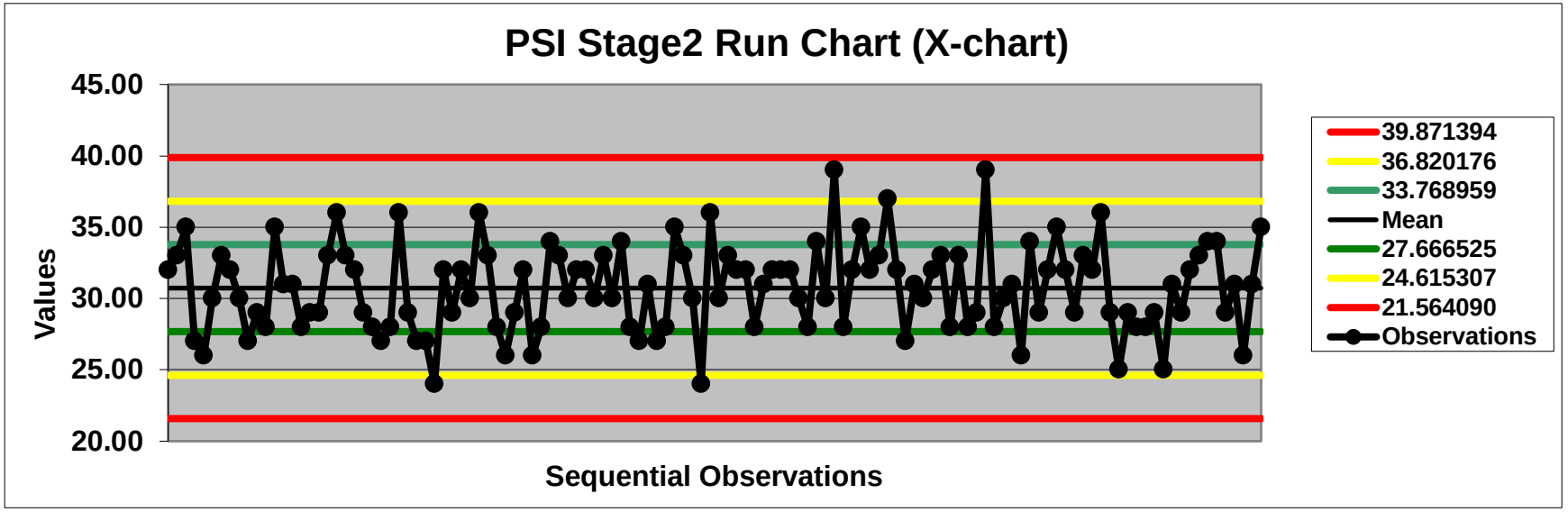
Mesa Products Stage II Data Analysis

Greasigma

PSI Basic Data Analysis Comparison(Stage I Vs. Stage II)

	Stage I	Stage II
Number of Observations	104	124
Sample P90	35.0000	35.0000
Sample P75	33.0000	33.0000
Sample P50 (median)	31.0000	31.0000
Sample P25	28.0000	28.0000
Sample P10	27.0000	27.0000
Sample Mean	30.7308	30.7177
Maximum Value	40.0000	39.0000
Minimum Value	23.0000	24.0000
Sample variance	9.9851	9.3099
Sample standard deviation	3.1599	3.0512
Skewness at alpha = .05	No Significant Skewness	No Significant Skewness
Kurtosis at alpha = .05	No Significant Kurtosis	No Significant Kurtosis
2-tailed t-test critical Vs. probability	±1.9832 Vs. 0.0202 (Reject Ho)	±1.9794 Vs. 0.0099 (Reject Ho)
2-SD Rule (includes at least 75% of cases)	Min: 24.4109 Max: 37.0506	Min: 24.6153 Max: 36.8202
3-SD Rule (includes at least 88.9% of cases)	Min: 21.2510 Max: 40.2105	Min: 21.5641 Max: 39.8714
Data Boundaries: 1.96 (includes 95% of cases, if normal)	Min: 24.5374 Max: 36.9241	Min: 24.7375 Max: 36.6980
Data Boundaries: 2.58 (includes 99% of cases, if normal)	Min: 22.5914 Max: 38.8702	Min: 22.8583 Max: 38.5772
Mean Boundaries: 95% Confidence Interval (alpha at 0.05)	Min: 30.1162 Max: 31.3453	Min: 30.1754 Max: 31.2601
Mean Boundaries: 99% Confidence Interval	Min: 29.9176 Max: 31.5440	Min: 30.0008 Max: 31.4347

Conclusions: Descriptive analysis shows similarities between stage I and stage II data



PSI Raw Data Distribution Stage1 Vs. Stage2

PSI Data Stage1 Raw Score Cutoffs for Various Zones

Distance from Mean	Mean +/− k Standard Deviations	Cutoffs
+3 Sigma	Mean + 3 SD	40.2105
+2 Sigma	Mean + 2 SD	37.0506
+1 Sigma	Mean + 1 SD	33.8907
Mean	Mean	30.7308
−1 Sigma	Mean - 1 SD	27.5709
−2 Sigma	Mean - 2 SD	24.4109
−3 Sigma	Mean - 3 SD	21.2510

Distribution of Values within Zones

Zone		Count	% of Total	Cumulative
Beyond +3 Sigma	Between +3 Sigma and +∞	0	0.00	0
A	Between +2 Sigma and +3 Sigma	2	1.92	2
B	Between +1 Sigma and +2 Sigma	15	14.42	17
C	Between the Mean and +1 Sigma	37	35.58	54
C	Between the Mean and −1 Sigma	36	34.62	90
B	Between −1 Sigma and −2 Sigma	12	11.54	102
A	Between −2 Sigma and −3 Sigma	2	1.92	104
Beyond −3 Sigma	Between −3 Sigma and −∞	0	0.00	104

PSI Data Stage2 Raw Score Cutoffs for Various Zones

Distance from Mean	Mean +/− k Standard Deviations	Cutoffs
+3 Sigma	Mean + 3 SD	39.8714
+2 Sigma	Mean + 2 SD	36.8202
+1 Sigma	Mean + 1 SD	33.7690
Mean	Mean	30.7177
−1 Sigma	Mean - 1 SD	27.6665
−2 Sigma	Mean - 2 SD	24.6153
−3 Sigma	Mean - 3 SD	21.5641

Distribution of Values within Zones

Zone		Count	% of Total	Cumulative
Beyond +3 Sigma	Between +3 Sigma and +∞	0	0.00	0
A	Between +2 Sigma and +3 Sigma	3	2.42	3
B	Between +1 Sigma and +2 Sigma	17	13.71	20
C	Between the Mean and +1 Sigma	44	35.48	64
C	Between the Mean and −1 Sigma	43	34.68	107
B	Between −1 Sigma and −2 Sigma	15	12.10	122
A	Between −2 Sigma and −3 Sigma	2	1.61	124
Beyond −3 Sigma	Between −3 Sigma and −∞	0	0.00	124

Conclusion: again, very similar results between stage I and stage II data.

PSI Data Two-sample Independent t-test Stage1 Vs. Stage2

Two-directional F-test for homogeneity of variance		
Lower and upper computed F-values	0.9324	1.0725
Lower and upper critical F-values	0.6914	1.4463
numerator df	123.0000	103.0000
denominator df	103.0000	123.0000
Lower and upper computed probabilities for F-test	0.3536	0.3536
Decision regarding homogeneity of variance	**Fail to reject Ho**	

Two-sample t-test for comparing means		
Observed differences between means	0.0130	
Expected differences between means	0.0000	
Pooled standard error of the differences	0.4124	
Unpooled standard error of the differences	0.4136	
Two-sample independent t-test based on pooled SE term	0.0316	
df	226.0000	
Critical t-value	±1.9705	
2-tailed computed probability	0.9748	
Decision regarding test for means	**Fail to reject Ho**	

Hypothesis: Ho: mean_stage1 = mean_stage2 vs. Ha: mean_stage1 ≠ mean_stage2

Conclusion: Fail to reject Ho, the sample means from stage1 PSI data and stage2 PSI data are not statistical significantly different from each other at $\alpha = 0.05$ level

PSI Data Stage2 SPC and Process Capability Analysis

Results - Part 2 - Process Capability

Number of Subgroups (Rows) =	31

X-Bar Chart

LCL	Center	UCL
26.2731935	30.7177419	35.1622903

R Chart

LCL	Center	UCL
0.0000000	6.0967742	13.9128387

Specification Limits

LSL	Nominal or Target	USL
21.5641000	30.0000000	39.8714000

Number and Percent of Observed Values Beyond Specifications

# Below LSL	# Above USL	# Outside
0	0	0
Percent Below LSL	**Percent Above USL**	**Percent Outside Limits**
0.00000%	0.00000%	0.00000%

Number of Expected Values Beyond Specifications (Assuming Normality)

z-score for LSL	*z*-score for USL	Expected Percent of Observations Outside Specification Limits Assuming Normality
-3.0000	3.0000	
Percent for LSL Assuming Normality	**Percent for USL Assuming Normality**	
0.13499%	0.13499%	0.26998%
PPM below LSL Assuming Normality	**PPM above USL Assuming Normality**	**PPM outside Specification Limits Assuming Normality**
1349.91	1349.89	2699.80

Number of Subgroup Means Outside Control Limits

# Below LCL	# Above UCL	# Outside	Percent Outside Limits
0	0	0	0.000%

Number of Subgroup Ranges Outside Control Limits

# Below LCL	# Above UCL	# Outside	Percent Outside Limits
0	1	1	3.226%

Number of Individual Observations Outside 2 Sigma Limits

# Below LCL	# Above UCL	# Outside	Percent Outside Limits
2	3	5	4.032%

Number of Individual Observations Outside 3 Sigma Limits

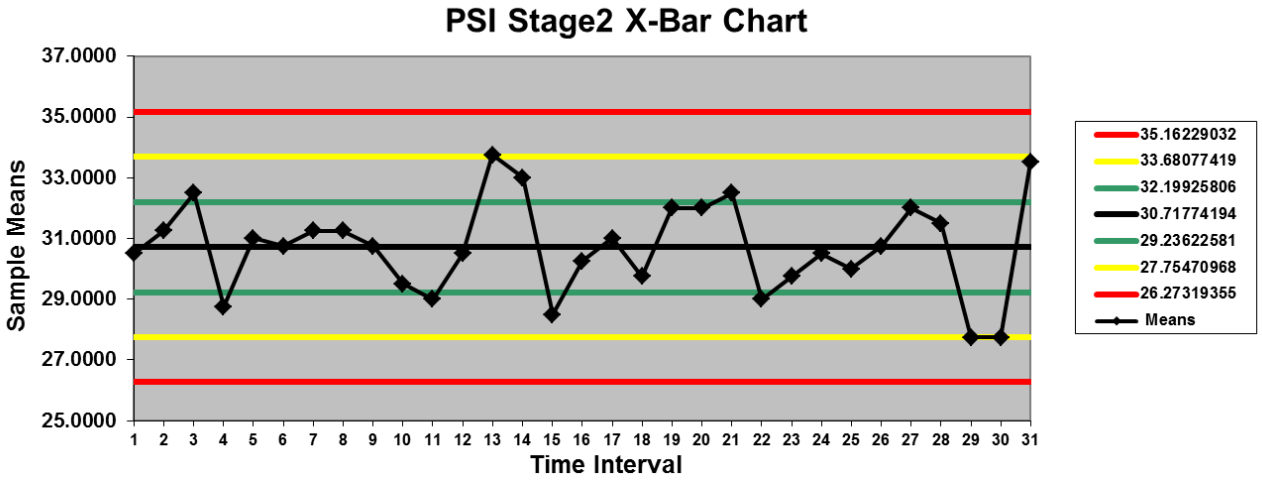
# Below LCL	# Above UCL	# Outside	Percent Outside Limits
0	0	0	0.000%

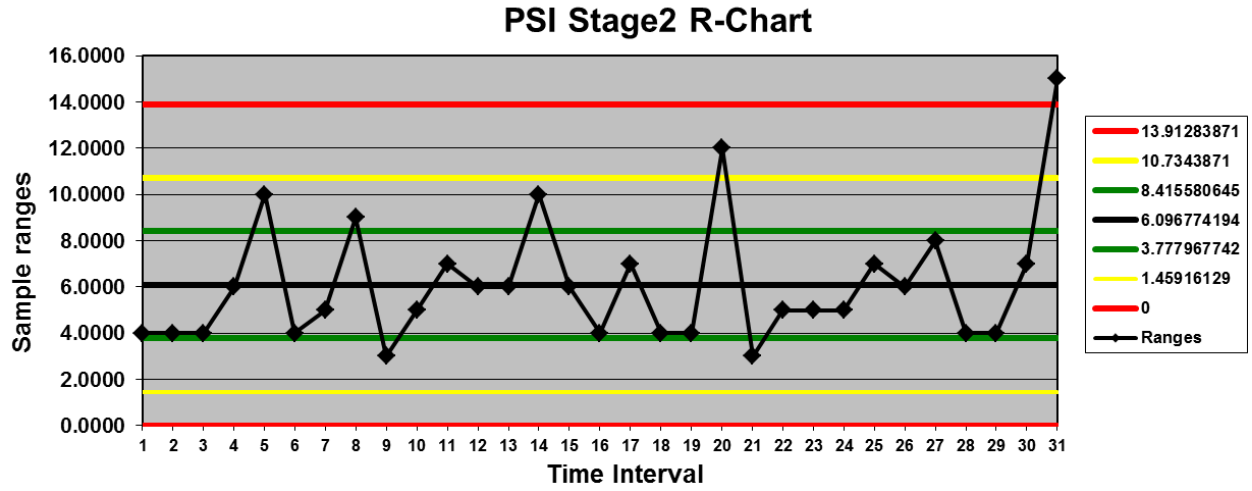
Process Capability Analysis

	Based on Sample Statistics		Based on Population Parameters	
Sample SD	3.051217		Pop SD = 3.038889	
Cp =	1.000000		Cp = 1.004057	
K =	0.000001		K = 0.000001	
Abs K =	0.000001		Abs K = 0.000001	
Cpk =	0.999999	min	Cpk = 1.004056	min
Cpk =	1.000001	max	Cpk = 1.004058	max
Cpk =	**0.999999**		Cpk = **1.004056**	

To achieve "X" Sigma:	The Cpk needs to be:	To obtain this Cpk level, the SD must be equal to or less than:
6 Sigma	2.000000	1.525607
5 Sigma	1.666667	1.830728
4.5 Sigma	1.500000	2.034143
4 Sigma	1.333333	2.288410
3.5 Sigma	1.166667	2.615326
3 Sigma	1.000000	3.051214
1.5 Sigma	0.500000	6.102428

Conclusion: According to Stage2 PSI data, Cpk = 1 indicates we are currently still at 3 sigma level





Translation of Time Interval			
1	Day 1	Shift 1	8:00
2	Day 1	Shift 1	9:00
3	Day 1	Shift 1	10:00
4	Day 1	Shift 1	11:00
5	Day 1	Shift 1	12:00
6	Day 1	Shift 1	13:00
7	Day 1	Shift 1	14:00
8	Day 1	Shift 1	15:00
9	Day 1	Shift 2	17:00
10	Day 1	Shift 2	18:00
11	Day 1	Shift 2	19:00
12	Day 1	Shift 2	20:00
13	Day 1	Shift 2	21:00
14	Day 1	Shift 2	22:00
15	Day 1	Shift 2	23:00
16	Day 2	Shift 1	8:00
17	Day 2	Shift 1	9:00
18	Day 2	Shift 1	10:00
19	Day 2	Shift 1	11:00
20	Day 2	Shift 1	12:00
21	Day 2	Shift 1	13:00
22	Day 2	Shift 1	14:00
23	Day 2	Shift 1	15:00
24	Day 2	Shift 2	17:00
25	Day 2	Shift 2	18:00
26	Day 2	Shift 2	19:00
27	Day 2	Shift 2	20:00
28	Day 2	Shift 2	21:00
29	Day 2	Shift 2	22:00
30	Day 2	Shift 2	23:00
31	Day 2	Shift 2	24:00

Observation:

- The starting shifts of the days are good
- Poor results toward the last three shifts of the day
- The last shifts are the worst

PSI Data Stage2 One-way ANOVA Between Days

Results							
Group Names	**Group No.**	**Count**	**df**	**Mean**	**S.D.**	**Variance**	**SS**
Day1	1	60	59	30.8167	2.8730	8.2540	486.9833
Day2	2	64	63	30.6250	3.2293	10.4286	657.0000
Total	**Total**	124	123	30.7177	3.0512	9.3099	1145.1210

Analysis of Variance (ANOVA) Test to Compare Means

ANOVA Table

Source of Variation	*df*	*SS*	*MS*	*Omnibus Computed F*	*Omnibus Critical F*	*Probability Associated with Computed F*	*Decision Regarding Ho*
Among	1	1.1376	1.1376	0.1213	3.9188	0.7282	Fail to reject Ho
Within	122	1143.9833	9.3769				
Total	123	1145.1210	9.3099				

Hypothesis: Ho: mean(psi)_day1 = mean(psi)_day2 vs. Ha: mean(psi)_day1 ≠ mean(psi)_day2

Conclusion: Fail to reject Ho, the sample means from day1 and day2 are not statistical significantly different from each other at $\alpha = 0.05$ level

PSI Data Stage2 One-way ANOVA Between Day-time Shifts and Night-time Shifts

Results

Group Names	Group No.	Count	df	Mean	S.D.	Variance	SS
Day-time Shift	1	64	63	30.8438	2.6976	7.2768	458.4375
Night-time Shift	2	60	59	30.5833	3.4063	11.6031	684.5833
Total	Total	124	123	30.7177	3.0512	9.3099	1145.1210

Analysis of Variance (ANOVA) Test to Compare Means

ANOVA Table

Source of Variation	*df*	*SS*	*MS*	*Omnibus Computed F*	*Omnibus Critical F*	*Probability Associated with Computed F*	*Decision Regarding Ho*
Among	1	2.1001	2.1001	0.2242	3.9188	0.6367	Fail to reject Ho
Within	122	1143.0208	9.3690				
Total	123	1145.1210	9.3099				

Hypothesis: Ho: mean(psi)_day-time shifts = mean(psi)_night-time shifts vs. Ha: mean(psi)_day-time shifts $\neq$ mean(psi)_night-time shifts

Conclusion: Fail to reject Ho, the sample means from day-time shifts and night-time shifts are not statistical significantly different from each other at $\alpha = 0.05$ level

PSI Data Stage2 Treatment-by-Subjects ANOVA

PSI Data Stage2 Treatment-by-Subjects ANOVA

Treatment-by-Subjects ANOVA (i.e., Randomized Blocks Design)

Source of Variation	*df*	*SS*	*MS*	*F*	*P-value*	*Critical F-Value Based on User-Determined Alpha*	*Decision*
Rows (Subjects)	30	286.3710	9.5457	1.0513	0.4139	1.5859	Fail to Reject Ho
Columns (Treatments)	3	41.5726	13.8575	1.5262	0.2131	2.7058	Fail to Reject Ho
Error (Interaction)	90	817.1774	9.0797				
Total	123	1145.1210					

Homogeneity of Variance (Requires More than 2 Groups)

Bartlett's Chi-Square Test for Homogeneity of Variance --- Comparing Variances Across Columns Without Regard to Correlations or Dependencies

Bartlett's Chi-Square Test for Homogeneity of Variance	Degrees of Freedom for Chi-Square Test	Critical Chi-Square Value	Computed Probability	Decision Regarding Ho
0.0679	3	7.8147	0.9954	Fail to reject Ho

Note:
Subjects: PSI among one sample
Treatments: the 4 cans

According to our data from **31** total time intervals from previous page.
Hypothesis: Ho: mean_1 = mean_2= … = mean_i for i = 1,2,…31 vs. Ha: Not all means are equal.
Conclusion: Fail to reject Ho. There is no statistical significant difference between the 31 time intervals at $\alpha = 0.05$ level

Hypothesis: Ho: mean_1 = mean_2= … = mean_i for i = 1,2,3,4 vs. Ha: Not all means are equal.
Conclusion: Fail to reject Ho. There is no statistical significant difference between the 31 time intervals at $\alpha = 0.05$ level

PSI Data Stage2 2-Way ANOVA

Category Names	Row	Column	Count	df	Mean	S.D.	Variance	SS
1, 1	Day1 Shift1	Can #1	8.0000	7.0000	31.0000	3.1168	9.7143	68.0000
1, 2	Day1 Shift1	Can #2	8.0000	7.0000	30.7500	3.1510	9.9286	69.5000
1, 3	Day1 Shift1	Can #3	8.0000	7.0000	31.2500	1.5811	2.5000	17.5000
1, 4	Day1 Shift1	Can #4	8.0000	7.0000	30.6250	3.0208	9.1250	63.8750
2, 1	Day1 Shift2	Can #1	7.0000	6.0000	30.1429	2.6095	6.8095	40.8571
2, 2	Day1 Shift2	Can #2	7.0000	6.0000	30.2857	2.8702	8.2381	49.4286
2, 3	Day1 Shift2	Can #3	7.0000	6.0000	31.5714	3.9097	15.2857	91.7143
2, 4	Day1 Shift2	Can #4	7.0000	6.0000	30.8571	3.5322	12.4762	74.8571
3, 1	Day2 Shift1	Can #1	8.0000	7.0000	31.1250	2.7999	7.8393	54.8750
3, 2	Day2 Shift1	Can #2	8.0000	7.0000	30.7500	2.4349	5.9286	41.5000
3, 3	Day2 Shift1	Can #3	8.0000	7.0000	32.3750	2.9246	8.5536	59.8750
3, 4	Day2 Shift1	Can #4	8.0000	7.0000	28.8750	2.1002	4.4107	30.8750
4, 1	Day2 Shift2	Can #1	8.0000	7.0000	28.2500	3.4538	11.9286	83.5000
4, 2	Day2 Shift2	Can #2	8.0000	7.0000	30.5000	4.1057	16.8571	118.0000
4, 3	Day2 Shift2	Can #3	8.0000	7.0000	31.5000	3.6645	13.4286	94.0000
4, 4	Day2 Shift2	Can #4	8.0000	7.0000	31.6250	3.0208	9.1250	63.8750

Main Effects: Rows

Category Names	Rows	Count	df	Mean	S.D.	Variance	SS
Day & Shift	11	32	31	30.9063	2.6683	7.1200	220.7188
	12	28	27	30.7143	3.1371	9.8413	265.7143
	21	32	31	30.7813	2.7677	7.6603	237.4688
	22	32	31	30.4688	3.6719	13.4829	417.9688

Main Effects: Columns

Category Names	Columns	Count	df	Mean	S.D.	Variance	SS
Can Number	1	31	30	30.1290	3.1064	9.6495	289.4839
	2	31	30	30.5806	3.0526	9.3183	279.5484
	3	31	30	31.6774	2.9932	8.9591	268.7742
	4	31	30	30.4839	2.9763	8.8581	265.7419

PSI Data Stage2 2-Way ANOVA Results

Totals							
		Count	df	Mean	S.D.	Variance	SS
All Cells Combined	Total Values for All Cells Combined	124	123	30.7177	3.0512	9.3099	1145.1210

ANOVA TABLE							
Source	*df*	*SS*	*MS*	*F*	*Critical F*	*Prob.*	*Decision*
Among (Cells)	15	122.8888	8.1926	0.8656	1.7600	0.6037	**Fail to reject Ho**
Rows	3	3.2504	1.0835	0.1145	2.6887	0.9515	**Fail to reject Ho**
Columns	3	41.5726	13.8575	1.4641	2.6887	0.2284	**Fail to reject Ho**
Interaction	9	78.0658	8.6740	0.9164	1.9677	0.5139	**Fail to reject Ho**
Within (Error or Residual)	108	1022.2321	9.4651				
Total	123	1145.1210	9.3099				

Results for the Bartlett's Chi-Square Test for Homogeneity of Variance				
Bartlett's Chi-Square	df for Chi-Square	Critical Chi-square	Computed Prob.	Decision About Ho
9.6237	15	24.9958	0.8427	Fail to reject Ho

Hypothesis: Ho: mean_(Day 1, shift 1) = mean_(Day 1, shift 2) = mean_(Day 2, shift 1) = mean_(Day 2, shift 2) vs. Ha: Not all means are equal.
Conclusion: Fail to reject Ho. There is no statistical significant difference between the four different shifts from two days.

Notice, it also confirms our earlier conclusion of no difference on can numbers.

Linear Regression Model

Regression Model

Input Variables	Coefficient	Std. Error	t-Statistic	P-Value	CI Lower	CI Upper	RSS Reduction
Intercept	30.77848	1.374536	22.39191	1.74E-44	28.05677	33.5002	117003.9
Day	-0.18867	0.555947	-0.33937	0.734929	-1.2895	0.912158	1.137634
Shift	-0.45324	1.221333	-0.3711	0.711223	-2.8716	1.965125	2.000575
Time	0.022712	0.124206	0.182857	0.855221	-0.22323	0.268653	0.318752
Can Group	0.216129	0.247998	0.871495	0.385239	-0.27493	0.70719	7.240323

Residual DF	119
R^2	0.009342
Adjusted R^2	-0.02396
Std. Error Estimate	3.087551
RSS	1134.424

ANOVA

Source	DF	SS	MS	F-Statistic	P-Value
Regression	4	10.6973	2.6743	0.2805	0.8901
Error	119	1134.424	9.533		
Total	123	1145.121	12.2073		

Error Summary

Total sum of squared errors	RMS Error	Average Error
1134.423684	3.02466165	1.32E-15

Variable Selection (Backward Elimination)

						Model				
#Coeffs	RSS	Cp	R^2	Adjusted R^2	Probability	1	2	3	4	5
5	1134.4237	5	0.0093	-0.024	1	Intercept	Day	Shift	Time	Can Group
4	1134.7424	3.0334	0.0091	-0.0157	0.8552	Intercept	Day	Shift		Can Group
3	1135.7805	1.1423	0.0082	-0.0082	0.9313	Intercept		Shift		Can Group
2	1137.8806	-0.6374	0.0063	-0.0018	0.9477	Intercept				Can Group
1	1145.121	-1.8779	0	0	0.8901	Intercept				

Dependent variable: PSI Value.
Independent variables: Day, Shift, Time, Can group.
Conclusion: None of the coefficients are statistically significant enough in the model.