The Anisotropy of Parafilm From Latin Square Tests

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Study Object

One of the most widely used materials in modern laboratories.

- Mostly used to temporarily seal something like a tube.

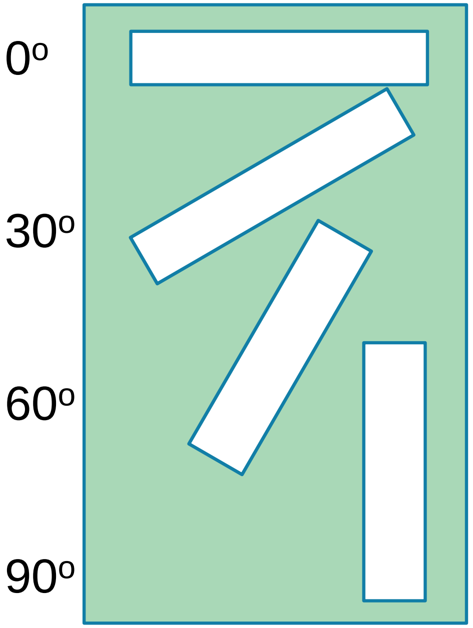
- So, the extension features of the parafilm is quite important

How could I use the parafilm most effectively?
>>>>> How could I pull this as long as possible ?
>>>> What variable may possible affect this?

Identify design factors and their roles

1. Angles

Dependent on how the material is made, the extension properties may be different at different directions.



2. Temperature

For most materials, temperature would affect the extension properties.

At what temperature can I use PARAFILM?

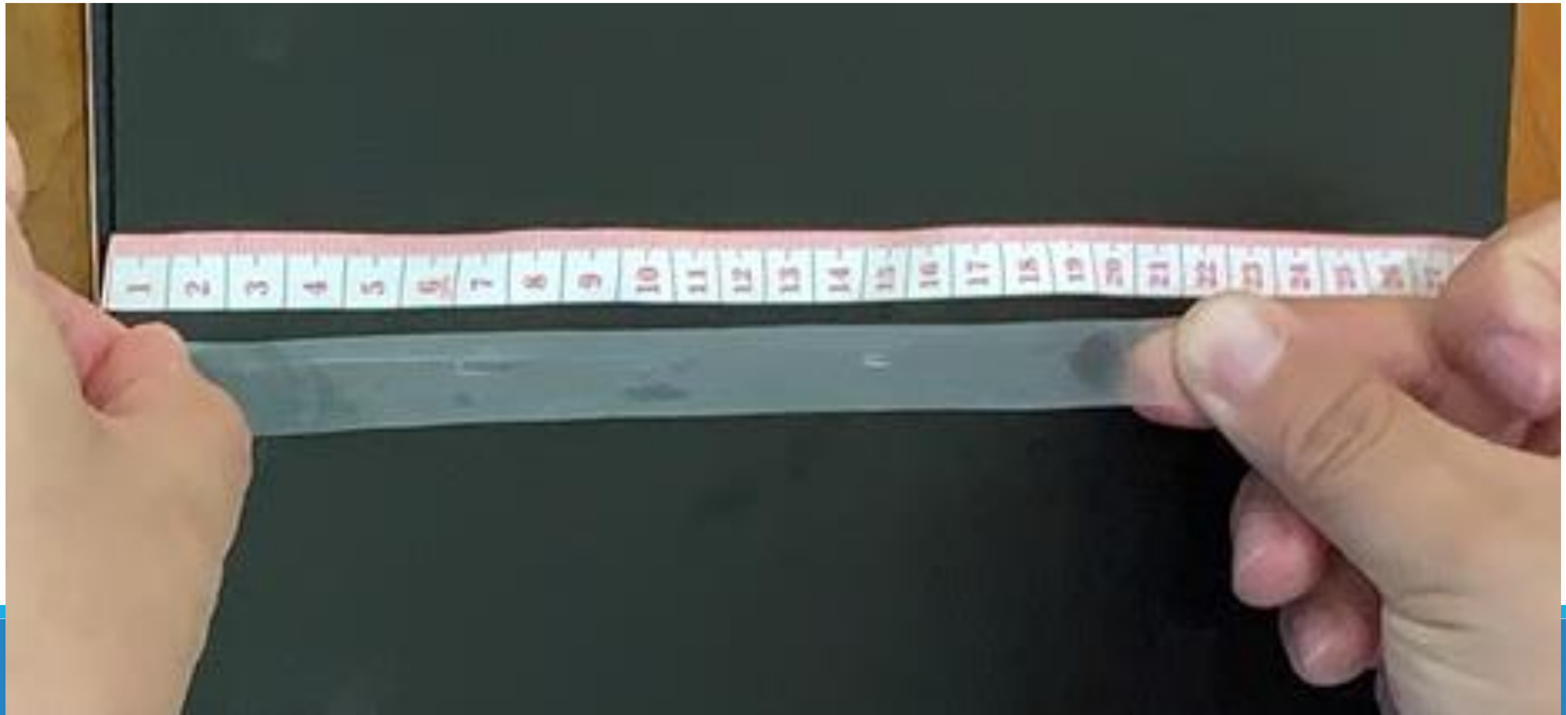
Temperature range (continuous use): -45 to +50°C,

melting point: 60°C, flash point: 301°C

A: 0 ^oC B: 15 ^oC C: 30 ^oC D: 45 ^oC

Response Parameters:

1. Fix the width and initial length (1cm x **5cm**)
2. Select the experimental conditions(Angle and Temperature)
3. Pull
4. Measure the **maximum length** before breaks.



Experimental Design

Factors we want to exam:

- **Angle**
  (4 Levels: 0º,30º,60º, 90º)
- **Temperature**
  (4 Levels: 0 ºC, 15 ºC, 30 ºC, 45 ºC)

Factors we need to include into the model:

- **Block effect from persons**
  (4 Levels: Liu, Shang, Xu, Shi)
- **Repeat effect from two independent**
  (N repeats)

Full Factorial Design:
64N data points

Latin Square Design
16N data points

	cars			
drivers	1	2	3	4
1	A=24	B=26	D=20	C=25
2	D=23	C=26	A=20	B=27
3	B=15	D=13	C=16	A=16
4	C=17	A=15	B=20	D=20

Latin Square Design – 1

Model and Assumptions

$$y_{ijk} = \mu + \alpha_i + \tau_j + \beta_k + \epsilon_{ijk}, \quad i, j, k = \textbf{1,2,3,4}$$

μ - grand mean

α_i - ith block 1 effect (ith row effect); $\sum_{i=1}^{p} \alpha_i = 0.$ **Person effect**

τ_j - jth treatment effect; $\sum_{i=1}^{p} \tau_j = 0$ **Temperature effect**

β_k - kth block 2 effect (kth column effect); $\sum_{k=1}^{p} \beta_k = 0$ **Angle effect**

$\epsilon_{ijk} \sim \mathrm{N}(0, \sigma^2)$; (Normality, Independence, Constant Variance).

Completely additive model (no interaction)

Degree of Freedom for the error term: (p-1) (p-2) = 3x2 = **6**

With 2 replicates: (p-1) [n(p+1)-3] = 3 x (5n-3) = **21**

16 more data points contribute to 15 more degree of freedom (3.5 times the original)

Latin Square Design – with 2 replicates

temperature effect repeat effect

$$y_{ijkl} = \mu + \alpha_i + \tau_j + \beta_k + \delta_l + \epsilon_{ijkl} \quad \begin{cases} i = 1,2,3,4 \\ j = 1,2,3,4 \\ k = 1,2,3,4 \\ l = 1,2 \end{cases}$$

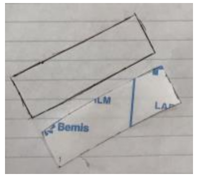
person effect angle effect

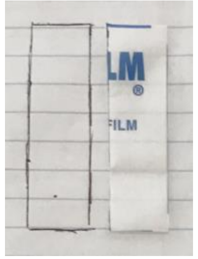
Degree of Freedom for the error term: (p-1) (p-2) = 3x2 = **6**

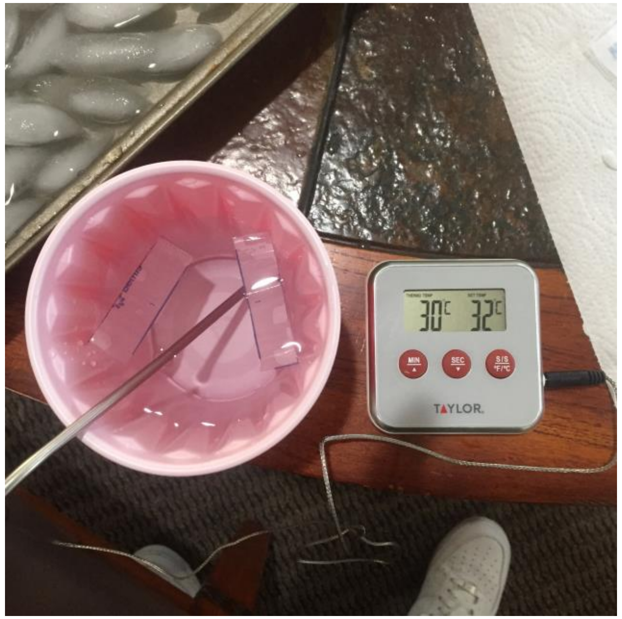
With 2 replicates: (p-1) [n(p+1)-3] = 3 x (5n-3) = **21**

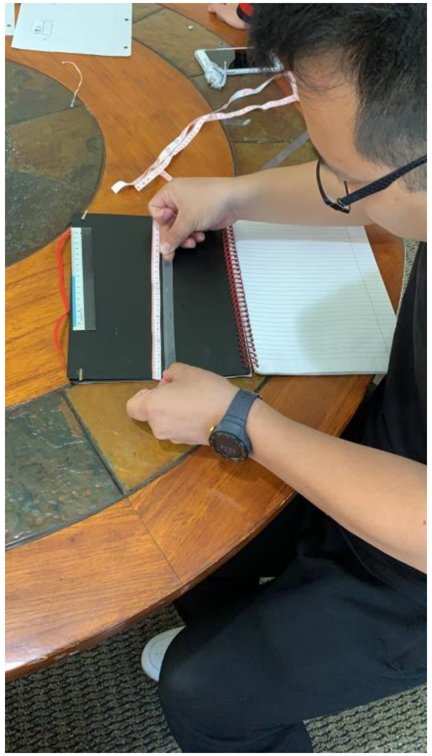
16 more data points contribute to 15 more degree of freedom (3.5 times the original)

Data Collection









4 different angles

4 different temperatures

Pull and Measure

Raw Data

Repeat 1		Angle			
		0^o	30^o	60^o	90^o
Person	Shang	A=20.2	B=19.1	C=16.4	D=18.5
	Liu	B=21.1	C=21.9	D=16.6	A=20.6
	Xu	C=18.8	D=18.5	A=16.5	B=18.6
	Shi	D=20.0	A=20.2	B=16.6	C=17.6

Repeat 2		Angle			
		0^o	30^o	60^o	90^o
Person	Shang	A=19.6	B=19.4	C=15.7	D=19.4
	Liu	B=21.9	C=21.3	D=17.0	A=19.8
	Xu	C=18.9	D=18.0	A=16.8	B=18.3
	Shi	D=21.0	A=19.6	B=17.0	C=18.0

Temperature

A : 0° C

B: 15° C

C: 30° C

D: 45° C

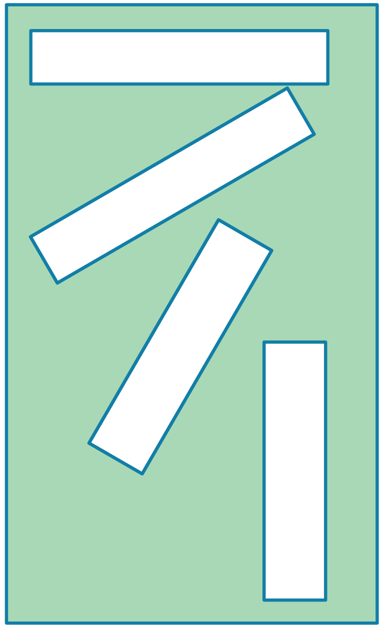
Angle

0^o

30^o

60^o

90^o



SAS code: Latin square design

```
proc glm data=parafilm;
  title 'GLM model of Latin Square Design with 2 replicates';
  class repeat person angle temp;
  model length=repeat person angle temp;
  means angle/lines tukey;
  means temp/lines tukey;
  means person/lines tukey;
  means repeat/lsd;
  output out=diag p=pred r=res;
run;
```

SAS output

GLM model of Latin Square Design with 2 replicates

The GLM Procedure

Dependent Variable: length

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	81.18812500	8.11881250	16.93	<.0001
Error	21	10.06906250	0.47947917		
Corrected Total	31	91.25718750			

R-Square	Coeff Var	Root MSE	length Mean
0.889663	3.675273	0.692444	18.84063

Source	DF	Type I SS	Mean Square	F Value	Pr > F
repeat	1	0.00281250	0.00281250	0.01	0.9397
person	3	17.02343750	5.67447917	11.83	<.0001
angle	3	62.19343750	20.73114583	43.24	<.0001
temp	3	1.96843750	0.65614583	1.37	0.2797

Tukey's Studentized Range (HSD) Test for length

ols the Type I experimentwise error rate, but it generally has a higher Type II error

Alpha	0.05
Error Degrees of Freedom	21
Error Mean Square	0.479479
Critical Value of Studentized Range	3.94181
Minimum Significant Difference	0.965

Means with the same letter are not significantly different.				
Tukey Grouping		**Mean**	**N**	**angle**
	A	20.1875	8	0°
	A			
B	A	19.7500	8	30°
B				
B		18.8500	8	90°
	C	16.5750	8	60°

Tukey's Studentized Range (HSD) Test for length

ıe Type I experimentwise error rate, but it generally has a higher Type II error

Alpha	0.05
Error Degrees of Freedom	21
Error Mean Square	0.479479
Critical Value of Studentized Range	3.94181
Minimum Significant Difference	0.965

Means with the same letter are not significantly different.			
Tukey Grouping	**Mean**	**N**	**temp**
A	19.1625	8	0°C
A			
A	19.0000	8	15°C
A			
A	18.6250	8	45°C
A			
A	18.5750	8	30°C

Tukey's Studentized Range (HSD) Test for length

ıe Type I experimentwise error rate, but it generally has a higher Type II ε

Alpha	0.05
Error Degrees of Freedom	21
Error Mean Square	0.479479
Critical Value of Studentized Range	3.94181
Minimum Significant Difference	0.965

Means with the same letter are not significantly different.			
Tukey Grouping	**Mean**	**N**	**person**
A	20.0250	8	LIU
B	18.7500	8	SHI
B			
B	18.5375	8	SHANG
B			
B	18.0500	8	XU

t Tests (LSD) for length

; the Type I comparisonwise error rate, not the experime

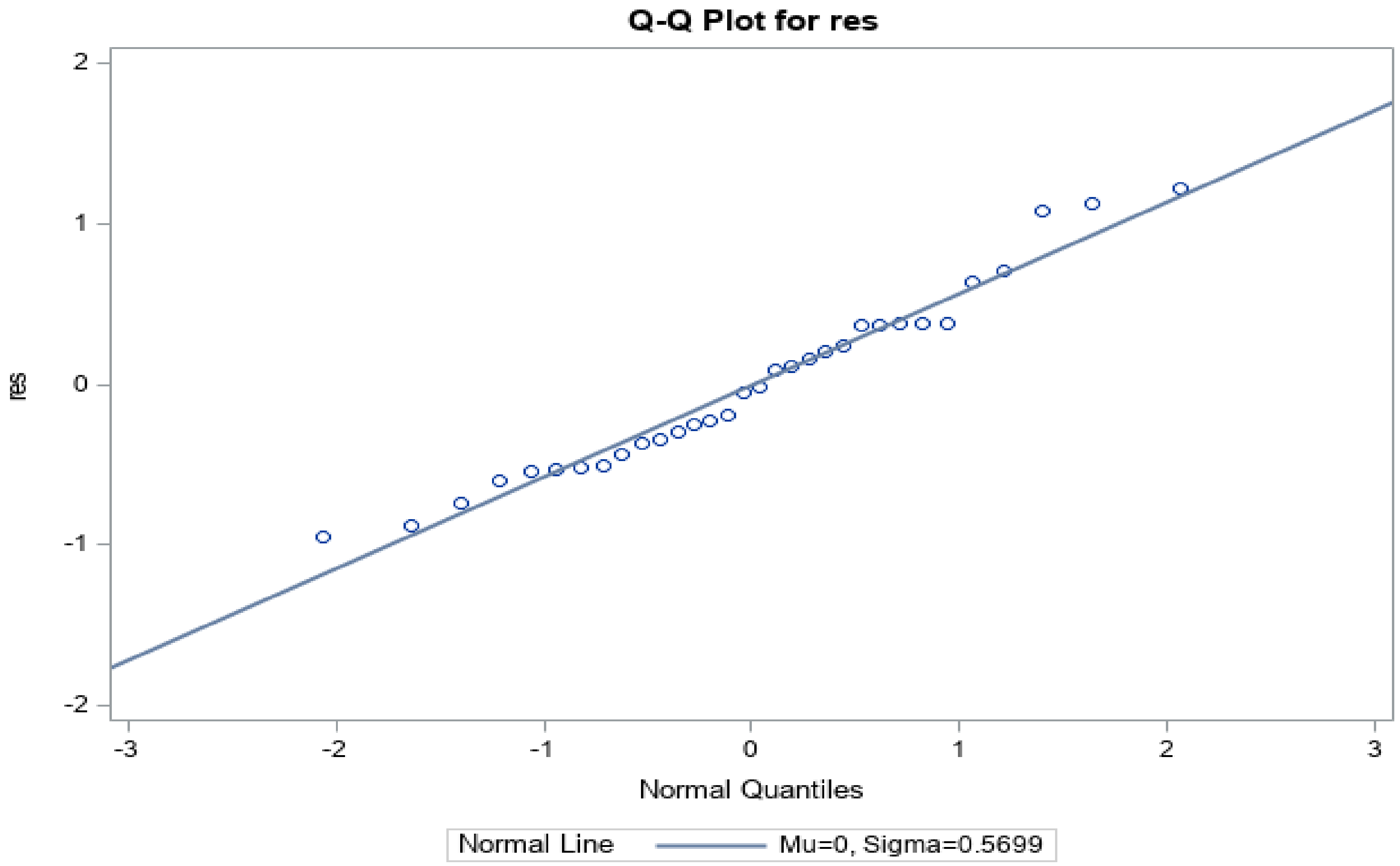
Alpha	0.05
Error Degrees of Freedom	21
Error Mean Square	0.479479
Critical Value of t	2.07961
Least Significant Difference	0.5091

Means with the same letter are not significantly different.			
t Grouping	**Mean**	**N**	**repeat**
A	18.8500	16	1
A			
A	18.8313	16	2

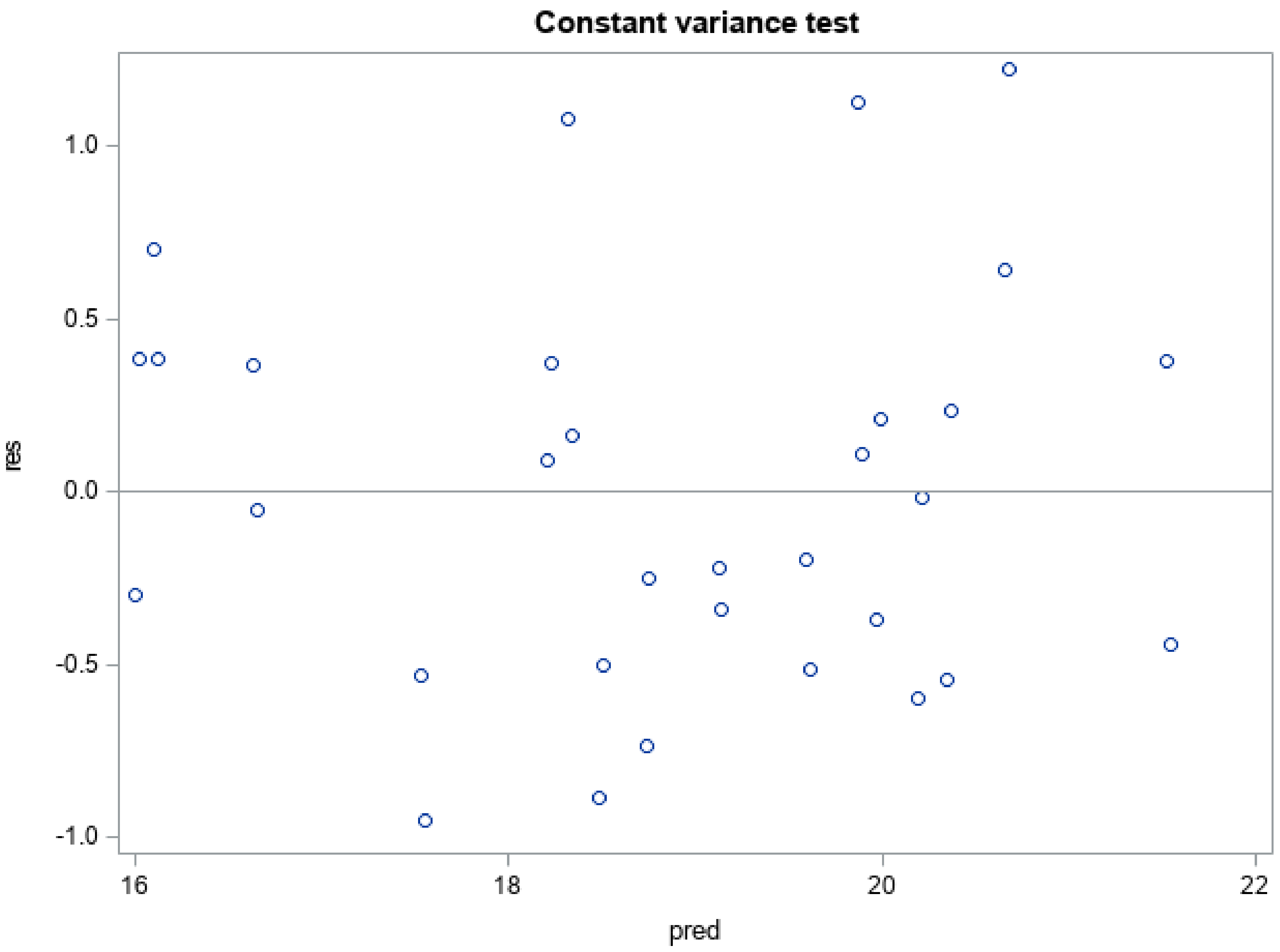
SAS code: model adequacy checking

```
proc univariate data=diag normal plot;
  title 'Residual Normality Test';
  var res;
  qqplot res/normal(mu=est sigma=est color=red L=1);
run;

proc sgplot data=diag;
  title 'Constant variance test';
  scatter x=pred y=res;
  refline 0;
run;
```

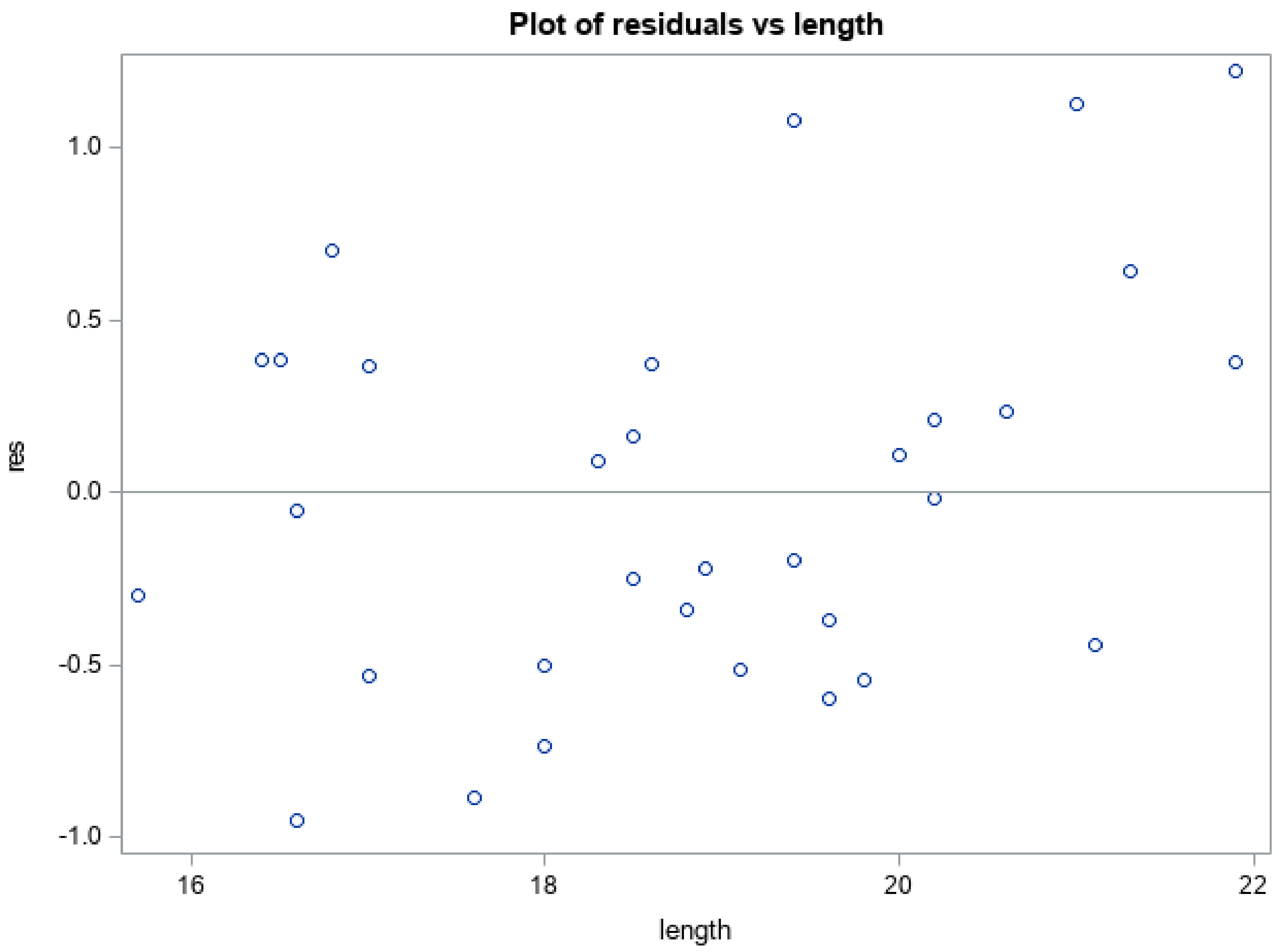


Tests for Normality				
Test	**Statistic**		**p Value**	
Shapiro-Wilk	W	0.962822	Pr < W	0.3275
Kolmogorov-Smirnov	D	0.103869	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.05056	Pr > W-Sq	>0.2500
Anderson-Darling	A-Sq	0.363934	Pr > A-Sq	>0.2500


Constant variance test
1.0
0.5
0.0
-0.5
-1.0
res
16
18
20
22
pred

SAS code: Independence checking

```
/* independence checking */
proc sgplot data=diag;
  title 'Plot of residuals vs length';
  scatter y=res x=length;
  refline 0;
run;
```


Plot of residuals vs length
res
1.0
0.5
0.0
-0.5
-1.0
16
18
20
22
length

Conclusion

- The factor of person and factor of angle are statistically significant to the model of the Latin Squared design.
- The factor of angle is most significant.
- The factor of person is significant, and statistically different by gender.
- The factor of temperature is not significant.
- Side-line experiment at 53° C：
  The product description on temperature range is precise and accurate.

Recommendation

- Cut and pull the parafilm at the degree of 0°

- While pull the parafilm, apply the force as gentle as possible. The more gentle, the longer can be pull.
- While using the parafilm, follow the product description of the temperature of usage.

Application

1. Laboratories
2. Produce
3. Stem wrap
4. Grafting