Commercial Solutions Division

Extension Observations of 3M™ Print Wrap Film IJ280 and 3M™ Gloss Wrap Overlaminate 8428G

Technical Report

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Contents

Introduction and Background

The new 3M™ Print Wrap Film IJ280 with 3M™ Gloss Wrap Overlaminate 8428G (IJ280 + 8428G) were designed to provide superior conformability for vehicle wrap applications. Customers observed relative ease while stretching the films in recesses and around curvatures on vehicles. We set out to quantify the forces required to stretch IJ280 + 8428G in comparison to other leading print wrap films. At 12.5% strain, IJ280 + 8428G stretched with less force than other print wrap films.

Application of graphic films to vehicles varies greatly from installer-to-installer and film-to-film. We observed typical strains where installers attempted to stretch films either with or without the aid of hot air or heat gun. In some instances, installers cold stretch films with or without the aid of a low friction application glove. One location this was frequently observed was on the rear quarter panel of a Chevy HHR (General Motors, Chevrolet HHR, 2011). In this location the engineering strain during installation of the graphic was estimated to be 5%.

Figure 1. Rear quarter panel of 2011 Chevy HHR indicating representative location for conformability experiential testing.

Alternatively, installers stretched films around the bumpers with approximately 20% strain in extreme circumstances depending on the install technique. Considering the range of common strains, 12.5% was selected to represent the strain for testing in the laboratory.

Experimental Procedure

The force to stretch a film a constant displacement or strain was used as an analog to the ease of conformability during an install on a vehicle. Using a Universal Test Machine (UTM), films were stretched according to ASTM D3759-05(2011) [1] at 23°C {73.4°F} and 50°C {122°F}.

Samples were prepared by laminating a clear overlaminate to an unprinted wrap film. Lamination was completed on a 76.2 cm {30 inch} wide rubber roll laminator at approximately 1.8 meters {6 feet} per minute with 550 kPa {80 psi} laminator input pressure. Care was taken to minimize the input and output lamination tensions. Each sample was cut to 25.4 mm {1.0 inch} wide strips. Samples were acclimated in a constant temperature and humidity (CTH) room at 23°C {73.4°F} and 50% relative humidity for a minimum of 1 day prior to measurement. Samples were cut from adjacent sections of the film to minimize thru roll contributions to variation.

Strips of film were mounted in the UTM with a 50.8 mm {2.0 inch} wide jaw spacing with the adhesive liner removed. Care was taken to ensure samples were flat, not wrinkled, and mounted parallel to the direction of travel of the UTM. The maximum initial preload force was 0.67 N {0.15 lbf}. Samples were stretched in the UTM at a rate of 304.8 mm {12 inches} per minute.

Measurements at 50°C {122°F} were captured using a UTM equipped with an oven capable of heating and cooling the film sample and the test fixture. The oven and test fixture were acclimated for 15 minutes after reaching the set point before testing was started. Samples were clamped in the jaws and heated for 60 seconds before initiating the test routine.

Figure 2. UTM with chamber/oven for testing tensile properties at alternative temperatures.

Comparative industry leading print wrap films were chosen for their prevalence in the marketplace (see Table 1).

Table 1. List of film pairs tested.

	Product Name	
Short Name	**Print Film**	**Overlaminate**
IJ180mC + 8518	3M™ Controltac™ Print Wrap Film IJ180mC-10	3M™ Scotchcal™ Gloss Overlaminate 8518
IJ180Cv3 + 8518	3M™ Controltac™ Graphic Film with Comply™ Adhesive IJ180Cv3-10	3M™ Scotchcal™ Gloss Overlaminate 8518
IJ280 + 8428G	3M™ Print Wrap Film IJ280	3M™ Gloss Wrap Overlaminate 8428G
1105 EZRS + 1460Z	Avery Dennison™ MPI1105 SuperCast Easy Apply RS	Avery Dennison™ DOL 1460Z Gloss Overlaminate
SLX + 3210	Arlon™ SLX™ Cast Wrap	Arlon™ Series 3210 Premium Cast Overlaminate

Ten films from 3 lots of each laminated print film and overlaminate film combination were measured for 30 total measurements. Further details can be found in Appendix C. Films were measured in random order at each temperature.

Analysis Procedures

Data was analyzed with Minitab 19.2020.1 (Minitab, LLC. State College, PA, USA).

Minitab was used to determine if any print film with overlaminate film pair was statistically the same or statistically different than other film pairs. One-way ANOVA with Tukey pairwise comparison was used to identify groups. Grouping by the Tukey pairwise method identified groups either statistically the same or statistically different with a 95% confidence interval (null hypothesis: all means are equal).

Results and Discussion

Individual value plots of all data at each temperature was plotted for visual examination of the results. The analysis of variance, Tukey pairwise comparison and residuals were reported for both temperatures. See Appendix D for a complete summary.

23°C Results

Visual examination of the individual value plot shows the distribution of forces required to stretch films 12.5% (Figure 3).

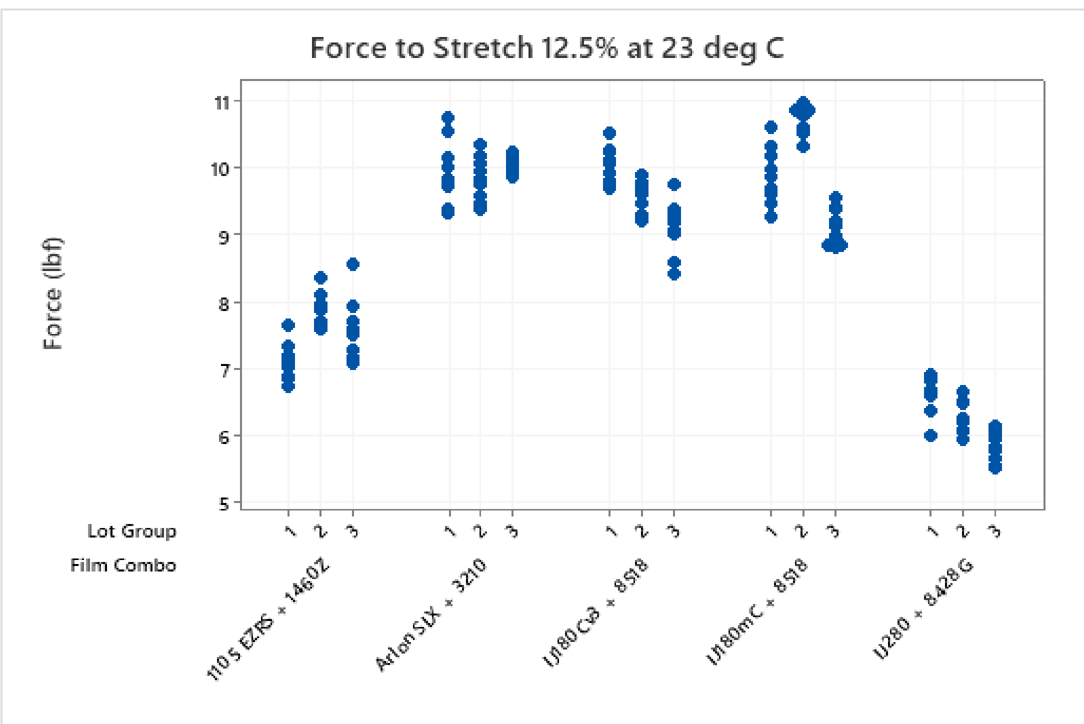


Figure 3.

Examining the results for the films measured at CTH conditions, the analysis of variance had a P-Value of 0.000 indicating we had multiple groups. The new IJ280 + 8428G combination of print wrap film and overlaminate had the lowest average force needed to stretch the film at 23°C and was grouped statistically lower than the next lowest combination, 1105 EZRS + 1460Z.

Analysis of Variance

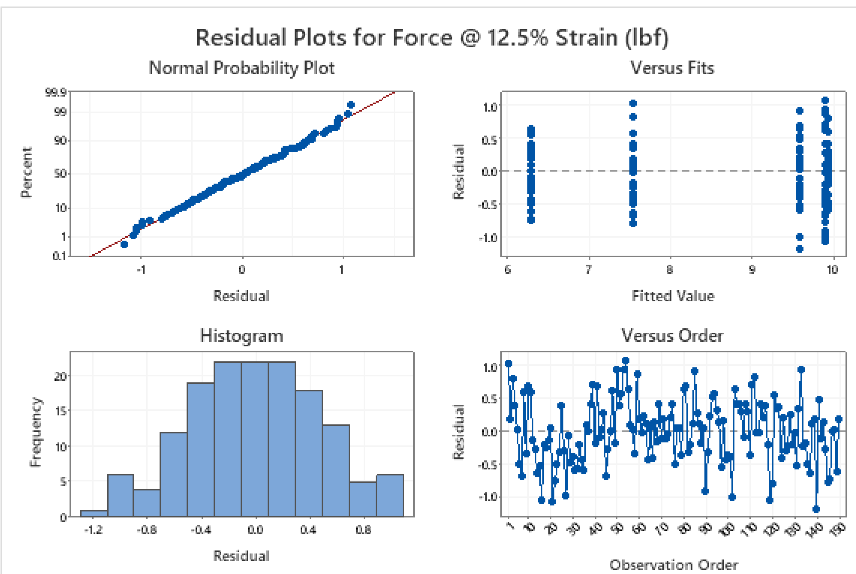
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Film Combo	4	328.54	82.1358	333.85	0.000
Error	145	35.67	0.2460		
Total	149	364.22			

Grouping Information Using the Tukey Method and 95% Confidence

Film Combo	N	Mean	Grouping		
Arlon SLX + 3210	30	9.9352	A		
IJ180mC + 8518	30	9.900	A		
IJ180Cv3 + 8518	30	9.5852	A		
1105 EZRS + 1460Z	30	7.5354		B	
IJ280 + 8428G	30	6.2795			C

Means that do not share a letter are significantly different.

The residual plots validate the experiment execution sample preparation and random measurement order with a normal distribution.



The individual value plot highlighted the new IJ280 + 8428G required the least amount of force to stretch 12.5% with at least 95% confidence.

50°C Results

Visual examination of the individual value plot shows the distribution of forces required to stretch films 12.5% (Figure 4) and again the IJ280 + 8428G required the least amount of force.

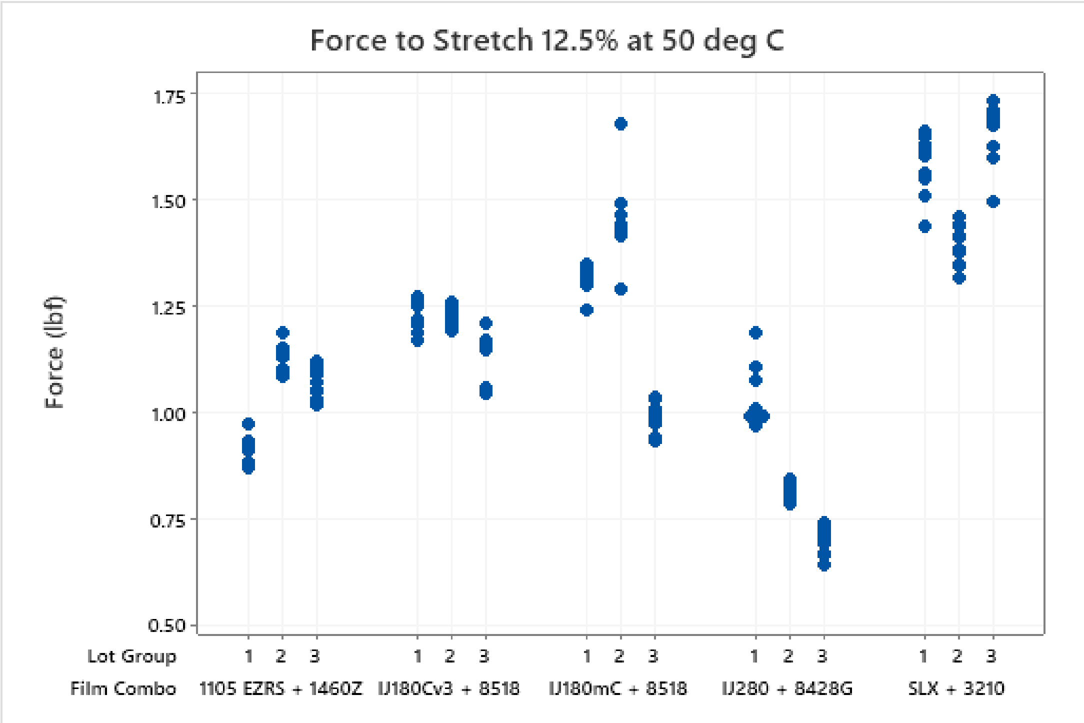


Figure 4.

Next, we examined the results for the films measured at 50°C test conditions. The analysis of variance had a P-Value of 0.000 indicating we had multiple groups. Again, the new IJ280 + 8428G combination of print wrap film and overlaminate had the lowest average force needed to stretch the film at 50°C and was grouped statistically lower than the next lowest combination, 1105 EZRS + 1460Z.

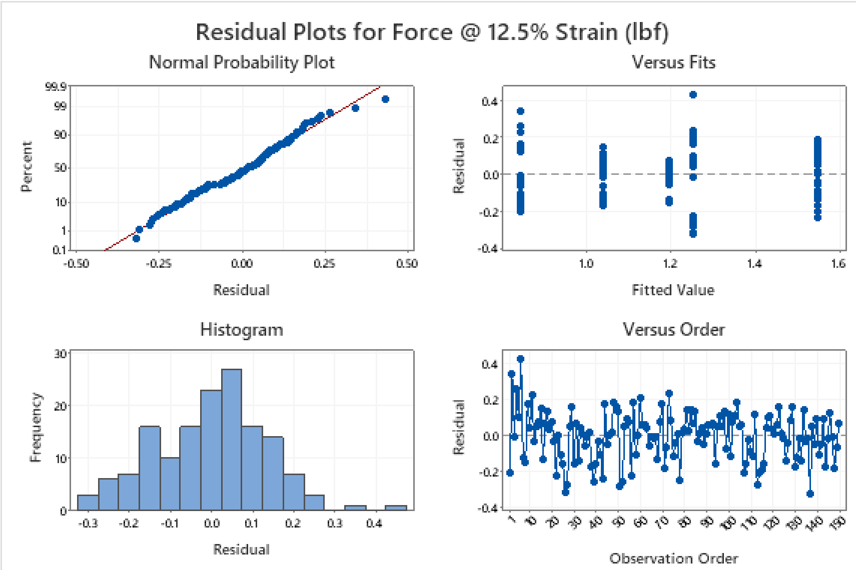
Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Film Combo	4	8.225	2.05613	108.64	0.000
Error	145	2.744	0.01893		
Total	149	10.969			

Grouping Information Using the Tukey Method and 95% Confidence

Film Combo	N	Mean	Grouping			
SLX + 3210	30	1.5490	A			
IJ180mC + 8518	30	1.2522		B		
IJ180Cv3 + 8518	30	1.19737		B		
1105 EZRS + 1460Z	30	1.0377			C	
IJ280 + 8428G	30	0.8448				D

Means that do not share a letter are significantly different.



The residual plots validate the experiment execution sample preparation and random measurement order with a normal distribution.

The individual value plot showed the new IJ280 + 8428G required the least amount of force to stretch 12.5% with at least 95% confidence.

At 23°C, it was clear the new IJ280 + 8428G required less force to stretch. As films were heated to 50°C, the absolute difference in the forces required to stretch were smaller but IJ280 + 8428G still required the least amount of force to stretch.

Summary and Conclusions

As vehicle wrap installers stretch films into recesses and around curvatures the force required to stretch the film directly translates into the amount of work required. The less force, the less work [2]. For a shallow recess a film requiring less force to stretch may mean an installer requires less heat from a heat gun. In some circumstances no heat may be required at all. The new IJ280 + 8428G was easier to install and requires a minimal amount of heat during installations. In other words, IJ280 + 8428G conforms with less heat as compared to leading alternatives (see Table 1).

References

[1] "ASTM D3759-05(2011)," ASTM-International, 2011.

[2] W. Benenson, J. W. Harris, H. Stocker and H. Lutz, "Work and Energy," in *Handbook of Physics*, New York, Springer, 2002, pp. 63-65.

Appendices

Appendix A. Acronyms & Definitions

Acronym	Definition
ASTM	ASTM International (formerly known as American Society for Testing and Materials)
Cold Stretch	Stretching film at ambient temperature without the aid of a heat source.
CSD	3M™ Commercial Solutions Division
CTH	Constant Temperature and Humidity
UTM	Universal Test Machine

Appendix B. Equipment

Universal Test Machine

Manufacturer: Instron™, Norwood, MA.

Test Apparatus. System ID EMSYSU4242

Load Cell: Model 2580-500N

Oven/Chamber: Model 3119-609

Software: Bluehill Version 4.13

Appendix C. Test Films

Print Film	Lot/Identifier Lot Group 1	Lot Group 2	Lot Group 3
3M™ Print Wrap Film IJ280	A479030	L2024614	L2029408
3M™ Controltac™ Graphic Film with Comply™ Adhesive IJ180Cv3-10	L2001119	L2020308	L2024404
3M™ Controltac™ Print Wrap Film IJ180mC-10	L2016905	L2003305	L2024906
Avery Dennison™ MPI1105 SuperCast Easy Apply RS	ZF2906190L2602111	ZF2906200A2001703	ZF2906200C1000519
Arlon™ SLX™ Cast Wrap	S07160024	S02260104	T07010027

Overlaminate	Lot/Identifier Lot Group 1	Lot Group 2	Lot Group 3
3M™ Gloss Wrap Overlaminate 8428G	G72203	P202400106	P2029401
3M™ Scotchcal™ Closs Overlaminate 8518	P200750318	P202540208	P202640111
3M™ Scotchcal™ Closs Overlaminate 8518	P200030405	P202250119	P202640116
Avery Dennison™ DOL 1460Z Gloss Overlaminate	290E200A080001	ZF2908190G3002103	ZF2906200G2800230
Arlon™ Series 3210 Premium Cast Overlaminate	S04070050	T04200039	S08260122

Appendix D. One-way ANOVA Output

AT 23C

One-way ANOVA: Force @ 12.5% Strain (lbf) versus Film Combo

Method

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Film Combo	5	1105 EZRS + 1460Z, Arlon SLX + 3210, IJ180Cv3 + 8518, IJ180mC + 8518, IJ280 + 8428G

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Film Combo	4	328.54	82.1358	333.85	0.000
Error	145	35.67	0.2460		
Total	149	364.22			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.496009	90.21%	89.94%	89.52%

Means

Film Combo	N	Mean	StDev	95% CI
1105 EZRS + 1460Z	30	7.5354	0.4571	(7.3564, 7.7144)
Arlon SLX + 3210	30	9.9352	0.3244	(9.7562, 10.1142)
IJ180Cv3 + 8518	30	9.5852	0.4858	(9.4062, 9.7642)
IJ180mC + 8518	30	9.900	0.719	(9.721, 10.079)
IJ280 + 8428G	30	6.2795	0.4043	(6.1005, 6.4585)

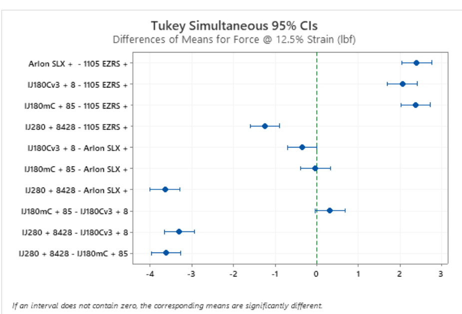
Pooled StDev = 0.496009

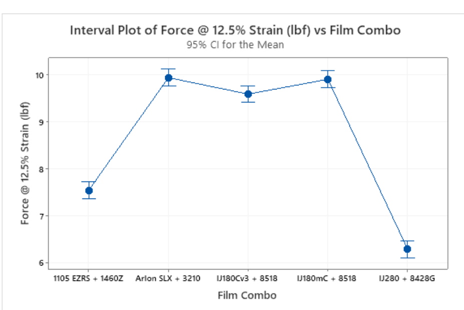
Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Film Combo	N	Mean	Grouping		
Arlon SLX + 3210	30	9.9352	A		
IJ180mC + 8518	30	9.900	A		
IJ180Cv3 + 8518	30	9.5852	A		
1105 EZRS + 1460Z	30	7.5354		B	
IJ280 + 8428G	30	6.2795			C

Means that do not share a letter are significantly different.





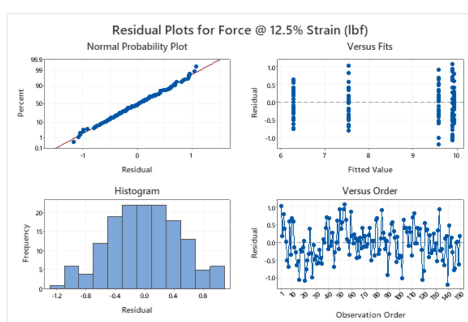


Figure 5. One-way ANOVA with Tukey Pairwise for 23°C

AT 50C

One-way ANOVA: Force @ 12.5% Strain (lbf) versus Film Combo

Method

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Film Combo	5	1105 EZRS + 1460Z, IJ180Cv3 + 8518, IJ180mC + 8518, IJ280 + 8428G, SLX + 3210

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Film Combo	4	8.225	2.05613	108.64	0.000
Error	145	2.744	0.01893		
Total	149	10.969			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.137574	74.98%	74.29%	73.23%

Means

Film Combo	N	Mean	StDev	95% CI
1105 EZRS + 1460Z	30	1.0377	0.0979	(0.9881, 1.0874)
IJ180Cv3 + 8518	30	1.19737	0.05382	(1.14772, 1.24701)
IJ180mC + 8518	30	1.2522	0.2071	(1.2025, 1.3018)
IJ280 + 8428G	30	0.8448	0.1487	(0.7952, 0.8945)
SLX + 3210	30	1.5490	0.1310	(1.4993, 1.5986)

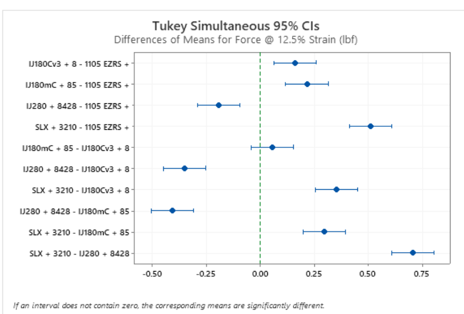
Pooled StDev = 0.137574

Tukey Pairwise Comparisons

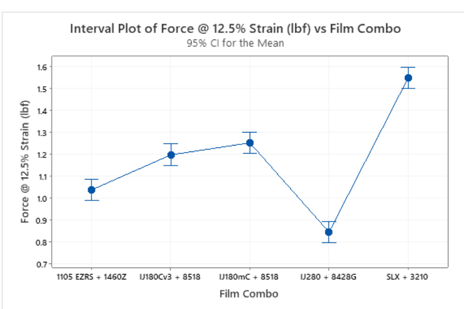
Grouping Information Using the Tukey Method and 95% Confidence

Film Combo	N	Mean	Grouping			
SLX + 3210	30	1.5490	A			
IJ180mC + 8518	30	1.2522		B		
IJ180Cv3 + 8518	30	1.19737		B		
1105 EZRS + 1460Z	30	1.0377			C	
IJ280 + 8428G	30	0.8448				D

Means that do not share a letter are significantly different.



If an interval does not contain zero, the corresponding means are significantly different.



The pooled standard deviation is used to calculate the intervals.

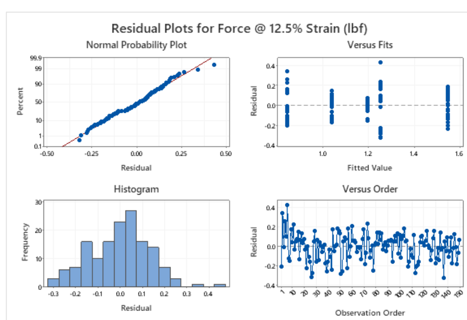


Figure 6. One-way ANOVA with Tukey Pairwise for 50°C