Freeze Fitting Project – Test Report 12/10/15

Important Note:

The data and conclusions in this test report are for *Slide*Rite Materials ONLY and not applicable to other manufacturers or materials.

1.1 Purpose :

To accumulate and record data regarding the behavior of three grades of *Slide*Rite composite materials: P103, P302 and P314 when subjected to a shrink fit, using LN_2, and installed into a steel housing. All measurements are in inches. The data will be used to:

1.1.1 Calculate the amount and percentage the outside diameter reduces when immersed in LN_2 for a period of 20-25 Minutes.

1.1.2 The amount of press transferred to the inside diameter, calculation the amount of loss, if any, due to the elasticity of the material.

1.1.3 Determine if the three material grades react differently with respect to 1.1.1 and 1.1.2

1.1.4 Create an operator friendly computer program using the data to determine the machining dimensions of any size bushing.

1.2 Set-up :

1.2.1 Housings

Five heavy walled steel housing were constructed and measured. The results are shown in Table 001.

Table 001

Inside Diameter	Outside Diameter	Length
5.000	6.75	3.50
6.700	8.50	3.50
9.229	12.00	3.50
14.128	16.75	3.50
20.180	22.75	3.50

1.2.2 Bushing

Bushing samples were machined using an ID - OD tool. This technique eliminates the variance in the wall thickness that occurs when using a 'single point' method of machining, and subsequently the need to factor in tolerances when recording the data. All bushing were machined using a .25% interference fit. Samples are marked with an index number. Results are recorded in tables 002-004 by material specification.

Table 002 P103

Index Number	Cross Section	Outside Diameter
1	0.499	5.015
2	0.749	5.015
2	0.995	5.015
4	0.499	6.721
5	0.750	6.720
6	0.995	6.721
7	0.499	9.320
8	0.750	9.320
9	0.994	9.321
10	0.750	14.180
11	0.994	14.181
12	1.225	14.180
13	0.750	20.225
14	0.994	20.226
15	1.224	20.225

Table 003 P302

Index Number	Cross Section	Outside Diameter
1	0.490	5.016
2	0.750	5.014
2	0.795	5.015
4	0.499	6.720
5	0.750	6.721
6	0.995	6.721
7	0.499	9.320
8	0.750	9.320
9	0.994	9.321
10	0.750	14.180
11	0.994	14.180
12	1.250	14.180
13	0.750	20.224
14	0.994	20.225
15	1.250	20.225

Table 004 P314

Index Number	Cross Section	Outside Diameter
1	0.499	5.015
2	0.750	5.016
2	0.995	5.015
4	0.499	6.721
5	0.750	6.720
6	0.995	6.721
7	0.499	9.319
8	0.750	9.320
9	0.994	9.321
10	0.750	14.180
11	0.994	14.181
12	1.249	14.180
13	0.749	20.225
14	0.994	20.225
15	1.251	20.225

1.3 Test - Immersion and Fitting :

The samples, in no particular order, are placed in a container which is filled with LN_2 until the samples are fully immersed for a period of 20-25 minutes.

After the required time the samples are, one by one, mounted in a vise and the outside diameter is measured with a stainless steel Pi tape.

The data recorded and the sample placed into its corresponding housing. Results are recorded in tables 005-007 by material specification.

Table 005 - P103

Index Number	Outside Diameter	Percent Reduction
1	4.996	0.38%
2	4.992	0.46%
2	4.990	0.50%
4	6.693	0.41%
5	6.690	0.45%
6	6.688	0.48%
7	9.274	0.49%
8	9.275	0.48%
9	9.274	0.50%
10	14.124	0.39%
11	14.125	0.39%
12	14.121	0.42%
13	20.115	0.54%
14	20.145	0.40%
15	20.133	0.45%

Table 006 – P302

Index Number	Outside Diameter	Percent Reduction
1	5.0020	0.27%
2	4.9900	0.48%
2	4.9920	0.46%
4	6.6900	0.45%
5	6.6830	0.56%
6	6.6850	0.53%
7	9.2760	0.47%
8	9.2710	0.53%
9	9.2750	0.49%
10	14.1100	0.49%
11	14.1160	0.45%
12	14.1100	0.49%
13	20.1250	0.49%
14	20.1200	0.52%
15	20.1270	0.48%

Table 007 - P314

Index Number	Outside Diameter	Percent Reduction
1	4.988	0.54%
2	4.985	0.61%
2	4.990	0.50%
4	6.692	0.42%
5	6.691	0.43%
6	6.690	0.45%
7	9.273	0.49%
8	9.260	0.64%
9	9.272	0.52%
10	14.115	0.46%
11	14.120	0.43%
12	14.115	0.46%
13	20.140	0.42%
14	20.145	0.40%
15	20.140	0.42%

1.4 Data Collection

The samples are allowed to return to ambient temperature, 65-72 degrees F. The inside diameters are measured, recorded and the percentage of wall thickness transfer is calculated using the difference, if any, between the calculated and measured inside diameters. Results are in tables 008-010

Table 008 – P103

Index Number	Calculated ID After Fitting	Measured ID After Fitting	% Wall Transfer
1	4.002	4.004	99.95%
2	3.502	3.502	100.00%
2	3.001	3.012	99.97%
4	5.703	5.703	100.00%
5	5.201	5.201	100.00%
6	4.711	4.771	100.00%
7	8.301	8.302	99.99%
8	7.799	7.799	100.00%
9	7.311	7.311	100.00%
10	12.648	12.650	99.98%
11	12.160	12.160	100.00%
12	11.699	11.700	99.99%
13	18.681	18.682	99.99%
14	18.192	18.193	99.99%
15	17.732	17.733	99.99%

Table 009 P302

Index Number	Calculated ID After Fitting	Measured ID After Fitting	% Wall Transfer
1	4.021	4.021	100.00%
2	3.501	3.502	99.97%
2	3.011	3.012	99.97%
4	5.702	5.703	99.98%
5	5.201	5.201	100.00%
6	4.711	4.707	100.08%
7	8.301	8.302	99.99%
8	7.799	7.800	99.99%
9	7.311	7.311	100.00%
10	12.648	12.649	99.99%
11	12.160	12.161	99.99%
12	11.648	11.649	99.99%
13	18.681	18.686	99.97%
14	18.192	18.193	99.99%
15	17.680	17.687	99.96%

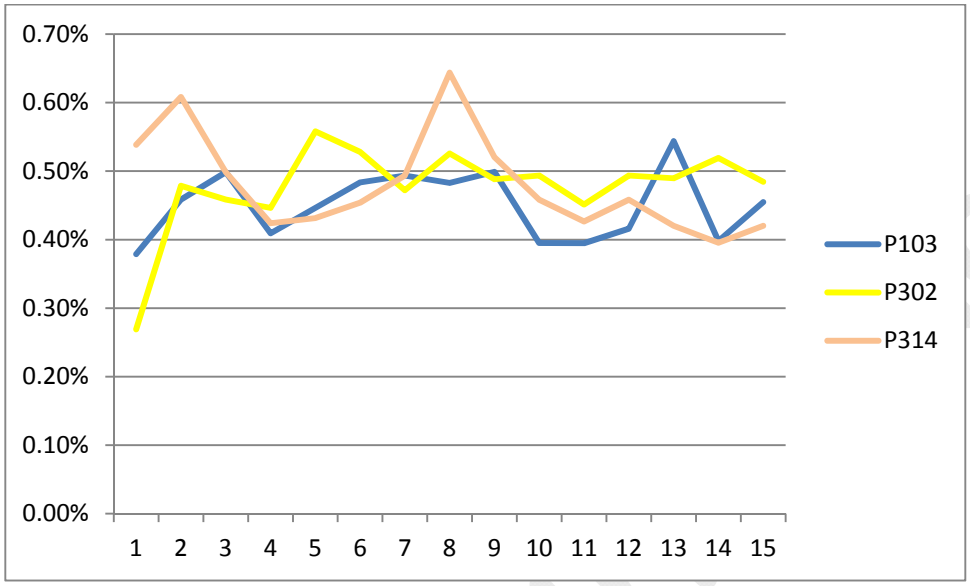
Table 010_P314

Index Number	Calculated ID After Fitting	Measured ID After Fitting	% Wall Transfer
1	4.002	4.002	100.00%
2	3.501	3.501	100.00%
2	3.011	3.011	100.00%
4	5.702	5.703	99.98%
5	5.201	5.200	100.02%
6	4.771	4.708	100.06%
7	8.311	8.303	99.98%
8	7.799	7.805	99.92%
9	7.311	7.307	100.05%
10	12.648	12.649	99.99%
11	12.160	12.157	100.02%
12	11.650	11.648	100.02%
13	18.682	18.685	99.98%
14	18.192	18.189	100.02%
15	17.679	17.687	99.95%

1.5 Conclusions :

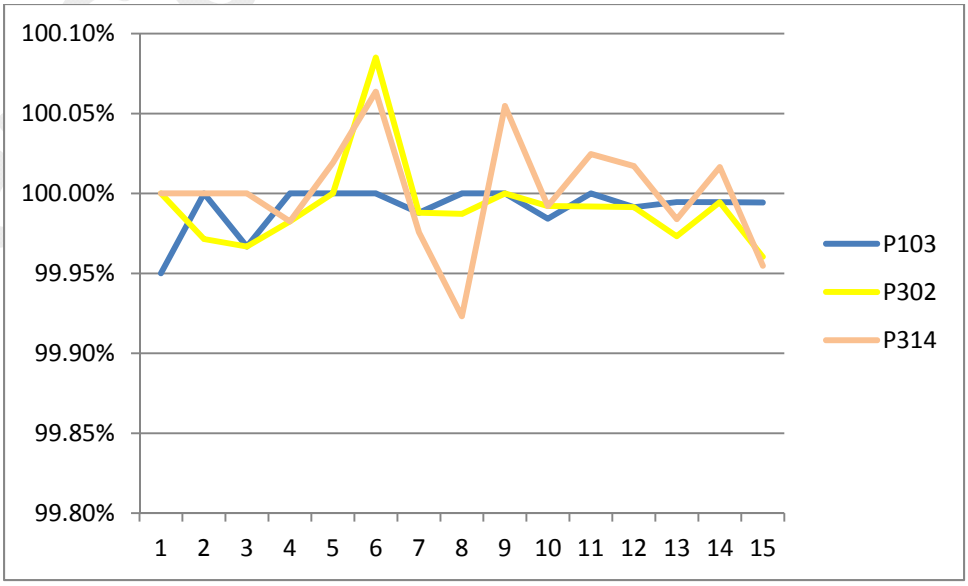
1.5.1 The percentage of outside diameter reduction of the three materials is illustrated in Graph 001. For software calculations a shrinkage rate of .5% will be used.

Graph 001



1.5.2 The percentage of wall thickness transfer due to bore closure of the three materials is illustrated in Graph 002. For software calculations this will be disregarded as the value is consistently close enough to 100% and is considered negligible.

Graph 002



1.5.3 The materials do not react differently and is a non-factor in bushing design dimensions with respect to freeze fitting techniques.

1.5.4 Software calculations are as follows:

Bushing interference fit = Outside Diameter * .25%

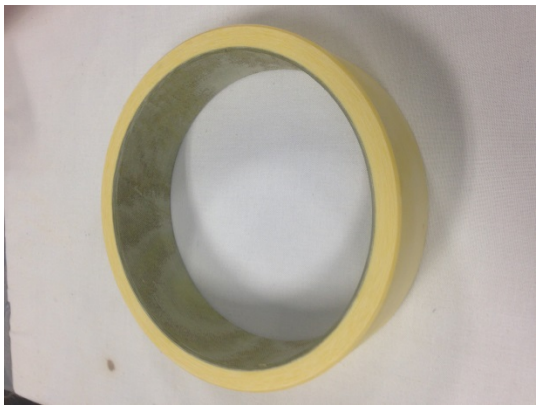
Bushing Shrink in LN_2 = Outside Diameter * .50%

1.6 Addendum:

Three additional questions arose during the testing:

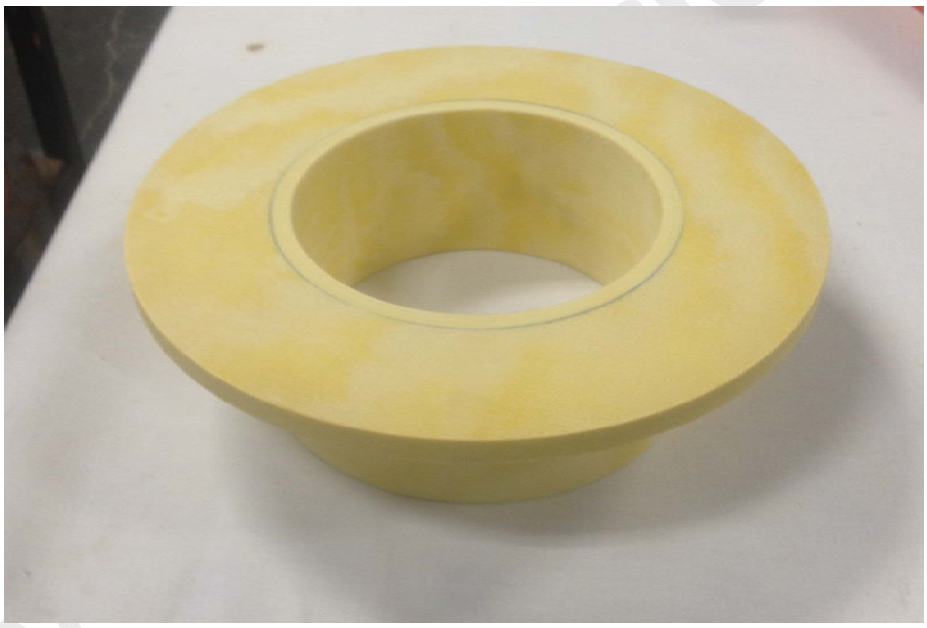
1.6.1 Will the hybrid material P302/PTFE react the same when subjected to LN_2. A bushing with a .125 inside layer of PTFE fabric, illustration 001, and an outside diameter of 11.450 reduced to 11.401 or a percentage of .43% concluding that it does.

Illustration 001



1.6.2 Flanged bushing with high thrust loads are often constructed by bonding a washer to a bushing using a proprietary adhesive. Would the cryogenic temperatures required in the shrinking fitting process damage the bond? A sample was made, illustration 002, and immersed in LN_2 for 20-25 minutes. Once removed the flange was subject to repeated hammer blows attempting to separate it from the bushing. The bond did not break.

Illustration 002



1.6.3 Does a bushing after installation loosen in the housing when subjected to subzero weather? A test sample installed in housing and allowed to reach ambient temperature was immersed in LN_2 until the temperature reached -40° F. Repeated hammer blows failed to move the bushing. The sample was replaced in the LN_2 for 20-25 minutes. The bushing moved slightly under repeated hammer blows, shown in illustration 003, but did not continue movement after a few minutes when the temperature of the bushing reached about -100° F.

Illustration 003