Specifications, R&D
for Intermodule Bladder Assembly

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SPECIFICATIONS, R&D
FOR INTERMODULE BLADDER ASSEMBLY

1. INSTALLATION

This section describes the procedures and tooling required for the installation of the intermodule bladder assembly, which is installed into the gap between the inner and outer module of the ITER CSMC.

1.1 Component Description

1.1.1 Intermodule bladder assembly description

The intermodule bladder assembly consists of eight bladder/shim units. Each unit is installed into and fills a 45 degree segment of the annular gap between the inner and outer modules of the ITER CSMC. These units are defined by MIT drawing 600-795-003 (Appendix A). Each unit consists of three components that are preassembled and installed as units. A glass–epoxy laminate shim plate extends vertically from the lower support structure plate up into the annular gap between the upper pressure plates. This plate fills approximately one-third of the thickness of the gap between the coil modules. A bladder assembly is positioned on both sides of the shim plate. The bladder assembly consists of continuous Teflon film adjacent to each buffer zone on each side of the shim plate and a two-sided bladder, with fill and vent tubes, adjacent to the conductor section of the coil on each side of the shim plates. The Teflon film extends around the lower end of the shim plate and is clamped to the upper end on both sides of the shim plate through the use of fasteners. The weight of each bladder/shim unit is less than 25 kg at installation. Calculation of gap dimensions and resin-fill capacities are contained in Appendix A.

1.1.1.1 Bladders

The bladders were manufactured from 0.12 mm thick glass-fabric-reinforced Teflon film. Both bladders for each unit were formed on one length of film by welding additional pieces of film ~~over pieces of random fiberglass mat~~. The two fill tubes and overflow tubes were also formed by welding additional pieces of the film together. The bladder assembly is folded at its midpoint over the lower end of the shim plate, and it is attached to the shim plate at the upper end. Each bladder segment contains two fill tubes and one overflow (vent) tube. Each fill tube should extend to the bottom of the bladder; the overflow tube should extend from the top of the bladder. The bladder assemblies are defined by MIT drawing 600-795-002 (Appendix A).

1.1.1.2 Shim plates

The shim plates are 3.2 mm (1/8 in) thick G-10 sheets. The plates are dimensioned vertically to provide adequate clearance to fit in the space between the lower support plate and the upper radial preload beams. Each plate is provided with 26 mm handling holes at the top end. The

overall dimensions of each shim plate are 2921 mm (115 in) long × 1064 mm (42 in) wide and are defined by MIT drawing 600-795-001 (Appendix A).

1.1.1.3 Epoxy

A low viscosity, room temperature cure, epoxy system with about 50 vol. % chopped glass (0.4 and 1.6 mm long fibers) is used to fill the bladders after installation in the annular gap between the coil modules. This epoxy system is CTD-528, a two-part (resin/hardener) system that must be mixed at room temperature immediately before transfer pumping into the bladders. This resin has a shelf life of one year and a pot (working) life of two hours at temperatures less than 25 °C. The data sheets and properties of this resin system are contained in Appendix B and section 1.3.

1.1.2 Tooling and materials supplied by USHT

The USHT will supply ten bladder assemblies. Eight will be installed into the intermodule gap. The two additional assemblies are provided as spares. The USHT will also supply eight shim units. All hardware required for the assembly of the bladder/shim units will be supplied. Adequate epoxy and catalyst will be provided for filling all bladder units. Two pumps (body, head, controller; see section 1.4.3) and tubing will be supplied for transfer of the epoxy resin.

1.1.3 Tools and facility requirements to be supplied by JAHT

The JAHT will be required to supply overhead hoist and rigging to position and lower the bladder/shim units into place. Simple measuring tools, such as a graduated scale, will be required to confirm the position of each unit after installation. Electrical power (110 VAC, 1 KVA) will be required for pumps. A source of clean, low pressure (0.5 bar) air or gas will be required for leak testing of the bladder units.

1.2 Installation Procedure

1.2.1 Preinstallation inspection

Inspect all components for contamination or physical damage. Verify that there is no visible evidence of puncture, tear, or weld failures in the bladder assemblies and that there are good connections and no damage to the fill and overflow tubes.

1.2.2. Prerequisites for installation

Both CSMC modules are required to be in final position. Upper pressure plates are installed and the coil assembly is prepared and ready for installation of upper radial preload beams. Verify average intermodule gap of 10 mm ± 5 mm at all locations.

1.2.3. Preassembly of bladder/shim units

CAUTION: Use care in handling to avoid damage to bladder assemblies from sharp edges or corners.

The bladder assemblies must be folded over the lower end of the shim plates and be secured at the top end with the fasteners provided for this purpose. This operation can be performed on a horizontal tabletop surface.

1.2.4 Insertion of bladder/shim units

Lift one bladder/shim assembly to vertical and move it into position over the intermodule gap. The assembly should be centered on one inner module upper pressure plate to ± 10 mm. Verify positioning by measurement to each edge of the pressure plate. Carefully lower the assembly into the intermodule gap until it reaches the bottom support plate. Verify vertical positioning by measurement from top of upper pressure plate to top of shim plate. Verify that centering of the unit on the upper pressure plate is within 10 mm.

This procedure is repeated until all eight units are in place.

1.2.5 Inspection prior to epoxy fill

1.2.5.1 Mechanical inspection

Reverify vertical positioning of all bladder/shim units as in section 1.2.4. Reverify centering of units on upper pressure plates as in section 1.2.4. Measure coil to coil gap clearance around circumference.

1.2.5.2 Leak test

Install supplied tube fittings, valves, and tube extensions on all fill inlets and install supplied pressure gages on vent lines on all bladders. Close vent line valves. Using a source of dry, clean air or gas at 0.5 bar, pressurize each bladder and close fill line valves. Record pressure readings and time. After one hour, verify that the pressure reading has not decreased by more than TBD in any bladder. I excessive pressure drop is observed, check all lines and fittings for leaks.

1.2.6 Epoxy fill

The epoxy fill system is defined in drawing 600-795-004 (Appendix A). The process involves filling of both inner and outer bladders in one unit simultaneously. This step is repeated until all eight units are filled in sequence. Note that it is not necessary to allow the epoxy to harden on one unit before proceeding to repeat this procedure for the fill of the next unit.

1.2.6.1 Epoxy fill system connection

Disconnect the air supply and remove the gages that were used for leak testing. Connect the fill tubing for the first pair of bladders to the two supplied peristaltic pumps. Lead the overflow lines from the bladders into polyethylene overflow containers.

1.2.6.2 Mixing epoxy

Prior to mixing, both parts (resin, hardener) of the epoxy system should be thoroughly shaken (or vibrated with paint-mixing tooling). The epoxy resin contains a large quantity of chopped glass fibers that tend to settle when the resin is in storage.

The epoxy is to be mixed according to the directions supplied with the epoxy (CTD-528). All information, including Material Safety Data Sheets and mixing instructions, are contained in Appendix B. All required mixing apparatus is supplied with the epoxy.

The mixing of part A (the resin) to part B (the hardener) is 100 to 70 parts by weight. The resin is intended to be mixed, transferred, and cured at room temperature (20–25 °C). The cure schedule to be used is 7 days at 20 to 25 °C.

Mix only enough resin to complete the transfer to one bladder/shim segment (two bladders on each side of one G-10 sheet). The amount required will depend on the average gap between the two coils. Each 5 gal. of CTD-528 (40 lb) must be mixed with 2.5 gal. of hardener (17 lb); thus, about 7.5 gal. (57 lb) is produced on mixing one batch. The working life of the resin is inversely dependent on the volume of mixed resin. For 5 gal., this working life is estimated at 2 h. Prior to mixing of the two-part resin, the gap distance between the two coils should be measured to provide an estimate of the amount of resin required. The table below provides an approximate guide to the amount of mixed resin that will be required per bladder unit (2 bladders), considering bladder and tube volumes and an excess of 1 L. Also, the time required to transfer this amount of resin, considering a pumping rate of 0.6 L/min, is provided.

Total gap distance (mm)	Resin volume		Time to transfer (min)
	L	(gal.)	
minimum = 7.7	9	(2.4)	8
average = 12.7	19	(5.0)	16
maximum = 17.7	28	(7.4)	24

For average coil and material dimensions, calculations of bladder resin volume are included on a data sheet in Appendix A.

1.2.6.3 Filling of bladders

Pumping should proceed immediately after mixing. Immerse the pump inlet tubes to the bottom of the supply container. The pumps are peristaltic pumps that pump at approximately constant volume flow rate (0.6 L/min). The pumps are operated until continuous fluid flow is observed in the overflow line. At that point, the associated pump is stopped and filling continues into the other bladder until continuous epoxy flow is observed in the overflow tube.

1.2.6.4 Removal of fill tubes

The fill line is disconnected from the pump, and the pumps are removed. The fill line is then immersed in the overflow container along with the overflow line. The excess epoxy in the supply container is discarded along with that container. The pump tubing is replaced with the replacement tubing that is supplied with the pump, so that the pump is ready to be used to fill the next unit. The fill and vent lines are left in the supply container until the epoxy has hardened, approximately 72 h at 20 °C. After the epoxy has hardened, both tubes are cut off near the top of the upper pressure plates.

1.3 Epoxy Properties

The compressive properties of CTD-528 have been measured at 76 K. Cast specimen coupons (7.5 × 7.0 × 7.0 mm "cubes"} were tested at a load rate of 0.02 mm/s in liquid nitrogen; strain-gage extensometers were used to measure strain. The results (average of 3 tests) are listed below

Compressive property at 76 K	Value	
	Average	Standard deviation
Young's modulus	6.4 GPa	0.4 GPa
compressive strength	0.33 GPa	0.05 GPa
strain to failure	5.1 %	0.5 %

In this chopped-glass-reinforced epoxy resin system, the above properties are isotropic or equivalent in all directions.

1.4 Research and Development

1.4.1 Resin development

The selection of the resin was based on the desire to increase the elastic moduli, yet a flexible resin system must be provided that is capable of occupying all irregular spaces and dimensions between the two coils and that must cure at room temperature. Compression tests were conducted on the following resin systems prepared by Composite Technology Development (CTD):

(a) chopped glass, about 50 vol. %
(b) cotton reinforced, estimated 30 vol. %
(c) cotton reinforced, estimated 15 vol. %
(d) Al_2O_3 filled, about 20 vol. %
(e) neat resin

All test specimens were cubes, 6 to 7 mm square. Tests were conducted in compression at 76 K. The results of the selected resin system are reported in section 1.3. All results from the testing laboratory (CTD) are contained in Appendix C.

1.4.2. Resin viscosity

The viscosity versus time of a small quantity (1 g) of the CTD-528 neat resin was measured at room temperature. Also, larger quantities (1-3 gal.) of the neat and chopped-glass resin systems were measured. These data are useful in assessing the working life of the mixed resin system. They are contained in Appendix B. The viscosity dependence on time increases as the volume of resin increases. Thus, the graph of viscosity versus time for the 1 g specimen is not conservative and represents the best case. Resin temperature also increases with time, and this increase depends on batch volume. As pointed out by CTD, temperature measurement is an easy way to monitor resin working life.

1.4.3 Resin transfer trials

A dual head, peristaltic pumping system, consisting of Cole Parmer pump body, pump heads, and controller, was assembled by CTD for the resin transfer trial. Pump specifications from Cole Parmer are included below:

Part	Name	Order Number
pump body	Masterflex	07553-70
pump head	Masterflex L/S II	77201-60
controller	Masterflex	07553-71
tubing	Masterflex pump tubing LS/18	96420-18

The pump capacity is 0.6 L/min when using a pressure head of 9.8 kPa. The tubing is 95 mm (3/8 in) I.D., and one package contains a tube length of 76 200 mm (25 ft).

A Teflon, fiberglass-reinforced, rectangular bladder was purchased that was about 1270 × 910 mm. It was mounted with dowel pins on a plywood panel, as illustrated in Figure 1. A horizontal taper, from 5 to 15 mm, was included to assess the effect of thickness or gap variability. The entire assembly is shown in Figure 2. Details about pumping times, resin volumes, and bladder dimensions are contained in CTD worksheets in Appendix C.

Three thicknesses (gaps) were used in the trials: 5, 10, and 15 mm. In all cases, the resin easily filled these volumes at the rate of 0.6 L/min. In total, about 5 gal. of resin were transferred in 30 min.

Subsequently, the entire impregnated bladder was cooled to 76 K, and no cracks or audible "cracks" were detected in either the bladder or the resin.

Photographs of progress during the resin transfer are contained in Figure 3. Notice that there is no interface from the flow of the resin from the inlet tubes on either side of the bladder. The resin assumes a uniform horizontal front, as is clearly shown in Figure 3.

Thus, the resin system, the pumping equipment, and the bladder all appear to be applicable for the inner/outer coil interface.

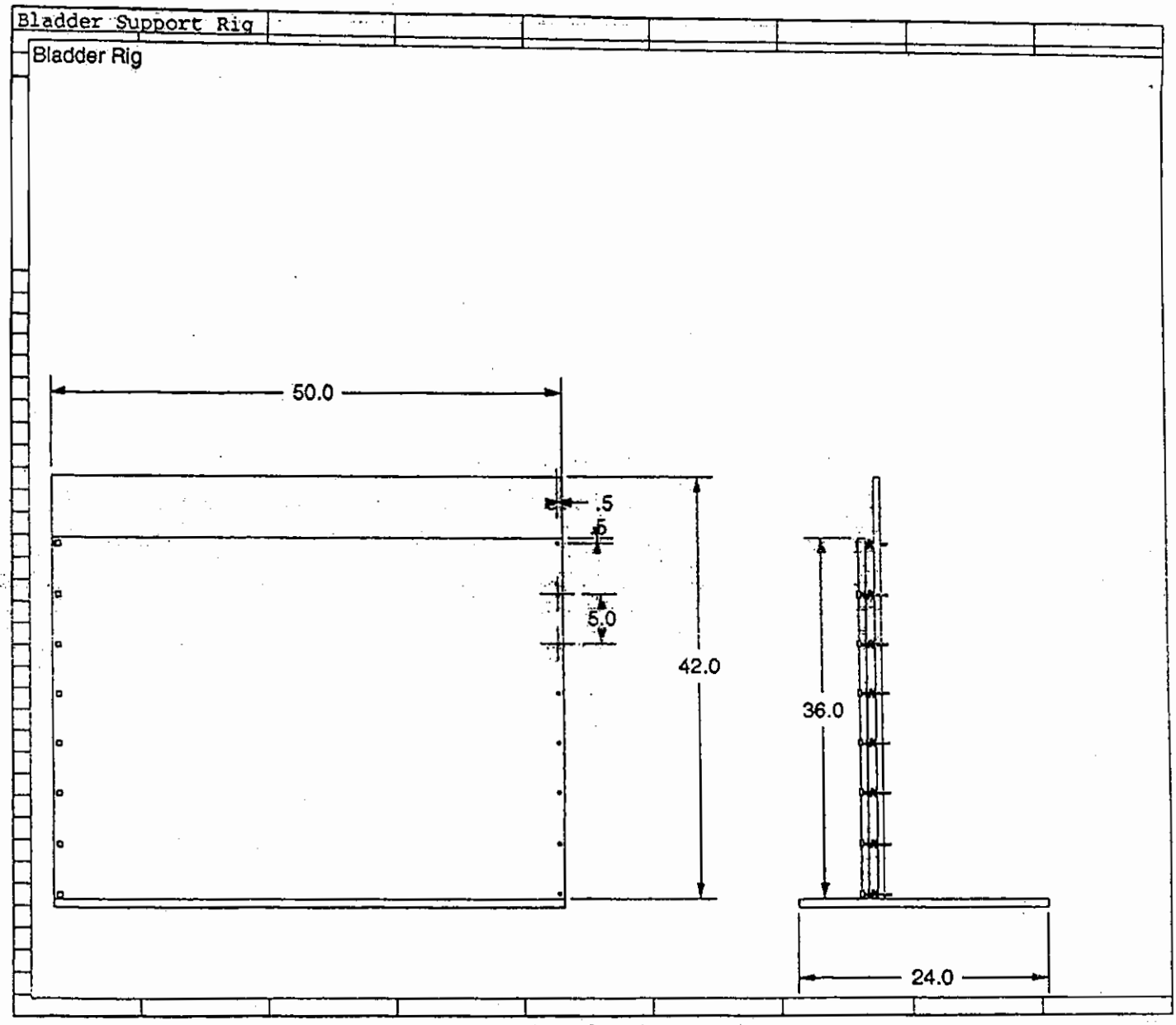


Figure 1. Assembly of Teflon bladder on support structure. All dimensions in inches.

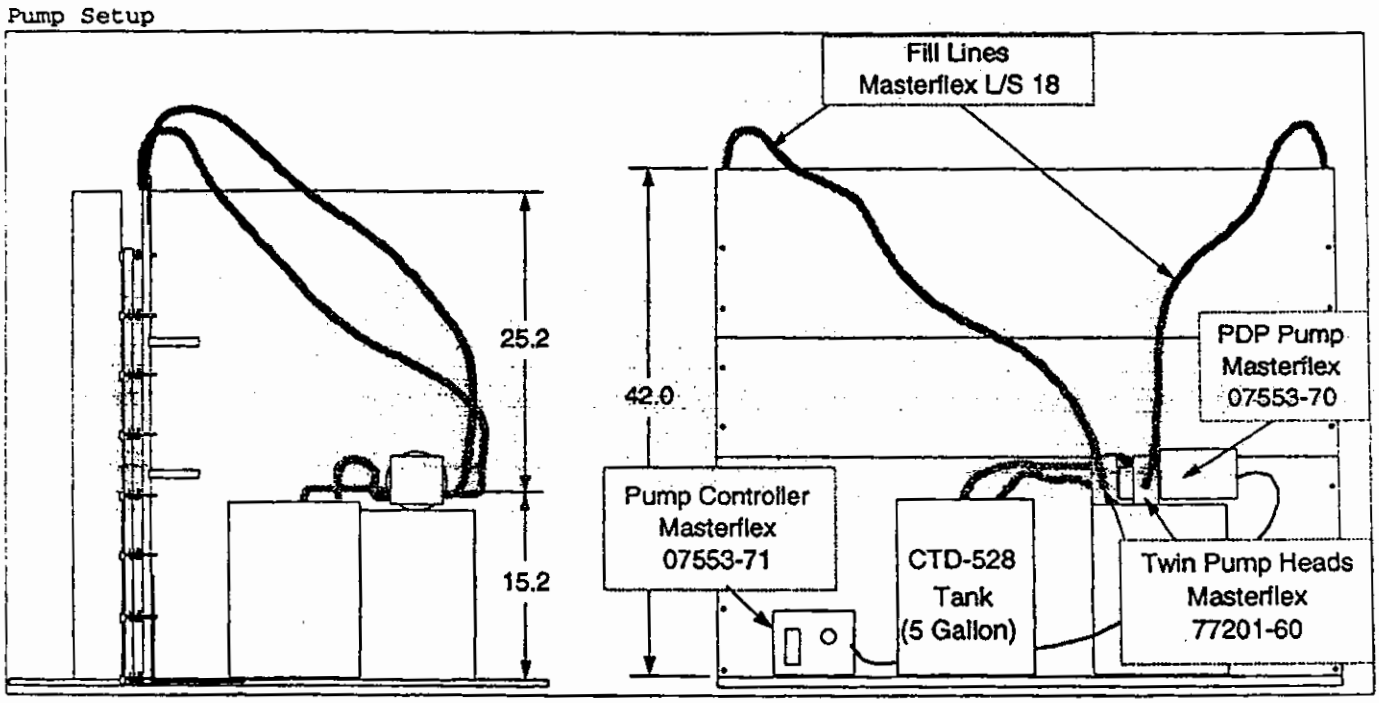


Figure 2. Assembly of equipment for resin transfer trial.

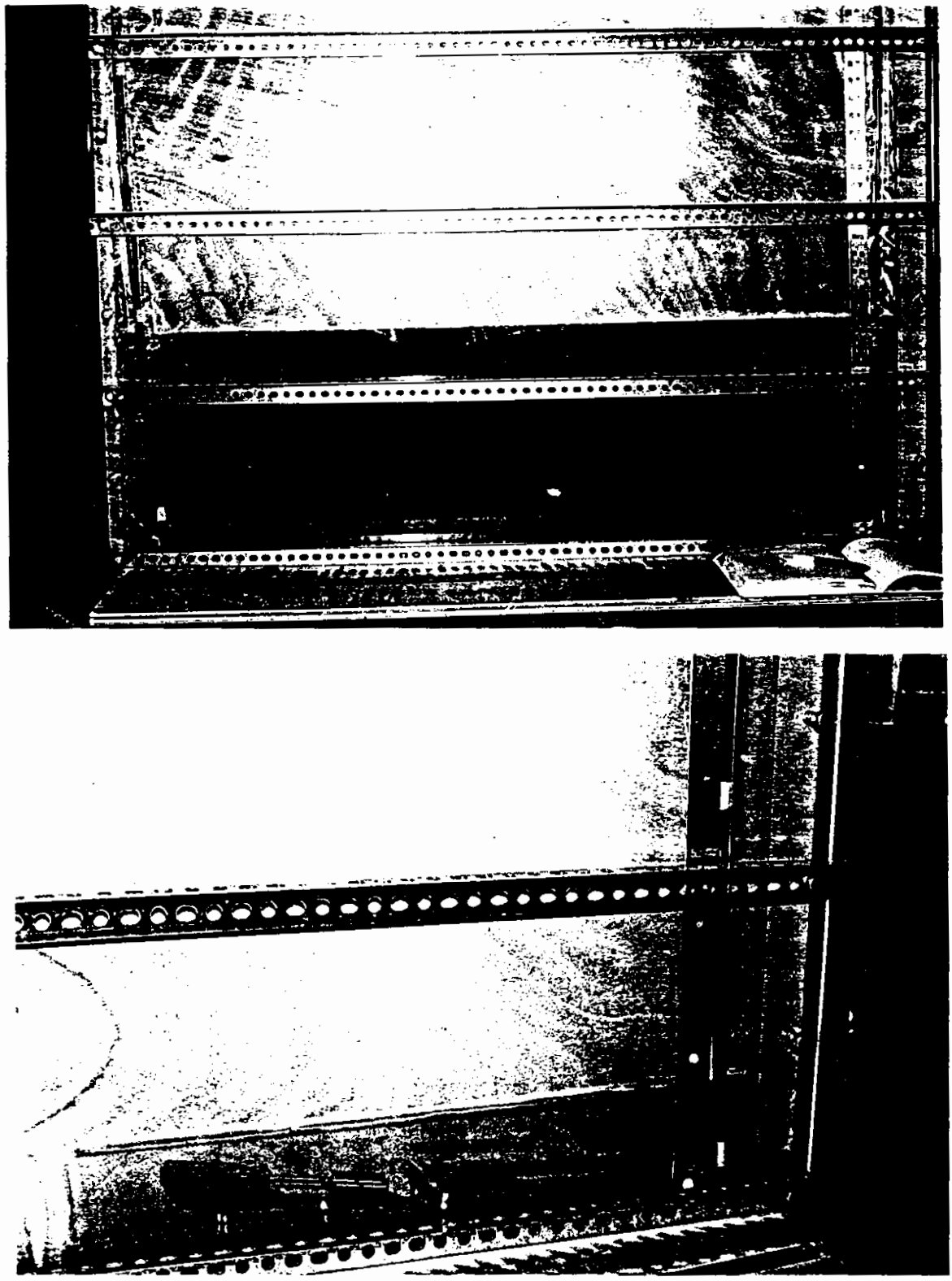


Figure 3. Filling of bladder during resin transfer experiment.

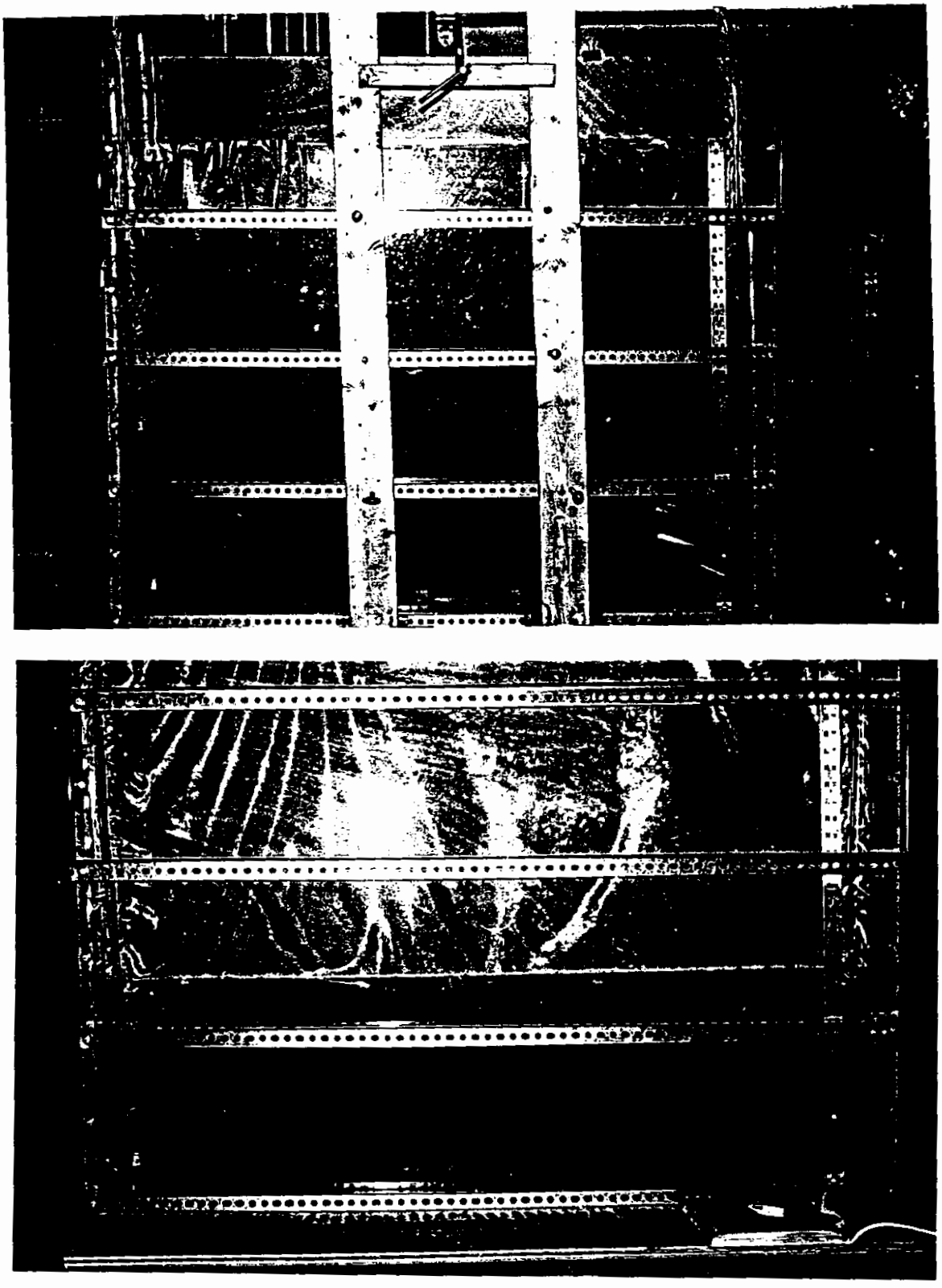
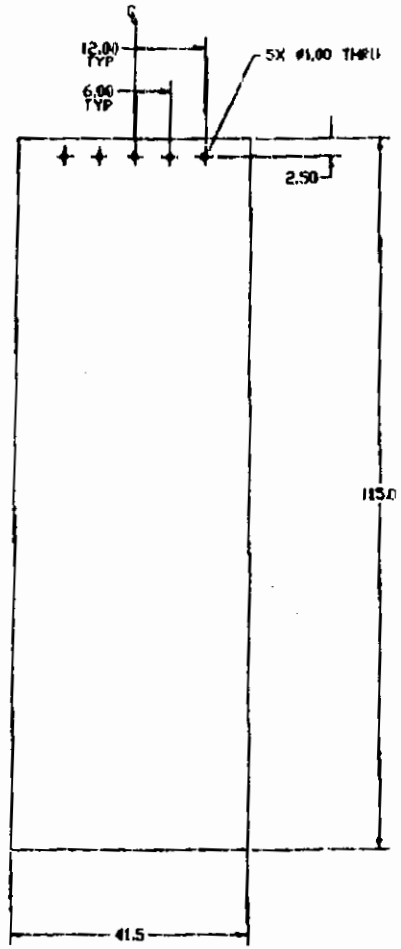


Figure 4. Continued filling of bladder with epoxy resin.

Appendix A. Component and Assembly Drawings and Dimension Calculations

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED

Education Version Only
Not For Commercial Use

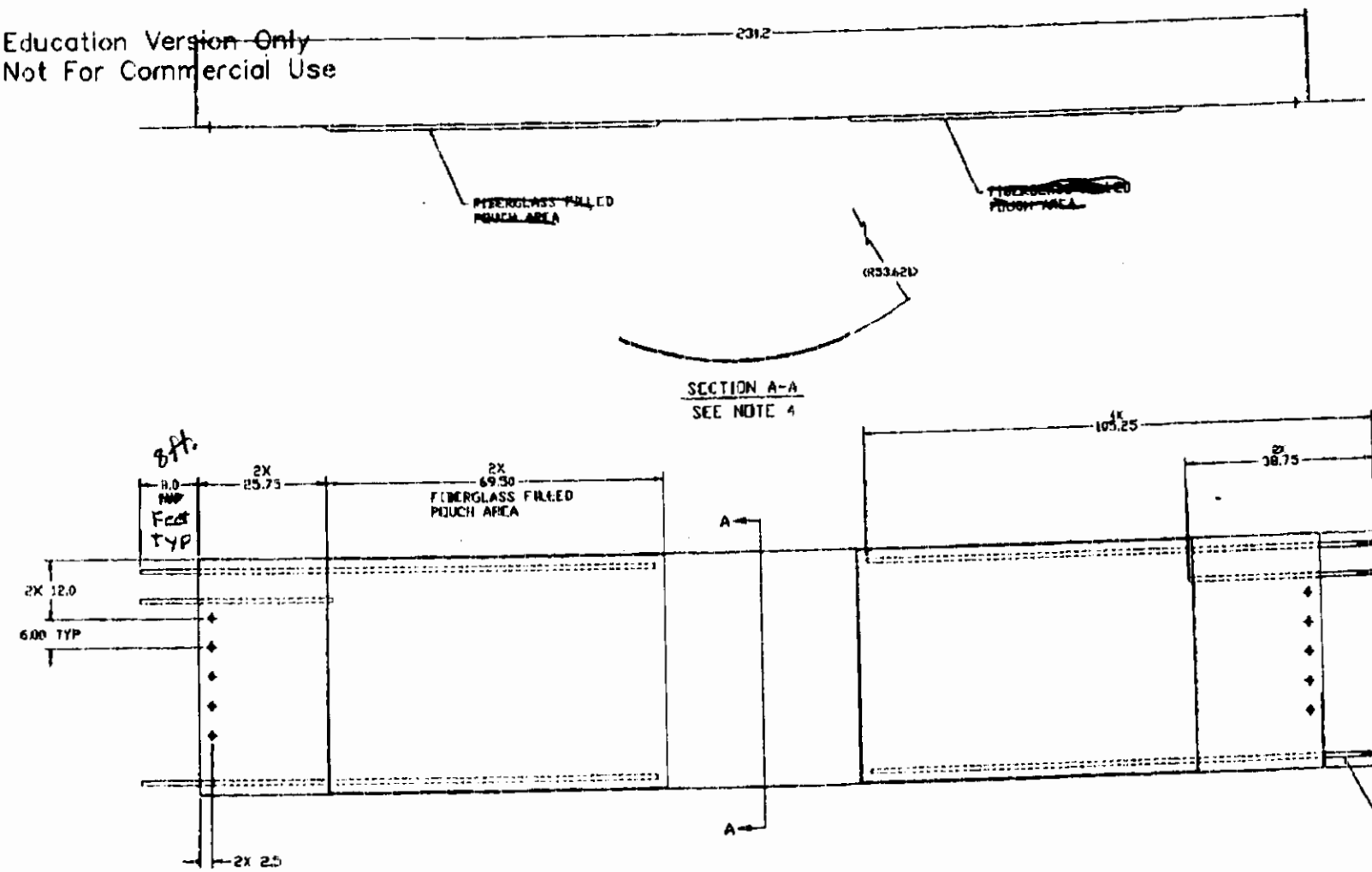


NOTES:
1. MATL: 2 PCS. .125 THK G10, 1 LAYER B-STAGE PREPREG.
2. PROCESS: LAMINATE - CLAMP TO MANDREL, VACUUM BAG, CURE @ 150° C.

USED ON ASSEMBLY	PLASMA FUSION CENTER MASSACHUSETTS INSTITUTE OF TECHNOLOGY	ITEM	PART NO.	DESCRIPTION	QTY.
	TOLERANCES UNLESS OTHERWISE SPECIFIED			G10 LAMINATION	DWG C SIZE
	DECIMALS: 2 PLACES ±.005, 3 PLACES ±.010, 4 PLACES ±.015	ANGLES: ±0° 15'			REV
	125 ✓ REMOVE ALL BURRS BREAK SHARP EDGES	DRAWN M. SABER	DATE 1/12/98	DWG NO. 600-795-001	
	DO NOT SCALE DRAWING	DESIGNED	DATE		
		APPROVED	DATE		
		CAD FILE 60079501	SCALE 1/8	SHEET 1 OF 1	

ZONE	REV	DESCRIPTION	DATE	APPROVED

REVISIONS



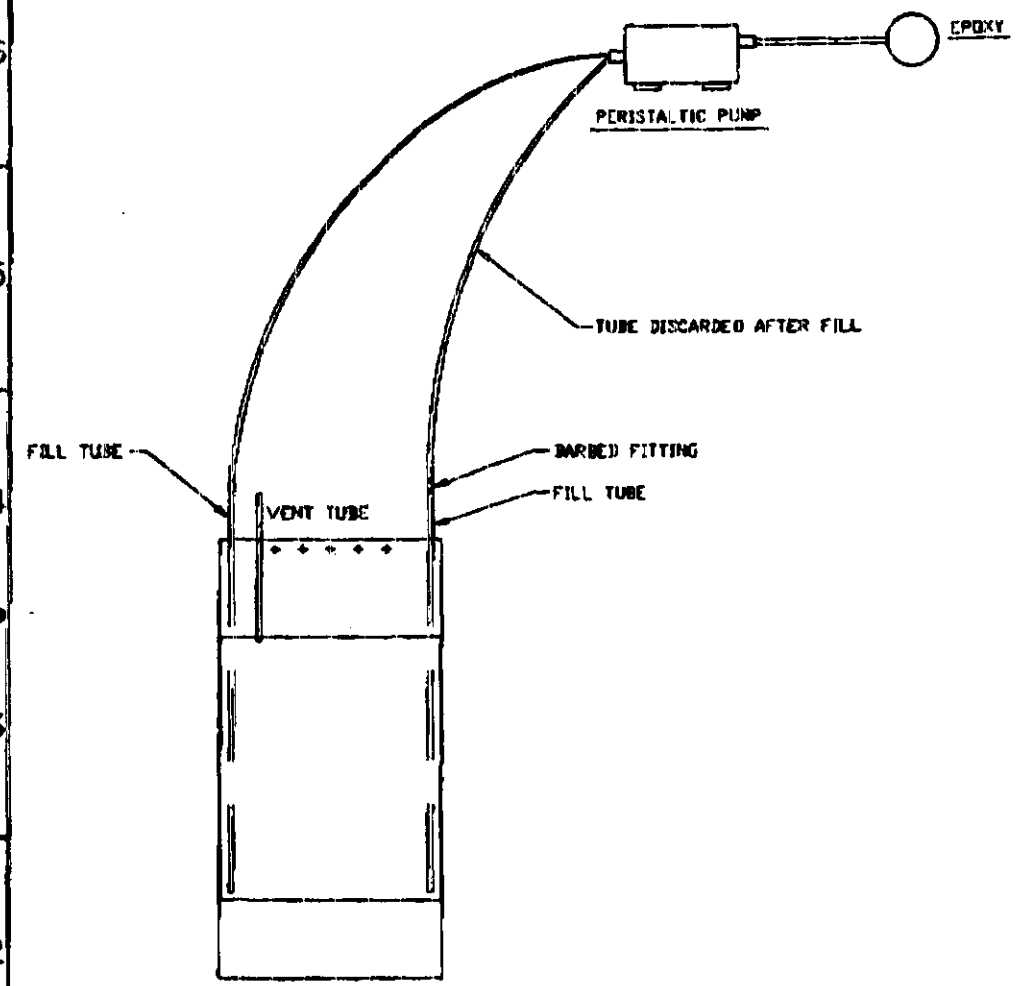
NOTES
1. MATL: REFLOW PFA BAG .005 THICK.
2. EDGE SEALS TO BE .50 WIDE, END AND CENTER SEALS PER DIMS SHOWN

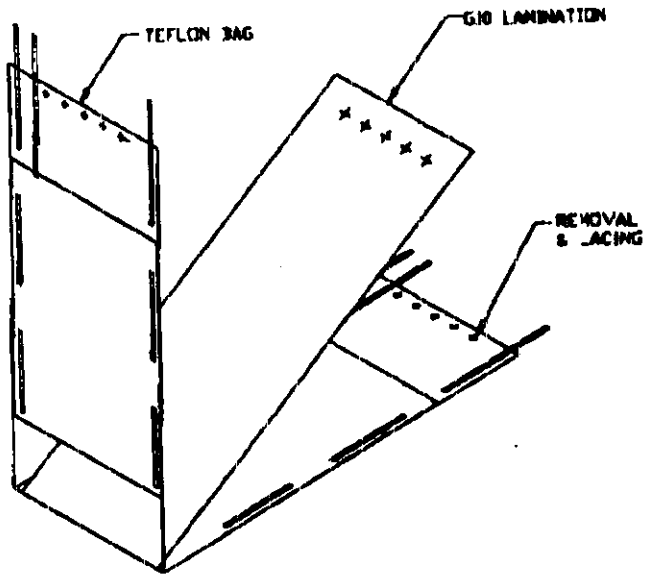
USED ON ASSEMBLY	PLASMA FUSION CENTER MASSACHUSETTS INSTITUTE OF TECHNOLOGY	ITEM	PART NO.	DESCRIPTION	QTY.
				ITER, FLEXIBLE BAG SHIM	DWG C SIZE REV

UNLESS OTHERWISE SPECIFIED
DECIMALS: 3 PLACES ±.005, 2 PLACES ±.010, 1 PLACE ±.10
ANGLES: ±0° 15' 125√
REMOVE ALL BURRS BREAK SHARP EDGES
DO NOT SCALE DRAWING

DRAWN	N. SABER	DATE	1/13/98
CHKD		DATE	
APPVD		DATE	
CAD FILE 60079502		SCALE 1/8	

DWG NO. 600-795-002
SHEET 1 OF 1



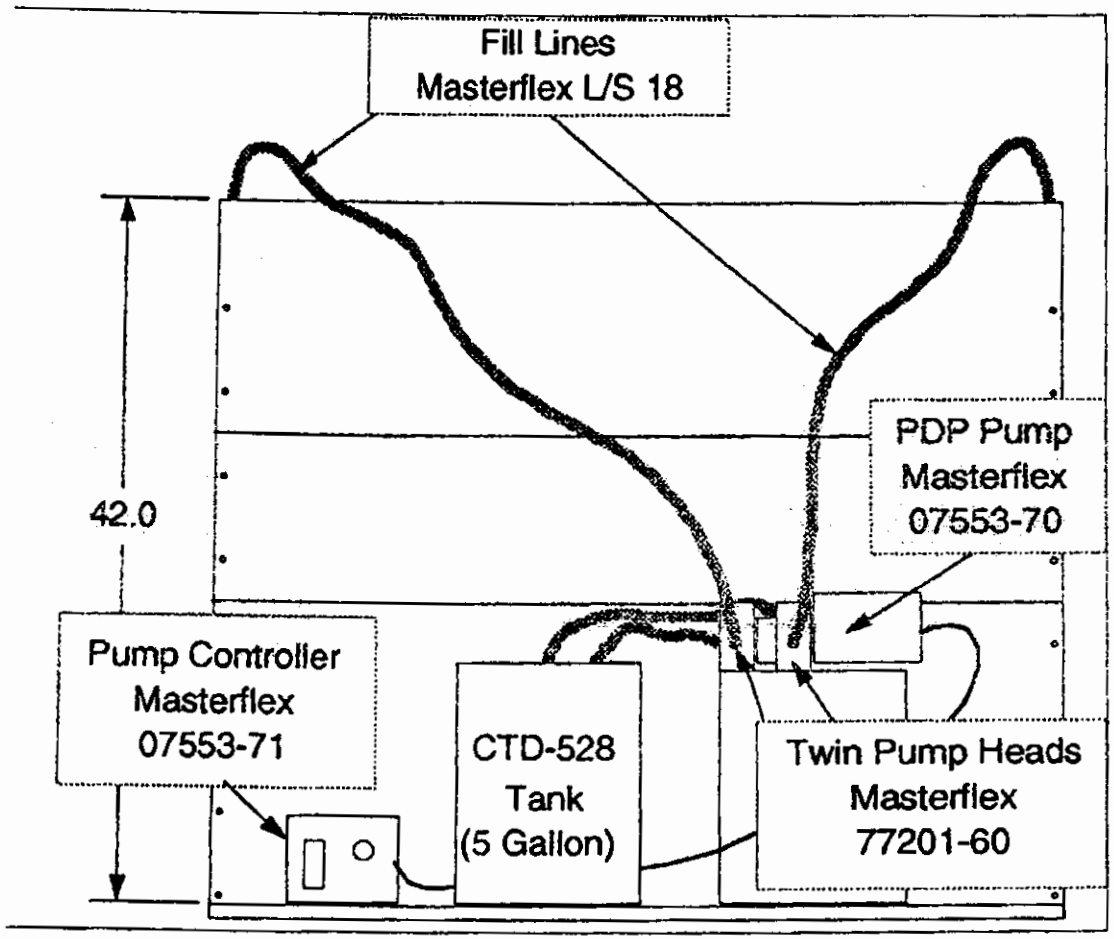


BAG ASSEMBLY

PRELIMINARY

USED ON ASSEMBLY	PLASMA FUSION CENTER MASSACHUSETTS INSTITUTE OF TECHNOLOGY	ITEM / PART NO. / DESCRIPTION		QTY.
		ASSY/INSTALLATION ITER FLEXIBLE SHIM		
	DRAWN: SABER	DATE 1/13/98	DWG NO. 600-795-003	SIZE C REV
	CHKD	DATE		
	APPD	DATE		
	CAD FILE 600Z795C3	SCALE 1/16	SHEET 1 OF 1	

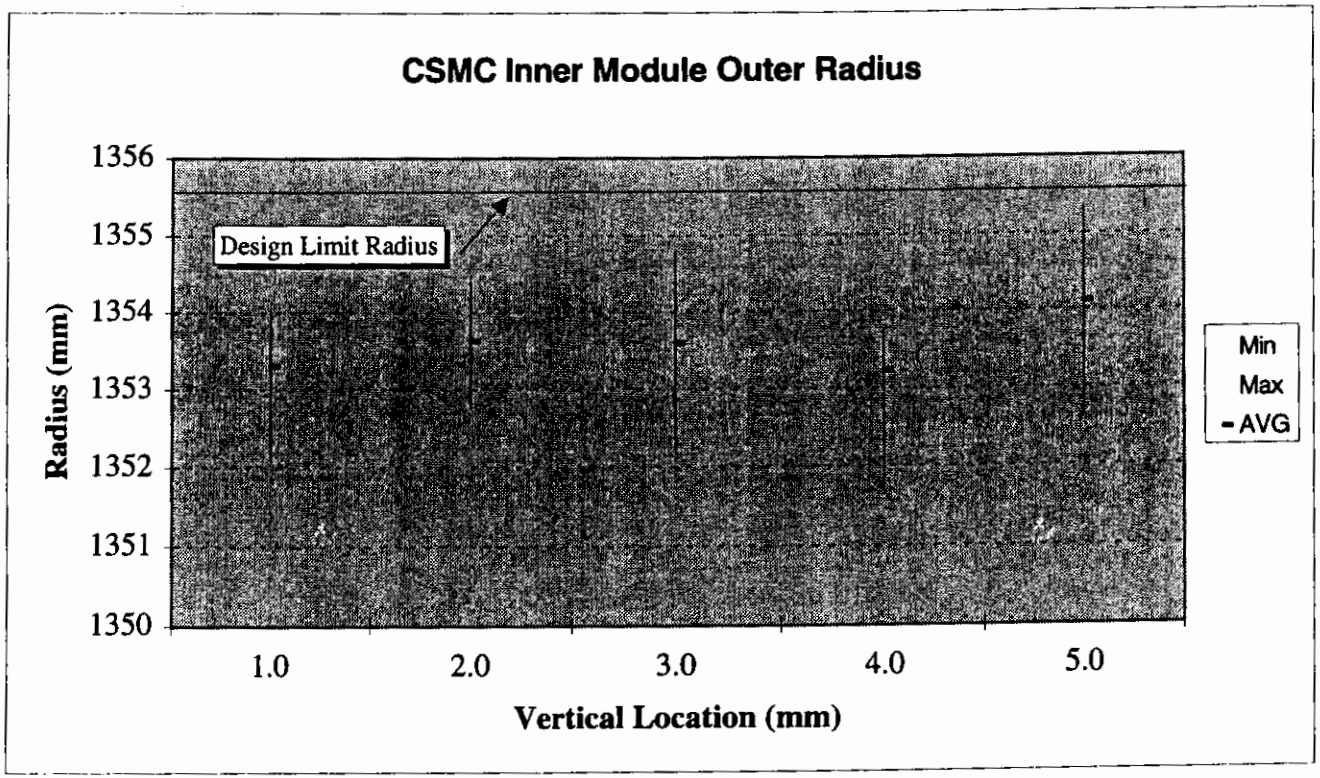
Pump Setup



600-795-004

CSMC Inner Module Outer Radius
(After VPI)

Data in mm					
Location	Vert. Loc (mm)	Min	Max	AVG	AVG DIAM
A	1.000	1352.088	1354.031	1353.306	2706.613
B	2.000	1352.751	1354.407	1353.624	2707.249
C	3.000	1352.199	1354.773	1353.592	2707.183
BOTT	4.000	1351.714	1353.759	1353.221	2706.442
TOP	5.000	1352.654	1355.331	1354.110	2708.219
		53.241	53.322	1353.571	2707.141



Dimension Calculations

Diameters: JA I.D. 2734 mm

US O.D. 2707.1 mm (see attached LM measurements)
1.5 mm (paint thickness × 2)
2708.6 mm

Gap between coils: 25.4 mm × 1/2 = 12.7 mm

Thickness of G-10 shim plate: 3.2 mm
4 bladder walls: 0.5 mm

Average thickness of resin-fill volume: 12.7–3.2–0.5 mm = 0.9 mm

Total volume of resin fill (from bladder size): 9 mm × 1765 mm × 8433 mm
= 134 L (35.4 gal.)

Average volume of one bladder on one side of shim plate: 134 L/16 = 8.4 L (2.2 gal.)

Appendix B. Information on Epoxy Resin CTD-528

CTD

CTD-528
Super Tuff™ Cryogenic Resin
Low Viscosity & Long Room Temperature Working Life

MATERIALS	DESIGNATION	COLOR	PARTS BY WEIGHT
RESIN:	CTD-587 PART A	Yellow	100.0
HARDENER:	CTD-528 PART B	Clear	70.0

MIXING TEMPERATURE: 20-25°C

MIXING PROCEDURE:

- Add 100 parts by weight of Part A (yellow) to 70 parts by weight of Part B (clear). Mix thoroughly.

CURE: 2 Hrs. @ 80°C;
7 Days @ 25°C (>90% of properties will be obtained in 72 hours)

OPTIONAL POST CURE: 4 Hrs @ 125°C

HANDLING AND SAFETY:

The handling of this product should present no problems if ordinary care is exercised. Please consult the MSDS for further information and recommended personnel protection equipment.

COMPOSITE TECHNOLOGY DEVELOPMENT, INC.
1505 Coal Creek Drive • Lafayette, Colorado 80026
Ph: (303) 664-0394 • Fax: (303) 664-0392
www.CTD-materials.com

CTD

MATERIAL SAFETY DATA SHEET

COMPOSITE TECHNOLOGY DEVELOPMENT, INC.
1505 COAL CREEK DRIVE
LAFAYETTE, COLORADO 80026

EMERGENCY TELEPHONE NUMBER: (303) 664 0394

1. PRODUCT IDENTIFICATION

Trade Name and Synonyms
CTD-528-CG20 PART A

Chemical Name and/or Family or Description
Formulated liquid epoxide resin with inert fillers

CHEMICAL IDENTITY TRADE SECRET. COMPOSITION WILL BE REVEALED TO A HEALTH PROFESSIONAL IN THE CASE OF A MEDICAL EMERGENCY.

2. COMPOSITION/INFORMATION ON INGREDIENTS

Special Health Effects - Carcinogenicity
Not a carcinogen as considered by NTP, IARC, or OSHA.
This product contains less than 50 ppm Epichlorohydrin, a substance known to be a carcinogen in the State of California

CHEMICAL NAME	CAS #	RANGE %	EXPOSURE LIMITS
Epoxide Resin mixture	Proprietary	60 - 90	OSHA PEL - Not established OSHA STEL - Not established ACGIH TWA - Not established ACGIH STEL - Not established

3. HAZARDS IDENTIFICATION

Emergency Overview: Warning! Causes irritation. May cause allergic skin reactions.
Primary Route(s) of Entry: Dermal

4. FIRST AID MEASURES

EYE	Flush eyes with water for at least 15 min. Get medical attention if irritation occurs.
SKIN CONTACT	Wipe away excess material with dry towel. Wash with mild soap and plenty of water. Get medical attention if irritation occurs.
INHALATION	Remove to fresh air. If breathing is difficult, or irritation occurs, get medical attention.
INGESTION	Give 3-4 glasses of water. Do not induce vomiting. Get medical attention.
OVEREXPOSURE EFFECTS	May cause moderate skin and mild eye irritation. May cause allergic skin reations.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE Allergy, eczema or skin conditions

SENSITIZATION	Negative

12. ECOLOGICAL INFORMATION

Data not yet available

13. DISPOSAL CONSIDERATIONS

According to Federal, State, and Local regulations. Not a hazardous waste under RCRA.

14. TRANSPORT INFORMATION

DOT SHIPPING NAME	Amines, liquid, corrosive n.o.s (contains polyoxypropylenediamine)
DOT HAZARD CLASS	8
UN IDENTIFICATION NUMBER	2735
PACKING GROUP	III
LABEL REQUIRED	Corrosive

15. REGULATORY INFORMATION

OSHA STATUS	This MSDS has been prepared in compliance with Federal OSHA Hazard Connumication Standard 29 CFR 1910.1200. This product is considered to be a hazardous chemical under that standard.
RCRA	Not a hazardous waste under RCRA (40 CFR 261)
TSCA INVENTORY STATUS	Chemical components listed on TSCA Inventory
SARA/TITLE III:	This product does not contain a toxic chemical under SEC. 313 (40 CFR 372)
CERLA	Not listed
CALIFORNIA PROPOSITION 65	This product does not contain any substance known to the State of California to cause cancer or adverse reproductive effects.

16. OTHER INFORMATION

FOR TECHNICAL INFORMATION CONTACT:	DR. NASEEM A. MUNSHI COORDINATOR OF PRODUCT SAFETY
COMPOSITE TECHNOLOGY DEVELOPMENT,INC 1505 COAL CREEK DRIVE LAFAYETTE, CO 80026 (303) 664-0394	ISSUE DATE: 12/08/98 REVISION DATE & NO.:

THE INFORMATION AND RECOMMENDATIONS CONTAINED HEREIN ARE BASED UPON DATA BELIEVED TO BE ACCURATE. HOWEVER, NO GUARANTEE OR WARRANTY OF ANY KIND EXPRESSED OR IMPLIED IS MADE WITH RESPECT TO THE INFORMATION CONTAINED HEREIN.

FIRE AND EXPLOSION HAZARDS	Combustion products may be toxic

6. ACCIDENTAL RELEASE MEASURES

ACCIDENTAL RELEASE, BREAKAGE OR LEAK	Avoid all personal contact. Absorb onto asorbent material. Shovel into closeable containers. Flush area with water. Do not flush residue into sewers discharging into domestic water systems or natural waterways. Wear protective equipment. Ventilate area.

7. HANDLING AND STORAGE

STORAGE TEMPERATURE	If stored above 100°F, a nitrogen atmosphere recommended.
HANDLING/STORAGE	Store in cool, dry area in closed containers. Avoid breathing vapor, mist or spray. Use only with adequate ventilation. Eye wash and safety shower should be available nearby when product is handled. For industrial use only.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

EYES	Chemical goggles; do not wear contact lenses.
SKIN	Lab coats or coveralls, and impervious rubber gloves.
INHALATION	Use NIOSH approved respirator suitable for organic vapors.
VENTILATION	Local Exhaust.
EXPOSURE LIMIT FOR PRODUCT	Not established

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL FORM	Liquid
APPEARANCE AND ODOR	Clear; ammoniacal odor
SOLUBILITY IN WATER	Soluble
SPECIFIC GRAVITY	Not determined
BOILING POINT	> 200°C
DECOMPOSITION TEMPERATURE	> 250°C

10. STABILITY AND REACTIVITY

STABILITY	Stable
INCOMPATIBILITIES	Strong oxidants, strong acids
HAZARDOUS DECOMPOSITION PRODUCTS	Ammonia, carbon monoxide, nitric oxides
HAZARDOUS POLYMERIZATION	Will not occur
CONDITIONS TO AVOID	This material reacts violently with acids

11. TOXICOLOGICAL INFORMATION

ORAL LD_{50}	> 2.8 g/kg rat - slightly toxic
DERMAL LD_{50}	~ 3.0 g/kg (rabbit) - practically non-toxic
INHALATION	Not determined
SKIN IRRITATION	Corrosive; may cause burns
EYE IRRITATION	Extremely irritating

CTD

MATERIAL SAFETY DATA SHEET

COMPOSITE TECHNOLOGY DEVELOPMENT, INC.
1505 COAL CREEK DRIVE
LAFAYETTE, COLORADO 80026

EMERGENCY TELEPHONE NUMBER: (303) 664 0394

1. PRODUCT IDENTIFICATION

Trade Name and Synonyms
CTD-528-CG20 PART B
Chemical Name and/or Family or Description
Proprietary aliphatic amine mixture

CHEMICAL IDENTITY TRADE SECRET. COMPOSITION WILL BE REVEALED TO A HEALTH PROFESSIONAL IN THE CASE OF A MEDICAL EMERGENCY.

2. COMPOSITION/INFORMATION ON INGREDIENTS

Carcinogenicity
Not a carcinogen as considered by NTP, IARC, or OSHA.

CHEMICAL NAME	CAS #	RANGE %	EXPOSURE LIMITS
Polyoxypropylenediamine	Proprietary	< 50	OSHA - Not established ACGIH - Not established STEL - Not noted CEIL - Not noted

3. HAZARDS IDENTIFICATION

Emergency Overview: Corrosive. Causes skin and eye burns. Harmful or fatal if swallowed. May cause allergic skin reaction. Can cause lung damage if swallowed.

4. FIRST AID MEASURES

EYE	Flush eyes with water for at least 15 min. Get medical attention immediately.
SKIN CONTACT	Remove contaminated clothing and shoes. Wash with mild soap and plenty of water. Get medical attention immediately.
INHALATION	Remove to fresh air. Give artificial respiration if not breathing. If breathing is difficult, give oxygen, and get medical attention.
INGESTION	Give 2-3 glasses of water. Do not induce vomiting. Do not give anything by mouth to an unconcious person. Get medical attention.

5. FIRE-FIGHTING MEASURES

FLASH POINT	> 200°F PMCC
EXTINGUISHING MEDIA	CO_2; dry chemical; water spray; foam
SPECIAL FIREFIGHTING PROCEDURES	Use self-contained breathing apparatus and protective clothing

EYE IRRITATION	Slight irritation - rabbit
SENSITIZATION	Moderate sensitizer

12. ECOLOGICAL INFORMATION

Data not yet available

13. DISPOSAL CONSIDERATIONS

According to Federal, State, and Local regulations. This product is not considered to be a hazardous waste by RCRA.

14. TRANSPORT INFORMATION

DEPARTMENT OF TRANSPORTATION	Not regulated

15. REGULATORY INFORMATION

OSHA STATUS	This MSDS has been prepared in compliance with Federal OSHA Hazard Communication Standard 29 CFR 1910.1200. This product is considered to be a hazardous chemical under that standard.
RCRA	Not a hazardous waste under RCRA (40 CFR 261)
TSCA INVENTORY STATUS	Chemical components listed on TSCA Inventory
SARA/TITLE III:	This product does not contain a toxic chemical under SEC. 313 (40 CFR 372)
CERLA	Not listed
CALIFORNIA PROPOSITION 65	This product contains less than 50 ppm Epichlorohydrin, a substance known to the State of California to cause cancer.

16. OTHER INFORMATION

FOR TECHNICAL INFORMATION CONTACT:	DR. NASEEM A. MUNSHI COORDINATOR OF PRODUCT SAFETY
COMPOSITE TECHNOLOGY DEVELOPMENT,INC 1505 COAL CREEK DRIVE LAFAYETTE, CO 80026 (303) 664-0394	ISSUE DATE: 12/08/98 REVISION DATE & NO.:

THE INFORMATION AND RECOMMENDATIONS CONTAINED HEREIN ARE BASED UPON DATA BELIEVED TO BE ACCURATE. HOWEVER, NO GUARANTEE OR WARRANTY OF ANY KIND EXPRESSED OR IMPLIED IS MADE WITH RESPECT TO THE INFORMATION CONTAINED HEREIN.

CTD

5. FIRE-FIGHTING MEASURES

FLASH POINT	> 200°F (> 93°C)
EXTINGUISHING MEDIA	CO_2; dry chemical; water spray; foam
SPECIAL FIREFIGHTING PROCEDURES	Use self-contained breathing apparatus
FIRE AND EXPLOSION HAZARDS	Combustion products may be toxic

6. ACCIDENTAL RELEASE MEASURES

ACCIDENTAL RELEASE, BREAKAGE OR LEAK	Avoid all personal contact. Clean with absorbent material. Put into closeable containers. Flush area with water.

7. HANDLING AND STORAGE

STORAGE TEMPERATURE	Minimum handling temperature for storage.
HANDLING/STORAGE	Store in cool, dry area in closed containers. Avoid breathing vapor, mist or spray. Use only with adequate ventilation. Eye wash and safety shower should be available nearby when product is handled. For industrial use only.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

EYES	Chemical goggles
SKIN	Lab coats or coveralls, and impervious rubber gloves. Use of barrier cream recommended.
INHALATION	Use NIOSH approved respirator suitable for organic vapors.
VENTILATION	General mechanical ventilation and local exhaust.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL FORM	Liquid
APPEARANCE AND ODOR	Opaque, slight odor
BOILING POINT	> 200°C (> 392°F)
SOLUBILITY IN WATER	Insoluble
SPECIFIC GRAVITY	Not determined
DECOMPOSITION TEMPERATURE	> 200°C (> 392°F)

10. STABILITY AND REACTIVITY

STABILITY	Stable
INCOMPATIBILITIES	Strong oxidizing agents
HAZARDOUS DECOMPOSITION PRODUCTS	Carbon monoxide, carbon dioxide and aldehydes.
HAZARDOUS POLYMERIZATION	Will not occur
CONDITIONS TO AVOID	Strong acids or bases in bulk and elevated temperatures

11. TOXICOLOGICAL INFORMATION

ORAL LD_{50}	> 5000 mg/kg - rat
DERMAL LD_{50}	> 6000 mg/kg - rabbit
SKIN IRRITATION	Moderate irritation - rabbit

COMPOSITE TECHNOLOGY DEVELOPMENT, INC.
1505 Coal Creek Drive • Lafayette, Colorado 80026
Phone: (303) 664-0394 • Fax: (303) 664-0399

January 13, 1998

2 pages

Richard P. Reed
Cryogenic Materials, Inc.
Ph: (303) 494-1852
Fax: (303) 494-0134

Dear Dick:

Following is the viscosity vs time curve for the CTD-528-CG20. This curve is for a 10 gram quantity.

We did two pot life studies one on neat CTD-528 and one on filled CTD-528-CG20. The neat resin study was conducted with about 26 lbs of material (slightly more than 3 gallons. We monitored temperature change from the start until the material cured. The results are below:

time [hrs]	Temp [°C]
0	23.6
0.5	26.7
1.0	29.7
1 1/2	32.9
2	38.9
2 1/2	49.6

The second pot life study was conducted with approximtely 1 gallon of the filled system (about 8 lbs). This material remained usable for about 3 1/2 hours. The results are below:

time [hrs]	Temp [°C]
0	20.0
3.0	38.7
3 1/2	43.2

It appear that monitoring the temperature of the material is a good method of watching the pot life for the bladder filling operation. Should the material reach 35 to 40°C, it should be recommended to discard that material and mix a new batch.

Sincerely,

Michael L. Tupper

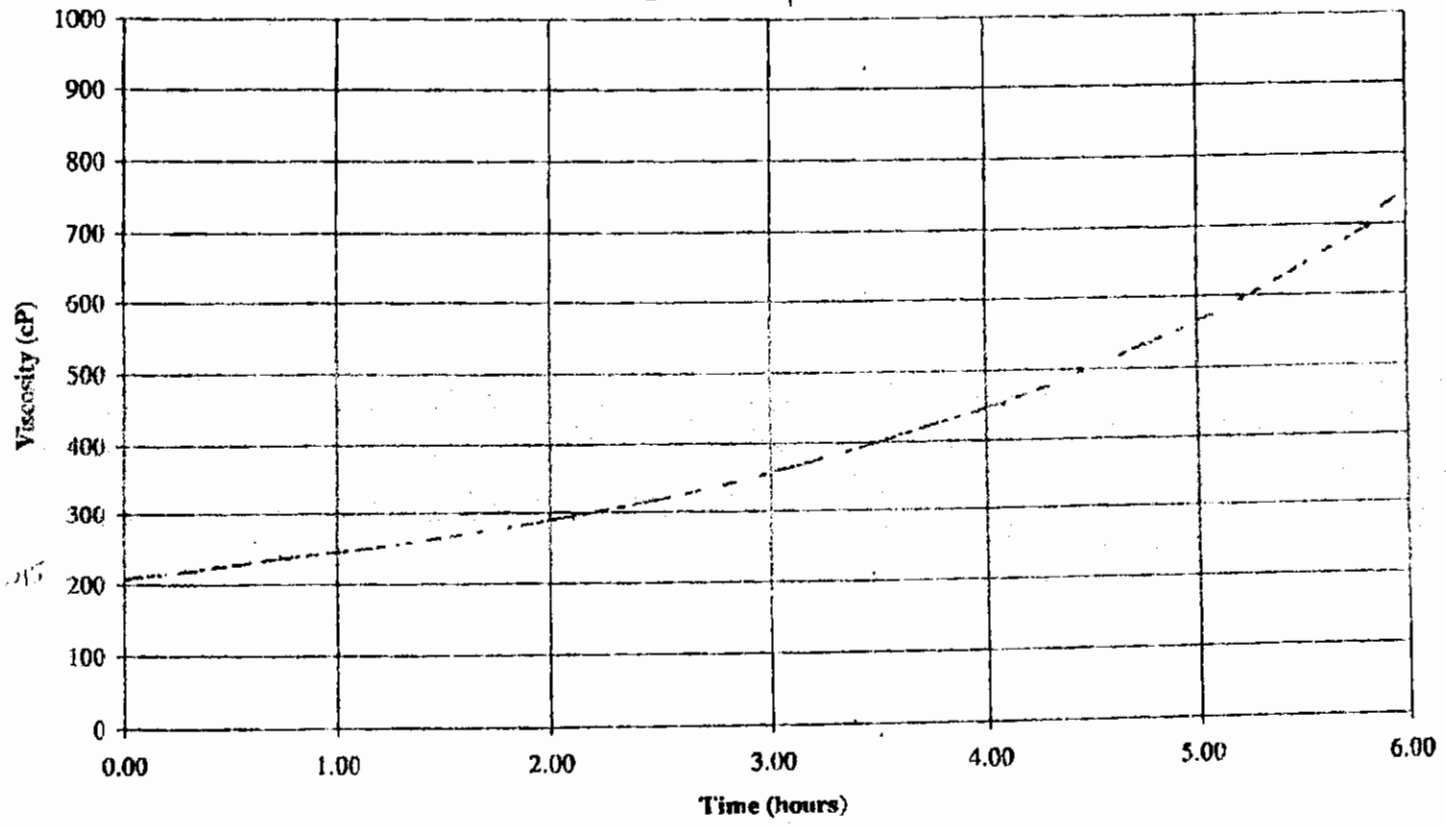
P.S. Paul would like to know if you have data for tracking distance in LN2. We did these tests years ago in which we varied the distances between the electrodes without any material between them. Also do you remember at what voltage this was conducted at.

Appendix C. Research and Development Data

CTD

CTD-528 Neat at 20°C

10 gm Qty



COMPOSITE TECHNOLOGY DEVELOPMENT, INC.

1505 Coal Creek Drive • Lafayette, Colorado 80026 • Ph: (303) 664-0394 • Fax : (303) 664-0392

www.CTD-materials.com

PDP Pumping with CTD-528

Bladder Specs

	Bladder Volume			
	Height (in)	36		
	Width (in)	48		
Thickness (max,in)		0.2	0.1968504	
Thickness (nom,in)		0.4		
Thickness (max,in)		0.6		
Volume	in³	Liters	Gallons	
Minimum	345.6	5.7	1.5	
Nominal	691.2	11.3	3.0	
Maximum	1036.8	17.0	4.5	
	Pumping Times			
	Dual Pumping with LS/18			
Volume	Pump speed (l/min)	Pump Time (min)	Nominal Thickness	
Minimum	0.6	9	5 mm	
Nominal	0.6	19	10 mm	
Maximum	0.6	28	15 mm	
Pumping head		9.81 kPa	1.4 psi	

[redacted]

PDP Pumping with CTD-528 Bladder Specs

Pumping Results				
	Pump	Masterflex 77201 Dual Heads		
	LS/18 Tubing	2 lines		
	Pump Speed	6		
	Oclusion	5		
	Flow Rate	0.6 l/m	(0.16 gpm)	
	Nominal Thickness (in_)	10 mm		
	Final thickness	10 to 20 mm		
	Resin Volume	5 Gallons		
	Pumping time	30 minutes		

Results of compression tests at 76 K of candidate resin systems

by Composite Technology Development, Inc.

Compression Test Results

Resin System: CTD-528 CG 20% (wt)
Reinforcement: 0.4 mm and 1.6 mm chopped glass fib Cure: 72 h @ 25°C
Barrier: NA 5% 5%
Specimen Type: Compression (40.32 mm^2)
Material Reference: N/A

Load Rate: 0.0212 mm/s
Strain Measurement: 3 Extensometers

Test Fixture: Compression Test Temperature: 76 K
Test Date: 7/17/98

Specimen #	Thickness (mm)	Width (mm)	Depth (mm)	Area (mm^2)	Ultimate Load (kN)	Young's Modulus (GPa)	Compression Strength (GPa)	Strain to Failure (%)
528cg-1	7.7	7.4	7.6	56.3	15.8	5.9	0.28	4.73
528cg-2	7.5	6.3	7.4	47.2	17.9	6.8	0.38	5.61
528cg-3	7.2	7.0	6.8	47.7	15.5	6.6	0.33	4.92

YOUNG'S MODULUS		COMPRESSION STRENGTH		STRAIN TO FAILURE	
Average (GPa):	6.4	Average (GPa):	0.33	Average (%):	5.08
Std. Dev.:	0.4	Std. Dev.:	0.05	Std. Dev.:	0.46
CV:	0.07	CV:	0.15	CV:	0.09

Compression Test Results

to 15→10mm compressed

Resin System: CTD-528
Reinforcement: 15mm thick cotton, 33% corr Cure: 72 h @ 25°C
Barrier: NA
Specimen Type: Compression (40.32 mm^2)
Material Reference: N/A

Load Rate: 0.0212 mm/s
Strain Measurement: 3 Extensometers

Test Fixture: Compression Test Temperature: 76 K
Test Date: 7/21/98

Specimen #	Thickness (mm)	Width (mm)	Depth (mm)	Area (mm^2)	Ultimate Load (kN)	Young's Modulus (GPa)	Compression Strength (GPa)	Strain to Failure (%)
528c0-1	6.0	6.0	6.5	39.5	9.5	4.6	0.24	5.29
528c0-2	6.1	6.3	6.7	41.9	7.5	4.3	0.18	4.17
528c0-3	5.7	5.9	6.3	37.0	8.8	4.2	0.24	5.68

YOUNG'S MODULUS		COMPRESSION STRENGTH		STRAIN TO FAILURE	
Average (GPa):	4.4	Average (GPa):	0.22	Average (%):	5.05
Std. Dev.:	0.2	Std. Dev.:	0.03	Std. Dev.:	0.78
CV:	0.04	CV:	0.16	CV:	0.15

Compression Test Results

Resin System: CTD-528
Reinforcement: 15mm thick cotton, uncomp Cure: 72 h @ 25°C
Barrier: NA
Specimen Type: Compression (40.32 mm^2)
Material Reference: N/A

Load Rate: 0.0212 mm/s
Strain Measurement: 3 Extensometers

Test Fixture: Compression Test Temperature: 76 K
Test Date: 7/21/98

Specimen #	Thickness (mm)	Width (mm)	Depth (mm)	Area (mm^2)	Ultimate Load (kN)	Young's Modulus (GPa)	Compression Strength (GPa)	Strain to Failure (%)
528c5-1	6.7	6.1	6.9	42.2	11.2	5.0	0.27	5.33
528c5-2	6.2	5.7	6.1	35.0	4.7	3.2	0.13	4.15
528c5-3	6.6	6.2	5.9	37.0	6.8	4.7	0.18	3.91

YOUNG'S MODULUS		COMPRESSION STRENGTH		STRAIN TO FAILURE	
Average (GPa):	4.3	Average (GPa):	0.19	Average (%):	4.46
Std. Dev.:	1.0	Std. Dev.:	0.07	Std. Dev.:	0.76
CV:	0.22	CV:	0.34	CV:	0.17

Compression Test Results

Resin System: CTD-528/A20 – Al_2O_3 fillers 20% (wt)
Reinforcement: NA
Barrier: NA
Specimen Type: Compression (40.32 mm^2)
Material Reference: N/A

Cure: 72 h @ 25°C

Load Rate: 0.0212 mm/s
Strain Measurement: 3 Extensometers

Test Fixture: Compression
Test Date: 7/17/98

Test Temperature: 76 K

Specimen #	Thickness (mm)	Width (mm)	Depth (mm)	Area (mm^2)	Ultimate Load (kN)	Young's Modulus (GPa)	Compression Strength (GPa)	Strain to Failure (%)
528a-1	7.2	7.0	7.7	53.8	8.5	4.9	0.16	3.25
528a-2	7.1	7.3	7.1	51.8	9.6	4.3	0.19	4.35
528a-3	7.4	6.9	7.0	48.3	11.7	5.7	0.24	4.23

YOUNG'S MODULUS		COMPRESSION STRENGTH		STRAIN TO FAILURE	
Average (GPa):	5.0	Average (GPa):	0.20	Average (%):	3.94
Std. Dev.:	0.7	Std. Dev.:	0.04	Std. Dev.:	0.60
CV:	0.15	CV:	0.22	CV:	0.15

Compression Test Results

Resin System:	CTD-528 NEAT		
Reinforcement:	NA	Cure:	72 h @ 25°C
Barrier:	NA		
Specimen Type:	Compression (40.32 mm^2)		
Material Reference:	N/A		
Load Rate:	0.0212 mm/s		
Strain Measurement:	3 Extensometers		
Test Fixture:	Compression	Test Temperature:	76 K
Test Date:	7/17/98		

Specimen #	Thickness (mm)	Width (mm)	Depth (mm)	Area (mm^2)	Ultimate Load (kN)	Young's Modulus (GPa)	Compression Strength (GPa)	Strain to Failure (%)
528n-1	7.9	7.4	8.0	59.2	24.7	8.0	0.42	5.23
528n-2	7.7	7.3	6.5	47.6	11.5	4.6	0.24	5.25
528n-3	7.7	6.9	7.1	49.0	7.2	3.9	0.15	3.79

YOUNG'S MODULUS		COMPRESSION STRENGTH		STRAIN TO FAILURE	
Average (GPa):	5.5	Average (GPa):	0.27	Average (%):	4.76
Std. Dev.:	2.2	Std. Dev.:	0.14	Std. Dev.:	0.84
CV:	0.40	CV:	0.51	CV:	0.18

Fabrication Equipment

Peristeltic pump : pump body, pump head, controller:
Cole Palmer
pump speed : 0.6 l/min
pump pressure head - 9.8 kPa

Tubing : Masterflex pump tubing - LS/18

Dimensions

Widths: Coil gap: O.D. of SA coil: 2734 mm
I.D. of US coil: 2708 mm
gap: 1/2 x 26 mm = 13 mm

G-10 panel: 0.8 mm
Tetlon bladders: 0.127 mm x 4 sides = 0.5 mm

Resin fill width: 13 - 0.8 - 0.5 = 11.7 mm

Length (height): 1800 mm

Length (circumference): 8544 mm

Volume resin: 180 l (476 gal)

Resin Transfer Trial

Bladder Size — 915 mm x 1220 mm
5-15 mm thick

Volume resin — 6-17 l, 1.5-4.5 gal.

Pump speed — 0.6 l/min

Pump times — 5-15 min.

Materials

G-10 panels - 7 panels . total coverage diameter 8544 mm
each panel: 1219 mm wide x 1800 mm long

CTD 528 epoxy resin - includes chopped glass fibers
estimated volume: 46 gal = 127 l
room temperature cure

Tefton bladders - glass reinforced
each bladder: ~1220 mm wide x 800 mm long x 0.25 mm total thickness (2 sides)

~~Tefb~~ # of bladders - 8
~ volume of resin/bladder: 6 gal = ~~[redacted]~~ 25 l