EXHIBIT 2

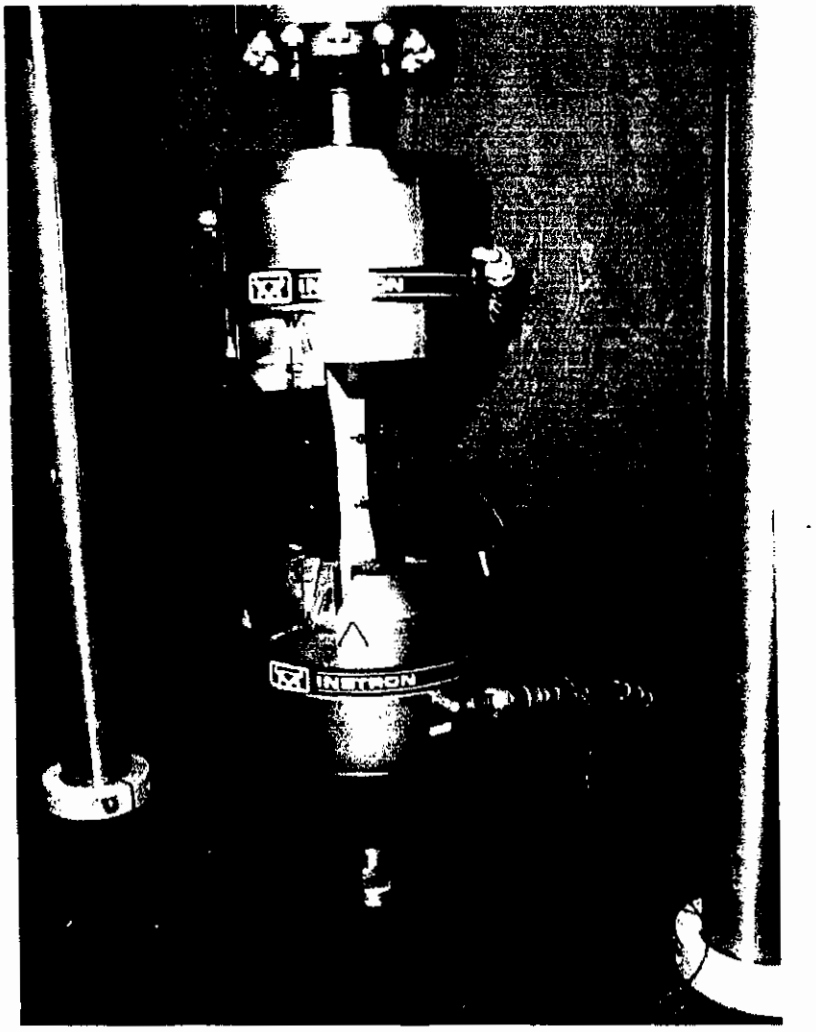
Advanced
Engineered
Wood
Composites
Center

University
of Maine

Research
Report
Number
AEWC 02-20

July 2002

On the Manufacture and Testing of Rigid PVC-Wood Composites



Douglas J. Gardner and Shane O'Neill

Memorandum

Date: July 8, 2002

To: Michael Zeliger
Fish & Richardson P.C.
225 Franklin Street
Boston, MA 02110-2804

From: Douglas J. Gardner, Ph.D.
Professor of Wood Science
Shane O'Neill, MSc.
Research Associate
Advanced Engineered Wood Composites Center
University of Maine

Subject: Results of Manufacturing and Testing of rigid PVC-wood composites.

Mr. Zeliger,

The purpose of this memo is to detail the manufacturing procedures used for the extrusion of rigid poly(vinyl) chloride (rPVC) and wood plastic composite samples, and the testing conducted per the April 15, 2002 letter from Heidi Harvey (see Appendix) and Proposal #02-31, approved by your office on April 18th, 2002. In that document, three wood:plastic ratios were to be manufactured: 33:67, 45:55, and 60:40. Also, the dimensions of the product were defined as ¾"thick and 5.5" wide. A test to measure the coefficient of thermal expansion ASTM D 696 and a non-destructive tensile test (ASTM D 638) were conducted to evaluate material properties (also outlined in Proposal #02-31).

The manufacturing of the wood-rPVC composite took place at the University of Maine's Advanced Engineered Wood Composites (AEWC) center on May 3rd and 6th, 2002. The extruder used was a Davis-Standard WT-94 Woodtruder® system, consisting of a counter-rotating 94 mm diameter twin parallel screw extruder with an adjoined 75 mm single screw extruder. The 75 mm extruder introduces molten polymer into the 94 mm extruder, which then mixes and extrudes the dried wood and molten polymer together. Both extruders are fed via Colortronics Graviblend gravimetric feeders. The extruded composite is then sent down a cooling tank, where it is then cut to length and stacked. Table 1 indicates the operating parameters recorded during the manufacture of the three wood-plastic composite groups.

Material testing was limited to two tests: a thermal expansion test (ASTM D 696) and a tensile test (ASTM D 638). The tensile test was conducted in accordance to the ASTM D 638 standard. The testing apparatus was an Instron 8801 servo-hydraulic universal testing machine at the AEWC center (Figure 1). Load and strain were electronically collected from the Instron, and a calculated value for the tensile stiffness (MOE) was determined. Figure 2 shows a representative stress-strain curve. Strain was directly measured using an extensometer, and stress is calculated as the load (measured directly using a load-cell) divided by the area (determined using calipers). Note that the line created in the stress-strain data contains a linear region. The slope of this line, in comparison of stress/strain, is the tensile stiffness of the composite. Table 2 indicates the results of the tensile testing. The important points to note is that the Average MOE for the three types of material are similar, with the highest value being the 45%.

For thermal expansion, ASTM D 696 was employed. This test uses a quartz-tube dilatometer (Figure 3). A sample is placed inside the dilatometer, which is then placed into a controlled temperature bath (both 30 C and –30 C are employed). The change in the length of the sample is noted on the dilatometer for both conditions, and the total change in length is compared to the total length in relation to temperature to get the coefficient of thermal expansion. Table 3 indicates the results of this testing. The values observed for the thermal expansion are similar to what is reported and observed for most wood-plastic composites.

Table 1: Processing Parameters During Extrusion

Parameter (all Temps are Celcius)	Run #1	Run #2	Run #3
75mm Temperature Zone 1	176	176	176
75mm Temperature Zone 2	188	188	188
75mm Temperature Zone 3	188	188	188
75mm Temperature Zone 4	190	190	190
75mm Temperature Zone 5	191	191	191
75mm Clamp 1 Temperature	190	190	190
75mm Clamp 2 Temperature	185	185	185
75mm Melt Temperature	183	184	184
75mm Adapter Temperature	187	186	186
75mm Pressure (psi)	850	900	1000
75mm Speed (RPM)	25	25	25
75mm Load (%)	33	33	34
Plastic Feed Rate (PPH)	70	70	70
WT94 Temperature Zone 1	190	190	200
WT94 Temperature Zone 2	190	190	200
WT94 Temperature Zone 3	190	190	190
WT94 Temperature Zone 4	180	180	180
WT94 Temperature Zone 5	185	185	185
WT94 Temperature Zone 6	181	181	181
WT94 Temperature Zone 7	175	175	175
WT94 Temperature Zone 8	163	163	163
WT94 Melt Temperature	150	152	158
WT94 Adapter Temperature	169	165	177
WT94 Pressure (psi)	600	400	1250
WT94 Speed (RPM)	18	18	18
WT94 Load (%)	40	33	64
Wood Feed Rate (PPH)	57	38	105
Ratio of Wood:Plastic	45:55	35:65	60:40
Extrusion Rate (FPM)	0.9	0.6	1.2
Vacuum (in Hg)	26	26	26
Die Temperature Zone 1	178	178	178
Die Temperature Zone 2	180	181	181
Die Temperature Zone 3	178	183	183
Die Temperature Zone 4	181	181	181

Figure 1: Instron 8801 Universal Testing Machine Conducting Tensile Test

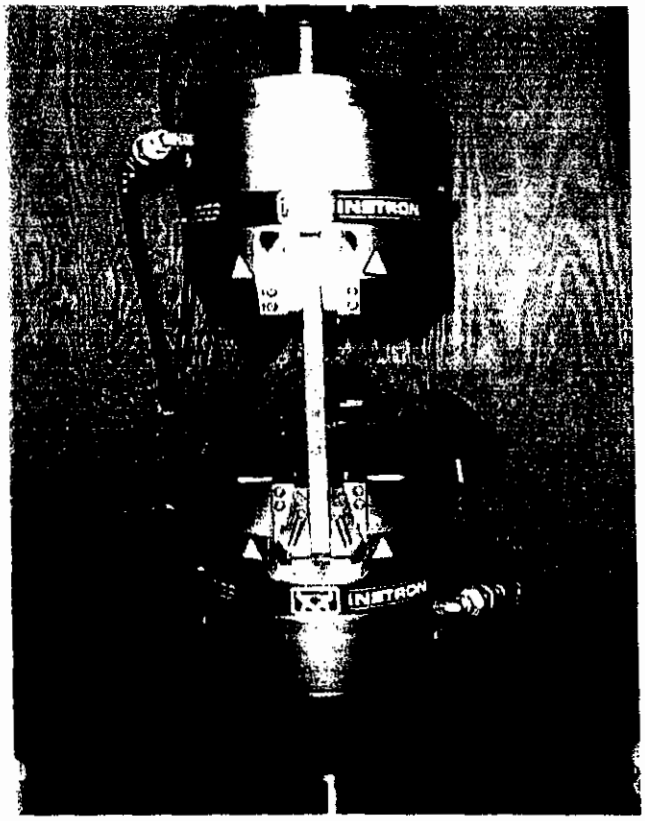


Figure 2: Tensile Stress-Strain Curve

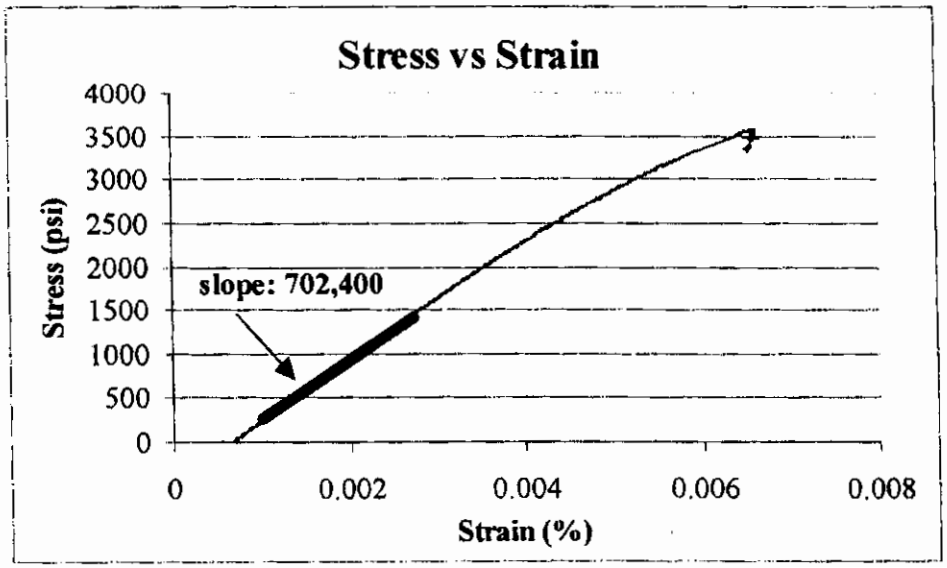
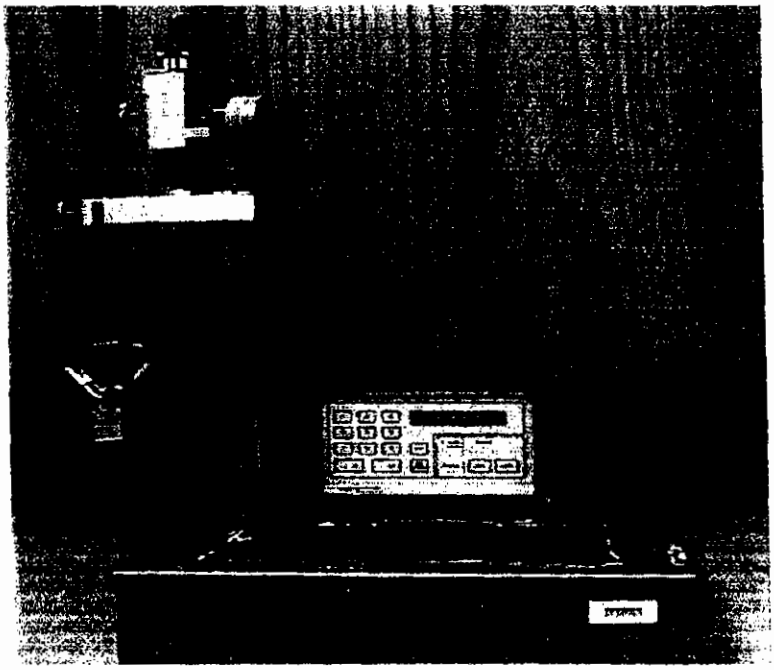


Table 2: ASTM D 638 Tensile Testing Results

Sample ID	Width 1 (in)	Width 2 (in)	Thickness 1 (in)	Thickness 2 (in)	Area (in^2)	Modulus (psi)	Average Modulus	COV (%)
35W-1	0.7850	0.7810	0.5840	0.5865	0.4583	695,298	669,911	5.2%
35W-2	0.7820	0.7950	0.5805	0.5825	0.4585	658,183		
35W-3	0.7985	0.8150	0.5855	0.5850	0.4722	630,104		
35W-4	0.7865	0.8015	0.5855	0.5835	0.4641	699,279		
35W-5	0.8010	0.7865	0.5800	0.5815	0.4610	706,154		
35W-6	0.7850	0.7965	0.5880	0.5850	0.4638	630,446		
45W-1	0.7810	0.7935	0.5730	0.5725	0.4509	698,656	745,528	3.9%
45W-2	0.7880	0.8045	0.5870	0.5855	0.4668	737,861		
45W-3	0.7940	0.7785	0.5850	0.5850	0.4600	730,494		
45W-4	0.7910	0.7775	0.5830	0.5820	0.4568	763,173		
45W-5	0.7875	0.8035	0.5850	0.5850	0.4654	776,487		
45W-6	0.8050	0.7840	0.5840	0.5845	0.4642	766,496		
60W-1	0.7830	0.8010	0.5830	0.5820	0.4613	694,006	728,386	4.7%
60W-2	0.7850	0.8050	0.5850	0.5840	0.4647	705,462		
60W-3	0.8045	0.7860	0.5490	0.5440	0.4346	719,864		
60W-4	0.7960	0.7805	0.5430	0.5490	0.4304	754,861		
60W-5	0.8060	0.7900	0.5495	0.5495	0.4385	712,152		
60W-6	0.7850	0.8055	0.5220	0.5400	0.4223	783,973		

Figure 3: Quartz Tube Dilatomer for Testing Thermal Expansion of Materials



Appendix: Copies of email correspondence between Mike Zeliger and Doug Gardner.

From: Michael Zeliger <zeliger@fr.com>
To: 'Doug Gardner' <doug_gardner@umenfa.maine.edu>, Michael Zeliger <zeliger@fr.com>, Heidi Harvey <harvey@fr.com>
Subject: RE: email test
Date: Mon, 15 Apr 2002 16:17:06 -0400
X-Mailer: Internet Mail Service (5.5.2653.19)

Message received. Thanks. My contact information appears below. Please call me if you have any questions.

Regards,

Mike

Michael E. Zeliger
Fish & Richardson P.C.
225 Franklin Street
Boston, MA 02110-2804
Tel: 617-956-5925
Fax: 617-542-8906
email: zeliger@fr.com
http://www.fr.com

NOTE: This email is intended for the addressee(s) only and may contain privileged or confidential information. If you have received this email in error please, please notify us immediately.

-----Original Message-----
From: Doug Gardner [mailto:doug_gardner@umenfa.maine.edu]
Sent: Monday, April 15, 2002 4:11 PM
To: zeliger@fr.com; harvey@fr.com
Subject: email test

Hi:

Regarding our phone conversation this morning, I am sending you an email message. I will need you contact information for sending you a proposal.

Address:
Phone and FAX numbers

THanks for you help,

Doug Gardner

From: Michael Zeliger <zeliger@fr.com>
To: 'Doug Gardner' <doug_gardner@umenfa.maine.edu>
Subject: RE: letter received
Date: Wed, 17 Apr 2002 13:38:38 -0400
X-Mailer: Internet Mail Service (5.5.2653.19)

Doug,

Table 3: Coefficient of Thermal Expansion Data

Sample ID	Ambient Length (mm)	Length @ -30 C (mm)	Change in Length (mm)	Length @ 30 C (mm)	Change in Length (mm)	Coeff. Of Thermal Expansion (m/m/C)	Average Thermal Expansion	COV
35W-1	80.6196	80.5026	-0.117	80.6466	0.027	2.98E-05	2.99E-05	11.7%
35W-2	81.5848	81.4508	-0.134	81.6048	0.02	3.15E-05		
35W-3	81.4197	81.3007	-0.119	81.4437	0.024	2.93E-05		
35W-4	81.1403	81.0023	-0.138	81.1663	0.026	3.37E-05		
35W-5	80.5434	80.4134	-0.13	80.5654	0.022	3.15E-05		
35W-6	81.5975	81.5015	-0.096	81.6165	0.019	2.35E-05		
45W-1	81.68	81.562	-0.118	81.704	0.024	2.90E-05	2.67E-05	14.8%
45W-2	81.67	81.571	-0.099	81.69	0.02	2.43E-05		
45W-3	81.86	81.78	-0.08	81.886	0.026	2.16E-05		
45W-4	81.7	81.595	-0.105	81.72	0.02	2.55E-05		
45W-5	81.79	81.677	-0.113	81.81	0.02	2.71E-05		
45W-6	81.76	81.634	-0.126	81.796	0.036	3.30E-05		
60W-1	81.81	81.702	-0.108	81.832	0.022	2.65E-05	2.75E-05	12.6%
60W-2	81.93	81.828	-0.102	81.948	0.018	2.44E-05		
60W-3	81.81	81.69	-0.12	81.842	0.032	3.10E-05		
60W-4	81.85	81.723	-0.127	81.881	0.031	3.22E-05		
60W-5	81.53	81.42	-0.11	81.554	0.024	2.74E-05		
60W-6	81.45	81.353	-0.097	81.468	0.018	2.35E-05		

Conclusion

Three different wood-rPVC extruded composite panels were produced here at the AEWC per Proposal #02-31 between the AEWC and Fish and Richardson P.C. The tensile MOE was determined non-destructively using ASTM D 638, and the coefficient of thermal expansion was determined using ASTM D 696, also within accordance of said proposal.

Thanks for the information. If I understand your email correctly, you believe you have all the raw materials you need. Is that correct? Also, is it possible to move the report date up to May 10, since our deadline to turn it around in the case is the 15th? Please advise. Thanks.

Regards,

Mike

Michael E. Zeliger
Fish & Richardson P.C.
225 Franklin Street
Boston, MA 02110-2804
Tel: 617-956-5925
Fax: 617-542-8906
email: zeliger@fr.com
http://www.fr.com

NOTE: This email is intended for the addressee(s) only and may contain privileged or confidential information. If you have received this email in error please, please notify us immediately.

-----Original Message-----
From: Doug Gardner [mailto:doug_gardner@umenfa.maine.edu]
Sent: Wednesday, April 17, 2002 11:34 AM
To: Michael Zeliger; harvey@fr.com
Cc: shane.O'Neill@umit.maine.edu
Subject: RE: letter received

Dear Mike and Heidi:

Received your letter and the copies of patents. This work will be kept confidential based on your request.

Some comments:

1. The patents don't specify the type of PVC formulation, so I am assuming that we may be able to use what we have on hand here to expedite our extrusion runs.

2. The 45% wood 55% PVC may be doable on our equipment. We can try the 33% wood 67% PVC but I can't promise that we will get a lumber type product.

3. We have 4 dies available. All dies have 5.5" widths. 2 dies are 5/4" thick (solid or hollow cross section) and 2 dies 3/4" thick (solid or hollow cross section). I suggest using the 3/4" solid cross section die because we have experience with this die running PVC and wood.

4. Running wood fiber with a 1 mm length will be problematic for our extruder feed system. We typically extrude at 0.5 mm or less in length. WE purchase wood flour that has been milled and passed through a particular screen mesh size such as 20 mesh, 40 mesh, etc. The mesh size provides for a distribution of particle sizes. See this web site for more detail http://www.restekcorp.com/meshes.htm One of the patents (Hopperdietzel) describes particle sizes in the range we typically run. We can discuss in greater detail.

5. I have a rough proposal (see attached) that has been routed internally through our lab. and once we agree on the formulations. we can set up a project.

Call or write if you have questions.

Sincerely,

Doug Gardner

From: Michael Zeliger <zeliger@fr.com>
To: 'Doug Gardner' <doug_gardner@umenfa.maine.edu>, Michael Zeliger <zeliger@fr.com>
Cc: shane.O'Neill@umit.maine.edu
Subject: RE: American Wood Fibers, Inc.
Date: Thu, 18 Apr 2002 08:44:03 -0400
X-Mailer: Internet Mail Service (5.5.2653.19)

Great. lets proceed. Thanks. -Mike

Michael E. Zeliger
Fish & Richardson P.C.
225 Franklin Street
Boston, MA 02110-2804
Tel: 617-956-5925
Fax: 617-542-8906
email: zeliger@fr.com
http://www.fr.com

NOTE: This email is intended for the addressee(s) only and may contain privileged or confidential information. If you have received this email in error please, please notify us immediately.

-----Original Message-----
From: Doug Gardner [mailto:doug_gardner@umenfa.maine.edu]
Sent: Thursday, April 18, 2002 8:42 AM
To: zeliger@fr.com
Cc: shane.O'Neill@umit.maine.edu
Subject: Fwd: American Wood Fibers, Inc.

Mike:

Here is some info on wood flour aspect ratios.

Doug

>From: Mike Pisczor <MPisczor@AWF.com>
>To: "'doug_gardner@umenfa.maine.edu'" <doug_gardner@umenfa.maine.edu>
>Subject: American Wood Fibers, Inc.
>Date: Wed, 17 Apr 2002 18:00:05 -0400
>X-Mailer: Internet Mail Service (5.5.2653.19)
>
>Doug,

>
>How are things going up in Maine? I just wanted to follow-up with you on
>your questions regarding aspect ratios in our wood flour products.
>Generally our products have the following aspect rations (l/w):
>
>
>oak - 2.5 - 3/1
>maple - 3/1
>ponderosa pine - 4/1
>southern pine - 4/1
>spruce - 4/1
>
>
>These aspect ratios remain similar even when moving from one mesh size
>product to another. For instance, a 20 mesh maple and a 40 mesh maple will
>have similar aspect ratios. about 3/1.
>
>
>Hopefully this helps. Call or e-mail if we can be of further assistance.
>
>Regards,
>
>
>Mike Pisczor
>Industrial Account Manager
>American Wood Fibers, Inc.
>
>715-355-1900 phone
>715-355-5721 fax
>mpisczor@awf.com e-mail
>www.awf.com Website

From: Michael Zeliger <zeliger@fr.com>
To: 'Doug Gardner' <doug_gardner@umenfa.maine.edu>
Subject: RE: Fiber Composites Testing
Date: Wed, 1 May 2002 10:40:57 -0400
X-Mailer: Internet Mail Service (5.5.2653.19)

Thanks for the update.

-----Original Message-----
From: Doug Gardner [mailto:doug_gardner@umenfa.maine.edu]
Sent: Wednesday, May 01, 2002 10:37 AM
To: Michael Zeliger
Cc: shane.O'Neill@umit.maine.edu
Subject: Re: Fiber Composites Testing

We are scheduled to run your extrusion trial on friday. The materials
testing will be run early next week.

Doug

At 08:33 AM 5/1/2002 -0400, you wrote:
>Hi Doug,
>

>I'm just checking in to see how the testing is going. If you could give me
>an update, I would appreciate it. Thanks.
>
>Regards.
>
>Mike
>
>Michael E. Zeliger
>Fish & Richardson P.C.
>225 Franklin Street
>Boston, MA 02110-2804
>Tel: 617-956-5925
>Fax: 617-542-8906
>email: zeliger@fr.com
>http://www.fr.com
>
>NOTE: This email is intended for the addressee(s) only and may contain
>privileged or confidential information. If you have received this email in
>error please, please notify us immediately.

From: Michael Zeliger <zeliger@fr.com>
To: 'Doug Gardner' <doug_gardner@umenfa.maine.edu>, Michael Zeliger
<zeliger@fr.com>
Cc: shane.O'Neill@umit.maine.edu
Subject: RE: Fiber Composites Testing
Date: Tue, 7 May 2002 08:21:48 -0400
X-Mailer: Internet Mail Service (5.5.2653.19)

Doug,

Thanks for the update. Please give me or Heidi a call after you have some results and before you prepare your report, so we can discuss the form of the report.

-Mike

Michael E. Zeliger
Fish & Richardson P.C.
225 Franklin Street
Boston, MA 02110-2804
Tel: 617-956-5925
Fax: 617-542-8906
email: zeliger@fr.com
http://www.fr.com

NOTE: This email is intended for the addressee(s) only and may contain privileged or confidential information. If you have received this email in error please, please notify us immediately.

-----Original Message-----
From: Doug Gardner [mailto:doug_gardner@umenfa.maine.edu]
Sent: Monday, May 06, 2002 2:06 PM
To: Michael Zeliger
Cc: shane.O'Neill@umit.maine.edu
Subject: RE: Fiber Composites Testing

Mike:

We successfully extruded the wpc composites today. The testing should be done over the next few days. I will talk with you later in the week.

Doug

At 10:40 AM 5/1/2002 -0400, you wrote:
>Thanks for the update.
>
>-----Original Message-----
>From: Doug Gardner [mailto:doug_gardner@umenfa.maine.edu]
>Sent: Wednesday, May 01, 2002 10:37 AM
>To: Michael Zeliger
>Cc: shane.O'Neill@umit.maine.edu
>Subject: Re: Fiber Composites Testing
>
>
>We are scheduled to run your extrusion trial on friday. The materials
>testing will be run early next week.
>
>Doug
>
>
>At 08:33 AM 5/1/2002 -0400, you wrote:
> >Hi Doug,
> >
> >I'm just checking in to see how the testing is going. If you could give
me
> >an update, I would appreciate it. Thanks.
> >
> >Regards,
> >
> >Mike
> >
> >Michael E. Zeliger
> >Fish & Richardson P.C.
> >225 Franklin Street
> >Boston, MA 02110-2804
> >Tel: 617-956-5925
> >Fax: 617-542-8906
> >email: zeliger@fr.com
> >http://www.fr.com
> >
> >NOTE: This email is intended for the addressee(s) only and may contain
> >privileged or confidential information. If you have received this email
in
> >error please, please notify us immediately.

From: Michael Zeliger <zeliger@fr.com>
To: 'Doug Gardner' <doug_gardner@umenfa.maine.edu>
Subject: RE: Fiber Composites Testing
Date: Thu, 16 May 2002 15:47:53 -0400
X-Mailer: Internet Mail Service (5.5.2653.19)

Doug,

Thank you very much for the results. Do you have time Tuesday to discuss the form of the report? I am available all day. Thanks.

Regards,

Mike

-----Original Message-----
From: Doug Gardner [mailto:doug_gardner@umenfa.maine.edu]
Sent: Friday, May 10, 2002 4:41 PM
To: Michael Zeliger
Subject: RE: Fiber Composites Testing

Mike:

Attached is a brief letter that summarizes the material property values for the extruded PVC-wood composites. We can discuss these in more detail.

Doug

From: Michael Zeliger <zeliger@fr.com>
To: 'Doug Gardner' <doug_gardner@umenfa.maine.edu>, Michael Zeliger <zeliger@fr.com>
Cc: Heidi Harvey <harvey@fr.com>
Subject: RE: Fiber Composites Testing
Date: Thu, 16 May 2002 16:40:38 -0400
X-Mailer: Internet Mail Service (5.5.2653.19)

Doug,

Thanks for the update. I am not available on those days, but Heidi Harvey will call you early Monday afternoon. In the interim, feel free to forward the bill for the run and testing to me and I will see that it is paid.
Thanks again.

Regards,

Mike

-----Original Message-----
From: Doug Gardner [mailto:doug_gardner@umenfa.maine.edu]
Sent: Thursday, May 16, 2002 4:11 PM
To: Michael Zeliger
Subject: RE: Fiber Composites Testing

Mike:

I will only be in on Monday next week. I will be attending the wood fiber plastics conference in Toronto the remainder of the week. Do you have time to discuss on Friday or Monday?

We have samples cut and ready to palletized for shipment.

The costs for the extrusion run and testing is $6480.

Look forward to hearing from you.

Doug

From: Michael Zeliger <zeliger@fr.com>
To: 'Doug Gardner' <doug_gardner@umenfa.maine.edu>
Subject: RE: Fiber Composites Testing
Date: Tue, 21 May 2002 08:49:50 -0400
X-Mailer: Internet Mail Service (5.5.2653.19)

Great. thanks for the update.

-----Original Message-----
From: Doug Gardner [mailto:doug_gardner@umenfa.maine.edu]
Sent: Monday, May 20, 2002 1:13 PM
To: Michael Zeliger
Cc: harvey@fr.com
Subject: RE: Fiber Composites Testing

Mike:

I spoke with Heidi today about the testing report, and I plan to have a draft to you by the end of the month (May 30 or 31).

Sincerely,

Doug