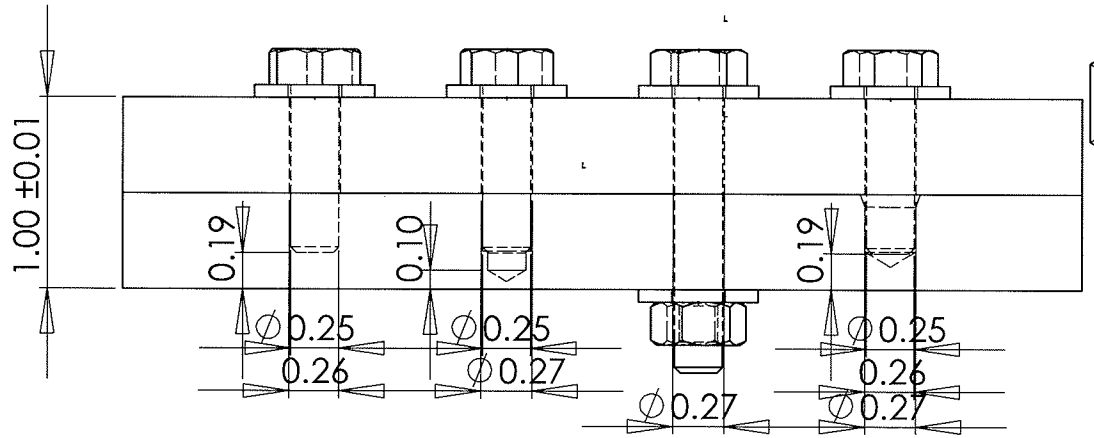
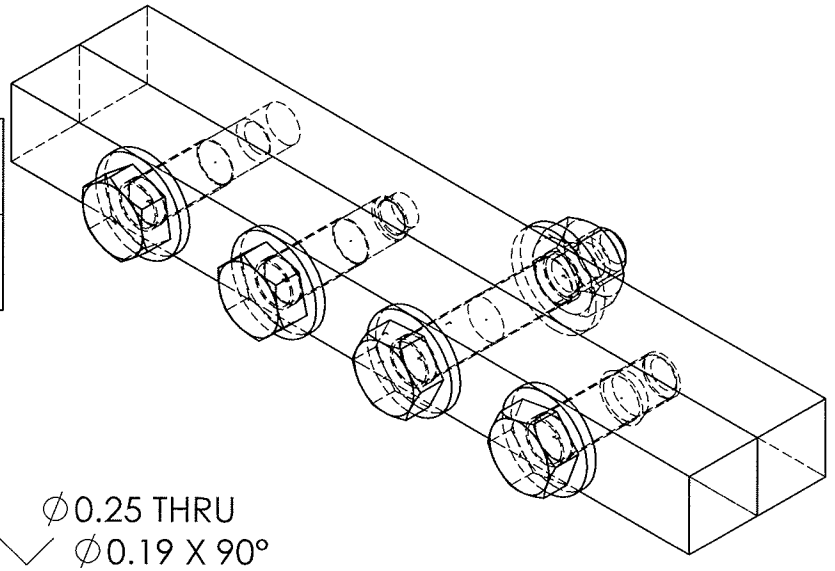
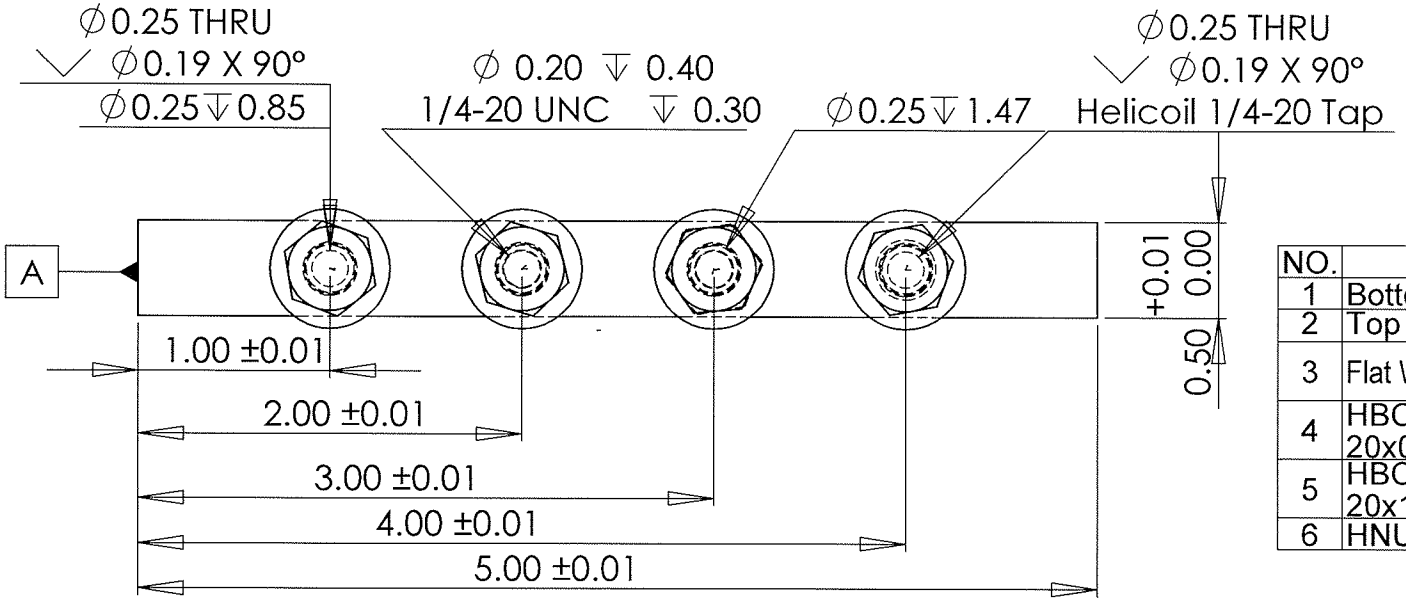






NO.	Name	Part NO.	QTY.
1	Bottom Plate	9525K121	1
2	Top Plate	9525K121	1
3	Flat Washer 0.25	91083A029	5
4	HBOLT 0.2500-20x0.875x0.875-C	91251A541	3
5	HBOLT 0.2500-20x1.5x1.5-C	91205A546	1
6	HNUT 0.2500-20-D-C	90499A029	1

NEXT ASSY	USED ON	
APPLICATION		DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

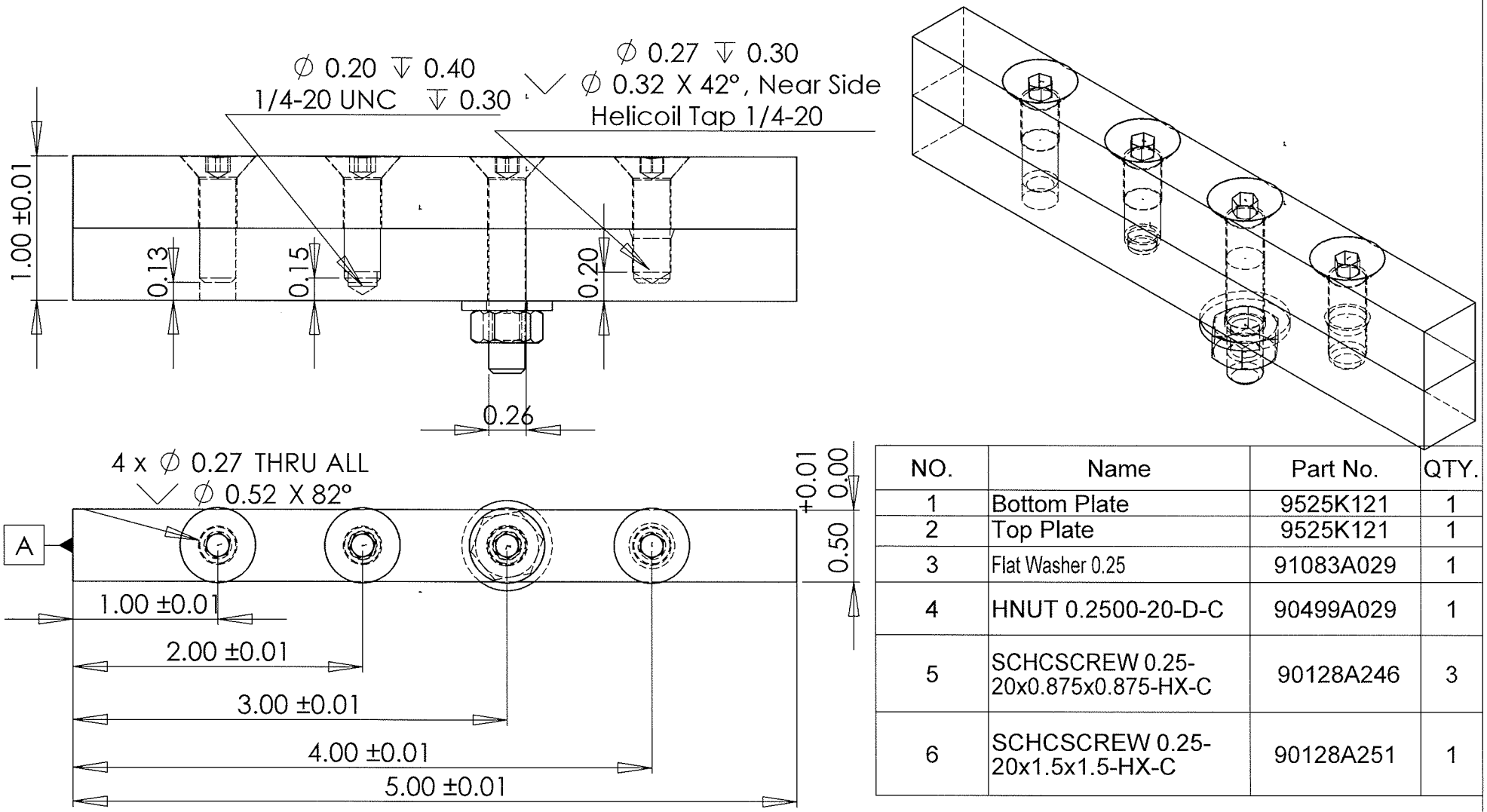
TITLE:

.25-20 Hex Head Cap screw with Washer

SIZE	DWG. NO.	REV
A		

SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1



NO.	Name	Part No.	QTY.
1	Bottom Plate	9525K121	1
2	Top Plate	9525K121	1
3	Flat Washer 0.25	91083A029	1
4	HNUT 0.2500-20-D-C	90499A029	1
5	SCHCSCREW 0.25-20x0.875x0.875-HX-C	90128A246	3
6	SCHCSCREW 0.25-20x1.5x1.5-HX-C	90128A251	1

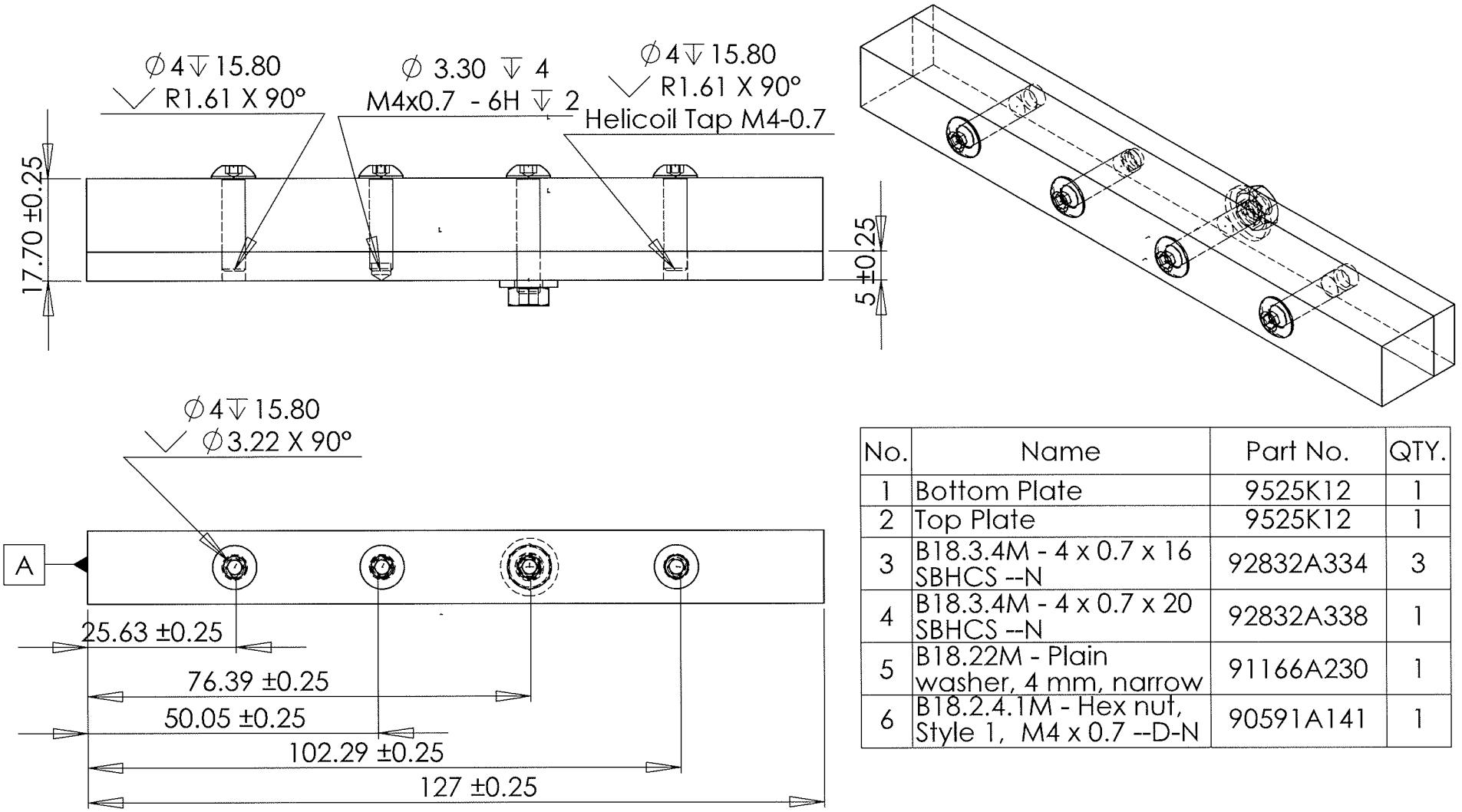
		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

TITLE: .25-20 Socket Head Cap screw with Countersink

SIZE	DWG. NO.	REV
A		

SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1



No.	Name	Part No.	QTY.
1	Bottom Plate	9525K12	1
2	Top Plate	9525K12	1
3	B18.3.4M - 4 x 0.7 x 16 SBHCS --N	92832A334	3
4	B18.3.4M - 4 x 0.7 x 20 SBHCS --N	92832A338	1
5	B18.22M - Plain washer, 4 mm, narrow	91166A230	1
6	B18.2.4.1M - Hex nut, Style 1, M4 x 0.7 --D-N	90591A141	1

NEXT ASSY	USED ON	
APPLICATION		DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN mm
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

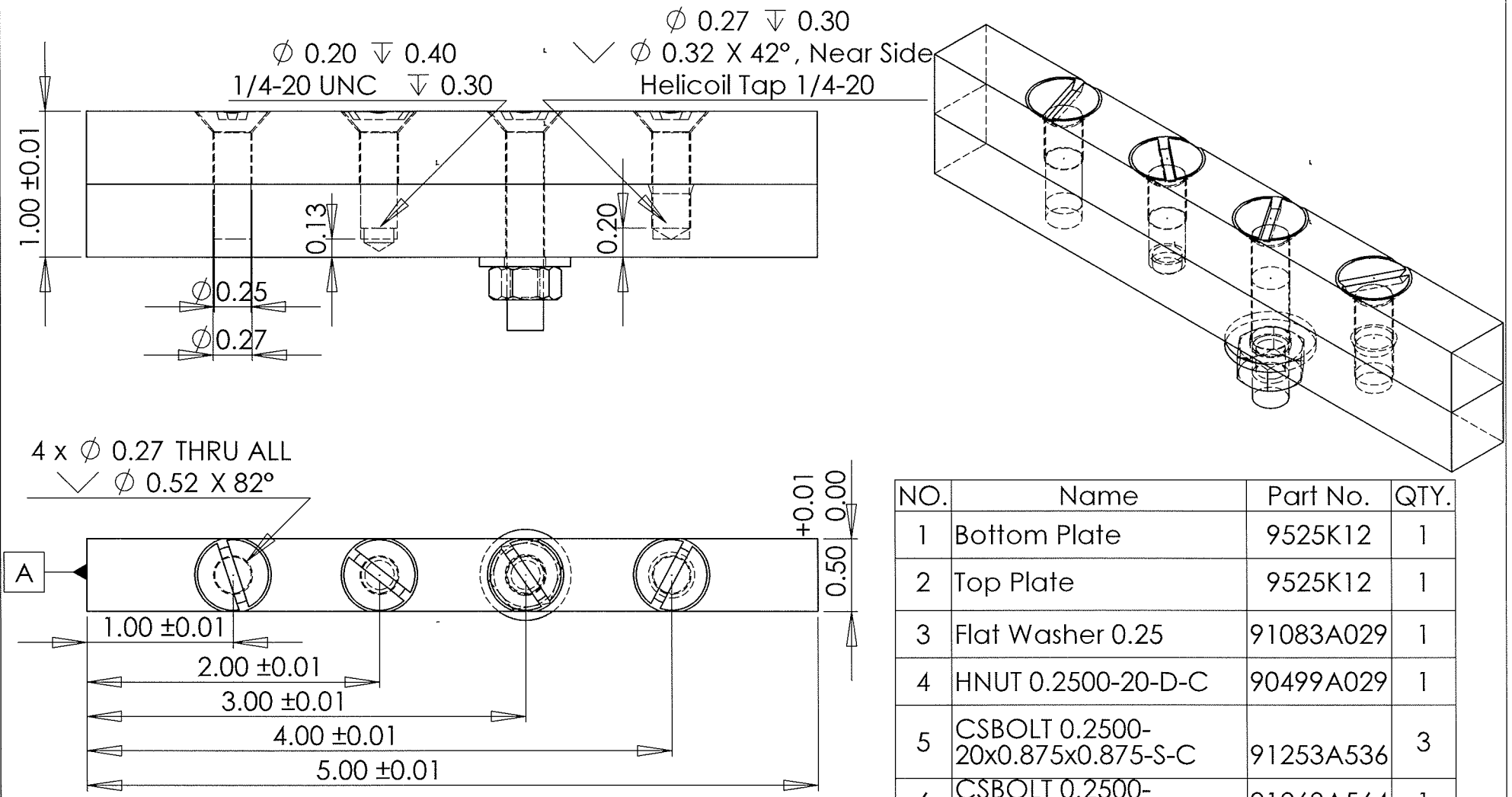
COMMENTS:

TITLE:

SIZE	DWG. NO.	REV
A	M4 Round	

SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1



NO.	Name	Part No.	QTY.
1	Bottom Plate	9525K12	1
2	Top Plate	9525K12	1
3	Flat Washer 0.25	91083A029	1
4	HNUT 0.2500-20-D-C	90499A029	1
5	CSBOLT 0.2500-20x0.875x0.875-S-C	91253A536	3
6	CSBOLT 0.2500-20x1.5x1.5-S-C	91263A564	1

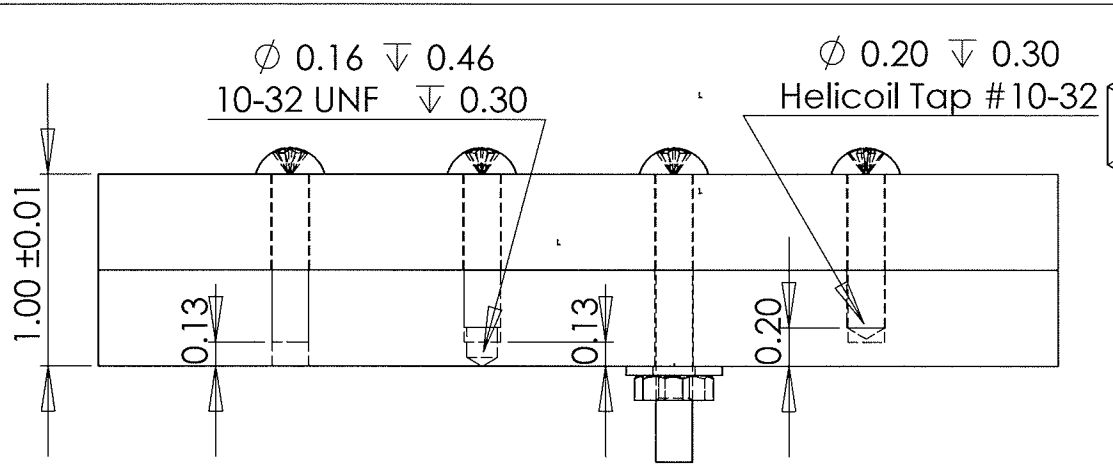
		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

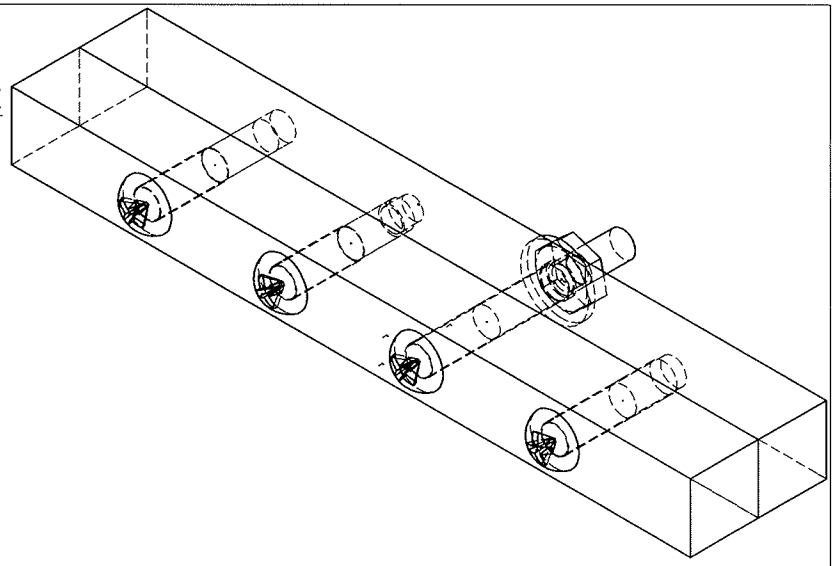
TITLE:

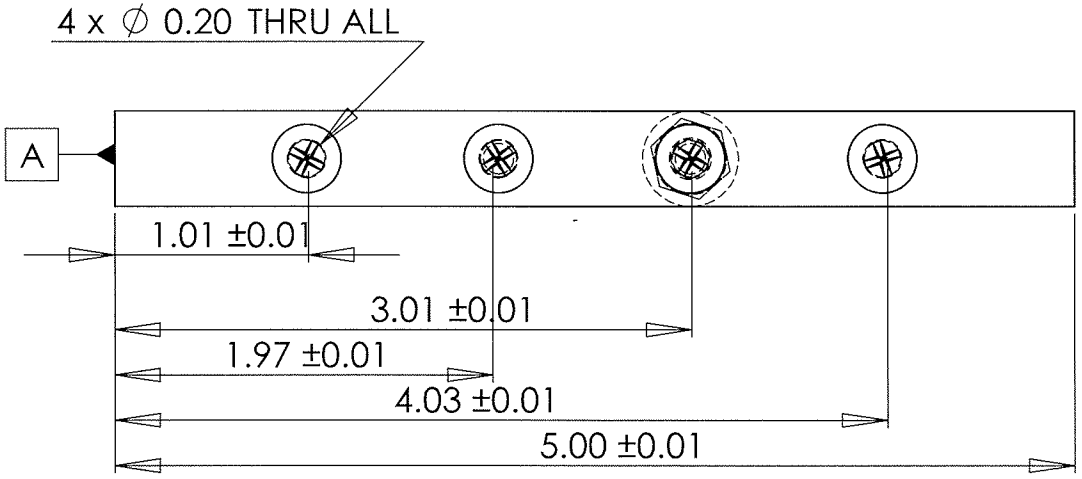
.25-20 Flat Head screw

SIZE	DWG. NO.	REV
A		
SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1







No.	Name	Part No.	QTY.
1	Bottom Plate	9525K12	1
2	Top Plate	9525K12	1
3	CR-RHMS 0.19-32x0.875x0.875-C	91255A271	3
4	CR-RHMS 0.19-32x1.5x1.5-C	91255A275	1
5	Flat Washer #10	91201A011	1
6	MSHXNUT 0.190-32-S-N	90545A111	1

NEXT ASSY	USED ON	
APPLICATION		DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

SIZE	DWG. NO.	REV
A	10-32 Button	
SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1

Problem 2: Adhesive Summary

Urethane Adhesives: Typically these are formed as a two-part solution mixed before application. Sometimes a cleansing primer is applied to ensure a clean contact area to smooth surfaces such as polished metal or glass. The structural strength of urethane adhesives is typically obtained with a cure at room temperature or with additional heat and cure time. Overall, these adhesives provide tough, impact-resistant bonds with high peel strength. There are different formulations available which include rapid-curing adhesive for flexible bonds of many plastics, woods, and rubber. As a two-part epoxy, these can typically be stored for 6-12 months without degradation to performance. In optics, these are useful for structural bonding and temporary bonds which can be broken with a sharp shear stress.

Some limitations:

- Must be used at temperatures less than 100 degC.
- Highly polished surfaces may result in a weaker grip
- Very low chemical resistance so the environment used is important

References:

http://www.3m.com/product/information/Scotch-Weld-Two-Part-Urethane-Adhesive.html
http://www.optics.arizona.edu/optomech/tutorials_in_optomechanics.htm "Choosing Optomechanical Adhesives Tutorial Presentation"
http://www.gspolymers.com/adhesives.html#two_part_systems

3M: Scotch-Weld Urethane Adhesive DP605 NS Off-White (Opaque)	**GS Polymers Inc.: GSP 1552-2 (Water-Clear)**
Shore A Hardness (ASTM D 2240): 75-85	**Shore A Hardness (ASTM D 2240):** 60-65
Time to Handling Strength: 15-20 min. @ 23°C	**Time to Handling Strength:** 10 min. @ 23°C
Cure Time: 48 hours @ 23°C	**Cure Time:** 24-48 hours @ 82°C
Coefficient of Thermal Expansion (in./in./°C) 121 x 10-6 below 41°C 219 x 10-6 above 41°C	Optically clear, resists UV light and water degradation
Key Test: Aluminum-Aluminum; Substrate Thicknesss: 0.063 in; **Bond Thickness:** 0.005 in.; **Temperature:** 23°C; **Peel Strength:** 1460 psi	**No strength/ peel test information available from manufacturer**

3M

Scotch-Weld™

Urethane Adhesive

DP605 NS Off-White • DP640 Brown

Technical Data **April, 2007**

Product Description

3M™ Scotch-Weld™ Urethane Adhesives DP605 NS Off-White and DP640 Brown are two-part, non-sag urethane adhesives. They feature tough, flexible bonds with good adhesion to a wide variety of substrates, especially wood and many properly abraded and cleaned plastics. Good adhesion can also be obtained on etched aluminum as well as primed aluminum, steel and glass. For maximum bond durability under moisture conditions, priming of glass and metal substrates is required.

Available in bulk containers as 3M™ Scotch-Weld™ Urethane Adhesive 605 NS Off-White B/A or 3M™ Scotch-Weld™ Urethane Adhesive 3549 B/A.

Features

- Tough, flexible bonds
- Non-Sag/Thixotropic
- 1:1 Mix Ratio
- 5 or 40 minute worklife
- Bonds wood and many plastics

Typical Uncured Physical Properties

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

Product		Scotch-Weld Urethane Adhesive DP605 NS Off-White	Scotch-Weld Urethane Adhesive DP640 Brown
Color		Off-White	Brown
Base Resin		Polyol/Isocyanate	Polyol/Isocyanate
Mix Ratio (B:A)	Volume Weight	1:1 1:1.08	1:1 1:1.09
Net Weight Lbs./Gal.	Base Accelerator	8.8-9.2 9.7-10.2	10.1-10.5 11.1-11.5
Viscosity[1a] (Approx.) time to deliver 20 gms @ 20 psi thru a .104" orifice @ 75°F (24°C) seconds.	Base Accelerator	11-20 11-20	– –
Viscosity[1b] Brookfield RVF @ 10 rpm	Base (#6 Spindle)	–	10,000-40,000
cps @ 75°F (24°C)	Accelerator (#5 Spindle)	–	15,000-55,000

1a. Viscosity determined using 3M test method C-1019. Procedure involves pressure flowmeter, 104 orifice sample cup, pressure of 20 psi and temperature of 75°F ± 2°F (24°C ± -16°C).

1b. Viscosity determined using C-1D. Procedure involves using a RVF Brookfield viscometer with either a #6 or #5 spindle at 10 rpm.

Typical Cured Thermal Properties

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

Product	3M™ Scotch-Weld™ Urethane Adhesive DP605 NS Off-White	3M™ Scotch-Weld™ Urethane Adhesive DP640 Brown
Physical:		
Color	Off-White	Brown
Shore A Hardness (ASTM D 2240)	75-85	70-80
Time to Handling Strength[2]	15-20 min. @ 23°C (73°F)	6-8 hrs. @ 23°C (73°F)
Cure Time[3]	48 hours @ 23°C (73°F)	7 days @ 23°C (73°F)
Elongation[4]	100%	100%

Electrical:	Scotch-Weld Urethane Adhesive DP605 NS Off-White	Scotch-Weld Urethane Adhesive DP640 Brown
Dielectric Constant (ASTM D 150)	3.1 @ 1 KHz @ 23°C	5.9 @ 1 KHz @ 23°C
Dissipation Factor (ASTM D 150)	.021 @ 1 KHz @ 23°C	.12 @ 1 KHz @ 23°C
Dielectric Strength (ASTM D 149)	640 volts/mil	470 volts/mil
Volume Resistivity (ASTM D 257)	1.0 x 10^{14} ohm-cm	2.6 x 10^{12} ohm-cm

Thermal:	Scotch-Weld Urethane Adhesive DP605 NS Off-White	Scotch-Weld Urethane Adhesive DP640 Brown
Wt. loss by Thermal[5] Gravimetric Analysis	5% @ 300°C	–
Coefficient of Thermal[6] Expansion (in./in./°C)	121 x 10^{-6} below 41°C 219 x 10^{-6} above 41°C	– –
Thermal Conductivity[7] (btu-ft./sq. ft.-hr. °F)	0.101 @ 45°C	–
Glass Transition Temp[8]	41°C	–

2. Handling strength determined per 3M test method C-3179. Time to handling strength taken to be that time required to achieve 50 psi OLS strength using aluminum substrates.
3. The cure time is defined as that time required for the adhesive to achieve a minimum of 80% of the ultimate strength as measured by aluminum - aluminum OLS.
4. Elongation is determined using 3M test method C-3094/ASTM D 882.
5. Weight loss by TGA reported as that temperature at which 5% weight loss occurs by TGA in air at 5°C rise per minute per ASTM 1131-86.
6. TCE determined with TMA Analyzer using a heating rate of 50°F (10°C) per minute. Second heat values given.
7. Thermal conductivity determined using ASTM C177 and C-matic Instrument with 2" diameter samples.
8. Glass transition temperature (Tg) determined using DSC Analyzer with a heating rate of 68°F (20°C) per minute. Second heat values given.

Typical Adhesive Performance Characteristics *(continued)*

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

Peel Strength

Peel strength tests were run on 1" wide specimens that were aged for 1 week at 73°F (21°C). The 180° peel testing was run according to Test Method ASTM D1876-61T. Substrates were prepared according to the surface preparation section.

Substrate	Substrate Thickness (in.)	Bondline Thickness (in.)	Test Temperature (°F)	Peel Strength (piw) 3M™ Scotch-Weld™ Urethane Adhesive DP605 NS Off-White
CRS/CRS	.022	.005	73 (23°C)	13
	.022	.015	73 (23°C)	18
CRS/CRS	.035	.005	73 (23°C)	36
	.035	.015	73 (23°C)	47
Al/Al	.022	.005	73 (23°C)	17

3M™ EPX™ Pneumatic Applicator Delivery Rates

50 ml Applicator – Maximum Pressure 50 psi

Adhesive*	1/4 in. Nozzle gms/minute
3M™ Scotch-Weld™ Urethane Adhesive DP605 NS Off-White	68.5
3M™ Scotch-Weld™ Urethane Adhesive DP640 Brown	44.7

*Tests were run at a temperature of 70°F ± 2°F (21°C ± 1°C) and at maximum applicator pressure.

Handling/Curing Information

Directions for Use

1. For optimum strength structural bonds, paint, oxide films, oils, dust, mold release agents and all other surface contaminants must be completely removed. However, the amount of surface preparation directly depends on the required bond strength and the environmental aging resistance desired by the user. For suggested surface preparations on common substrates, see the section on surface preparation.
2. These products consist of two parts.

   Mixing:

   For Duo-Pak Cartridges - 50 ml

   Remove the Scotch-Weld urethane adhesive DP605 NS Off-White or DP640 Brown duo-pak cartridge from its foil package and place it into the 3M™ EPX Applicator. Remove the cap and dispense a small amount of adhesive to equalize piston displacement and to assure that no material is blocking either the base or accelerator ports. Attach the mixing nozzle to the duo-pak cartridge and apply the adhesive to clean surfaces. To store a partially used duo-pak cartridge leave mixing nozzle in place and replace after storage. **Note:** Scotch-Weld urethane adhesive DP605 NS Off-White is sensitive to moisture. For best results, use the entire contents of the cartridge within a few weeks after removing the cartridge from the sealed foil pack. If extended storage is necessary, the duo-pak cartridge should be stored in a sealed plastic bag. For hand mixing, expel the desired amount of adhesives and mix thoroughly (10-15 seconds after uniform color is obtained).

3M™ Scotch-Weld™
Urethane Adhesive
DP605 NS Off-White • DP640 Brown

Handling/Curing Information *(continued)*

For Duo-Pak Cartridges - 200/400 ml

Directions for Use: While holding cartridge in an upright position, remove insert from duo-pak cartridge by unscrewing plastic nut. Detach metal removal disc from insert to free plastic nut nozzle attachment. Clear orifices if necessary. Attach mixing nozzle and secure with plastic nut. Place cartridge into 3M™ EPX Applicator. Discard a small quantity of dispensed adhesive to assure both components are dispensing equally. Apply adhesive to clean surfaces, join parts, secure until set up (15 minutes @ 75°F (24°C) for 3M™ Scotch-Weld™ Urethane Adhesive DP605 NS Off-White, 6-8 hours for 3M™ Scotch-Weld™ Urethane Adhesive DP640 Brown @ 75°F (24°C). Leave nozzle attached to store. Replace nozzle after storage.

For Bulk Containers

Mix thoroughly by weight or volume in the ratios specified in the typical uncured properties section. Resulting color should be uniform. After opening, containers of adhesive should be used completely. If storage of partially used containers is necessary, flush each container with dry nitrogen just before sealing the containers.

4. Application to the substrates should be made within 5 minutes for Scotch-Weld urethane adhesive DP605 NS Off-White or 40 minutes for Scotch-Weld urethane adhesive DP640 Brown. Larger quantities and/or higher temperatures will reduce this working time.
5. Join the adhesive coated surfaces and allow to cure at 60°F (16°C) or above until firm. Heat up to 200°F (93°C) will speed curing.
6. Scotch-Weld urethane adhesive DP605 NS Off-White will fully cure in 48 hours @ 75°F (24°C). Scotch-Weld urethane adhesive DP640 Brown will fully cure in 7 days 75°F (24°C).
7. Keep parts from moving during cure. Contact pressure is necessary. Maximum shear strength is obtained with a 3-5 mil bond line.
8. Excess uncured adhesive can be cleaned up with ketone type solvents.*

***Note:** When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use.

Adhesive coverage (typical): A 0.005 in. thick bondline will yield a coverage of 320 sq. ft./gallon.

Application Equipment Suggestions

For small or intermittent applications, the 3M EPX applicator is a convenient method of application.

For larger applications, these products may be applied by use of flow equipment.

Two-part mixing/proportioning/dispensing equipment is available for intermittent or production line use. These systems may be desirable because of their variable shot size and flow rate characteristics and are adaptable to many applications.

GS POLYMERS, INC.
Polyurethane • Epoxy • Adhesives • Castings

GSP 1552-2

Technical Data Sheet (TDS)

General Description

Optically-Clear Urethane System

GSP 1552-2 is an optically-clear, two-part, polyurethane system that cures at room temperature. It is easily mixed into a pourable material. When cured, it produces a tough, flexible elastomer which resists water and ultraviolet light. This system is ideal for many potting and encapsulating applications where optical clarity is desired or where UV and weather resistance are needed.

Key features are:

- Contains no solvents. 100% reactive
- Optically-clear
- Pourable
- Hydrophobic
- Resistant to foaming

Component Properties

Property	GSP 1552-2 Part A	GSP 1552-2 Part B
Shelf Life	6 months	6 months
Density (lb/gal)	9.03	9.16
Viscosity	~6500 LV-4 @ 20 rpm	~350 LV–2 @ 20 rpm
Color	Water clear	Water Clear

Handling Properties

Property	GSP 1552-2
Mix Ratio by Weight	100 A : 100 B
Mix Ratio by Volume	1:1
Pot Life	10 min
Gel Time	15 min
Cure Time	24 - 48 hours @ room temperature 2 hours @ 180°F

Cured Properties

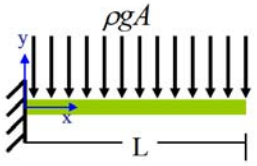
Property	GSP 1552-2
Hardness	60 – 65 Shore A
Color	Water Clear
Dielectric Strength (V/mil)	322 (ASTM D149-97a Method A)
Dielectric Constant (k)	3.79 (ASTM D150-98)
Volume Resistivity (Ω • cm)	2.783E+13 (ASTM D257-99)

195 Arovista Circle • Brea, CA 92821 • 714.672.0567 *phone*
714.672.0987 *fax* • www.gspolymers.com • sales@gspolymers.com

HW9 Solution – Part 3 – Dynamic Modeling

- **Cantilever Without Load**

Taken from the notes (14 Deflections Under Loading):



$$F = \rho g A L$$

$$\delta_y = \frac{FL^3}{8EI} = \frac{\rho g A L^4}{8EI}$$

Resonant frequency also depends on specific stiffness

$$\omega_n = 3.516\sqrt{\left(\frac{EI}{\rho A L^4}\right)}$$

$$\omega_n = 3.516\sqrt{\frac{EI}{\rho A L^4}} = 3.516\sqrt{\frac{(7{*}10^{10}Pa){*}(8.3{*}10^{-10}m^4)}{(0.0027\text{kg/cm}^3){*}(1\text{cm}^2) * (10cm)^4}} = 5168\frac{\text{rad}}{\text{s}}$$

$$f_n = \frac{\omega}{2\pi} = \frac{5168\ \frac{rad}{s}}{2\pi} = \mathbf{823Hz}$$

Additional Note:

The weight of the beam is distributed and the stiffness is also distributed, so you need the 3.516 factor in front and cannot apply the equation below:

$$\omega_n = \sqrt{\frac{g}{\delta}} = \sqrt{\frac{8EI}{\rho AL}}$$

- **Cantilever with load**

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{3EI}{L^3 m}} = \sqrt{\frac{3 * (7{*}10^{10}Pa) * (8.3{*}10^{-10}m^4)}{(10cm)^3 * (1kg)}} = 418\frac{rad}{s}$$

$$f_n = \frac{\omega}{2\pi} = \frac{418\ \frac{rad}{s}}{2\pi} = \mathbf{66Hz}$$