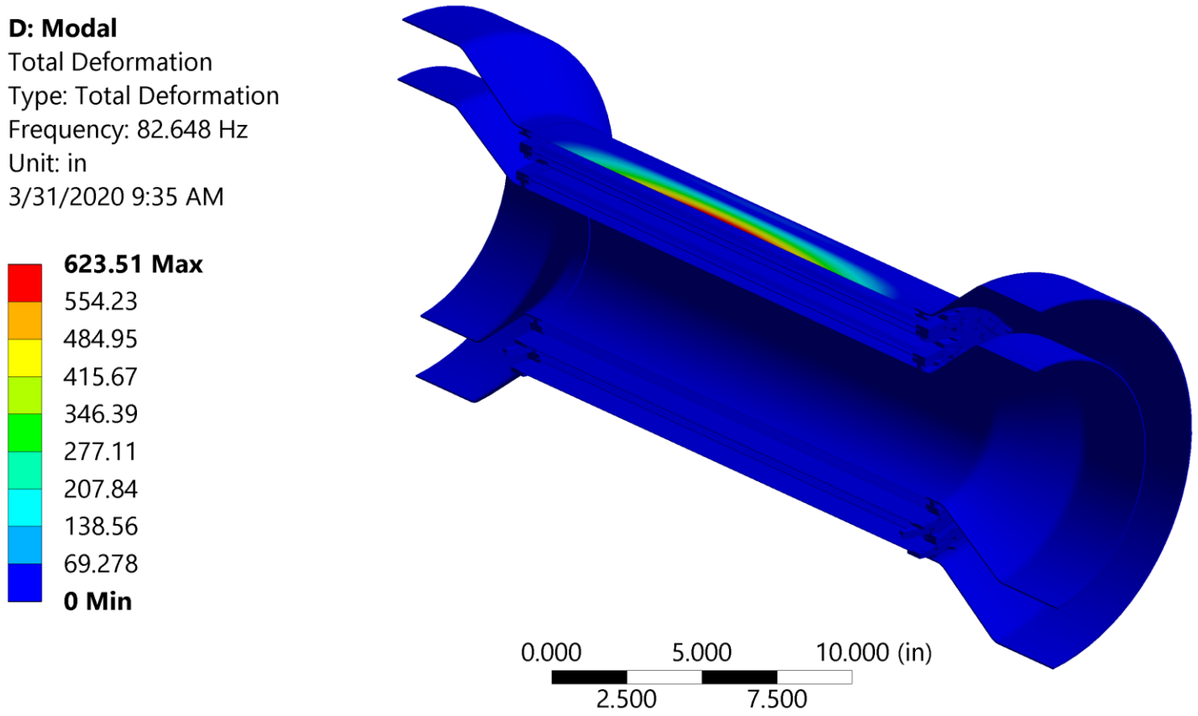
Stress – MAX: 170 psi (1.17 MPa)



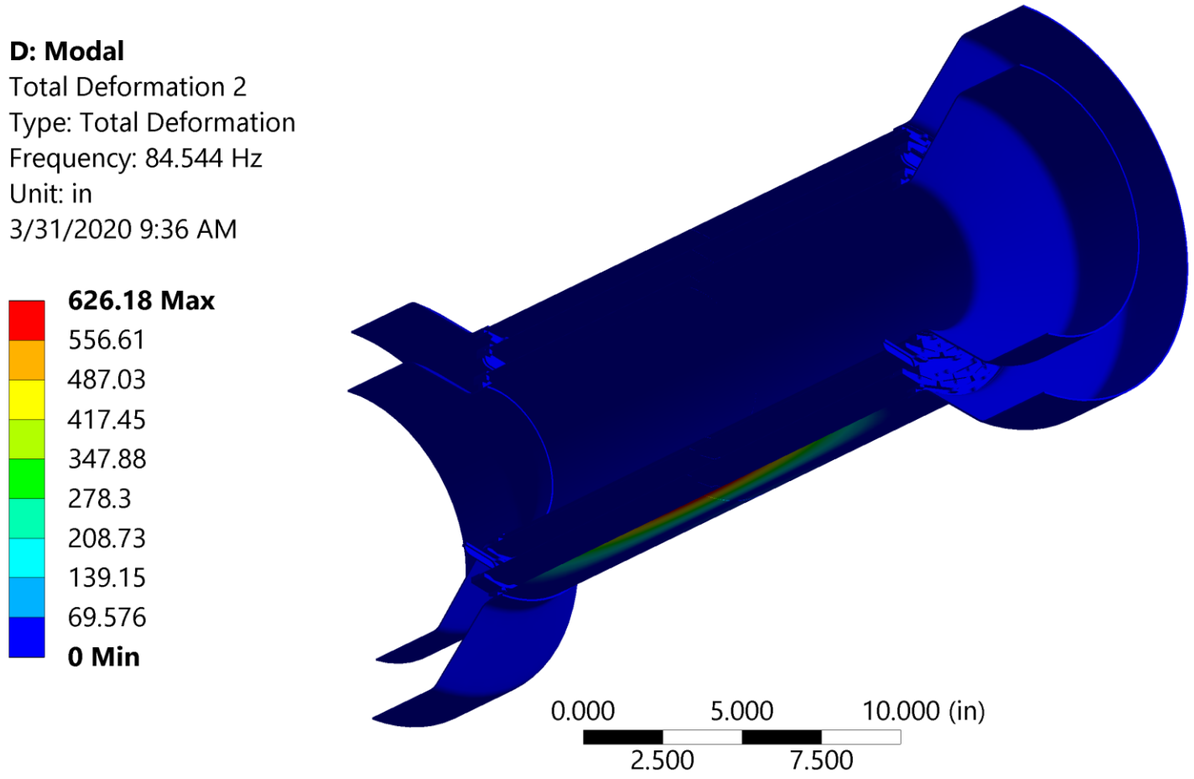
Boundary Conditions: Carbon fiber cones fixed-fixed, HDI weight added

Vibration – Natural Frequencies

First Mode – 83 Hz

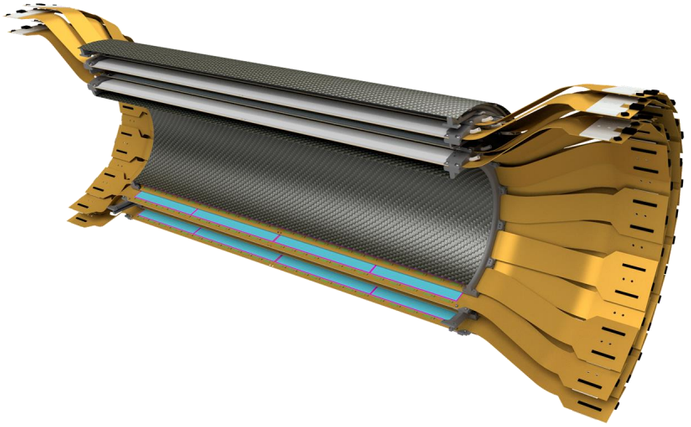


Second Mode – 85 Hz

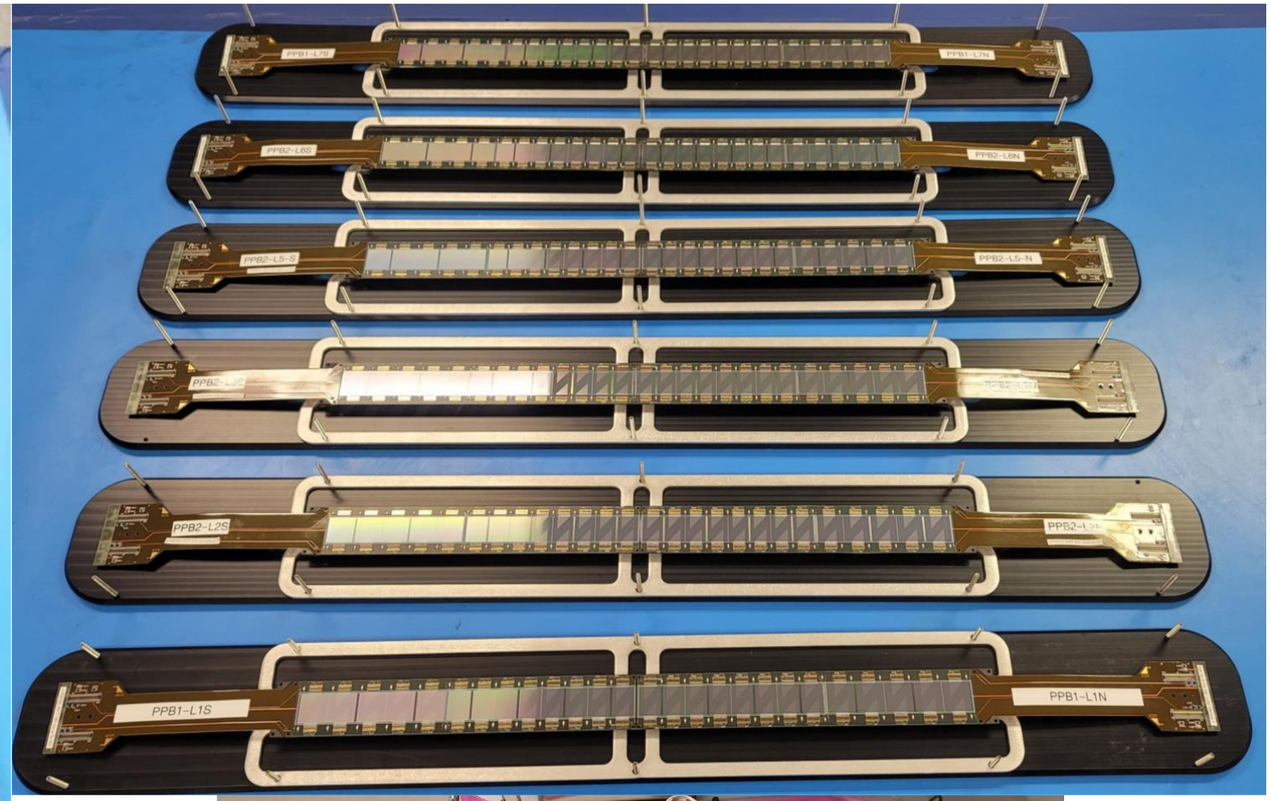


Boundary Conditions: Carbon fiber cones fixed-fixed

Summary

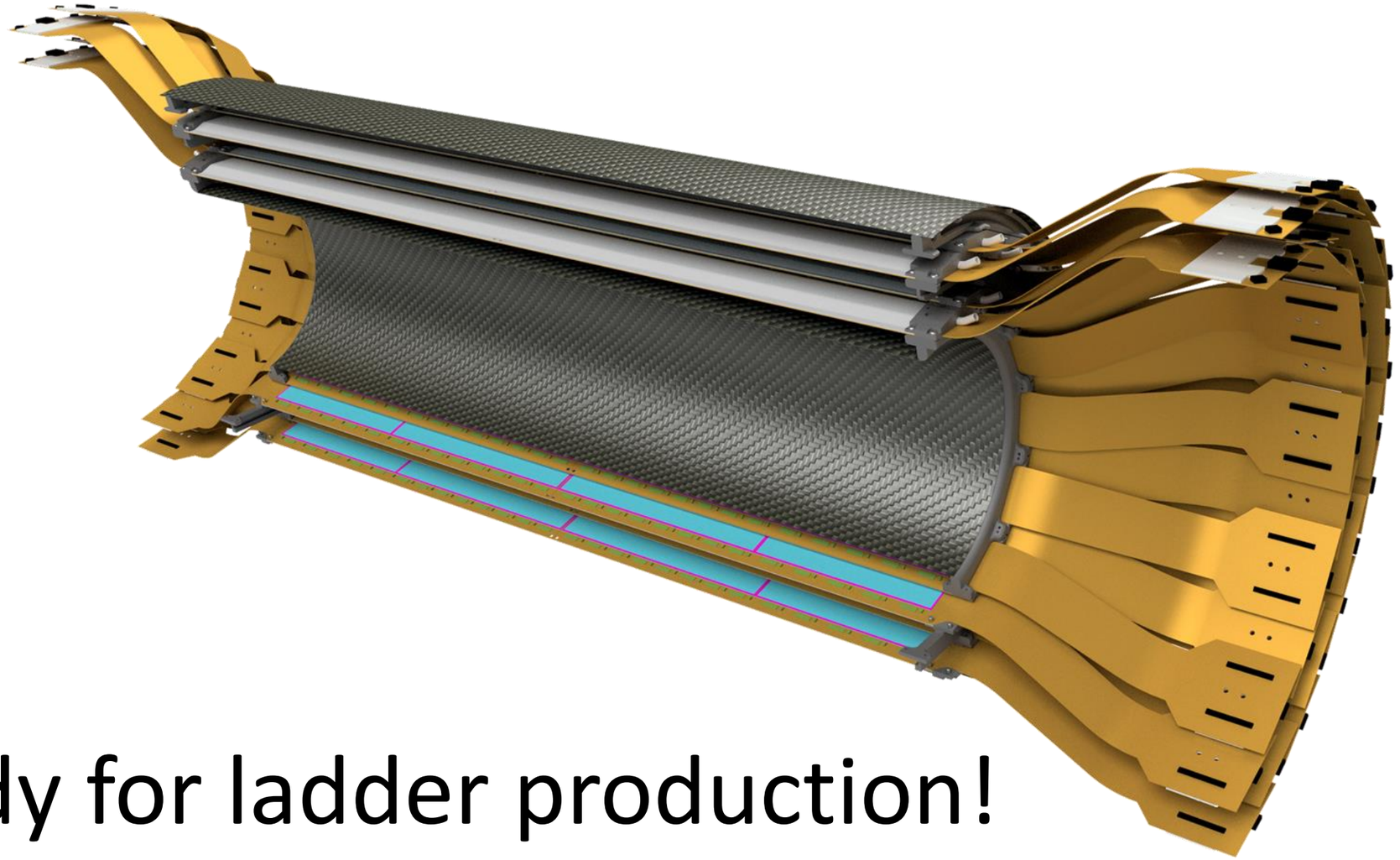


Pre-Production



Summary

- The Design of the stave meets all requirements for:
  - HDI ✓
  - Coverage ✓
  - Radiation Length ✓
  - Rigidity ✓
  - Stress ✓
  - Modes ✓
  - Cooling ✓
  - Geometry ✓
  - Clearances ✓
  - Tolerances ✓



Ready for ladder production!

Technical Data Sheets

Carbon Fiber - K13C2U

K13C2U

COAL TAR PITCH-BASED CARBON FIBERS

TYPICAL PROPERTIES

Tensile Strength	*550 Ksi*
Tensile Modulus	*130 Msi*
Ult Elongation	*.42 %*
Yield	*1800 yard/Lb*
Density	*2.2 g/cm³*
Electrical Resistivity	*1.9 x 10⁻³ohm·m*
Thermal Conductivity	*620 W/m˚K*
Sizing Amount (Epoxy Type)	*2 %*
Number of Filaments	*2 K*
Filament Diameter	*10 u*
Twist	*0 untwisted type*
Carbon Content	*over 99 %*

Standard Package Size:
.22 lb or .44 lb Spool Size, 16 Spools per Case

This information we believe to be useful for consideration and evaluation. However it should not be taken as a warranty or representation for which we undertake any legal responsibility, or as recommendation or permission to carry out any patented invention commercially.

MITSUBISHI CHEMICAL

Mitsubishi Chemical America ● 401 Volvo Parkway Chesapeake VA 23320 ● Phone: 757-382-5750
Fax: 757-312-8259 ● Website: www.mitsubishichemical.com

Carbon Fiber - XN-90-60S

PITCH BASED CARBON FIBER

GRANOC ヤーン XN シリーズ

		XN-60-60S	XN-60-A2S	XN-80-60S	XN-80-A2S	XN-90-60S
引張強度	ksi	500	500	500	500	500
	kgf/mm^2	350	350	350	350	350
	MPa	3430	3430	3430	3430	3430
引張弾性率	msi	90	90	114	114	125
	$10^3 kgf/mm^2$	63	63	80	80	88
	GPa	620	620	780	780	860
破断伸度	%	0.6	0.6	0.5	0.5	0.4
密度	g/cm^3	2.12	2.12	2.17	2.17	2.19
繊維径	Micron	10	10	10	10	10
フィラメント数		6000	12000	6000	12000	6000
繊度	g/km	890	1780	890	1780	880
熱膨張係数	$10^{-6}/K$	-1.4	-1.4	-1.5	-1.5	-1.5
熱伝導率	W/m-K	180	180	320	320	500
体積抵抗率	10^{-4} ohm-cm	7	7	5	5	3

注： (1) 上記数値は室温での標準的な値であり、保証値ではありません。
(2) 数値は改訂されることがあります。

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兵庫県姫路市広畑区富士町１番地
Tel 079-256-7010 Fax 079-237-8427
Website www.ngfworld.com

コンポジット物性

		XN-60	XN-80	XN-90
コンポジット物性				
0°引張強度	MPa	1800	1800	1800
引張弾性率	GPa	400	450	550
破断伸度	%	0.37	0.31	0.33
90°引張強度	MPa	32	33	25
引張弾性率	GPa	5.4	5.6	5.4
破断伸度	%	0.6	0.60	0.47
Vf	vol %	52	56	55
0°曲げ強度	MPa	790	720	690
曲げ弾性率	GPa	313	360	457
0°圧縮強度	MPa	400	380	370
圧縮弾性率	GPa	340	407	540
ILSS	MPa	81	80	60

※コンポジット物性は Vf = 60% 換算値

Carbon Fiber - T700

TECHNICAL DATA SHEET
No. CFA-005

TORAYCA®

T700S DATA SHEET

Highest strength, standard modulus fiber available with excellent processing characteristics for filament winding and prepreg. This never twisted fiber is used in high tensile applications like pressure vessels, recreational, and industrial.

FIBER PROPERTIES

		English	Metric	Test Method
Tensile Strength		711 ksi	4,900 MPa	TY-030B-01
Tensile Modulus		33.4 Msi	230 GPa	TY-030B-01
Strain		2.1 %	2.1 %	TY-030B-01
Density		0.065 lbs/in^3	1.80 g/cm^3	TY-030B-02
Filament Diameter		2.8E-04 in.	7 µm	
Yield	6K	3,724 ft/lbs	400 g/1000m	TY-030B-03
	12K	1,862 ft/lbs	800 g/1000m	TY-030B-03
	24K	903 ft/lbs	1,650 g/1000m	TY-030B-03
Sizing Type & Amount	50C	1.0 %		TY-030B-05
	60E	0.3 %		TY-030B-05
	F0E	0.7 %		TY-030B-05
	Twist	Never twisted		

FUNCTIONAL PROPERTIES

CTE	-0.38 $\alpha 10^{-6}$/°C
Specific Heat	0.18 Cal/g·°C
Thermal Conductivity	0.0224 Cal/cm·s·°C
Electric Resistivity	1.6 x 10^{-3} Ω·cm
Chemical Composition: Carbon	93 %
Na + K	<50 ppm

COMPOSITE PROPERTIES*

Tensile Strength	370 ksi	2,550 MPa	ASTM D-3039
Tensile Modulus	20.0 Msi	135 GPa	ASTM D-3039
Tensile Strain	1.7 %	1.7 %	ASTM D-3039
Compressive Strength	215 ksi	1,470 MPa	ASTM D-695
Flexural Strength	245 ksi	1,670 MPa	ASTM D-790
Flexural Modulus	17.5 Msi	120 GPa	ASTM D-790
ILSS	13 ksi	9 kgf/mm^2	ASTM D-2344
90° Tensile Strength	10.0 ksi	69 MPa	ASTM D-3039

* Toray 250°F Epoxy Resin. Normalized to 60% fiber volume.

TORAY CARBON FIBERS AMERICA, INC.

T700S

COMPOSITE PROPERTIES**

Tensile Strength	355 ksi	2,450 MPa	ASTM D-3039
Tensile Modulus	18.0 Msi	125 GPa	ASTM D-3039
Tensile Strain	1.7 %	1.7 %	ASTM D-3039
Compressive Strength	230 ksi	1,570 MPa	ASTM D-695
Compressive Modulus	--- Msi	--- GPa	ASTM D-695
In-Plane Shear Strength	14 ksi	98 MPa	ASTM D-3518
ILSS	15.5 ksi	11 kgf/mm^2	ASTM D-2344
90° Tensile Strength	10.0 ksi	70 MPa	ASTM D-3039

** Toray Semi-Toughened 350°F Epoxy Resin. Normalized to 60% fiber volume.

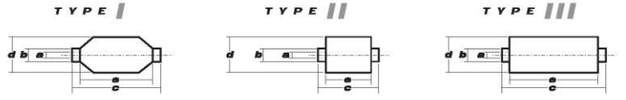
See Section 4 for Safety & Handling information. The above properties do not constitute any warranty or guarantee of values. These values are for material selection purposes only. For applications requiring guaranteed values, contact our sales and technical team to establish a material specification document.

PACKAGING

The table below summarizes the tow sizes, twists, sizing types, and packaging available for standard material. Other bobbin sizes may be available on a limited basis.

Tow Sizes	Twist[1]	Sizing	Bobbin Net Weight (kg)	Bobbin Type[2]	Bobbin Size (mm) a	b	c	d	e	Spools per Case	Case Net Weight (kg)
6K	C	50C	2.0	III	76.5	82.5	280	140	252	12	24
12K	C	50C	6.0	III	76.5	82.5	280	200	252	4	24
	C	60E	6.0	III	76.5	82.5	280	200	252	4	24
	C	F0E	6.0	III	76.5	82.5	280	200	252	4	24
24K	C	50C	6.0	III	76.5	82.5	280	200	252	4	24
	C	60E	6.0	III	76.5	82.5	280	200	252	4	24
	C	F0E	6.0	III	76.5	82.5	280	200	252	4	24

[1] **Twist** A: Twisted yarn B: Untwisted yarn made from a twisted yarn through an untwisting process C: Never twisted yarn
[2] **Bobbin Type** See Diagram below



TORAY CARBON FIBERS AMERICA, INC.
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Sales@Toraycfa.com Technical@Toraycfa.com www.torayusa.com

PEEK - CA30

MITSUBISHI CHEMICAL ADVANCED MATERIALS

Mitsubishi Chemical Advanced Materials Ketron® CA30 PEEK, Extruded 30% Carbon Fiber Reinforced Polyetherether Ketone (ASTM Product Data Sheet)

Categories:	Polymer; Thermoplastic; Polyketone; Polyetherketone (PEEK); Polyetherketone, PEEK, Carbon Fiber Filled
Material Notes:	Quadrant Engineering Plastic Products is now Mitsubishi Chemical Advanced Materials.

Physical Properties	Metric	English	Comments
Specific Gravity	1.41 g/cc	1.41 g/cc	ASTM D792
Water Absorption	0.060 %	0.060 %	Immersion, 24hr; ASTM D570(2)
Water Absorption at Saturation	0.30 %	0.30 %	Immersion; ASTM D570(2)

Mechanical Properties	Metric	English	Comments
Hardness, Rockwell M	102	102	ASTM D785
Hardness, Shore D	93	93	ASTM D2240
Tensile Strength	131 MPa	19000 psi	ASTM D638
Tensile Strength at 150°C (302°F)	6.89 MPa	1000 psi	ASTM D638
Tensile Strength at 65°C (150°F)	96.5 MPa	14000 psi	ASTM D638
Elongation at Break	5.0 %	5.0 %	ASTM D638
Tensile Modulus	7.58 GPa	1100 ksi	ASTM D638
Flexural Strength	177.5 MPa	25750 psi	ASTM D790
Flexural Modulus	8.62 GPa	1250 ksi	ASTM D790
Compressive Strength	200 MPa	29000 psi	10% Def.; ASTM D695
Izod Impact, Notched	0.580 J/cm	1.03 ft-lb/in	ASTM D256 Type A
Coefficient of Friction, Dynamic	0.20	0.20	Dry vs. Steel; QTM55007
K (wear) Factor	302 x 10⁻¹³ mm³/N-M	150 x 10⁻¹³ in³-min/ft-lb-hr	QTM 55010
Limiting Pressure Velocity	0.876 MPa-m/sec	25000 psi-ft/min	4:1 safety factor; QTM 55007

Electrical Properties	Metric	English	Comments
Surface Resistivity per Square	<= 1e+05	<= 1e+05	EOSD ESD S11.11
Dielectric Strength	1.26 kV/mm	32.0 kV/in	Short Term; ASTM D149

Thermal Properties	Metric	English	Comments
CTE, linear	18.0 µm/m-°C @Temperature -40.0 - 149 °C	10.0 µin/in-°F @Temperature -40.0 - 300 °F	ASTM E831
Thermal Conductivity	0.922 W/m-K	6.40 BTU-in/hr-ft²-°F	ASTM F433
Melting Point	340 °C	644 °F	Crystalline, Peak; ASTM D3418
Maximum Service Temperature, Air	250 °C	482 °F	Long Term
Deflection Temperature at 1.8 MPa (264 psi)	270 °C	518 °F	ASTM D648
Flammability, UL94	V-0 @Thickness 3.17 mm	V-0 @Thickness 0.125 in	Estimated Rating

Compliance Properties	Metric	English	Comments
3A Dairy	No	No	
Canada AG	No	No	
FDA	No	No	
NSF	No	No	
USDA	No	No	
USP Class VI	No	No	

Chemical Resistance Properties	Metric	English	Comments
Acids, Strong (pH 1-3)	Limited	Limited	
Acids, Weak	Acceptable	Acceptable	
Alcohols	Acceptable	Acceptable	
Alkalies, Strong (pH 11-14)	Acceptable	Acceptable	
Alkalies, Weak	Acceptable	Acceptable	
Chlorinated Solvents	Acceptable	Acceptable	
Conductive / Static Dissipative	Yes	Yes	
Continuous Sunlight	Acceptable	Acceptable	
Hot Water / Steam	Acceptable	Acceptable	
Hydrocarbons - Aliphatic	Acceptable	Acceptable	
Hydrocarbons - Aromatic	Acceptable	Acceptable	
Inorganic Salt Solutions	Acceptable	Acceptable	
Ketones, Esters	Acceptable	Acceptable	

Descriptive Properties		
Color	Natural	
Machinability	7	1-10, 1=Easier to Machine

Mitsubishi Chemical Advanced Materials Inc. • 2120 Fairmont Avenue • P.O. Box 14235 • Reading, PA 19612-4235
Tel: (610) 320-6660 • Fax: (610) 320-6866

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Foam - Rohacell 110 RIST

ROHACELL®

Product Information

ROHACELL® RIST-HT

FOAM FOR VACUUM INFUSION PROCESSES

ROHACELL® RIST-HT (heat treated) is closed-cell rigid foam based on polymethacrylimide (PMI) chemistry that is completely free of CFC's and specially developed for use as a structural core in connection with vacuum infusion processes. All RIST-HT products are heat treated before delivery to customers.

Its mechanical and thermomechanical properties are similar to those of ROHACELL® WF. Its cell size, however, represents an optimal compromise between low resin uptake – about 50% less than for ROHACELL® WF – and satisfactory bonding of the facings to the core.

PROCESSING AND PRODUCTION

The optimized cell structure of **ROHACELL® RIST-HT** makes it particularly suitable for vacuum infusion and RTM processes, where it can be used at temperatures up to 180 °C (356 °F) with pressures up to 0.7 MPa (102 psi).

THERMOFORMING AND SHAPING

ROHACELL® RIST-HT can be easily thermoformed or CNC machined to meet customer requirements.

High precision, pre-shaped and ready-to-use foam cores in complex or simple geometries can also be supplied by the ROHACELL® Shapes Department.

Property	Test Method*	Unit	ROHACELL® 51 RIST-HT	ROHACELL® 71 RIST-HT	ROHACELL® 110 RIST-HT
Density	ISO 845 ASTM D 1622	kg/m³ lbs/ft³	52 3.25	75 4.68	110 6.87
Compressive Strength	ISO 844 ASTM D 1621	MPa psi	0.8 116	1.7 246	3.6 522
Tensile Strength	ISO 527-2 ASTM D 638	MPa psi	1.6 232	2.2 319	3.7 536
Tensile Modulus	ISO 527-2 ASTM D 638	MPa psi	75 10,875	105 15,225	180 26,100
Elongation at Break	ISO 527-2 ASTM D 638	%	3	3	3
Shear Strength	DIN 53294 ASTM C 273	MPa psi	0.8 116	1.3 188	2.4 348
Shear Modulus	DIN 53294 ASTM C 273	MPa psi	24 3,480	42 6,090	70 10,170
Coefficient of Thermal Expansion		1/K*10E-5	3.18	3.45	3.43

Technical data values presented above are typical for nominal density, subject to normal manufacturing variations. *Data values are based on ISO & DIN standard test methods, however ASTM values can be confirmed upon request. All ROHACELL® products are closed-cell rigid foams based on polymethacrylimide (PMI) chemistry and contain no CFC's.

Evonik Resource Efficiency GmbH | **ROHACELL®** RIST-HT | March 2020

Epoxy - 25R

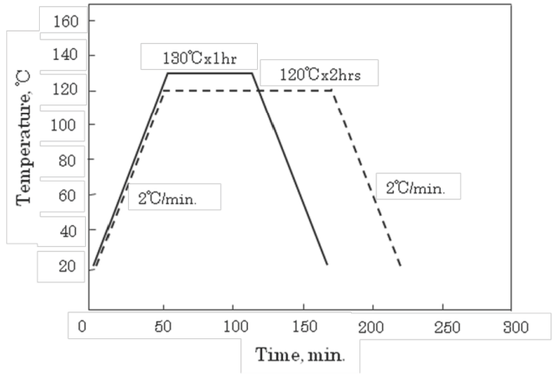
Technical Data 25R

GRANOC プリプレグ エポキシ樹脂(25R)

〈樹脂特性〉

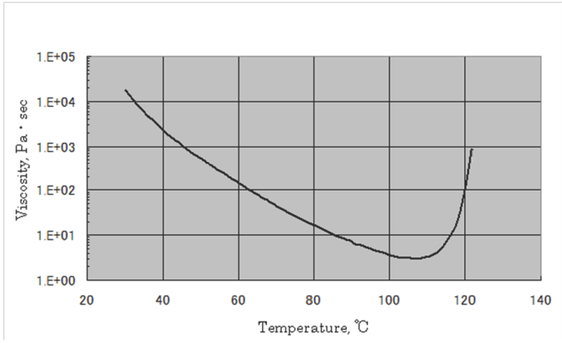
・比重	1.21
・Tg(ガラス転移点温度)	125℃ (130℃ x 1hr 硬化時)
・熱膨張係数	60 x 10^{-6}/K
・保管寿命	1 年 −18℃保管時
	1 ヶ月 室温(25℃)保管時
・硬化条件	130℃ x 1hr または 120℃ x 2hrs

・標準硬化パターン

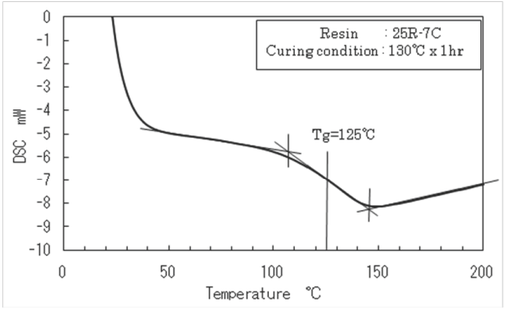


日本グラファイトファイバー株式会社.
〒103-0024 東京都中央区日本橋小舟町 3-8 小原ビル
TEL 03-5645-7671 FAX 03-5645-7675

・昇温粘度特性



・ Tg(ガラス転移点)



日本グラファイトファイバー株式会社.
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TEL 03-5645-7671 FAX 03-5645-7675

Epoxy - EP75-1

EP75-1 Master Bond Polymer System

Two component, graphite conductive epoxy system for bonding, sealing, coating

Key Features

- ✓ Cures at room temperature
- ✓ Non magnetic; graphite filled
- ✓ Good electrical conductivity
- ✓ Withstands 1,000 hours 85°C/85% RH

Product Description

Master Bond EP75-1 is a two component, graphite filled, electrically conductive epoxy for high performance bonding, sealing and coating. The mix ratio of the EP75-1 system is 100 to 15 by weight. It can cure at room temperature or more rapidly at elevated temperatures. The optimum cure schedule is overnight at 75°F followed by 1-2 hours at 150-200°F. The volume resistivity of EP75-1 is 50-100 ohm-cm placing it in the realm of applications involving static dissipation and for EMI/RFI shielding purposes. The graphite filler confers non-magnetic properties as well as a modicum of lubricity to the system. In fact, EP75-1 is a material of choice when the requirement is for a non-metallic electrically conductive epoxy.

EP75-1 contains no solvents and has a paste-like consistency after mixing. It bonds well to a wide variety of substrates including metals, composites, ceramics, glass and many rubbers and plastics. It has reputable lap shear strength of over 1,400 psi along with worthy dimensional stability. It has good chemical resistance to water, oils, acids and bases. Its service temperature range is 4K to +250°F. It can be used for electronic, aerospace, semiconductor, medical, fiber-optic, specialty OEM and related applications where a cost effective system for dissipating static electricity or EMI/RFI shielding, among the other properties mentioned above, might be needed.

Product Advantages

- Versatile cure schedules
- Well suited for shielding and static dissipation
- Non-magnetic
- Good lubricity
- Outstanding dimensional stability
- Cryogenically serviceable
- Very low coefficient of thermal expansion

Typical Properties

Tensile lap shear strength, aluminum to aluminum, 75°F	1,100-1,300 psi
Tensile strength, 75°F	5,000-6,000 psi
Tensile modulus, 75°F	300,000-350,000 psi
Hardness, 75°F	75-85 Shore D
Hardness after 1,000 hours 85°C/85% RH	85 Shore D
Thermal conductivity	13-14 BTU•in/(ft²•hr•°F) [1.87-2.02 W/(m·K)]
Coefficient of thermal expansion, 75°F	10-15 x 10^{-6} in/in/°C
Volume resistivity, 75°F	50-100 ohm-cm
Service temperature range	4K to +250°F [4K to +121°C]

Mixing and Curing

Mixing ratio, Part A to B	100:15
Viscosity of Part A, 75°F	paste
Viscosity of Part B, 75°F	200-500 cps
Working life after mixing, 75°F; 100 gram batch	30-60 minutes
Cure schedule options	
75°F	48-72 hours
150-200°F	2-3 hours
Optimum cure schedule	overnight at room temperature plus 1-2 hours at 150-200°F
Shelf life at 75°F, in original unopened containers	3 months minimum, 6 months maximum

Preparation of Adhesive

Master Bond EP75-1 is prepared by thoroughly mixing Part A with Part B in a 100:15 mix ratio by weight. Part A must be stirred individually prior to mixing. Mixing should be done slowly to avoid entrapping air.

Because of the 100:15 mix ratio of EP75-1, special care should be paid when mixing the A and B Parts together to ensure Part B is thoroughly distributed throughout Part A. The working life of a 100 gram batch is approximately 30-60 minutes. It can be lengthened by using shallower mixing vessels or mixing smaller size batches.

Preparation of Bonding Surfaces

All bonding surfaces should be carefully cleaned, degreased and dried. Non-porous or smooth surfaces should be roughened with sandpaper or mechanically abraded, to achieve maximum bond strength. When bonding to metal surfaces, chemical etching may be employed when the bonded joints are to exhibit optimal environmental durability.

Adhesive Application

Master Bond EP75-1 can be conveniently applied with a spatula, knife, or similar implement. Enough mixed adhesive should be applied to obtain a final adhesive bond line thickness of 1-4 mils. Porous surfaces may require somewhat more adhesive to fill the voids than non-porous ones. Thicker glue lines do not increase the strength of a joint but do not necessarily give inferior results. EP75-1 contains a limited amount of volatiles for ease of dispensation. The system is a paste and can be made more flowable by adding 5-10% by weight of an appropriate solvent such as acetone or MEK. The parts to be bonded should then be pressed together with just enough pressure to maintain intimate contact during cure. When used as a coating, thicknesses of 0.001-0.003 inches are more than adequate.

Cure

Master Bond EP75-1 can be cured at room temperature or at elevated temperatures as desired. At room temperature it cures in 48-72 hours. Faster cures can be realized at elevated temperatures, e.g., 2-3 hours at 200°F. Remove excess adhesive promptly before it hardens with a spatula. Then wipe with a rag and solvent such as acetone. The thinner the layer of epoxy, the slower the rate of cure. EP75-1 does not reach its ultimate electrical properties, nor its full strength, until it is completely cured.

Packaging

Product is available in:

- Glass jars
- Pint kits
- Quart kits
- Gallon kits

Handling and Storage

All epoxy resins should be used with good ventilation and skin contact should be avoided. For safe handling details, please consult the product SDS. Optimum storage is at or below 75°F in closed containers. No special storage conditions are necessary. Containers should, however, be kept closed when not in use to avoid contamination. Cleanup of spills and equipment is readily achieved with aromatic or ketone solvents employing proper precautions of ventilation and flammability.

Epoxy - Hysol EA 9396

LOCTITE Technical Process Bulletin

LOCTITE EA 9396 AERO
Epoxy Paste Adhesive
(KNOWN AS Hysol EA 9396)

INTRODUCTION
LOCTITE EA 9396 AERO is a low viscosity, room temperature curing adhesive system with excellent strength properties at temperatures from -67°F to 350°F (-55°C to 177°C). LOCTITE EA 9396 AERO has a shelf life of one year when stored @ 77°F/25°C for separate components. Qualified to MMM-A-132, Rev A, Type 1, Class 3.

FEATURES
- Low Viscosity
- Room Temperature Cure
- Room Temperature Storage
- High Strength at Low and High Temperatures

Uncured Properties

	Part A	Part B	Mixed
Color	Blue	Purple	Green to Dark Purple
Viscosity @ 77°F	700 Poise	0.9 Poise	35 Poise
Brookfield, HBT	Spdl 4 @ 10 rpm	Spdl 1 @ 100 rpm	Spdl 1 @ 20 rpm
Viscosity @ 25°C	70 Pa·S	0.09 Pa·S	3.5 Pa·S
Brookfield, HBT	Spdl 4 @ 2.1 rad/s	Spdl 1 @ 10.5 rad/s	Spdl 1 @ 2.1 rad/s
Density (g/ml)	1.17	0.98	1.14
Shelf life			
@ <40°F/4°C	1 year	1 year	
@ <77°F/25°C	1 year	1 year	

This material will normally be shipped at ambient conditions, which will not alter our standard warranty, provided that the material is placed into its intended storage upon receipt. Premium shipment is available upon request.

Handling
Mixing - This product requires mixing two components together just prior to application to the parts to be bonded. Complete mixing is necessary. The temperature of the separate components prior to mixing is not critical, but should be close to room temperature (77°F/25°C).

Mix Ratio	Part A	Part B
By Weight	100	30

Note: Volume measurement is not recommended for structural applications unless special precautions are taken to assure proper ratios.

Pot Life (100 gram mass) 120 minutes @77°F/25°C
Method - ASTM D2471 in water bath.

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LOCTITE Technical Process Bulletin

LOCTITE EA 9396 AERO
Epoxy Paste Adhesive
(KNOWN AS Hysol EA 9396)

Application
Mixing - Combine Part A and Part B in the correct ratio and mix thoroughly. THIS IS IMPORTANT! Heat buildup during or after mixing is normal. Do not mix quantities greater than 450 grams as dangerous heat buildup can occur causing uncontrolled decomposition of the mixed adhesive. TOXIC FUMES CAN OCCUR, RESULTING IN PERSONAL INJURY. Mixing smaller quantities will minimize the heat buildup.

Applying - Bonding surfaces should be clean, dry and properly prepared. For optimum surface preparation consult the LOCTITE Surface Preparation Guide. The bonded parts should be held in contact until the adhesive is set. Handling strength for this adhesive will occur in 24 hours @ 77°F/25°C, after which the support tooling or pressure used during cure may be removed. Since full bond strength has not yet been attained, load application should be small at this time.

Curing - This adhesive may be cured for 3 to 5 days @ 77°F/25°C to achieve normal performance. Accelerated cures of 1 hour @ 150°F/66°C may be used.

Cleanup - It is important to remove excess adhesive from the work area and application equipment before it hardens. Denatured alcohol and many common industrial solvents are suitable for removing uncured adhesive. Consult your supplier's information pertaining to the safe and proper use of solvents.

Bond Strength Performance
Tensile Lap Shear Strength
Tensile lap shear strength tested per ASTM D1002 after curing as shown below. Adherends are 2024-T3 Bare aluminum treated with phosphoric acid anodized per ASTM D3933.

	Typical Results					
Test Temperature °F/°C	Cure 5 days @ 77°F/25°C		Cure 1 hr @ 150°F/66°C		Cure 30 min @ 180°F/82°C	
	psi	MPa	psi	MPa	psi	MPa
-67/-55	3,300	22.8	3,300	22.8	3,500	24.1
77/25	3,500	24.1	4,000	27.6	4,000	27.6
180/82	3,200	22.0	3,300	22.8	3,300	22.8
300/149	1,800	12.4	1,800	12.4	1,900	13.1
350/177	1,250	8.6	1,200	8.3	1,200	8.3

Peel Strength
Bell Peel strength tested per ASTM D3167 after curing for 5 days @ 77°F/25°C. Adherends are 2024-T3 Bare aluminum treated with phosphoric acid anodized per ASTM D3933.

Test Temperature	Typical Results	
°F/°C	lb/in	N/25mm
77/25	25	111
180/82	20	89

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LOCTITE Technical Process Bulletin

LOCTITE EA 9396 AERO
Epoxy Paste Adhesive
(KNOWN AS Hysol EA 9396)

Service Temperature
Service temperature is defined as that temperature at which this adhesive still retains 1000 psi/6.9 MPa using test method ASTM D1002 and is approximately 350°F/177°C.

Bulk Resin Properties
Tensile Properties - tested using 0.125 inch/3.18 mm castings per ASTM D638. Adhesive cure 5 days @ 77°F/25°C and 1 hour @ 200°F/93°C.

	psi	MPa
Tensile Strength @ 77°F/25°C	8,000	35.2
Tensile Modulus @ 77°F/25°C	400,000	2,750
Elongation at Break @ 77°F/25°C	3.4%	

Electrical Properties - tested per ASTM D149, D150.

	0.1 KHz	1.0 KHz	10.0 KHz
Dielectric Constant	4.17	4.12	3.97
Dissipation Factor	0.006	0.017	0.031

Volume Resistivity	2.14×10^{15} (ohm-cm)
Surface Resistivity	3.17×10^{14} (ohm)
Thermal Conductivity	5.01×10^{-4} (cal/sec x cm x deg C)
Coefficient of Thermal Expansion (Alpha)	70.7 µm/m°C @ 40°C 108.0 µm/m°C @ 100°C
Shore D Hardness, @77°F/25°C	80

Handling Precautions
Do not handle or use until the Material Safety Data Sheet has been read and understood.
For industrial use only.

DISPOSAL INFORMATION
Dispose of spent remover and paint residue per local, state and regional regulations. Refer to HENKEL TECHNOLOGIES MATERIAL SAFETY DATA SHEET for additional disposal information.

PRECAUTIONARY INFORMATION
General:
As with most epoxy based systems, use this product with adequate ventilation. Do not get in eyes or on skin. Avoid breathing the vapors. Wash thoroughly with soap and water after handling. Empty containers retain product residue and vapors so obey all precautions when handling empty containers.

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Epoxy - TC2810

Science. Applied to Life.™

Technical Data | July 2018

3M™ Thermally Conductive Epoxy Adhesive TC-2810

Product Description

3M™ Thermally Conductive Epoxy Adhesive TC-2810 is a thermally conductive, 2-part epoxy using high performance filler for good thermal conductivity with high adhesion.

Key Features

- High adhesive strength
- Slight tack allows pre-assembly
- Good surface wet out
- Low viscosity for potting applications
- Good gap filling
- Thin bonding line
- Good thermal conductivity (0.8-1.4 W/m-K)
- Low chloride (Cl) ion content and outgassing

Typical Uncured Properties

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

3M™ Thermally Conductive Epoxy Adhesive TC-2810		
Property		**Value**
***Viscosity**	Base Accelerator Mixed	40,000-90,000 cps 11,000-21,000 cps 40,000-80,000 cps
Base Resin	Base Accelerator	Epoxy Amine
Filler	Ceramic	24% by weight
Mix Ratio (B:A)	Volume	2:1
Worklife		100-120 minutes at 23°C (72°F)
New Weight (lb/gal)	Base Accelerator Mixed	10.58 10.28 10.37

*Viscosity is measured using 40 mm, 2° cone, at 10 S^{-1}.

Applications

- LED Assembly
- Thermal fixing battery cell and thermal management for EV/HEV battery
- Potting applications
- General gap filling

Application Techniques and Product Use

For bonding rigid to rigid parts, it is suggested that the bond line thickness and edge fill be designed to optimize:

1. Bond Strength
2. Thermal Resistance

A typical suggested bond line is in the 3-7 mil (0.076- 0.018mm) thickness range
For improved thermal performance (lower thermal resistance), a thinner bond line is suggested. A thinner bond line can reduce the bond strength so each application needs to be tested to find correct balance between thermal and mechanical properties.

Bond Line Thickness vs Thermal Resistance vs Bond Strength

A "fillet" at the edge of a bond line is suggested to increase bond strength. The fillets are formed as the epoxy squeezes out past the side edges. Fillets can add strength to the assembly.

3M™ Thermal Conductive Epoxy TC-2810 is supplied in dual syringe plastic duo-pak cartridges as part of the 3M™ Scotch-Weld™ EPX™ Plus II Applicator. The duo-pak cartridges are supplied in 37ml or 50 ml configuration. To use the cartridge simply insert the duo-pak cartridge into the EPX Plus II Applicator and start the plunger into the cylinders using light pressure on the trigger. Next, remove the duo-pak cartridge cap and expel and discard a small amount of adhesive to be sure both sides of the duo-pak cartridge are flowing evenly and freely (ie: no voids, "plugs of adhesive", dis-continuity in flow, etc.) Once even side to side and uniform flow from both sides of the duo-pak is confirmed, attach the 3M™ Scotch-Weld™ EPX™ Mixing Nozzle to the duo-pak cartridge to ensure proper and uniform missing of the Part A and Part B and begin dispensing the adhesive.

Partially used cartridges must follow the above use instructions to ensure consistent product performance.

Complete and uniform mixing as noted above of the two components is required to obtain consistent product performance.

3M™ Scotch-Weld™ EPX™ Plus II Applicator and 3M™ Scotch-Weld™ EPX™ Mixing Nozzle

Use only 3M™ EPX™ Plus II Applicator and Mix Nozzles to ensure optimum product performance.

Typical Cured Physical Properties and Performance Characteristics

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes. Final product specifications and testing methods will be outlined in the products Certificate of Analysis (COA) that is shipped with the commercialized product once it is approved by 3M for general commercialization and development work is completed.

3M™ Thermally Conductive Epoxy Adhesive TC-2810		
Property	**Method***	**Value**
Color		Cream
Glass Transition Temperature	ASTM 1356	See Chart on page 3
Thermal Coefficient of Expansion	ASTM E831	85 X 10 $^{-6}$/K (below Tg) 240 X10 $^{-6}$/K (above Tg)
Thermal Conductivity	ASTM D5470	0.80-1.4 W/m-K
Volume Resistivity	ASTM D257	1.5 x 10^{14} ohm-cm
Dielectric Breakdown Voltage	ASTM D149	44.0 kV/mm (1119 Volts/mil)
Dielectric Constant	ASTM 150	4.1
Total Outgassing	ASTM 5116	<1000 µg/g (GC/MS, 85 C/3 hours)
Siloxane Outgassing	ASTM 5116	<5 µg/g (GC/MS, 85C/3 hours)
Extractable Chloride	ASTM D7994	<30 µg/g (hexane extraction)

*Methods listed as ASTM are tested in accordance with the ASTM method noted
*Disclaimer if applicable to chart above

Curing

Cure Schedule: 23°C/24 hours
50°C/270 minutes
70°C/90 minutes
90°C/30 minutes
120°C/10 minutes

Please contact 3M Application Engineers for more data on curing conditions.

Typical Shear Strength, Peel Strength, Tg vs Cure Temperature/Time

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes. Final product specifications and testing methods will be outlined in the products Certificate of Analysis (COA) that is shipped with the commercialized product once it is approved by 3M for general commercialization and development work is completed.

3M™ Thermally Conductive Epoxy Adhesive TC-2810			
	23°C (72°F) 24 hours	**90 °C (194 °F) 30 minutes**	**120 °C (248 °F) 10 minutes**
Overlap Shear N/mm² (psi) (ASTM D-1002)*	18.62 (2700)	18.62 (2700)	18.62 (2700)
T-Peel (piw) (ASTM D-1876)	7	7	7
Shore D Hardness (ASTM D2240)	75	80	80
Tg (°C) (ASTM E-1356)	60	73	64

*Methods listed as ASTM are tested in accordance with the ASTM method noted
*Disclaimer if applicable to chart above

Storage and Shelf Life

The shelf life of 3M™ Thermally Conductive Epoxy Adhesive TC-2810 is 12 months from the date of manufacture when stored in original cartons at 21° C (70° F) and 50% relative humidity

Certificate of Analysis (COA)

The 3M Certificate of Analysis (COA) for this product is established when the product is commercially available from 3M. The commercially available product will have a COA specification established. The COA contains the 3M specifications and test methods for the products performance limits that the product will be supplied against. The 3M product is supplied to 3M COA test specifications and the COA test methods. Contact your local 3M representative for this product's COA.

Final product specifications and testing methods will be outlined in the products Certificate of Analysis (COA) that is provided once the product is approved by 3M for general commercialization and development work is completed.

Safety Data Sheet: Consult Safety Data Sheet before use.

Technical Information: The technical information, recommendations and other statements contained in this document are based upon tests or experience that 3M believes are reliable, but the accuracy or completeness of such information is not guaranteed.

Product Use: Many factors beyond 3M's control and uniquely within user's knowledge and control can affect the use and performance of a 3M product in a particular application. Given the variety of factors that can affect the use and performance of a 3M product, user is solely responsible for evaluating the 3M product and determining whether it is fit for a particular purpose and suitable for user's method of application.

Epoxy - ABLESTIK 2902

LOCTITE

Technical Data Sheet

LOCTITE ABLESTIK 2902

October 2014

PRODUCT DESCRIPTION
LOCTITE ABLESTIK 2902 provides the following product characteristics:

Technology	Epoxy
Appearance	Silver
Filler Type	Silver
Cure	Room Temperature or Heat Cure
Components	Two component - requires mixing
Product Benefits	• Electrically conductive • Thermally conductive • Solvent-free • High adhesion • Two component • Room temperature cure • Good adhesion to a variety of substrates
Mix Ratio, by weight - Resin : Hardener	100 : 6
Typical Assembly Applications	Electrical modules, Printed circuitry, Wave guides, Flat cables, High frequency shields and Cold solder
Operating Temperature	-60 to 110 °C
Application	Bonding, Sealing or Repair
Surfaces	Ceramics, Many metals, Glass and Plastic laminates

LOCTITE ABLESTIK 2902 is designed for electronic bonding and sealing applications that require a combination of good mechanical and electrical properties.

LOCTITE ABLESTIK 2902 passes NASA outgassing standards.

ISO-10993-5
LOCTITE ABLESTIK 2902 was tested to and passed the requirements of ISO 10993-5 for Cytotoxicity.

TYPICAL PROPERTIES OF UNCURED MATERIAL

Mixed Viscosity, mPa·s (cP) :	
cp #52, 10 rpm	20,000
Specific Gravity, mixed	3.2
Pot life , minutes	60
Flash Point - See SDS	

TYPICAL CURING PERFORMANCE

Cure Schedule
24 hours @ 25°C or
1 to 4 hours @ 65°C

The above cure profile is a guideline recommendation. Cure conditions (time and temperature) may vary based on customers' experience and their application requirements, as well as customer curing equipment, oven loading and actual oven temperatures.

TYPICAL PROPERTIES OF CURED MATERIAL

Physical Properties

Coefficient of Thermal Expansion, cm/cm/°C	4.9×10^{-05}
Glass Transition Temperature (Tg), °C	52
Thermal Conductivity ,W/(m·K)	2.99×10^{00}
Hardness, Shore D	80

Electrical Properties

Volume Resistivity, ohms-cm:	
1 hour @ 110°C	0.0006
15 minutes @ 150°C	0.0005
2 hours @ 65°C	0.0009
24 hours @ 25°C	0.001
5 minutes @ 160°C	0.0003

Outgassing Properties

Total Mass Loss, %	0.64
Collected Volatile Condensable Material, %	0.05

TYPICAL PERFORMANCE OF CURED MATERIAL

Shear Strength
Lap Shear Strength :
Aluminum:

Cured @ 110 °C for 1 hour	N/mm² (psi)	11 (1,600)
Cured @ 150 °C for 15 minutes	N/mm² (psi)	11 (1,600)
Cured @ 65 °C for 2 hours	N/mm² (psi)	7 (1,000)
Cured @ 25 °C for 24 hours	N/mm² (psi)	5 (700)

GENERAL INFORMATION
For safe handling information on this product, consult the Material Safety Data Sheet, (MSDS).

DIRECTIONS FOR USE

1. Carefully clean and dry all surfaces to be bonded.
2. Remove clamp and thoroughly mix the LOCTITE ABLESTIK 2902 epoxy adhesive system components in the handy BIPAX mixing-dispenser package until color is uniform throughout.
3. Apply this completely mixed adhesive to the prepared surfaces, and gently press these surfaces together. Contact pressure is adequate for strong, reliable bonds; however, maintain contact until adhesive is completely cured.
4. Some separation of components is common during shipping and storage. For this reason, it is recommended that the contents of the shipping container be thoroughly mixed prior to use.
5. Some ingredients in this formulation provided in BIPAX, TRA-PAX and bulk packaging may crystallize when subjected to low temperature storage. A gentle warming cycle of 52°C for 30 minutes prior to mixing components may be necessary. Crystallized epoxy components do not react as well as liquid components and should be redissolved prior to use for best results.

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Not for product specifications
The technical data contained herein are intended as reference only. Please contact your local quality department for assistance and recommendations on specifications for this product.

Storage
Store product in the unopened container in a dry location. Storage information may be indicated on the product container labeling.

Optimal Storage : 27 °C

Material removed from containers may be contaminated during use. Do not return product to the original container. Henkel Corporation cannot assume responsibility for product which has been contaminated or stored under conditions other than those previously indicated. If additional information is required, please contact your local Technical Service Center or Customer Service Representative.

Conversions
(°C x 1.8) + 32 = °F
kV/mm x 25.4 = V/mil
mm / 25.4 = inches
N x 0.225 = lb
N/mm x 5.71 = lb/in
psi x 145 = N/mm²
MPa = N/mm²
N·m x 8.851 = lb·in
N·m x 0.738 = lb·ft
N·mm x 0.142 = oz·in
mPa·s = cP

Disclaimer
Note:
The information provided in this Technical Data Sheet (TDS) including the recommendations for use and application of the product are based on our knowledge and experience of the product as at the date of this TDS. The product can have a variety of different applications as well as differing application and working conditions in your environment that are beyond our control. Henkel is, therefore, not liable for the suitability of our product for the production processes and conditions in respect of which you use them, as well as the intended applications and results. We strongly recommend that you carry out your own prior trials to confirm such suitability of our product.
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