Section 9772

CHEMICAL PROCESSES &
MATERIALS R & D REPORT

AGC 4-45 REV. 7-65

AEROJET-GENERAL CORPORATION
SACRAMENTO CALIFORNIA

WORK REQUESTED BY T. A. Redfield			DEPT. 7132	EXT. 6756	BLDG. 2019	PAGE 1 OF
PROGRAM NERVA			WORK ORDER 7320-36-036			REPORT NO. ME-72-122 vmd
SUBJECT Nozzle Extension Documentation of Carbon Yield and Other Properties of Candidate Binder Systems for AGCarb Composites						DATE 3 May 1972
PART NO. -	SERIAL NO. -	PART NAME -	MATERIAL Fibrous Graphite			TYPE REPORT ☐ PROGRESS ☒ FINAL
PURPOSE						

The purpose of the report is to document miscellaneous fabrication and processing data for the NERVA Nozzle Extension not previously reported nor specifically contained within the Final Report (ME-72-129.)

DISCUSSION1. Scope of Data

The data presented in both tabular and graphical form includes dimension and weight change and carbon yield information for impregnated fibrous graphite laminates and impregnant specific gravity and viscosity information at various processing steps. Laminate dimensional and weight change and mechanical property data summaries are also presented for selected candidate impregnant (binder) systems. Data are also presented in tabular form describing T bar specimen construction features and mechanical property test results.

Each laminate is identified with a Process Identification Number (PIN). Complete processing history for each PIN are contained in PIN folders which are on file as part of Category 4 Back-up Data (187f, g, i-5d.)

2. Data Summary**MASTER**

The tables and figures contained in this report are listed in broad categories below.

a. Impregnant (Binder) System Densification Data

Table I Densification/Binder System Impregnation Processing and Laminate Physical Property Data; Three (3) Impregnation Cycles

Table II Densification/Binder System Impregnation Processing and Laminate Physical Property Data; More Than Three (3) Impregnation Cycles

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REPORT BY

H. O. Davis / J. A. Brown

APPROVED

V. Frick, Engrg. Supv.

A. D. Rosenberg, Manager

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Table III	Effect of Vacuum During Laminate Impregnation on Resin Pickup, Retention, and Laminate Density for a Single Densification/Binder System
Table IV	Carbon Yield and Impregnant Physical Property Data for FM 5228 Laminates Impregnated with Ashland 170 Processed Using Various Vacuum Levels
Table V	Carbon Yield and Impregnant Physical Property Data for FM 5228 Laminates Impregnated with Various Densification/Binder Systems
Table VI	Weight Change During Graphitization of Laminates Impregnated with Various Densification/Binder Systems
Table VII	Densification History for AGCarb Laminates Impregnated with Acenaphthalene-Isotruene-Indene
Table VIII	Densification History for AGCarb Laminates Impregnated with 1097 Mixture
Figure 1	Carbon Yield Through Cure + Carbonize Process Steps of Each Impregnation Cycle for Graphitized FM 5228 Laminates Impregnated with Various Densification/Binder Systems
Figure 2	Carbon Yield During Processing Steps for Graphitized FM 5228 Laminates Impregnated with Various Densification/Binder Systems Selected for Representative Behavior
Figure 3	Carbon Yield During Processing Steps for Graphitized FM 5228 Laminates and Various Impregnants
Figure 4	Effect of Vacuum Pressure During Impregnation on Carbon Yield in Graphitized Laminates Impregnated with Ashland 170 Densification/Binder System
Figure 5	Densification of FM 5228 Graphitized Laminates with 1097 Mixture

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b. Properties of Candidate Prepreg Resin Systems

Table IX Impregnant Systems in PINs 1066A, 1062, 1063, 1065, 1042, and 1057

Table X Summary of Strength, Shrinkage, and Weight Loss Data for Comparison of Candidate Prepreg Resin Systems

Figure 6 Strength Properties of Candidate Prepreg Resin Systems (No Densification)

Figure 7 Tensile and Compression Modulus of Candidate Prepreg Resin Systems (No Densification)

Figure 8 Weight Loss and Thickness Decrease of Candidate Prepreg Resin Systems (No Densification)

c. Honeycomb Development, T Bar Data

Table XI Description of T Bar Specimen Construction and Test Results

Figure 9 T Bar Construction Features and Nomenclature

TABLE I. DENSIFICATION/BINDER SYSTEM IMPREGNATION PROCESSING AND LAMINATE PHYSICAL PROPERTY DATA;
THREE (3) IMPREGNATION CYCLES

PIN	Laminate Identification	Impregnation System	Mixture Ratio	1st Impregnation				2nd Impregnation				3rd Impregnation				Density, gms/cc After Carb. Graph	
				Starting Density gms/cc	% Weight* Pickup	% Weight Retained After Cure	% Weight Retained After** Carbon.	Starting Density gms/cc	% Weight Pickup	% Weight Retained After Cure	% Weight Retained After Carbon	Starting Density gms/cc	% Weight Pickup	% Weight Retained After Cure	% Weight Retained After Carbon		
1085	FM 5228, Item 01 P.O. NO 1102	Varcum 8251 Oxalic Catal. Iso. alcohol	98% 2% 300 ml	1.164	28.58	76.83	41.37	1.300	15.81	93.44	66.41	1.385	10.53	83.33	55.56	1.47	1.48
1111	FM 5228, Item 01 P.O. NO 1102	Ashland 140	100%	1.155	27.89	97.56	37.32	1.309	16.77	93.09	23.64	1.352	14.04	99.94	36.82	1.42	1.41
1112	FM 5228, Item 01 P.O. NO 1102	Ashland 170	100%	1.146	28.13	93.75	39.00	1.263	20.38	75.00	35.0	1.355	14.15	94.94	33.8	1.42	1.42
1073-1	FM 5228 P.O. NO 1102	15V Indene	75% 25%	1.146	30.5											1.50	1.50
1073-2	FM 5228 P.O. NO 1102	15V Indene	75% 25%	1.149	30.5											1.51	1.50
1090-1	FM 5228 P.O. NO 1102	15V Indene	75% 25%	1.139	30.9											1.51	1.50
1090-2	FM 5228 P.O. NO 1102	15V Indene	75% 25%	1.135	31.4											1.51	1.49
1092	FM 5228, Item 01	15V Indene	75% 25%	1.164	24.1	69.7	54.0	1.317	5.81	89.5	57.9	1.343	13.9	89.2	48.3	1.43	1.42
1093	FM 5228, Item 01	15V Indene	75% 25%	1.132	23.6	67.6	52.4	1.288	6.67	87.0	67.4	1.325	12.4	88.6	44.2	1.40	1.39
1110	FM 5228, Item 01 P.O. NO 1614	15V Indene	75% 25%	1.163	26.9	76.5	59.3	1.350	7.69	90.8	69.2	1.406	9.94	85.7	42.9	1.47	1.46
1067A		15V Indene	75% 25%														
1007	FM 5228	Ashland 170 Indene	75% 25%	1.132	27.48	81.04	58.14	1.323	16.36	77.78	33.33	1.406	5.05	34.29	8.57	1.41	1.43
1011-1	FM 5228	ACN Indene	71% 29%	1.148	26.4	73.7	25.26	1.219	20.3	25.8	19.4	1.267	16.5	46.2	34.4	1.34	1.33
1011-2	FM 5228	ACN Indene	71% 29%	1.153	25.9	73.3	30.7	1.240	18.7	30.8	24.0	1.300	14.7	48.3	33.3	1.37	1.36
1012-1	FM 5228	ITX Indene	57% 43%	1.157	28.2	80.0	59.5	1.337	11.0	50.0	38.9	1.364	9.1	76.8	54.8	1.43	1.42
1012-2	FM 5228	ITX Indene	57% 43%	1.172	29.1	83.1	56.1	1.340	14.8	62.0	49.6	1.390	7.2	74.6	52.4	1.44	1.43

TABLE I. (cont.)

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PIN	Laminate Identification	Impregnation System	Mixture Ratio	1st Impregnation				2nd Impregnation				3rd Impregnation				Density, gms/cc After Carb. Graph	
				Starting Density gms/cc	% Weight* Pickup	% Weight Retained After Cure	% Weight Retained After** Carbon	Starting Density gms/cc.	% Weight Pickup	% Weight Retained After Cure	% Weight Retained After Carbon	Starting Density gms/cc	% Weight Pickup	% Weight Retained After Cure	% Weight Retained After Carbon		
1005	FM 5228	Ashland 170 P-3	75% 25%	1.133	21.45	94.92	63.6	1.283	8.55	85.77	60.22	1.362	2.61	84.09	38.6	-	1.38
1083	FM 5228, Item 01 P.O. NO 1102	524 P-3	75% 25%	1.167	29.30	71.13	54.69	1.313	15.20	76.00	40.0	1.381	10.34	72.2	38.88	1.44	1.43
1096	FM 5228 21436, 2nd batch	15V P-3	50% 50%	1.160	23.4	85.3	55.9	1.332	11.2	80.6	50.0	1.398	4.37	73.3	54.7	1.43	1.44
1097	FM 5228, Item 01	15V P-3	50% 50%	1.153	27.9	78.6	52.4	1.332	15.0	83.9	53.6	1.438	6.18	86.4	44.5	1.48	1.45
1013-1	FM 5228	ITX/ACN/ Indene	36%/36%/ 28%	1.163	28.1	88.5	48.2	1.320	16.3	79.5	57.2	1.436	9.0	67.5	35.6	1.48	1.48
1013-2	FM 5228	ITX/ACN/ Indene	36%/36%/ 28%	1.158	27.4	89.5	51.5	1.322	16.0	79.4	64.4	1.407	9.8	72.0	37.1	1.46	1.45

* Based on laminate weight.

** Based on resin pickup weight.

TABLE II. DENSIFICATION/BINDER SYSTEM IMPREGNATION PROCESSING AND LAMINATE PHYSICAL PROPERTY DATA;
MORE THAN THREE (3) IMPREGNATION CYCLES

PIN	Laminate Identification	Impregnation System	Mixture Ratio	1st Impregnation				2nd Impregnation				3rd Impregnation			
				Starting Density gms/cc	% Weight Pickup	% Weight Retained After** Cure Carbon		Starting Density gms/cc	% Weight Pickup	% Weight Retained After Cure Carbon		Starting Density gms/cc	% Weight Pickup	% Weight Retained After Cure Carbon	
1086	FM 5228, Item 01 P.O. NO 1102	EC 260 + Ethyl alcohol	100%	1.170	25.7	46.1	25.0	1.227	19.6	56.8	34.1	1.323	4.0	70.2	25.4
1099	FM 5228	15V Indene	75% 25%	1.133	29.2	95.1	50.6	1.270	3.5	72.7	54.5	1.270	15.5	87.5	45.8
1098	FM 5228	15V Indene	75% 25%	1.154	Questionable run			1.206	Questionable run			1.189	16.9	87.0	43.5
1030	FM 5228, 21436	15V/Indene/ DEN438, BF ₃ cat.	33%/33%/ 33%	1.192	25.9	82.7	42.7	1.309	16.0	63.4	30.8	1.355	11.6	79.5	22.1
1032	FM 5228, 21436	15V/USP 39/ Indene	50%/25%/ 25%	1.163	18.8	92.6	45.9	1.254	21.0	63.6	34.5	1.318	16.5	63.0	28.9
1081	FM 5228, Item 01 P.O. NO 1102	Furfural Furfural alcohol 15V/Indene	100% 100% 75%/25%	1.159	28.3	6.5	-	1.186	25.7	65.6	-	1.377	8.1	***86.7	***55.2
1084	FM 5228, Item 01 P.O. NO 1102	15V/Indene Furfural alcohol/ oxalic catalyst	75%/25% 100%/ 2%	1.154	28.6	81.0	65.5	1.378	11.5	33.5	-	1.426	8.8	**84.4	***71.1

TABLE II. (cont.)

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PIN	4th Impregnation				5th Impregnation				6th Impregnation				7th Impregnation				Density, gms/cc, After Carb Graph	
	Starting Density gms/cc	% Weight Pickup	% Weight Retained After Cure	Carbon	Starting Density gms/cc	% Weight Pickup	% Weight Retained After Cure	Carbon	Starting Density gms/cc	% Weight Pickup	% Weight Retained After Cure	Carbon	Starting Density gms/cc	% Weight Pickup	% Weight Retained After Cure	Carbon		
1086	1.338	1.2	50.0	0	-	-	-	-									?	1.36
1099	1.377	10.8	84.8	41.0	-	-	-	-									1.44	?
1098	1.278	5.3	87.5	62.5	-	-	-	-									1.32	?
1030	1.398	8.9	74.0	31.8	-	-	-	-									1.44	1.43
1032	1.386	11.9	75.9	39.4	-	-	-	-									1.45	1.45
1081	1.374	12.9	44.5	-	1.429	6.8	*** 86.4	*** 40.9	1.464	6.7	62.5	-	1.521	0.8	*** 84.4	*** 44.4	1.49	1.49
1084	1.429	6.9	64.0	-	1.506	0.8	*** 84.2	*** 47.4									1.48	1.48

* Based on laminate weight.

** Based on resin pickup weight.

*** Calculation based on total resin weight pickup and retention of 15V/Indene + furfurals from immediately prior cycle or cycles. Furfurals impregnations use 300°F max. cure.

TABLE III. EFFECT OF VACUUM DURING LAMINATE IMPREGNATION ON RESIN PICKUP, RETENTION, AND LAMINATE DENSITY FOR A SINGLE DENSIFICATION/BINDER SYSTEM

PIN	Laminate Identification	Impregnation System	Mixture Ratio	Vacuum in./Hg	1st Impregnation				2nd Impregnation				3rd Impregnation				Density, gms/cc After Carb. Graph	
					Starting Density gms/cc	% Weight Pickup	% Weight Retained After* Cure	% Weight Retained After** Carbon	Starting Density gms/cc	% Weight Pickup	% Weight Retained After* Cure	% Weight Retained After** Carbon	Starting Density gms/cc	% Weight Pickup	% Weight Retained After* Cure	% Weight Retained After** Carbon		
1113-2	FM 5228, Item 01 P.O.NO 1102	Ashland 170	100%	25	1.138	28.4	96.9	38.0	1.261	19.4	99.0	41.7	1.323	11.9	80.9	73.0	1.44	1.38
1113-1	FM 5228, Item 01 P.O.NO 1102	Ashland 170	100%	27	1.150	27.2	92.0	33.6	1.243	19.5	79.4	34.0	1.326	17.0	91.1	55.6	1.45	1.39
1113-3	FM 5228, Item 01 P.O.NO 1102	Ashland 170	100%	29	1.125	27.8	100.0	28.0	1.230	21.4	82.6	28.5	1.349	13.5	100.0	60.6	1.46	1.40

* Based on laminate weight.

** Based on resin pickup weight.

TABLE IV. CARBON YIELD AND IMPREGNANT PHYSICAL PROPERTY DATA FOR FM 5228 LAMINATES
IMPREGNATED WITH ASHLAND 170 PROCESSED USING VARIOUS VACUUM LEVELS

PIN	Vacuum in./Hg	Impreg. Cycle	Laminates									Impregnant								Comments
			Laminate Weight	Laminate Impreg	Weight Cure	After Carbon	Resin Impreg	Weight Cure	After Carbon	% Carbon Yield During			Specific Gravity gms/cc		Viscosity cps		Temperature °F			
										Cure	Carb	Cure + Carb	Pre*	Post*	Pre	Post	Pre	Post		
1113-1	27	1	46.0	58.5	57.5	50.2	12.5	11.5	4.2	92	37	34	1.120	-	50-55	-	325	-	Cooled greatly	
		2	49.7	59.5	57.5	53.1	9.8	7.8	3.4	80	44	35	1.096	-	35	165	355	303		
		3	53.0	62.0	61.2	58.0	9.0	8.2	5.0	91	61	56	1.069	-	20-22	625	380	235		
1113-2	25	1	45.5	58.4	58.0	50.4	12.9	12.5	4.9	97	39	38	-	1.075	55-60	120	324	300		
		2	49.5	59.1	59.0	53.5	9.6	9.5	4.0	99	42	42	1.095	-	38-40	110	350	305		
		3	52.9	59.2	58.0	57.5	6.3	5.1	4.6	81	90	73	1.072	-	25-27	240	370	292		
1113-3	29.5	1	45.0	57.5	57.0	49.0	12.5	12.0	4.0	96	31	32	1.110	-	49-53	-	328	-		
		2	39.0	60.5	59.5	53.5	11.5	10.5	4.5	91	43	39	1.080	-	25-30	160	370	290		
		3	52.7	59.8	59.8	57.0	7.1	7.1	4.3	100	61	61	1.081	-	22	520	370	240		

NOTES: All weights in grams.

* Pre is at start of impregnation cycle, Post is at completion of impregnation cycle.

TABLE V. CARBON YIELD AND IMPREGNANT PHYSICAL PROPERTY DATA FOR FM 5228 LAMINATES
IMPREGNATED WITH VARIOUS DENSIFICATION/BINDER SYSTEMS

PIN	Laminate Identi- fication	Densification/ Binder System	Impreg. Cycle	Original Laminate Weight	Laminate Weight After			Resin Weight After			% Carbon Yield During			Specific Gravity gms/cc		Viscosity cps		Temperature °F	
					Impreg	Cure	Carbon	Impreg	Cure	Carbon	Cure	Carb.	Cure + Carb	Pre*	Post*	Pre	Post	Pre	Post
1005	FM 5228	75% Ashland 170 25% P-3	1	284	345	342	323	61	58	39	95	67	64	-	-	56-60	100-112	246	248
			2	321	348	344	337	27	23	16	85	70	59	1.100	1.128	70-80	130	200	205
			3	337	346	345	341	9	8	4	90	50	44	1.094	1.160	50-53	> 1000	235	216
1006	FM 5228	75% 15V 25% P-3	1	286	321	315	310	35	29	24	83	83	69	1.233	-	140	-	230	-
			2	308	341	335	326	33	27	18	82	67	55	1.205	1.215	59	185	250	230
			3	324	333	331	329	9	7	5	78	71	56	1.180	1.190	45-47	100-110	234	210
			4	326	369	361	347	43	35	21	81	60	49	1.179	1.192	45-48	85	240	234
			5	343	352	351	349	9	8	6	90	75	67	1.187	1.190	52	65	240	250
			V15 heated 18 hrs @ 250°, P-3 then added.																
1007	FM 5228	75% Ashland 170 25% Indene	1	286	365	350	332	79	64	46	81	72	58	1.111	1.120	22	27	240	240
			2	330	384	372	348	54	42	18	78	43	33	1.078	1.088	15-17	22-25	230	202
			3	347	364	353	348	17	6	1	35	17	6	1.082	-	22-25	-	245	-
Heater blanket fuse blew after pressurize.																			
1008	FM 5228	75% 15V 25% Indene	1	286	370	357	334	84	71	48	85	68	57	1.175	1.180	60	63	245	240
			2	333	381	373	359	48	40	26	83	65	54	1.155	1.160	25	35-40	250	235
			3	358	402	393	372	44	35	14	80	40	32	1.130	1.124	16	22	216	222
1009	FM 5228	100% P-3	1	127	157	137	132	30	10	5	33	50	17	-	-	26	-	75	-
			2	135	166	148	139	31	13	4	42	31	13	1.175	1.175	35-38	40	75	75
			3	139	165	155	148	26	16	9	62	56	35	1.178	1.180	40	30-35	75	75
			4	148	164	156	153	16	8	5	50	63	31	1.103	1.110	4	12-15	116	120
1010	FM 5228	100% Furfural alcohol	1	127	161	139	134	34	12	7	35	58	21	-	-	90	-	75	-
			2	135	163	146	139	28	11	4	39	36	14	1.115	1.110	5-7	10	75	75
			3	138	165	150	145	27	12	7	44	58	26	1.115	1.115	5-9	9-12	75	75
			4	145	163	159	152	18	14	7	78	50	39	1.114	1.116	5	29	134	90
1011-1	FM 5228	71% ACN 29% Indene	1	144	182	172	154	38	28	10	74	36	26	1.042	1.043	10-12	10-12	155	171
			2	153	184	161	159	31	8	6	26	75	19	1.024	1.036	15	7-10	198	175
			3	159	185	171	168	26	12	9	46	75	35	1.039	1.034	25-27	22-24	180	160
1011-2	FM 5228	71% ACN 29% Indene	1	145	183	173	157	38	28	12	74	43	32	1.042	1.043	10-12	10-12	155	171
			2	156	185	165	163	29	9	7	31	78	24	1.024	1.036	15	7-10	198	175
			3	163	187	175	171	24	12	8	50	67	33	1.039	1.034	25-27	22-24	180	160
1012-1	FM 5228	57% Isotruzene 43% Indene	1	142	182	175	166	40	33	24	83	73	60	1.084	-	150	-	260	-
			2	164	182	173	171	18	9	7	50	78	39	1.104	-	43-45	-	255	-
			3	171	186	183	179	15	12	8	80	67	53	1.120	1.144	45-47	175-177	215	230

TABLE V. (cont.)

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PIN	Laminate Identifi- cation	Densification/ Binder System	Impreg. Cycle	Original Laminate Weight	Laminate Weight After			Resin Weight After			% Carbon Yield During			Specific Gravity gms/cc		Viscosity cps		Temperature °F	
					Impreg	Cure	Carbon	Impreg	Cure	Carbon	Cure	Carb.	Cure + Carb.	Pre*	Post*	Pre	Post	Pre	Post
1012-2	FM 5228	57% Isotruzene 43% Indene	1	143	184	177	166	41	34	23	83	68	56	1.084	-	150	-	260	-
			2	163	187	178	175	24	15	12	63	80	50	Temp. dropped to 180°, mixture thick.		1.104	1.114	43-45	255
			3	175	188	185	182	13	10	7	77	70	54	1.120	1.114	45-47	75-177	215	230
1013-1	FM 5228	36% ITX 36% ACN 28% Indene	1	145	186	181	165	41	36	20	88	56	49	-	-	105	510	242	225
			2	165	192	186	180	27	21	15	78	71	56	1.09	1.09	120	405	220	205
			3	180	197	192	186	17	12	6	71	50	35	Some polymerization.		1.067	1.088	38-40	270
1013-2	FM 5228	36% ITX 36% ACN 28% Indene	1	146	186	182	167	40	36	21	90	58	53	-	-	105	510	242	225
			2	167	194	188	184	27	21	17	78	81	63	1.09	1.09	120	405	220	205
			3	178	196	191	185	18	13	7	72	54	39	Some polymerization.		1.067	1.088	38-40	270
1027	FM 5228 21436	75% 15V 25% Furfural alcohol 2% oxalic catal.	1	143	183	175	165	40	32	22	80	69	55	1.210	1.220	36	95	250	220
			2	165	189	183	176	24	18	11	75	61	46	1.170	1.205	28	45	255	214
			3	176	194	185	180	18	9	4	50	44	22	1.183	1.190	37	52	215	192
1028	FM 5228 21436	50% 15V 50% Furfural alcohol 2% oxalic catal.	1	141	172	169	160	31	28	19	90	68	61	1.19	1.230	25	890	248	212
			2	160	181	174	169	21	14	9	67	64	43	1.120	1.140	15	24	240	218
			3	169	183	176	172	14	7	3	50	43	21	1.170	1.148	12	17	210	220
1029	FM 5228 21436	44% 15V 33% Indene 23% ITX	1	147	189	181	168	42	34	21	81	62	50	1.210	-	44	-	255	-
			2	168	193	187	181	25	19	13	76	68	52	1.115	1.110	18	23	225	210
			3	180	196	192	188	16	12	8	75	67	50	1.124	1.124	30-35	37	220	222
1030	FM 5228 21436	33% 15V, 33% DEN 438, BF ₃ cat., 33% Indene	1	145	183	176	161	38	31	16	82	52	42	1.200	-	45	98	240	238
			2	163	189	180	171	26	17	8	65	47	31	1.100	1.110	25	25	210	210
			3	169	188	184	173	19	15	4	79	27	21	1.110	-	13	9	215	220
			4	172	188	184	177	16	12	5	75	42	31	1.09	1.120	28-30	42-45	160	150
1031	FM 5228 21436	33% 15V 33% Indene 33% ITX	1	145	183	173	166	38	28	21	74	75	55	1.208	-	40	145	245	220
			2	171	191	184	180	20	13	9	65	69	45	1.114	1.113	33	40-45	230	230
			3	177	192	188	182	15	11	5	73	45	33	1.124	1.110	25-27	45	235	218
1032	FM 5228 21436	50% 15V 25% USP 39 25% Indene	1	144	171	169	156	27	25	12	93	48	44	1.150	1.170	50	165	245	215
			2	157	190	178	168	33	21	11	64	52	33	1.130	1.130	28	28	240	210
			3	164	191	181	172	27	17	8	63	47	30	1.134	-	25	-	260	-
			4	171	191	186	179	20	15	8	75	53	40	1.118	1.138	30-33	48-50	208	185
1033	FM 5228 21436	33% 15V 33% Indene 33% USP 39	1	143	170	164	160	27	21	17	78	81	63	-	1.011	15	20	225	180
			2	153	172	163	161	19	10	8	53	80	42	1.110	1.110	20	25	212	190
			3	163	184	178	170	21	15	7	71	47	33	1.110	1.110	22	25	170	178
			4	169	184	181	174	15	12	5	80	42	33	1.112	1.106	27	20-22	205	195

Settled in can, viscosity low.

TABLE V. (cont.)

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PIN	Laminate Identi- fication	Densification/ Binder System	Impreg. Cycle	Original Laminate Weight	Laminate Weight After			Resin Weight After			% Carbon Yield During			Specific Gravity gms/cc		Viscosity cps		Temperature °F	
					Impreg	Cure	Carbon	Impreg	Cure	Carbon	Cure	Carb.	Cure + Carb.	Pre*	Post*	Pre	Post	Pre	Post
1034	FM 5228 21436	33% 15V	1	140	175	167	162	35	27	22	77	81	63	1.153	1.170	45	120	230	212
		33% Benzene	2	162	181	174	169	19	12	7	63	58	37	1.064	1.051	20-22	44-46	100	100
		33% EC 260	3	169	183	178	172	14	9	3	64	33	21	1.069	1.066	35-38	65-70	96	100
1035	FM 5228	66% DEN 438, EF ₃ cat., 33% MEX	1	137	176	161	150	39	24	13	62	54	33	1.0	-	20	47	75	75
			2	153	181	170	162	28	17	9	61	53	32	1.045	1.065	18-20	32	92	92
			3	159	169	166	162	10	7	3	70	43	30	1.040	1.032	12-15	25	75	75
			4	161	172	169	164	11	8	3	73	38	27	1.095	-	50	180	122	124
1036	FM 5228	66% USP 39 33% Isopropyl alcohol	1	138	173	151	146	35	13	8	37	62	23	0.998	-	18	160	148	75
			2	149	178	161	153	29	12	4	41	33	14	1.000	1.015	32-35	42	108	118
			3	152	176	163	159	24	11	7	46	64	29	1.010	1.010	35	33	84	75
			4	158	176	169	164	18	11	6	61	55	33	1.072	1.120	53-55	223	150	150
			5	164	175	171	167	11	7	3	64	43	27	1.028	1.052	35-38	350	150	124
1037	FM 5228	100% CA 2223	1	140	179	161	153	39	21	13	54	24	33	-	-	30	520	148	110
			2	155	187	175	164	32	20	9	63	45	28	1.075	1.130	64	930	154	100
			3	164	169	167	165	5	3	1	60	33	20	1.080	1.105	52-55	498	148	137
			4	164	177	170	167	13	6	3	46	50	23	1.000	1.010	48-50	205	118	100
			5	166	179	170	168	13	4	2	31	50	15	1.048	1.061	38-40	151	144	118
1038	FM 5228	98% Varcum 8251+ 2% Oxalic cat.	1	141	183	170	157	42	29	16	69	55	38	1.100	1.110	24	43	150	120
			2	157	189	177	171	32	20	14	63	70	44	1.115	1.114	23	30	142	154
			3	168	185	181	176	17	13	8	76	62	47	1.147	1.145	37	28	114	142
1054	FM 5228 21436	40% 15V, 40% Varcum 8251, 20% Indene, 2% ox. cat.	1	141	180	167	158	39	26	17	67	65	44	1.124	-	30	-	166	-
			2	156	182	173	169	26	17	13	65	76	50	Pitch settled out at 166°.		22-25	50-52	220	190
			3	166	179	176	?	13	10	-	77	-	-	1.131	1.160	25-28	-	210	-
1055	FM 5228 21436	33% 15V, 33% Indene 33% CA 2223	1	141	180	171	162	39	30	21	77	70	54	1.098	-	45	-	156	-
			2	160	182	175	169	22	15	9	68	60	41	Settled out at 150°.		35	-	145	-
			3	167	171	170	169	4	3	2	75	67	50	1.020	-	60	>1000	140	126
1081	FM 5228 Item 01 PO N01102	100% Furfural	1	147	188	149*	-	41	2	-	5	-	-	1.160	1.160	5-7	5-7	75	75
		Furfural alcohol+	2	149	187	174*	-	38	25	-	66	-	-	1.160	1.162	7-9	10-12	75	75
		2% oxalic cat.																	
		75% 15V, 25% Indene	3	174	188	183	169	14	9	22**	88**	61**	54**	1.146	1.145	30	20-28	233	230
		Furfural alcohol	4	170	192	180*	-	22	10	-	45	-	-	1.110	-	4-5	10-15	75	75
		75% 15V 25% Indene	5	180	192	189	179	12	9	9**	86**	47**	41**	1.146	1.164	20-22	50	252	245
		Furfural alcohol	6	179	191	187*	-	12	8	-	67	-	-	1.104	1.110	4-7	10-12	75	75
		75% 15V 25% Indene	7	187	188	187	183	1	0	4**	89**	50**	44**	1.113	1.145	18-20	38-40	255	250

TABLE V. (cont.)

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PIN	Laminate Identification	Densification/ Binder System	Impreg. Cycle	Original Laminate Weight	Laminate Weight After			Resin Weight After			% Carbon Yield During			Specific Gravity gms/cc		Viscosity cps		Temperature °F	
					Impreg	Cure	Carbon	Impreg	Cure	Carbon	Cure	Carb.	Cure + Carb.	Pre*	Post*	Pre	Post	Pre	Post
1083	FM 5228 Item 01	75% 524 Pitch 25% P-3	1	146	188	176	169	42	30	23	71	77	55	1.126	1.122	5	8	200	195
			2	165	191	185	175	26	20	10	77	50	38	1.128	1.128	14	20	205	210
			3	174	192	187	181	18	13	7	72	54	39	1.126	1.132	20-22	15-20	210	219
1084	FM 5228 Item 01 PO N01102	75% 15V, 25% Indene Furfural alcohol + 2% oxalic cat. 75% 15V, 25% Indene Furfural alcohol 75% 15V 25% Indene	1	147	189	181	175	42	34	28	81	82	67	1.146	1.146	36	30	225	233
			2	174	194	180	-	20	6	-	30	-	-	1.110	1.102	4-5	10-15	75	75
			3	180	196	193	190	22	19	16	86**	84**	73**	1.146	1.164	20-22	50	252	245
			4	182	194	190	-	12	8	-	67	-	-	1.104	1.110	4-7	10-12	75	75
			5	190	191	190	186	9	8	4	89**	50**	44**	1.113	1.145	18-20	38-40	255	250
1085	FM 5228 Item 01 PO N01102	98% Varcum 8251+ 2% oxalic cat.+ iso. alcohol	1	148	190	181	166	42	33	18	79	55	43	1.146	1.160	20	45	150	136
			2	164	190	188	181	26	24	17	92	71	65	1.145	-	20-23	-	152	-
			3	171	189	186	181	18	15	10	83	67	56	1.157	1.170	45	40-42	132	142
1086	FM 5228 Item 01 PO N01102	100% EC 260+ Ethyl alcohol	1	148	186	166	158	38	18	10	47	56	26	1.017	1.034	56	164	105	105
			2	157	188	175	168	31	18	11	58	61	35	1.000	1.010	45-47	193	118	102
			3	166	173	171	168	7	5	2	71	40	29	0.956	0.975	12-15	70-75	127	105
			4	168	170	169	168	2	1	0	50	0	0	1.036	1.060	50-52	215	145	112
1092	FM 5228 Item 01	75% 15V 25% Indene	1	289	359	338	328	70	49	39	70	80	56	1.123	1.204	19-22	> 1000	255	221
			2	327	346	344	338	19	17	11	89	65	58	1.113	1.208	18-20	> 1000	255	220
			3	334	380	375	356	46	41	22	89	54	48	1.119	1.150	20-24	47	250	270
1093	FM 5228 Item 01	75% 15V 25% Indene	1	307	380	356	345	73	49	38	67	78	52	1.123	1.204	19-22	> 1000	255	221
			2	345	368	365	361	23	20	16	87	80	70	1.113	1.208	18-20	> 1000	255	220
			3	355	398	393	374	43	38	19	88	50	44	1.119	1.150	20-24	47	250	270
1096	FM 5228 21436	50% P-3 50% 15V	1	145	179	175	164	34	30	19	88	63	56	1.166	-	52-54	145-150	225	255
			2	163	181	178	172	18	15	9	83	60	50	1.162	1.179	45	136	222	230
			3	172	179	177	176	7	5	4	71	80	57	1.172	1.181	45	190	242	240
1097	FM 5228	50% P-3 50% 15V	1	143	185	176	165	42	33	22	79	67	52	1.172	1.181	45	190	240	240
			2	165	190	186	179	25	21	14	84	67	56	1.156	-	22-25	-	230	-
			3	178	189	188	183	11	10	5	91	50	45	1.149	1.074	32-35	130	238	250
1098	FM 5228	75% 15V 25% Indene	1	141	148	151	145	7	10	4	-	-	-	1.128	1.210	12-15	> 1000	265	210
			2	144	146	145	144	2	1	0	50	0	0	1.142	-	12	-	275	-
			3	142	165	162	152	23	20	10	87	50	43	1.119	1.150	20-24	47	250	270
			4	152	160	159	157	8	7	5	88	71	63	1.154	-	40-42	-	265	-
1099	FM 5228	75% 15V 25% Indene	1	139	179	177	159	40	38	20	95	53	50	1.128	1.210	12-15	> 1000	265	210
			2	155	161	159	158	6	4	3	67	75	50	1.142	-	12	-	275	-
			3	155	179	176	166	24	21	11	88	52	46	1.119	1.150	20-24	47	250	270
			4	165	183	180	173	18	15	8	83	53	44	1.154	-	40-42	-	265	-

TABLE V. (cont.)

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PIN	Laminate Identi- fication	Densification/ Binder System	Impreg. Cycle	Original Laminate Weight	Laminate Weight After			Resin Weight After			% Carbon Yield During			Specific Gravity gms/cc		Viscosity cps		Temperature °F	
					Impreg	Cure	Carbon	Impreg	Cure	Carbon	Cure	Carb	Cure + Carb.	Pre*	Post*	Pre	Post	Pre	Post
1110	FM 5228	75% 15V	1	291	369	351	338	78	60	47	77	78	60	1.123	1.204	19-22	> 1000	255	221
	Item 01	25% Indene	2	338	364	362	356	26	24	18	92	75	69	1.113	1.208	18-20	> 1000	255	220
	PO N 01614		3	352	387	382	367	35	30	15	86	50	43	1.119	1.150	20-24	47	250	270
1111	FM 5228	100% Ashland 140	1	147	186	185	160	39	38	13	97	34	33	-	1.058	54-70	165	300	275
	Item 01		2	164	192	190	171	28	26	7	93	27	25	1.042	1.052	50	100	302	282
	PO NO 1102		3	170	194	194	179	24	24	9	100	38	38	1.094	1.110	20-25	60-62	345	304
1112	FM 5228	100% Ashland 170	1	144	185	182	160	41	38	16	92	42	39	1.112	1.081	40	68	330	315
	Item 01		2	157	189	181	168	32	24	11	75	46	34	1.108	1.100	50-55	80-83	325	306
	PO NO 1102		3	167	191	190	176	24	23	9	96	39	38	1.095	1.130	28-30	100	370	300

NOTES: All weights in grams

* Pre is start of impregnation cycle, Post is at completion of impregnation cycle.

** Based on total resin pickup and retention of resin system plus furfurals from immediately prior cycle or cycles. Furfurals impregnations use 300°F max. cure.

TABLE VI. WEIGHT CHANGE DURING GRAPHITIZATION OF LAMINATES IMPREGNATED
WITH VARIOUS DENSIFICATION/BINDER SYSTEMS

PIN	Impreg. Cycle	Laminate Weight After		% Weight Change Carb to Graph
		Carbon	Graph	
1005	1	323	324	+0.3
	2	337	-	-
	3	345	341	-1.2
1006	1	310	310	0
	2	335	326	-2.7
	3	329	-	-
	4	347	-	-
	5	349	347	-0.6
1007	1	332	333	+0.3
	2	348	-	-
	3	348	353	+1.4
1008	1	334	334	0
	2	359	-	-
	3	372	372	0
1009	1	132	-	-
	2	139	-	-
	3	148	-	-
	4	153	152	-0.7
1010	1	134	135	+0.7
	2	139	-	-
	3	145	-	-
	4	152	152	0
1011-1	1	154	-	-
	2	159	-	-
	3	168	-	-
1011-2	1	157	-	-
	2	163	-	-
	3	171	-	-
1012-1	1	166	-	-
	2	171	-	-
	3	179	-	-
1012-2	1	166	-	-
	2	175	-	-
	3	182	-	-

PIN	Impreg. Cycle	Laminate Weight After		% Weight Change	
		Carbon	Graph	Carb to	Graph
1013-1	1	165	-	-	
	2	180	-	-	
	3	186			
1013-2	1	167	-	-	
	2	184	-	-	
	3	185			
1027	1	165	-	-	
	2	176	-	-	
	3	180	180	0	
1028	1	160	-	-	
	2	169	-	-	
	3	172	172	0	
1029	1	168	-	-	
	2	181	-	-	
	3	188	187	-0.5	
1030	1	161	-	-	
	2	171	-	-	
	3	173	-	-	
	4	177	176	-0.6	
1031	1	166	-	-	
	2	180	-	-	
	3	182	182	0	
1032	1	156	-	-	
	2	168	-	-	
	3	172	-	-	
	4	179	179	0	
1033	1	160	-	-	
	2	161	-	-	
	3	170	-	-	
	4	174	173	-0.6	
1034	1	162	-	-	
	2	169	-	-	
	3	172	171	-0.6	

(TABLE VI. cont.)

<u>PIN</u>	<u>Impreg. Cycle</u>	<u>Laminate Weight After</u>		<u>% Weight Change Carb to Graph</u>
		<u>Carbon</u>	<u>Graph</u>	
1035	1	150	-	-
	2	162	-	-
	3	162	-	-
	4	164	163	-0.6
1036	1	146	-	-
	2	153	-	-
	3	159	-	-
	4	164	-	-
	5	167	165	-1.2
1037	1	153	-	-
	2	164	-	-
	3	165	-	-
	4	167	-	-
	5	168	167	-0.6
1038	1	157	-	-
	2	171	-	-
	3	176	-	-
1054	1	158	-	-
	2	169	-	-
	3	?	171	-
1055	1	162	-	-
	2	169	-	-
	3	169	168	-0.6
1081	1	-	-	-
	2	-	-	-
	3	169	-	-
	4	-	-	-
	5	179	-	-
	6	-	-	-
	7	183	183	0
1083	1	169	-	-
	2	175	-	-
	3	181	181	0
1084	1	175	-	-
	2	-	-	-
	3	190	-	-
	4	-	-	-
	5	186	186	0

<u>PIN</u>	<u>Impreg. Cycle</u>	<u>Laminate Weight After</u>		<u>% Weight Change Carb to Graph</u>
		<u>Carbon</u>	<u>Graph</u>	
1085	1	166	-	-
	2	181	-	-
	3	181	182	+0.6
1086	1	158	-	-
	2	168	-	-
	3	168	-	-
	4	168	168	0
1092	1	328	-	-
	2	338	-	-
	3	356	-	-
1093	1	345	-	-
	2	361	-	-
	3	374	-	-
1096	1	164	-	-
	2	172	-	-
	3	176	177	+0.6
1097	1	165	-	-
	2	179	-	-
	3	183	179	-2.2
1098	1	145	-	-
	2	144	-	-
	3	152	-	-
	4	157	-	-
1099	1	159	-	-
	2	158	-	-
	3	166	-	-
	4	173	-	-
1110	1	338	-	-
	2	356	-	-
	3	367	-	-
1111	1	160	-	-
	2	171	-	-
	3	179	178	-0.6

<u>PIN</u>	<u>Impreg. Cycle</u>	<u>Laminate Weight After</u>		<u>% Weight Change Carb to Graph</u>
		<u>Carbon</u>	<u>Graph</u>	
1112	1	160	-	-
	2	168	-	-
	3	176	175	-0.6
1113-1	1	50.2	-	-
	2	53.1	-	-
	3	58.0	55.7	-4.0
1113-2	1	50.4	-	-
	2	53.5	-	-
	3	57.5	55.0	-4.2
1113-3	1	49.0	-	-
	2	53.5	-	-
	3	57.0	54.6	-4.2

TABLE VII DENSIFICATION HISTORY FOR AGCarb LAMINATES IMPREGNATED WITH ACENAPHTHALENE-ISOTRUXENE-INDENE

PIN	Composition	Mix Date	Additions	Impregnant		Viscosity-CPS		Specific Gravity		Weight Loss % (Vols.)	Carbon Yield %		Laminate			Specific Gravity			
				Before Reimpregnation	After Reimpregnation	Before Reimpregnation	After Reimpregnation	Uncured Basis	Cured Basis		Pickup	Increase mental	Cumulative	Total thru Regraph	Before Reimpregnation	After Reimpregnation	After Regraph		
1ST REIMPREGNATION																			
1011-1	5 lb Acenaptha-	9-8-71		10-21 @ 155°F	47 @ 141°F	1.042 @ 150°F	1.043 @ 198°F	26.4	25.3	34.3	26.4	8.8	8.8				1.148	1.219	
1011-2	lene,	"		"	"	"	"	26.7	30.7	41.8	25.9	7.9	7.9				1.153	1.240	
	2 lb Indene							26.6	28.0	38.1	26.2	8.3	8.3				1.151	1.230	
1012-1	4 lb Isotruxene,	9-9-71		150 @ 260°F		1.084 @ 260°F		12.5	59.5	72.1	28.2	16.8	16.8				1.157	1.337	
1012-2	3 lb Indene	"		"	"	"	"	16.9	56.1	67.5	29.1	16.4	16.4				1.172	1.340	
								14.7	57.8	69.8	28.7	16.6	16.6				1.165	1.359	
1013-1	2 lb Isotruxene,	9-13-71		105 @ 242°F	510 @ 225°F			11.5	48.2	54.4	28.1	13.5	13.5				1.163	1.320	
1013-2	2 lb Acenaptha-	"		"	"			10.7	51.5	57.7	27.5	14.2	14.2				1.158	1.322	
	lene,							11.1	49.9	56.1	27.8	13.9	13.9				1.161	1.321	
	1½ lb Indene																		
2ND REIMPREGNATION																			
1011-1	5 lb Acenaptha-	9-22-71		15 @ 198°F	7-10 @ 175°F	1.024 @ 198°F	1.024 @ 175°F	74.3	19.3	75.0	20.3	3.9	10.4				1.219	1.267	
1011-2	lene,	"		"	"	"	"	71.5	24.0	77.7	18.7	4.5	12.4				1.240	1.300	
	2 lb Indene							72.9	21.7	76.4	19.5	4.2	11.4				1.230	1.284	
1012-1	4 lb Isotruxene,	9-23-71		43-45 @ 255°F		1.104 @ 252°F		51.4	37.1	76.5	10.6	4.0	20.4				1.337	1.364	
1012-2	3 lb Indene	"		"	"	"	"	38.0	49.6	80.0	14.8	7.4	22.8				1.340	1.390	
								44.7	43.4	78.3	17.7	5.7	21.6				1.339	1.377	
1013-1	2 lb Isotruxene,	9-13-71	1 lb	120 @ 220°F	405 @ 205°F	1.09 @ 220°F	1.09 @ 205°F	20.4	57.2	72.0	16.3	9.4	24.1				1.230	1.436	
1013-2	2 lb Acenaptha-	"	Indene	"	"	"	"	20.6	64.4	81.1	16.0	10.3	25.9				1.322	1.458	
	lene,							20.5	60.8	76.6	16.2	9.9	25.0				1.321	1.447	
	1½ lb Indene																		
3RD REIMPREGNATION																			
1011-1	5 lb Acenaptha-	9-22-71		25-27 @ 180°F	22-24 @ 160°F	1.039 @ 180°F	1.034 @ 155°F	53.8	34.4	74.4	16.5	5.7	16.7	16.1			1.267	1.339	1.332
1011-2	lene,	"		"	"	"	"	51.7	33.3	69.0	14.7	4.9	17.9	17.4			1.300	1.365	1.358
	2 lb Indene							52.8	33.9	71.7	15.6	5.3	17.3	16.8			1.284	1.352	1.345
1012-1	4 lb Isotruxene	9-23-71	1½ lb	45-47 @ 215°F	175-177 @ 230°F	1.12 @ 215°F	1.144 @ 225°F	23.2	54.8	71.4	9.1	5.0	26.2	26.1			1.364	1.432	1.429
1012-2	3 lb Indene	"	Indene	"	"	"	"	25.4	52.4	70.2	7.2	3.8	28.1	27.4			1.390	1.442	1.439
								24.3	53.6	70.8	8.2	4.4	27.2	26.8			1.377	1.437	1.434
1013-1	2 lb Isotruxene,	9-13-71	1 lb	38-40 @ 230°F	270 @ 225°F	1.067 @ 230°F	1.088 @ 225°F	32.5	35.6	52.7	9.0	3.2	28.3	28.1			1.436	1.482	1.480
1013-2	2 lb Acenaptha-	"	Indene,					28.0	37.1	51.6	9.8	3.6	26.6	26.3			1.458	1.468	1.464
	lene,		1½ lb					30.3	36.4	52.2	9.4	3.4	27.5	27.2			1.447	1.475	1.472
	1½ lb Indene		Indene																

NOTE: Average value underlined.

TABLE VIII. DENSIFICATION HISTORY FOR AGCarb LAMINATES IMPREGNATED WITH 1097 MIXTURE

PIN	Viscosity- CPS		Impregnant Specific Gravity		Weight Loss % (Vols.)	Carbon Yield %		Laminate Weight Increase %			Specific Gravity			
	Before Reimpregnation	After Reimpregnation	Before Reimpregnation	After Reimpregnation		Uncured Basis	Cured Basis	Pickup	Incremental	Cumulative	Total thru Regraph.	Before / After Reimpregnation	After Regraph.	
1ST IMPREGNATION														
1067B	47 @ 250°F	130-135 @ 250°F	1.149 @ 245°F	1.172 @ 250°F	11.8	57.9	65.7	30.8	15.8	15.8		1.167	1.351	
1091-2	" "	" "	" "	1.144 250°F	12.1	58.5	66.5	30.6	17.9	17.9		1.150	1.356	
1094-1	" "	" "	" "	" "	12.1	58.6	66.5	29.3	17.2	17.2		1.133	1.328	
1094-2	" "	" "	" "	" "	12.8	58.6	67.2	29.4	17.2	17.2		1.142	1.339	
1104-1	" "	" "	" "	" "	11.3	58.5	65.9	28.9	16.9	16.9		1.175	1.374	
1104-2	" "	" "	" "	" "	12.1	58.7	66.7	29.4	17.2	17.2		1.152	1.351	
					<u>12.0</u>	<u>58.5</u>	<u>66.4</u>	<u>29.7</u>	<u>17.0</u>	<u>17.0</u>		<u>1.153</u>	<u>1.350</u>	
2ND IMPREGNATION														
1067B	40-47 @ 245°F	100 @ 220°F	1.162 @ 240°F	1.176 @ 220°F	13.3	55.6	64.1	10.1	5.6	22.0		1.347	1.423	
1091-2	" "	" "	" "	" "	13.6	54.5	63.2	13.7	7.5	26.0		1.349	1.450	
1094-1	" "	" "	" "	" "	14.3	56.0	65.3	13.3	7.4	25.8		1.327	1.426	
1094-2	" "	" "	" "	" "	12.4	56.9	65.1	11.0	6.3	24.5		1.338	1.422	
1104-1	" "	" "	" "	" "	16.7	55.3	66.4	12.8	7.1	25.1		1.372	1.470	
1104-2	" "	" "	" "	" "	14.8	56.1	66.8	12.4	6.9	25.0		1.347	1.440	
					<u>14.2</u>	<u>55.8</u>	<u>65.2</u>	<u>12.2</u>	<u>6.8</u>	<u>24.7</u>		<u>1.347</u>	<u>1.439</u>	
3RD IMPREGNATION														
1067B	150 @ 240°F				19.1	47.8	59.1	3.1	1.5	22.7	22.3	1.411	1.431	1.427
1091-2	" "				21.9	47.5	60.8	4.3	2.1	27.4	26.7	1.436	1.465	1.457
1094-1	" "				18.0	48.7	59.3	4.2	2.0	26.7	26.0	1.408	1.436	1.429
1094-2	" "				18.4	54.4	66.7	4.2	2.3	25.9	25.2	1.406	1.438	1.430
1104-1	" "				22.8	47.9	62.1	5.0	2.4	26.3	25.6	1.449	1.484	1.476
1104-2	" "				22.4	47.1	60.1	4.5	2.1	25.8	25.1	1.419	1.449	1.441
					<u>20.4</u>	<u>48.9</u>	<u>61.4</u>	<u>4.2</u>	<u>2.1</u>	<u>25.8</u>	<u>25.2</u>	<u>1.422</u>	<u>1.451</u>	<u>1.443</u>

NOTES: Mix date 10-4-71. Reimpregnation dates: 1st 10-4-71, 2nd 10-27-71, 3rd 11-9-71.
Average value underlined

TABLE IX

IMPREGNANT SYSTEMS IN PINS 1066A, 1062,
1063, 1065, 1042, AND 1057

<u>PIN No.</u>	<u>Prepreg Resin System</u>
1066A	Standard FM 5228
1062	EC 260 with USP 39 filler
1063	(EC 260 + USP 39) with USP 39 filler
1065	USP 39 and no pretreatment
1042	High volatiles
1057	EC 260 with a filler

TABLE X. SUMMARY OF STRENGTH, SHRINKAGE, AND WEIGHT LOSS DATA FOR COMPARISON OF CANDIDATE PREPREG RESIN SYSTEMS

PIN No.	Mat'l System	Strength-psi				Elastic Modulus psi $\times 10^6$		% Thickness Change			% Weight Change		
		Ultimate Tensile	Block Tensile	Ultimate Compression	Interlaminar Shear	Tensile	Compression	Precure to Postcure	Precure to Carb.	Precure to Graph.	Precure to Postcure	Precure to Carb.	Precure to Graph.
1066A	FM 5228 STD	6809	260	2778	583	.97	.42	A -1.45	-2.55	-3.27	A -3.83	-17.94	-18.99
		6842	246	2409	708	.97	.29	B -1.10	-1.84	-2.57	B -3.77	-17.86	-18.53
		6777	275	2848	681	.93	.44						
		<u>6809</u>	<u>260</u>	<u>2612</u>	<u>657</u>	<u>.96</u>	<u>.38</u>	<u>-1.28</u>	<u>-2.20</u>	<u>-2.92</u>	<u>-3.80</u>	<u>-17.90</u>	<u>-18.76</u>
1062	EC260 + USP 39 Filler	6800	290	2690	712	1.36	.47	A -1.09	-2.20	-4.03	A -5.62	-16.33	-16.90
		7800	273	3570	740	1.49	.27	B -1.45	-2.55	-4.38	B -5.90	-16.10	-16.71
		7600	244	3044	833	1.44							
		<u>7400</u>	<u>269</u>	<u>3101</u>	<u>762</u>	<u>1.40</u>	<u>.37</u>	<u>-1.27</u>	<u>-2.38</u>	<u>-4.21</u>	<u>-5.76</u>	<u>-16.22</u>	<u>-16.81</u>
1063	EC260 USP 39 + USP 39 Filler	7033	212	3055	602	1.25	.23	C -1.79	-2.15	-3.60	C -6.32	-16.76	-17.69
		7151	281	2925	806	1.30	.19	- .72	-2.15	-3.60	-6.44	-17.03	-17.69
		7750	277		861	1.41							
		<u>7311</u>	<u>256</u>	<u>2610</u>	<u>753</u>	<u>1.32</u>	<u>.21</u>	<u>-1.26</u>	<u>-2.15</u>	<u>-3.60</u>	<u>-6.38</u>	<u>-16.90</u>	<u>-17.69</u>
1065	USP 39 No Pre-treat	7240	242	2653	678	1.23	.22	A - .36	-1.46	-2.56	-7.07	-18.30	-18.91
		7172	418	2480	713	1.22	.29	B -1.09	-1.83	-2.56	-8.00	-19.02	-19.75
		7462	269	2802	706	1.34	.25	- .72	-1.64	-2.56	-7.54	-18.66	-19.33
		<u>7291</u>	<u>310</u>	<u>2551</u>	<u>699</u>	<u>1.26</u>							
1042	Hi Vols	6330	152	1344	446	.86	.27	A -3.23	-3.23	-3.94	-12.50	-23.15	-24.25
		5802	161	1910	566	.43	.15	B -1.82	-1.09	-1.82	-12.62	-23.13	-23.84
		7380	177	1955	597	.95	.21	<u>-2.52</u>	<u>-2.16</u>	<u>-2.88</u>	<u>-12.56</u>	<u>-23.14</u>	<u>-24.05</u>
		<u>6504</u>	<u>163</u>	<u>1646</u>	<u>530</u>	<u>.75</u>							
1057	EC260 + Filler	6930	115	775	333	1.00	.04	A -1.01	- .68	-1.35	- 6.23	-19.40	-18.96
		7125	127	940	297	.92	.06	B -1.32	- .66	-2.32	- 6.40	-19.20	-20.12
		6570	120	1026	339	1.43	.06	<u>-1.16</u>	<u>- .67</u>	<u>-1.84</u>	<u>- 6.32</u>	<u>-19.30</u>	<u>-19.54</u>
		<u>6875</u>	<u>121</u>	<u>914</u>	<u>323</u>	<u>1.12</u>	<u>.05</u>						
1057B		6456	-	968	336	.64	.12						
		6502	-	1150	339	.75	.09						
		6822	-	982	362	.67	.11						
		<u>6593</u>		<u>1000</u>	<u>346</u>	<u>.69</u>							
1057 + 1057B		<u>6734</u>	<u>121</u>	<u>957</u>	<u>334</u>	<u>.91</u>	<u>.08</u>						

NOTES: Underlined values are averages.

TABLE XI. DESCRIPTION OF T BAR SPECIMEN CONSTRUCTION AND TEST RESULTS

PIN No.	Specimen No.	Construction Description		Cell Wall (Web)			Liner (Flange)		Failure	
		Root (Radius)	Material	Thickness - in.			Width-in.	Length-in.	Load-lbs	Location
1047	1	Convex, old tool	Cell wall-fabric #3 PO 900112	.056,	.059,	.060	1.75 nom.	1.032	33.8	Cell wall
	2		Liner- 3D tufted PO 900112	.053,	.056,	.060	"	1.027	48.8	Root, liner to root
	3		No staging before mating	.055,	.057,	.059	"	1.030	35.4	Cell wall
1048	1	Convex, old tool	Cell wall-fabric #3 PO 900112	.066,	.069,	.073	"	1.020	66.8	Cell wall
	2		Liner- 3D tufted PO 900112	.065,	.067,	.074	"	1.020	62.2	Cell wall
	3		Staged prior to mating	.066,	.067,	.072	"	1.001	68.0	Root
1050	1	Convex, old tool	Cell wall-fabric #3 PO 900112	.057,	.059,	.060	"	1.015	78.8	Cell wall
	2		Liner- FM 5228 45° bias tape PO 900020	.055,	.058,	.060	"	1.011	52.2	Cell wall
	3		(PIN 1023) not macerated before mating	.056,	.058,	.060	"	1.012	60.4	Cell wall
1078	1	51° angle, root fibers extended .2-.4 from root base	Cell wall-fabric #3 PO 900112	.045,	.046,	.047	1.538	1.000	62.0	Root at base
	2		Liner- FM 5228 PO 01102, flat layup	.045,	.046,	.047	1.545	1.060	60.2	Root at base
	3		23 plies	.045,	.046,	.047	1.561	1.053	72.6	Root at base
1079	1	51° angle, root fiber edges only extended from root base	Cell wall-fabric #3 PO 900112	.053,	.052,	.053	1.75 nom.	1.035	44.2	Root at base
	2		Liner- FM 5228 PO 01102, flat layup	.053,	.052,	.053	"	1.026	52.9	Root at base
	3		23 plies	.051,	.052,	.051	"	1.040	38.6	Cell wall to root
1080	1	51° angle, root fibers extended 0-.3 from root base	Cell wall-fabric #3 PO 900112	.045,	.045,	.045	"	1.011	49.4	Root at base
	2		Liner- FM 5228 PO 01102, flat layup 23 plies, root mold debulked before mating	.045,	.045,	.045	"	1.012	62.4	Root at base
	3			.046,	.044,	.044	"	1.016	53.6	Cell wall to root
1087	1	Concave, new tool, root fibers extended 0-.3 from root base	Cell wall-fabric #3 PO 900112	.049,	.052,	.055	1.828	1.070	90.2	Cell wall to root
	2		Liner- FM 5228 PO 01102, flat layup	.049,	.052,	.056	1.826	1.074	39.0	Cell wall at root
	3		23 plies	.049,	.051,	.055	1.826	1.084	82.0	Cell wall in grips
1100	1	51° angle, root fibers extended .2-.4 from root base	Cell wall- FM 5228 PO 01102, 4 plies	.052,	.051,	.050	1.75 nom.	1.021	74.0	Cell wall to root
	2		preformed root FM 5228 strips	.053,	.052,	.050	"	1.029	48.4	Cell wall to root
	3		Liner- FM 5228 PO 01102 23 ply flat lay.	.054,	.051,	.050	"	1.016	73.2	Cell wall to root
1106	1	Concave, new tool root fibers extended .25-.35 from root base	Cell wall- FM 5228 PO 01102, 4 plies	.048,	.051,	.055	1.850	1.075	42.6	Liner radius
	2		preformed root FM 5228 strips; Liner-	.048,	.051,	.053	1.854	1.070	72.4	Liner radius
	3		FM 5228 PO 01102 flat layup 23 plies	.047,	.049,	.052	1.853	1.095	52.8	Liner radius
1107	1	51° angle, root fibers extended 0-.3 from root base	Cell wall- fabric #3 PO 900112	.060,	.053,	.048	1.75 nom.	1.020	59.8	Cell wall into root
	2		Liner- FM 5228 PO 01102, flat layup	.062,	.054,	.050	"	1.028	55.8	Cell wall into root
	3		23 plies	.065,	.059,	.053	"	1.022	42.4	Cell wall into root
1109	1	51° angle, 2 or 3 warp yarns extended from root base	Cell wall- fabric #3 PO 900112	.069,	.067,	.066	"	1.035	42.4	Cell wall
	2		Liner- FM 5228 PO 01102, flat layup	.065,	.063,	.064	"	1.014	44.0	Cell wall
	3		23 plies	.069,	.066,	.064	"	1.025	43.0	Cell wall

Figure 1. CARBON YIELD THROUGH CURE + CARBONIZE PROCESS STEPS OF EACH IMPREGNATION CYCLE FOR GRAPHITIZED FM 5228 LAMINATES IMPREGNATED WITH VARIOUS DENSIFICATION/BINDER SYSTEMS

Figure 2. CARBON YIELD DURING PROCESSING STEPS FOR GRAPHITIZED FM522B LAMINATES IMPREGNATED WITH VARIOUS DENSIFICATION/BINDER SYSTEMS SELECTED FOR REPRESENTATIVE BEHAVIOR

CARBON YIELD %

Figure 3. CARBON YIELD DURING PROCESSING STEPS FOR GRAPHITIZED FM5228 LAMINATES AND VARIOUS IMPREGNANTS

FM 5228 Item 01 P.O. NO 1102 Laminates;
ASHLAND 170 Densification/Binder System

Figure 4. Effect of Vacuum Pressure During Impregnation
on Carbon Yield in Graphitized Laminates Impregnated
With Ashland 170 Densification/Binder System

Figure 5. DENSIFICATION OF FM5228 GRAPHITE LAMINATES IMPREGNATED WITH 1057 MIXTURE

Figure 6. STRENGTH PROPERTIES OF CANDIDATE PREPREG
RESIN SYSTEMS (NO DENSIFICATION)

Figure 7. TENSILE AND COMPRESSION MODULUS OF CANDIDATE
PREPREG RESIN SYSTEMS (NO DENSIFICATION)

7. Thickness decrease
Precure to Process Step

Figure 9.

T BAR CONSTRUCTION FEATURES
AND NOMENCLATURE