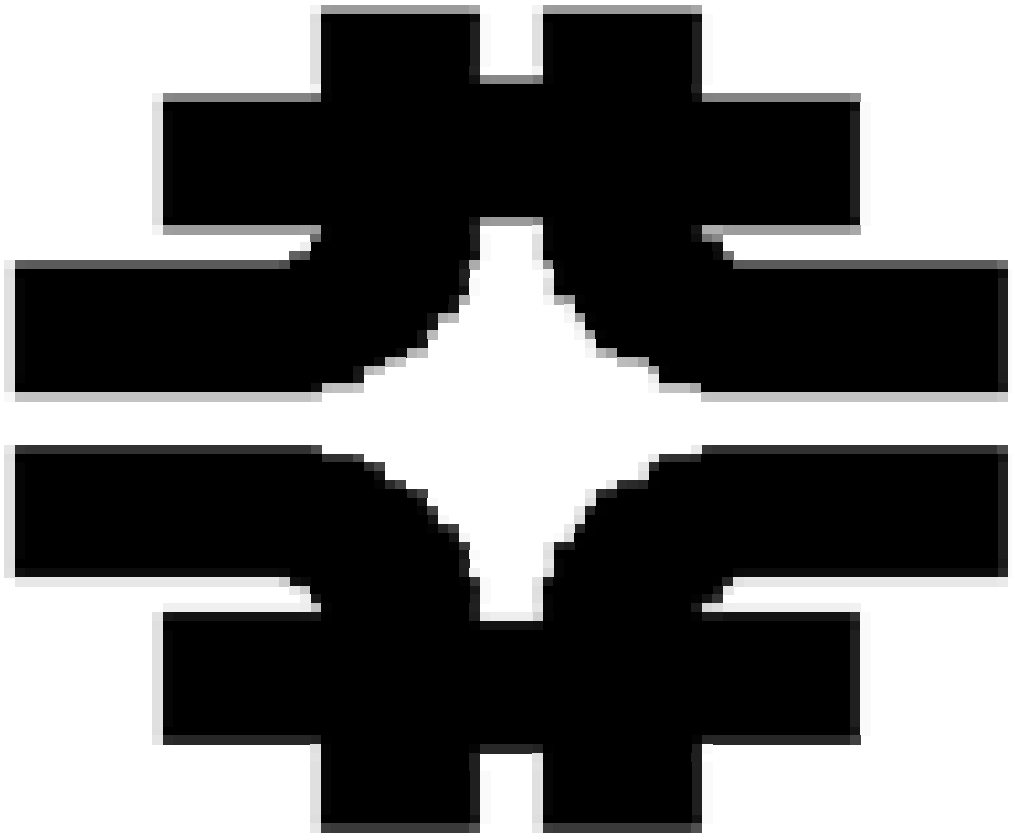
FERMI NATIONAL ACCELERATION LABORATORY



DESIGN & CONSTRUCTION OF ADHESIVE SHEAR TEST TOOL

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ADHESIVE SHEAR TEST TOOL

DESIGN OF ADHESIVE SHEAR TEST TOOL

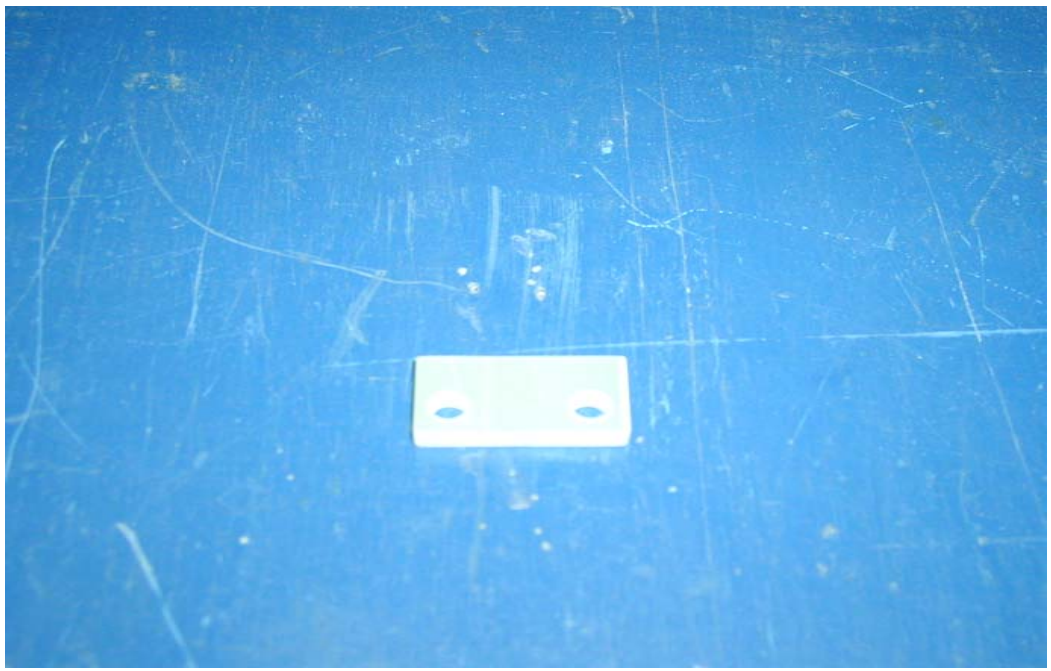
- **PURPOSE:**

  To test the shear strengths of the 3M 2216 epoxy/plastic bonds

- **AREAS OF BOND APPLICATIONS**
  - Nozzles of carbon fiber cooling tubes
  - Nuts in the stave-hybrid

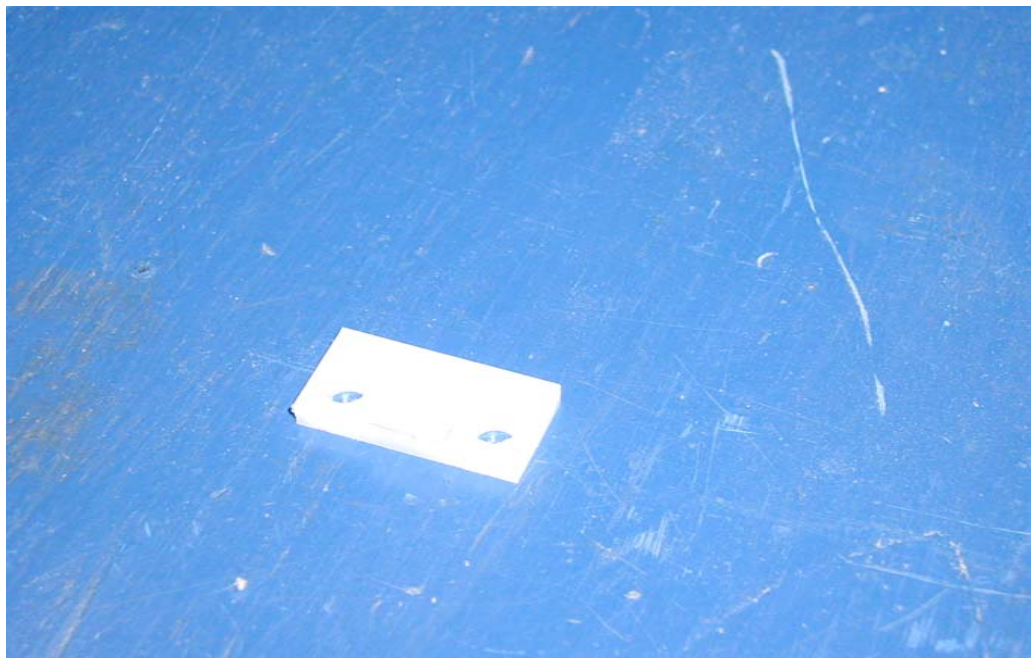
SELECTED PLASTICS

G-10



SELECTED PLASTICS

KYNAR

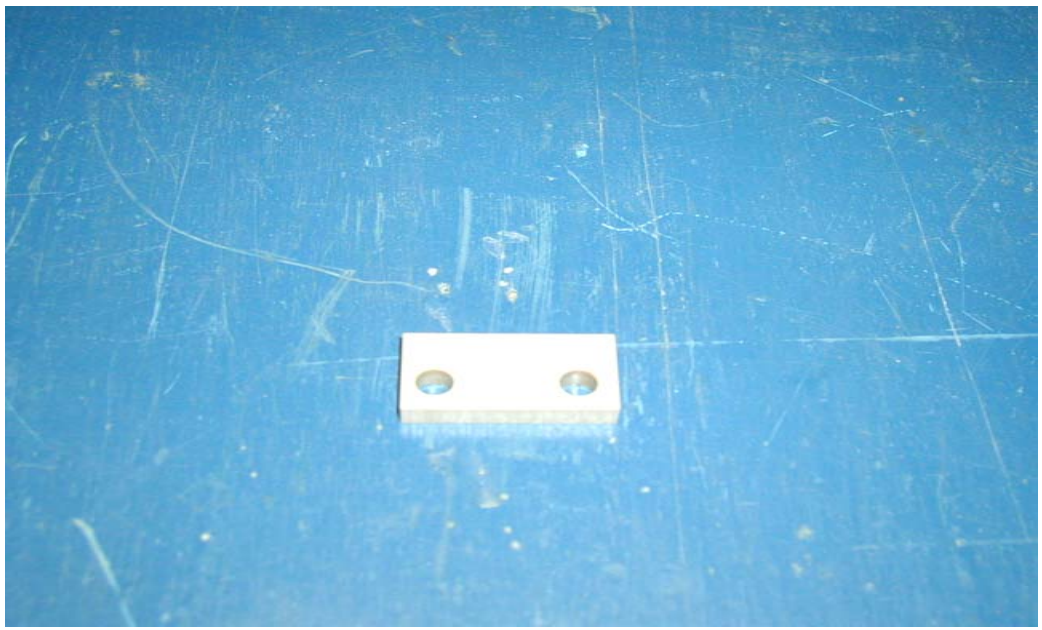


SELECTED PLASTICS

NORYL (PPO)

SELECTED PLASTICS

PEEK



SELECTION CRITERIA

	Tensile Strength (psi)	Radiation Resistance (Gy)	CTE (in./in./^{0}C)	Adhesive Shear Strength with 3M-2216 epoxy (psi)
G-10	4000	$1.0 \times 10^{7..5}$	1.8×10^{-5}	?
NORYL (PPO)	9600	$1.0 \times 10^{5..5}$	3.3×10^{-5}	?
PEEK	5000	$1.0 \times 10^{6..5}$	$4.5 – 7.0 \times 10^{-5}$	?
KYNAR (PVDF)	7800	n/a	7.1×10^{-5}	?

C

WHAT IS STRESS?

- The intensity of forces distributed over a given section
- Force, P, per unit area, A
- Denotation

$$\text{Stress} = \text{Force} / \text{Area}$$

$$\sigma = P / A$$

WHAT IS SHEAR STRESS?

- Found in bolts, pins and rivets used to connect various structural members and machine components
- Obtained when transverse forces are applied to a member eg. a beam

WHAT IS SHEAR STRESS?

- Internal forces from the transverse forces are called shearing forces

- Denotation

Shear Stress = Transverse Force / Area

$$\tau = P/A$$

PROCEDURES AND CALCULATIONS

Determination of load that would shear the 3M-2216 epoxy/plastic bond

- Assumptions

  Area of sample, A = 0.50” x 0.50”

  = 0.25 inch^2

  Shear strength = 2000 lbs. per inch^2 (psi)

FORCES

- The force, P, can be calculated as follows:

$$P = \tau \times A$$

$$P = 2000 \text{ psi} \times 0.25 \text{ inch}^2$$

$$\Rightarrow \text{Load} = 500 \text{ lbs}$$

  The handle of the tool must be able to withstand 500 lbs. of force exerted by the epoxy.

- Using a 10: 1 ratio, the maximum weight required to balance the force of the epoxy is 50 lbs.

- Using the shear and bending-moment diagram, the force required to balance the two above forces is 550 lbs.

WHAT IS A BEAM?

- A structural member
- A beam is designed to support loads applied perpendicular to their axis
- Handle of tool was designed to be a rectangular beam

HANDLE

- Choice of material for handle: Structural steel A36.
- Properties:

  - high ultimate strength in tension – 56×10^3 psi

  - high modulus of elasticity – 29×10^6 psi

Adhesive Shear Test Tool

Dimensions required for: - handle
- pin
- screws

Calculations required: - stress
- maximum deflection
- shear stress
- factor of safety (F.S.)

CALCULATIONS

- **HANDLE**

- **h = 1” b = ½” M = 1000 lbs.inch**

  $\sigma_{handle} = 1.20 \times 10^4$ psi

- **Maximum deflection (f_{max}) = 2.79×10^{-2} inch**

- **Diameter of pin, d = 0.375” h = 1” b = ½”**

  $\sigma_{handle\ with\ pin} = 1.27 \times 10^4$ psi

- **Factor of safety (F.S.) = Ultimate stress / Allowable stress**

  = 5.50

CALCULATIONS

- **PIN**

Diameter of thread, d = 0.241”

P (Resultant of balancing forces) = 550 lbs.

$A = \Pi \times (d^2/4) = \Pi \times ((0.241)^2/4) = 0.046 \text{ inch}^2$

$\tau = P/A$

$= 550 \text{ lbs.} / 0.046 \text{ inch}^2$

$\Rightarrow \tau_{pin} = 1.21 \times 10^4 \text{ psi}$

CALCULATIONS

- **SCREWS**

P = 500 lbs

Area = 0.032 inch^2

No. of screws = 2

$$\tau = P/A$$

$$= 500 \text{ lbs.} / 0.032 \text{ inch}^2$$

$$\Rightarrow \tau_{screw} = 7.81 \times 10^3 \text{ psi}$$

AutoCAD DRAWINGS

BASE PLATE

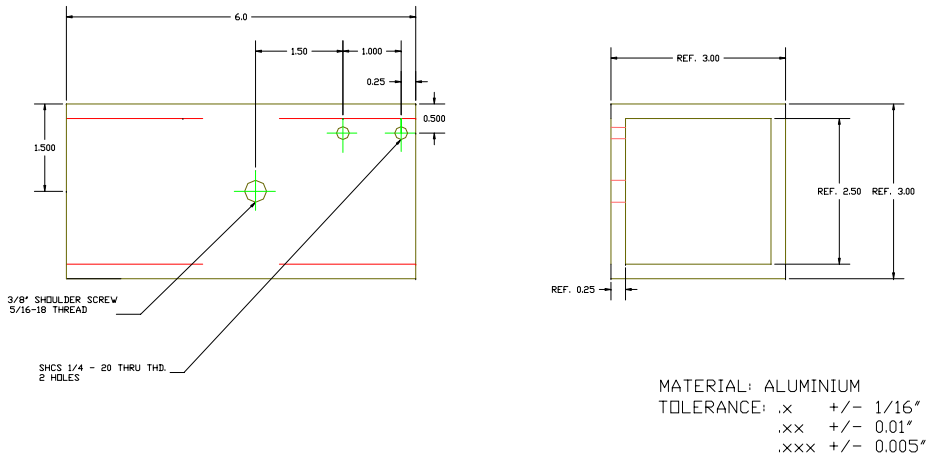
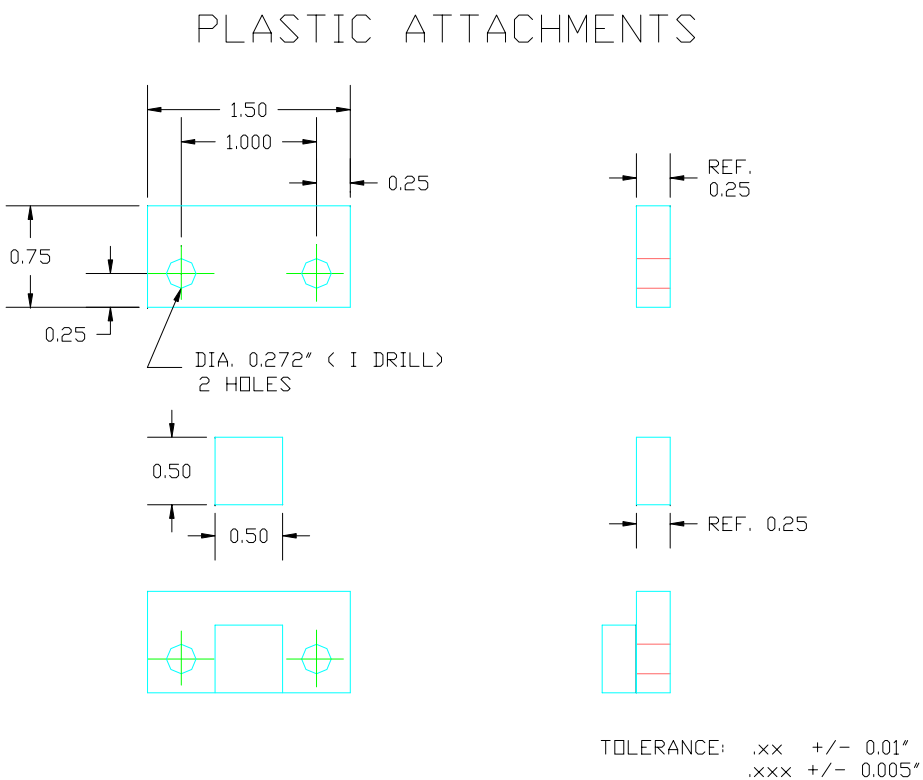
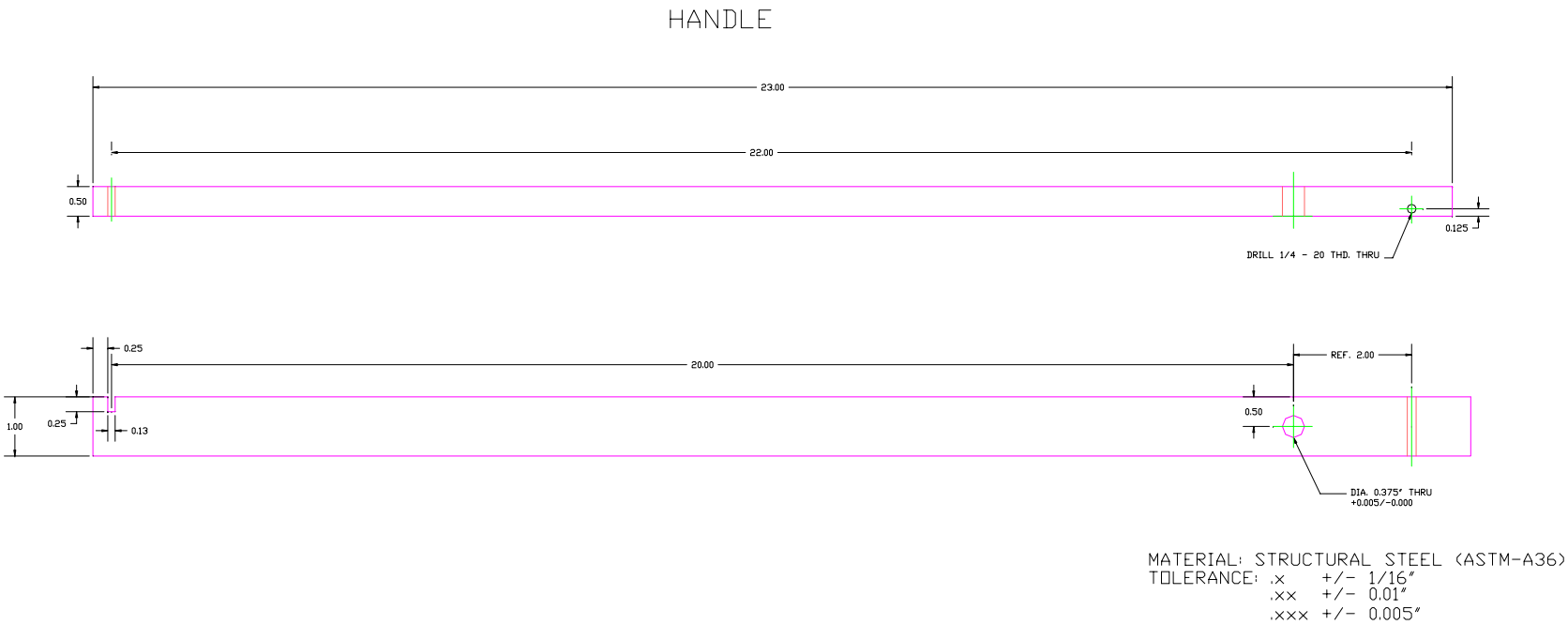


FIGURE #8

AutoCAD DRAWINGS



AutoCAD DRAWINGS



AutoCAD DRAWINGS

ASSEMBLY

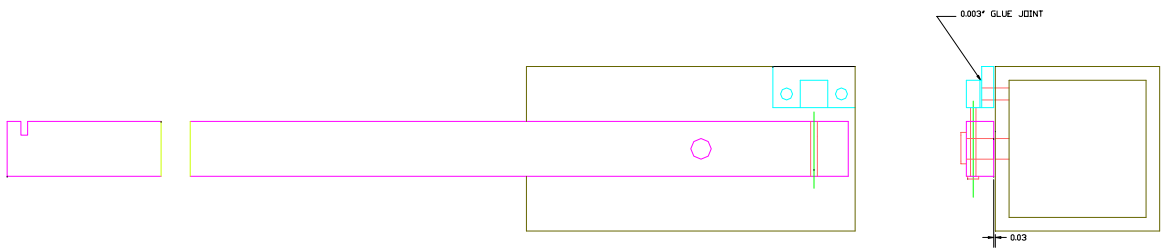
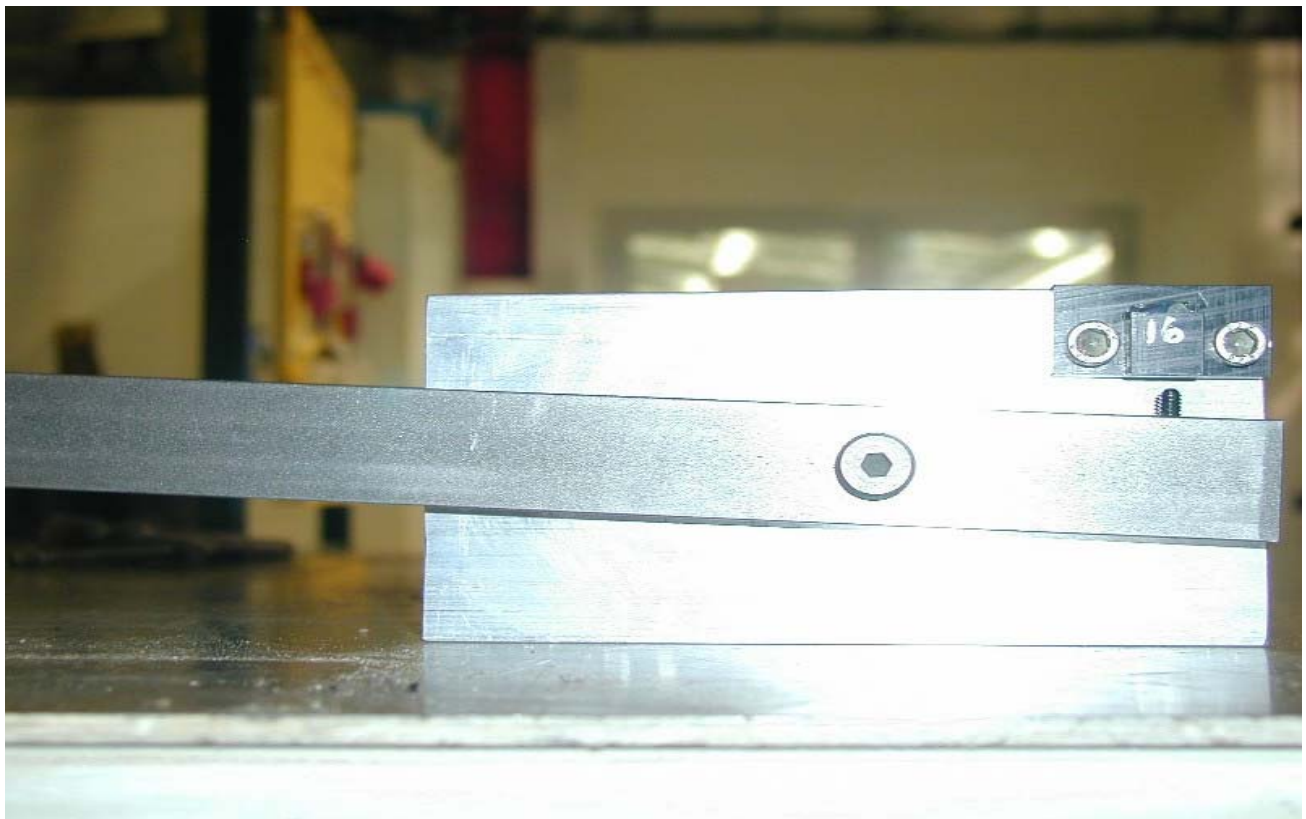
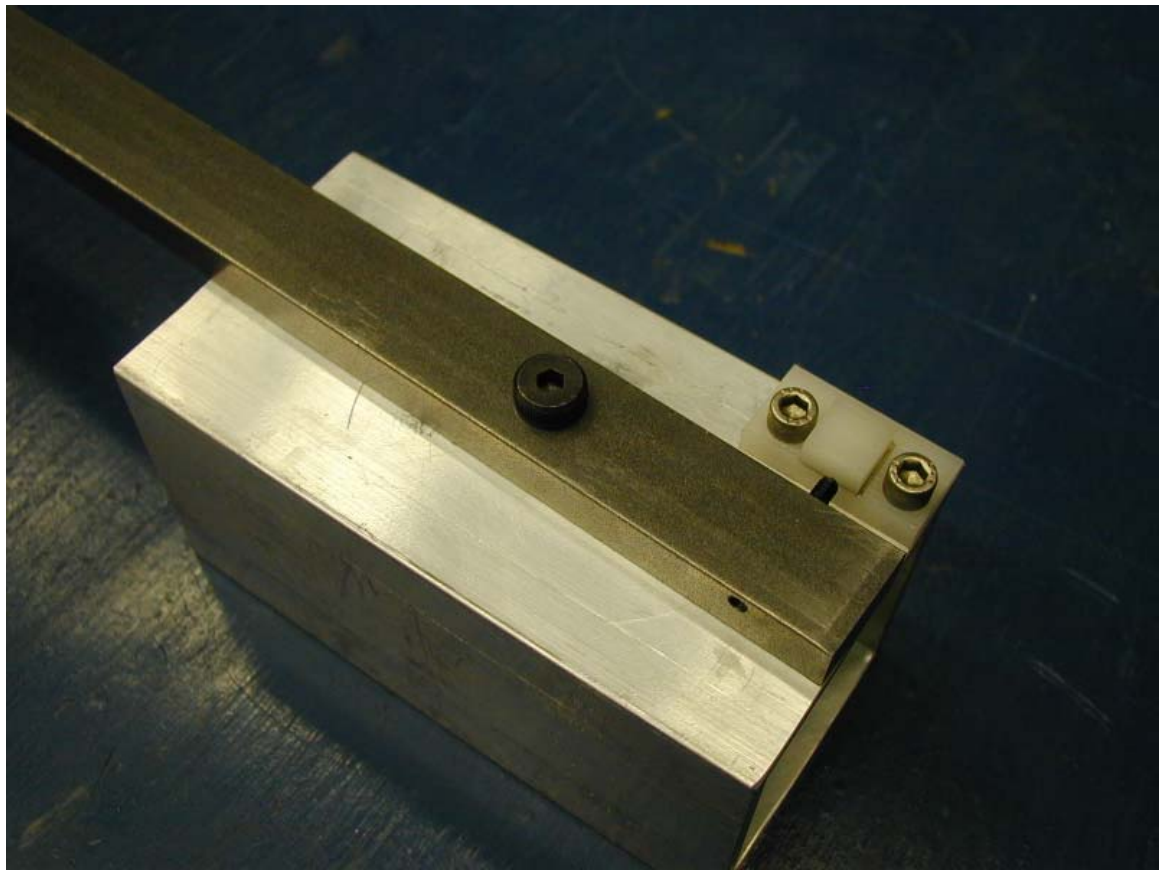


FIGURE #11

COMPLETED ADHESIVE SHEAR TEST TOOL



COMPLETED ADHESIVE SHEAR TEST TOOL



COMPLETED ADHESIVE SHEAR TEST TOO

QUALITY CONTROL

1. The surfaces of the plastics were washed using alcohol to obtain surfaces that were very clean of fingerprints
2. After the glue was applied to the larger surface, a razor blade was used to create uniform layer of glue on the surface using smooth and controlled strokes
3. The glue was not pressed down between the surfaces as this would create non-uniform contact between the surfaces; instead the smaller of the two pieces of plastics was placed onto the glue surface
4. All the pieces were allowed to cure for twenty-four (24) hours
5. The readings on the scale would be verified by two persons to allow the recordings of accurate measurements.

SAFETY PRECAUTIONS

- 1. A rag would be placed over the tool while the bucket of water was being filled and this was to act as a cover because when the shear force is achieved, the flying projectile might cause injury to persons in the lab area.
- 2. All objects around or on the testing table were cleared off
- 3. Safety glasses should be worn by all participants involved in the testing to prevent specks of materials from entering the face area.

4. All spilled water should be cleaned up before any additional testing is conducted.

RESULTS

Material Name	Material No.	Wgt. of water (lbs.)	Total wgt. (lbs.)	Total wgt. x 10 (lbs.)	Actual shearing force (psi)
PEEK	1	19.0	20.37	203.70	814.80
	2	9.5	10.87	108.70	434.80
	3	9.0	10.37	108.70	414.80
	4	16.5	17.87	178.70	714.80
G-10	5	36.5	37.87	378.70	1514.80
	6	37.5	38.87	388.70	1554.80
	7	36.0	37.37	373.70	1494.80
	8	41.0	42.37	423.70	1694.80

RESULTS

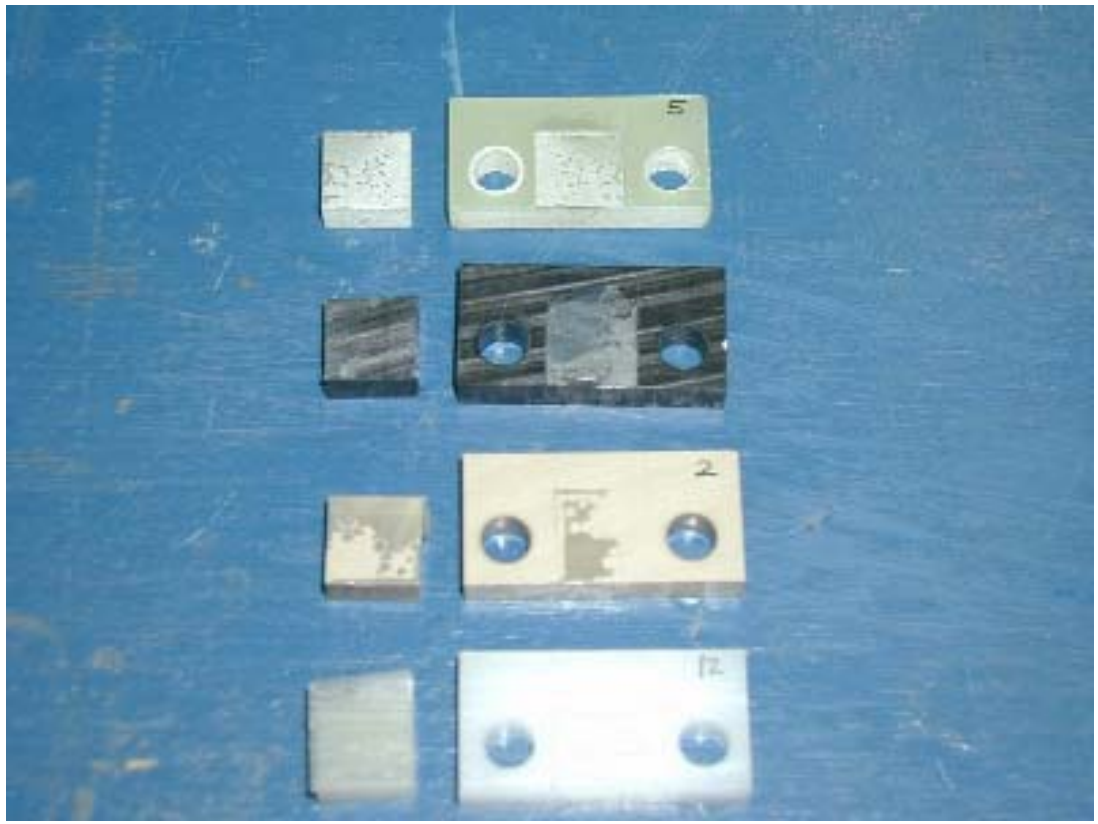
Material Name	Material No.	Wgt. of water (lbs.)	Total wgt. (lbs.)	Total wgt. x 10 (lbs.)	Actual shearing force (psi)
KYNAR	9	5.0	6.37	63.70	254.80
	10	6.0	7.37	73.70	294.80
	11	6.0	7.37	73.70	294.80
	12	6.0	7.37	73.70	294.80
NORYL	13	13.0	14.37	143.70	574.80
(PPO)	14	13.5	14.87	143.70	594.80
	15	5.0	6.37	63.70	254.80
	16	16.0	17.37	173.70	694.80

ANALYSIS

The general order of the strengths of the epoxy/plastic bonds, in decreasing order is as follows:

- G-10
- Noryl (PPO)
- Peek
- Kynar

ANALYSIS



ANALYSIS

Disparities with shear stress test results of:

- **Noryl (PPO)**
- **Peek**

Reasons:

1. **Preparation of these surfaces were not done properly**
2. **Surfaces of these plastics were not sufficiently "wetted"**
3. **The term "wetted" means that the epoxy was not firmly affixed to the plastic and hence did not have full adhesion to the surface**

RECOMMENDATIONS

- Gently rub sand paper over the surfaces of the sample plastics to attain a coarser surface, which would influence the adhesion of the epoxy to the plastic surface
- Attempt to test other types of epoxies that might increase the overall strength of the epoxy/plastic bond.