MIS 744 Team #5-Greasigma

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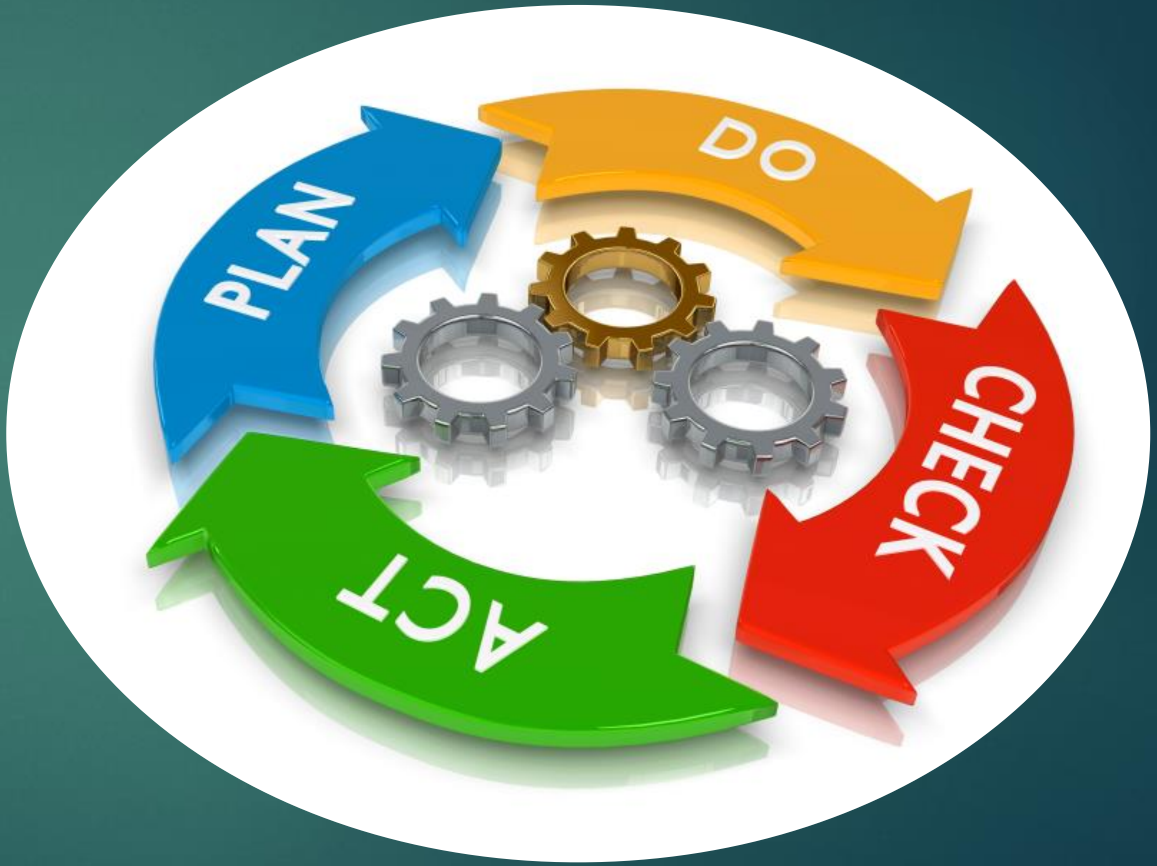
Agenda

- **Objectives**

- **Problem-solving**
  - PDCA cycle
  - CE diagram
  - Flowchart
  - Data analysis

- **5 Potential Tools**
  - Balanced Scoreboard
  - Muda
  - 5 Whys
  - Kaizen
  - SIPOC

- **Conclusions**



Objectives

- In order to improve the quality of Mesa products and satisfy our customers, we need to emphasize on three aspects for continuous improvement such as stakeholders improvement, product/service improvement and process improvement.
- We will introduce Baldrige quality management process and ISO9000 into our Mesa products.
- We will manipulate PCDA cycle, Six sigma, CE diagram, Flowchart, Data analysis and Kaizen to improve quality issues and productivity.
- We will keep training our stakeholders to reduce human error.

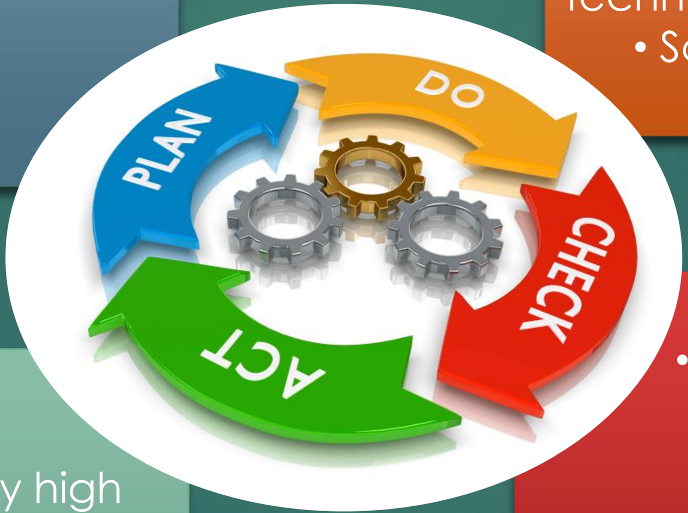
PDCA

Plan

- Reduce rework time of over-pressurized cans by 50%
- Ensure all fill equipment technicians receive equipment training within 1 week of starting work as well as every
- 6 months after that
- Ensure fill equipment is regularly calibrated every 2 months

Do

- Install live monitoring pressure gauges on filling equipment
- Take pressure readings after each can is filled
- Schedule initial and semi-annual regular technician equipment training
  - Schedule regular calibration maintenance for fill equipment



Check

- Tabulate number of cans that were over-pressurized per machine along with their corresponding rework time and which technician was working the equipment
- Establish any correlations between can over-pressurization and either a particular machine, a particular technician or a combination of both

Act

- Perform investigative root cause analysis on machines with unusually high over-pressurization rates
- Technicians with high rates of over-pressurization will be required to attend a corrective action seminar on the equipment

Cause/Effect Diagram

Cause — **Effect**

Machinery

filler (automated)
- needs to be replaced? (Lynn)
- purchased 2 years ago, but was never put through buy-off process?

filler head
- not designed for this machine or aplication
- no critical spares or studies on lifespan or usage

Process

PMs/Work Order MGMT
- 12 open work orders
- No standard settings: conflicting accounts of proper settings

removal of tags
- what existing process allows for removal of tags without formal disposition?
- no area to move discrepant part to and contain
- no notification process

Production is behind- running 50% taking shortcuts to catch up

Inspection regime too lenient (caught1/2way through shift)

Workforce

Culture of Delivery as #1 priority
- Darcy- lack of leadership skill
- Chris- shortcuts with impunity

Lack of training
- Pat Brown- 2 weeks, no training
- Chris-quality training

quality culture
- quality is not everyone's resposibility

Material/Tooling

filler head requires sourcing

new design causes issues

nozzles
- burrs from vendor
- vendor process, expedite

Environment

lack of long term planning

small issues are ignored
- no follow through

lack of preventive maintenance

new grip (issues/benefits)
- lack of discussion/analysis

Leadership

everyone taking shortcuts

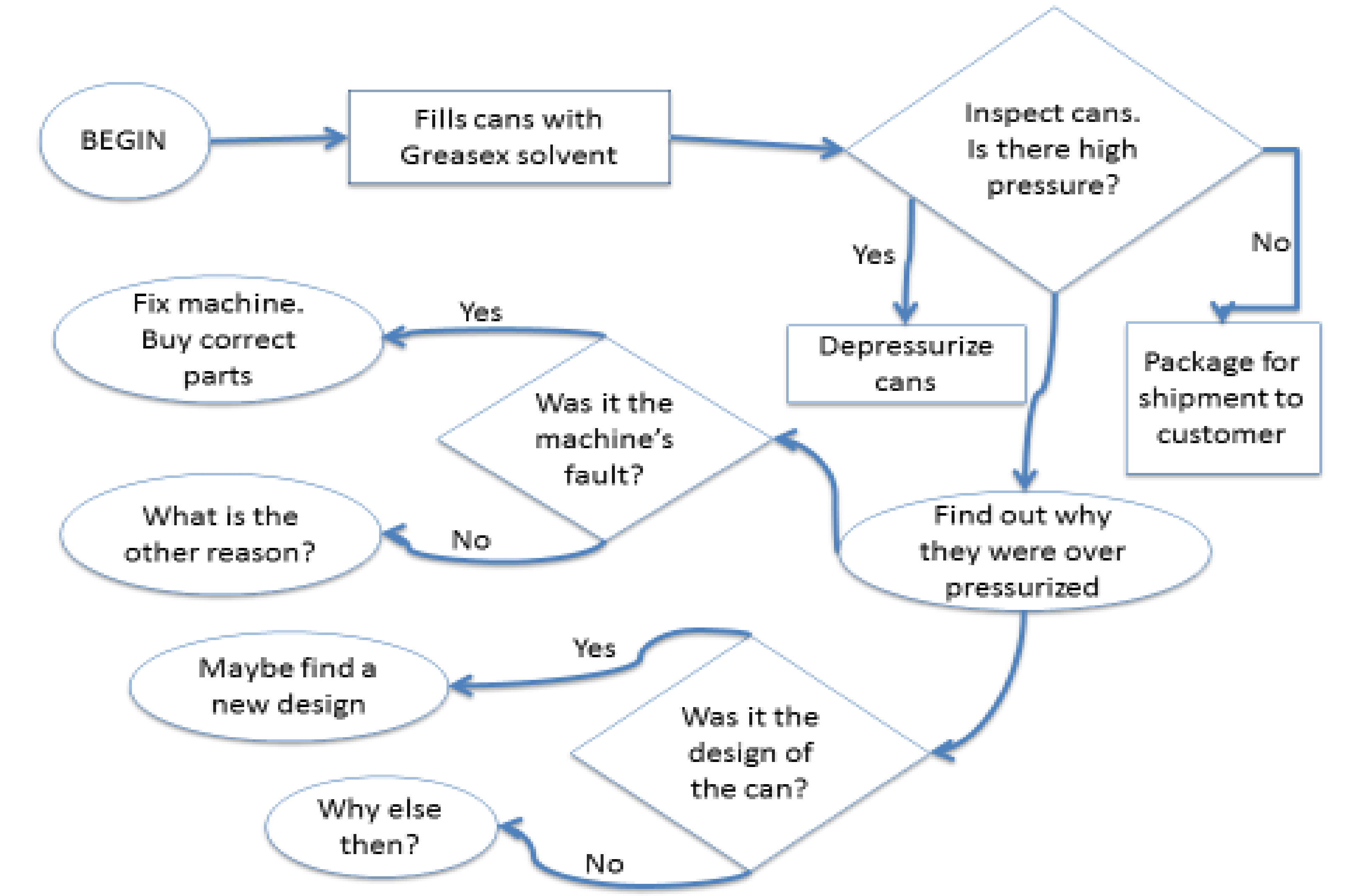
Lack of foresight
- no PM
- little planning
- stopping to do the right thing

Production is king
- chris gets production out the door - Sandy

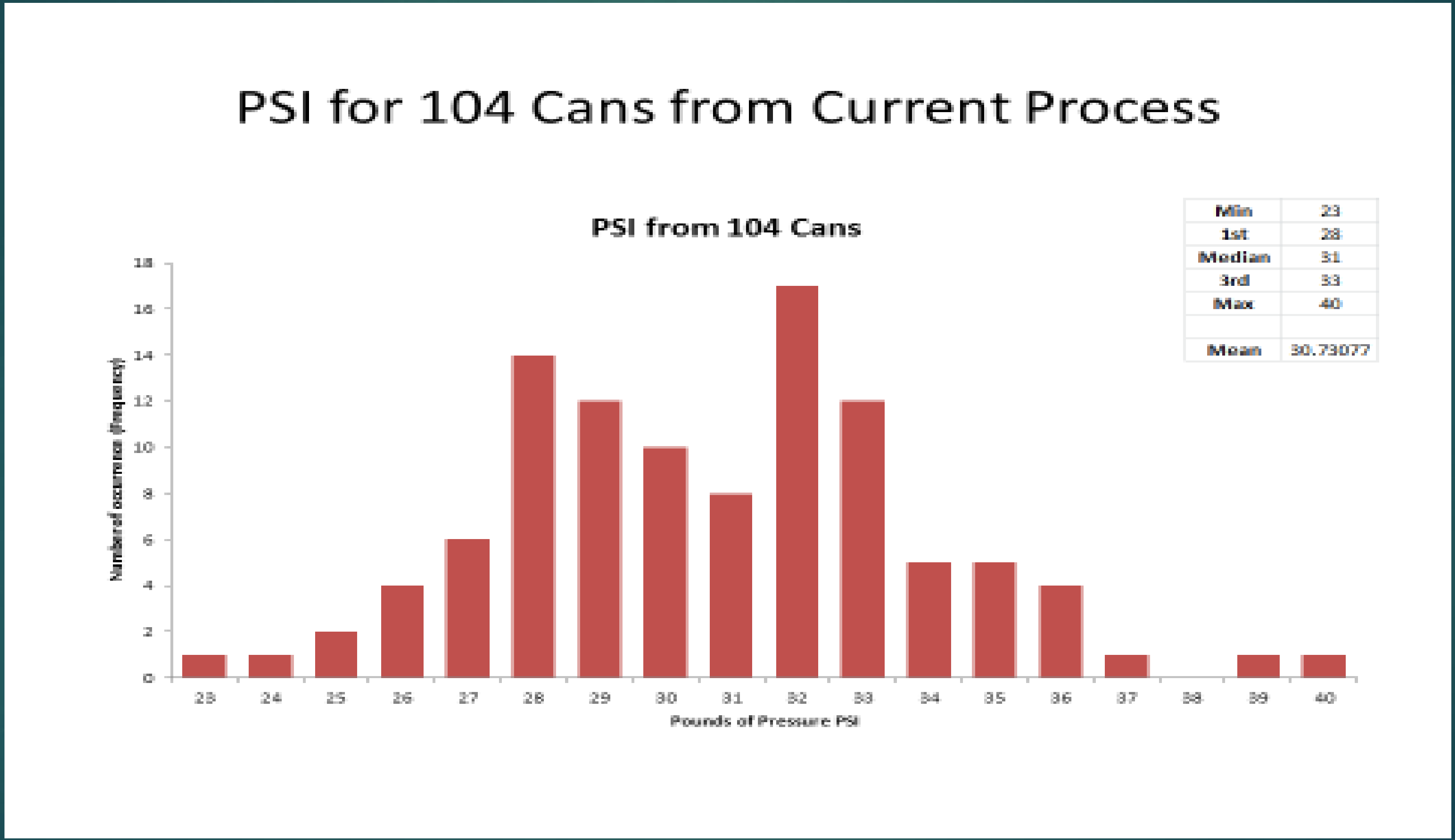
no focus on first time through

Potential Escape: Cans over-filled (potential safety and quality issue)

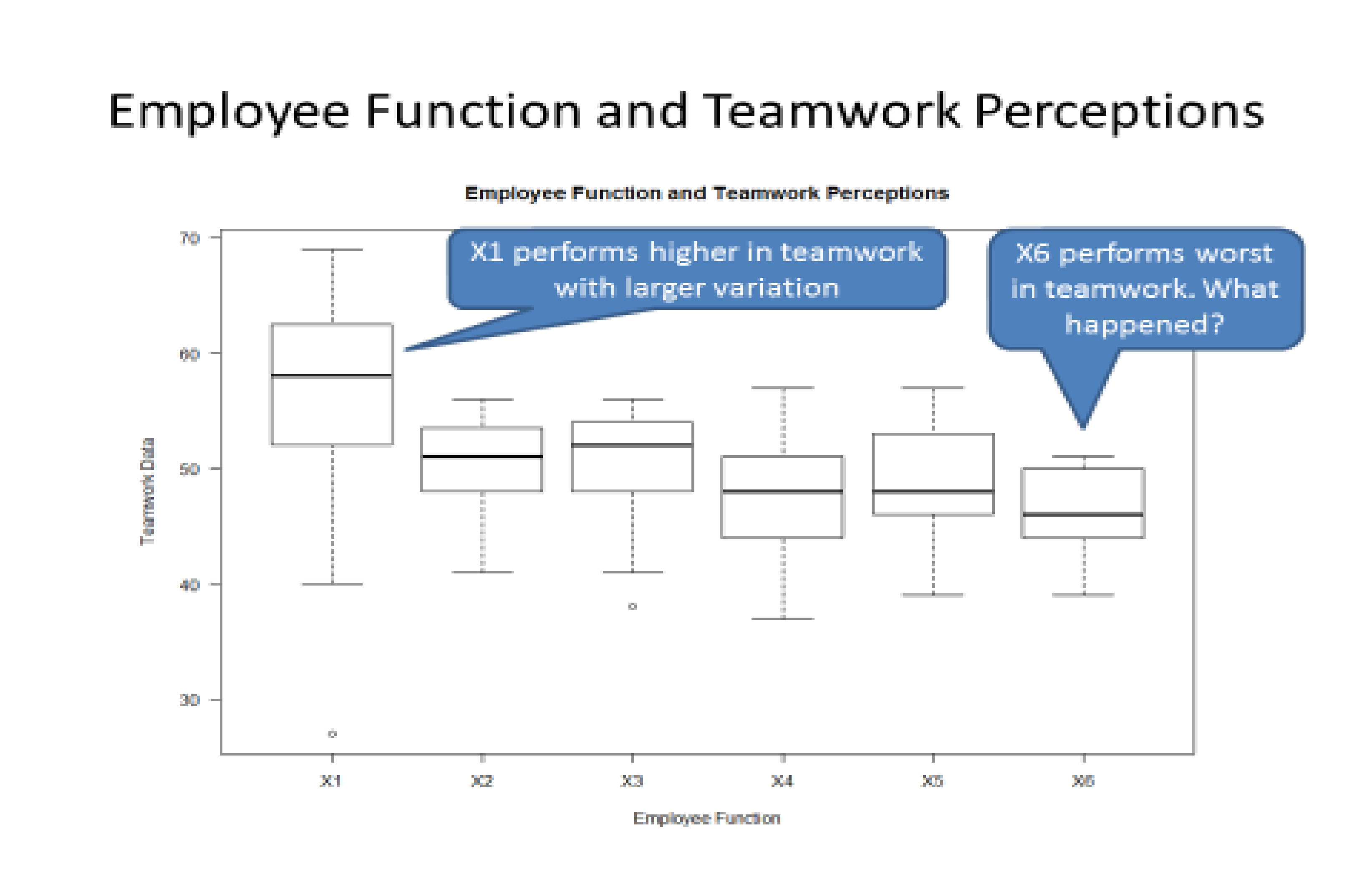
Flowchart


BEGIN
Fills cans with Greasex solvent
Inspect cans. Is there high pressure?
Yes
No
Depressurize cans
Package for shipment to customer
Find out why they were over pressurized
Was it the machine's fault?
Yes
Fix machine. Buy correct parts
No
What is the other reason?
Was it the design of the can?
Yes
Maybe find a new design
No
Why else then?

Data Analysis- PSI Histogram



Data Analysis- Teamwork Box Plot



Data Analysis- Teamwork ANOVA

Employee Function and Teamwork Perceptions (Cont')

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
1	23	1283	55.78261	102.4506		
2	19	959	50.47368	17.81871		
3	13	650	50	37.16667		
4	17	810	47.64706	26.24265		
5	19	922	48.52632	28.7076		
6	9	412	45.77778	19.44444		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1056.215	5	211.2431	4.828032	0.000566	2.31127
Within Groups	4112.825	94	43.75345			
Total	5169.04	99				

P-value = 0.000566

Reject Null

At least one employee function performs significantly different than the rest

Data Analysis- Market Response

Marketing Research Data – Customer Rating

Min	1
1st	3
Median	4
3rd	5
Max	7
Mean	3.8

Balanced Scorecards

- **Balanced Scorecard-** "A management system that provides feedback on both internal business processes and external outcomes to continuously improve strategic performance and results" – R. Munro, G. Ramu, D. Zrymiak, *The Certified Six Sigma Green Belt Handbook*
- Gives a strategic view and ensures focus and actions meet both customer and business needs
- Displays measures from four business perspectives:
  - Financial
  - Customer
  - Internal processes
  - Employee learning and growth

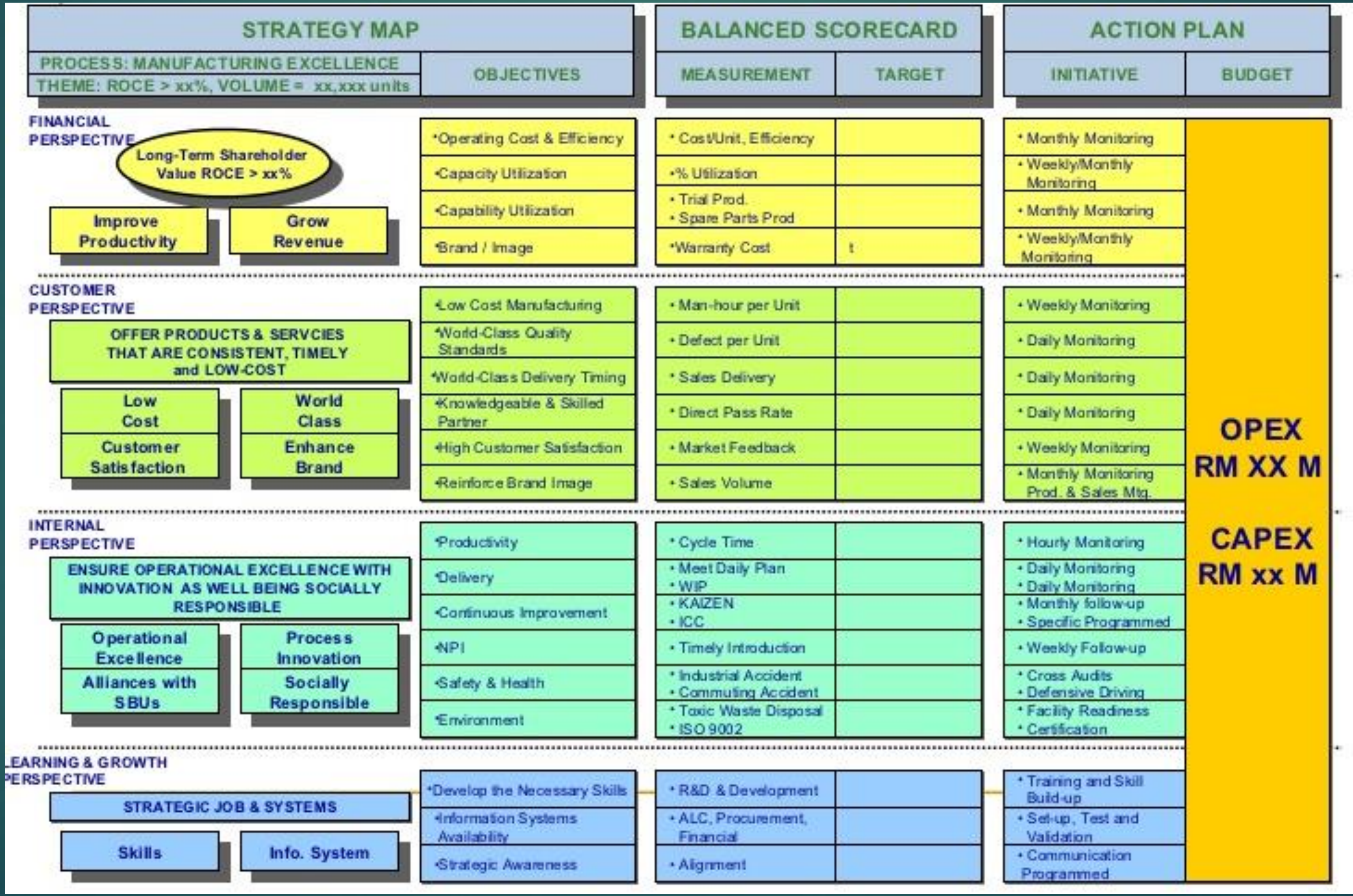
Balanced Scorecard- 4 Perspectives

- Financial- What actions should we take to generate sustainable revenue and profits?
- Internal Business Processes- What should our measures of productivity, quality and efficiency be in order to achieve success? How are we performing against those targets?
- Customers- What does the customer require and how are we performing to meet these requirements?
- Employee Learning and Growth- What actions are we taking toward employee engagement and professional development? Are they effective in improving performance?

Balance is the key. All perspectives of the business are considered as they impact one another.

Balanced Scorecard Applied to Strategy

From Strategy



STRATEGY MAP		BALANCED SCORECARD		ACTION PLAN	
PROCESS: MANUFACTURING EXCELLENCE THEME: ROCE > xx%, VOLUME = xx,xxx units	OBJECTIVES	MEASUREMENT	TARGET	INITIATIVE	BUDGET
FINANCIAL PERSPECTIVE Long-Term Shareholder Value ROCE > xx% Improve Productivity Grow Revenue	Operating Cost & Efficiency	Cost/Unit, Efficiency		Monthly Monitoring	OPEX RM XX M CAPEX RM xx M
	Capacity Utilization	% Utilization		Weekly/Monthly Monitoring	
	Capability Utilization	Trial Prod. Spare Parts Prod		Monthly Monitoring	
	Brand / Image	Warranty Cost	t	Weekly/Monthly Monitoring	
CUSTOMER PERSPECTIVE OFFER PRODUCTS & SERVCIES THAT ARE CONSISTENT, TIMELY and LOW-COST Low Cost World Class Customer Satisfaction Enhance Brand	Low Cost Manufacturing	Man-hour per Unit		Weekly Monitoring	
	World-Class Quality Standards	Defect per Unit		Daily Monitoring	
	World-Class Delivery Timing	Sales Delivery		Daily Monitoring	
	Knowledgeable & Skilled Partner	Direct Pass Rate		Daily Monitoring	
	High Customer Satisfaction	Market Feedback		Weekly Monitoring	
	Reinforce Brand Image	Sales Volume		Monthly Monitoring Prod. & Sales Mtg.	
INTERNAL PERSPECTIVE ENSURE OPERATIONAL EXCELLENCE WITH INNOVATION AS WELL BEING SOCIALLY RESPONSIBLE Operational Excellence Process Innovation Alliances with SBUs Socially Responsible	Productivity	Cycle Time		Hourly Monitoring	
	Delivery	Meet Daily Plan WIP		Daily Monitoring Daily Monitoring	
	Continuous Improvement	KAIZEN ICC		Monthly follow-up Specific Programmed	
	NPI	Timely Introduction		Weekly Follow-up	
	Safety & Health	Industrial Accident Commuting Accident		Cross Audits Defensive Driving	
	Environment	Toxic Waste Disposal ISO 9002		Facility Readiness Certification	
LEARNING & GROWTH PERSPECTIVE STRATEGIC JOB & SYSTEMS Skills Info. System	Develop the Necessary Skills	R&D & Development		Training and Skill Build-up	
	Information Systems Availability	ALC, Procurement, Financial		Set-up, Test and Validation	
	Strategic Awareness	Alignment		Communication Programmed	

To Actions

MUDA- The seven wastes in manufacturing

1. Overproduction
   - Manufacture an item before it is actually required.
2. Waiting
   - Whenever goods are not moving or being processed, the waste of waiting occurs.
3. Transporting
   - Excessive movement and handling cause damage and are an opportunity for quality to deteriorate.
4. Inappropriate Processing
   - Often termed as "using a sledgehammer to crack a nut," many organizations use expensive high precision equipment where simpler tools would be sufficient.
5. Unnecessary Inventory
   - Excess inventory tends to hide problems on the plant floor, which must be identified and resolved in order to improve operating performance.
6. Unnecessary/Excess Motion
   - This waste is related to ergonomics and is seen in all instances of bending, stretching, walking, lifting, and reaching.
7. Defects
   - Having a direct impact to the bottom line, quality defects resulting in rework or scrap are a tremendous cost to organizations.

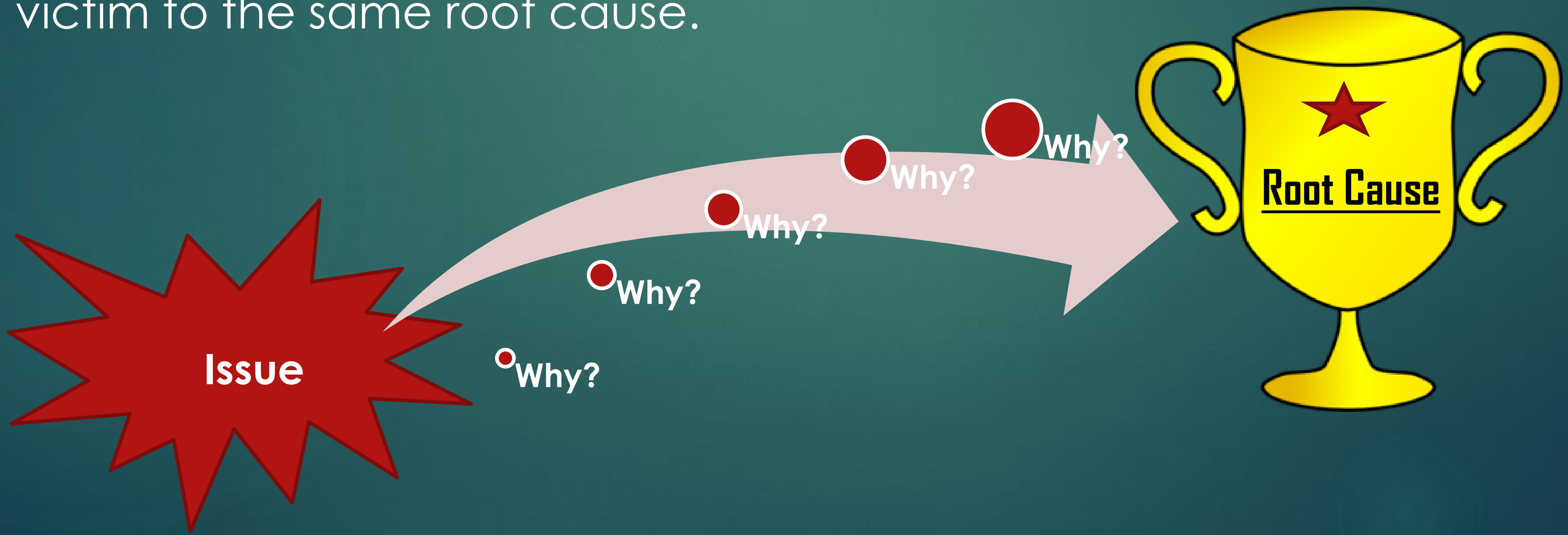
Muda- Applied to Mesa Products Case

- Inappropriate Processing
  - Product line not customized for specific use
- Defects
  - Lack of systematic approach to handle defects

5 Whys

The "5 Whys" Analysis is an investigative technique used to explore a particular issue's cause-and-effect relationships, with an end goal of getting to the **root cause** of the original issue.

The immediate cause of the issue is rarely the root cause. Therefore, if the root cause is not properly identified, corrective action and resources could be wasted on a solution that will eventually fall victim to the same root cause.



Kaizen

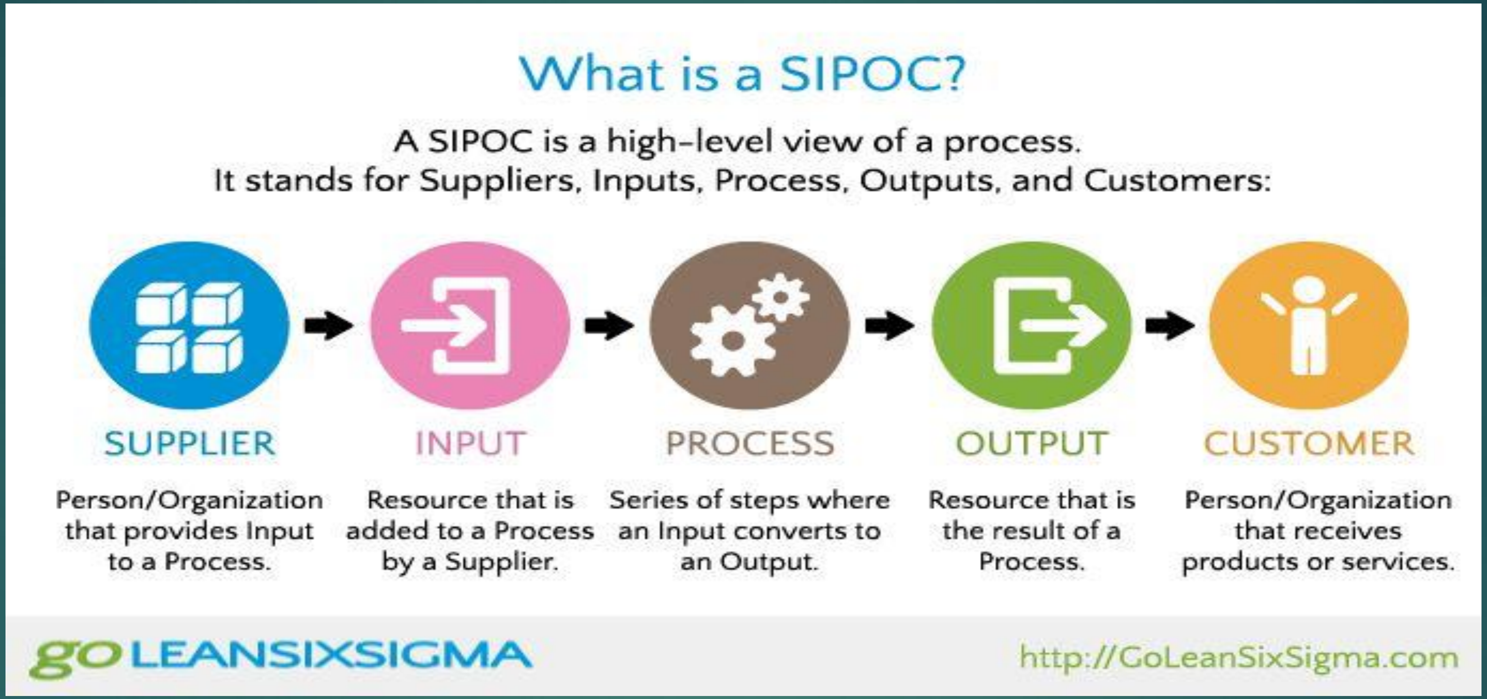
- What is Kaizen?
  - 改 Kai = change
  - 善 Zen = good
  - Kaizen = Continuous Improvement
- Principles
  - Team process
  - Clear objectives
  - Quick and simple, action first
  - Tight focus on time (one week)
  - Necessary resources available right away
  - Immediate results (new process function by end of week)

Kaizen – Problem Solving (Greasex case)

- Select a bottleneck situation
  high pressured can → reduce productivity
- Understand the "Current State" of the bottleneck
  plastic nozzle heads is not fit well or automated filling equipment is not forgreasex
- Brainstorm the "Future State" to set improvement goals

  Need to solve high pressure problem
- Implement within the five days
- Then use the 30 day opportunity log to finish up any items requiring more time

SIPOC



- High level map of process
- Tool used to inform whole team what the processes in relation to all need inputs, outputs, and suppliers
- Implemented during Define or Measure stage of DMAIC

How Does SIPOC Help?

- Identifies the potential gaps (deficiencies) between
  - suppliers and input specifications
  - Outputs specifications and customer expectations
- How is this given process servicing the customer?
- Helps clearly understand the purpose and scope of the process

Healthcare Example

SIPOC

Prepared By: Sue Jordan

Date: 11/29/2011

Project: Reduce Claims Cycle Time

How to fill out the SIPOC

Suppliers	Inputs	
	Description	Requirements
Hospitals	Medical claim	Completeness
QA	QA completeness stamp	Date/time stamped

Process
Receive claims package
Check for completeness
Process claim
Add claim to mainframe database
Compile all claims at end of shift
Check for data errors
Generate check
Generate confirmation e-mail

Outputs		Customers
Description	Requirements	
Payment check	Accurate amount	Hospitals
	Timeliness	
Confirmation email	Timeliness	Hospitals
Claim data	No errors or missing data	IT

Alternatives of SIPOC

- COPIS
  - Identify customer first then outputs
  - Working backwards until all suppliers are identified

- PISOC
  - Easier with larger team
  - Start with process, easier to identify and already know
  - Inputs going into this process

Stage 1 Conclusions

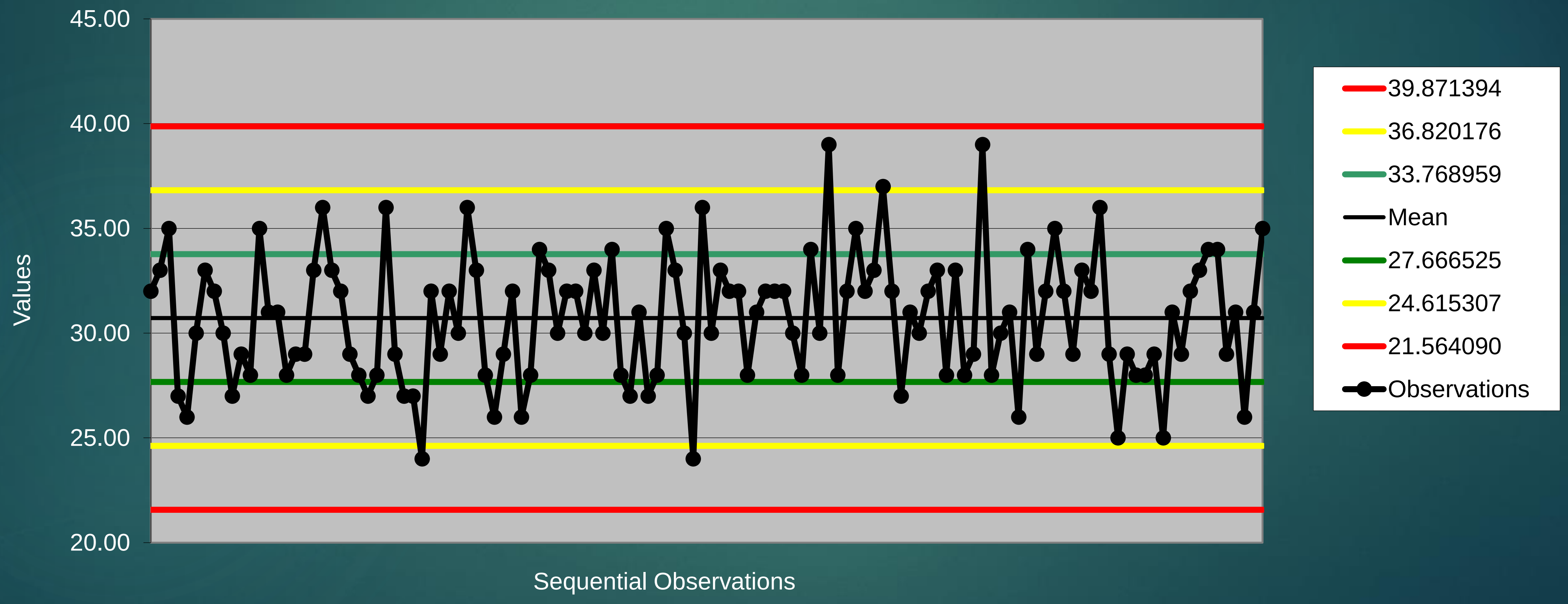
- Several Tools, such as Kaizen, 5 Whys, Muda and SIPOC could be useful in correcting this specific issue
- Balanced Scorecards could help the organization at a strategic level, but not with this specific issue
- More data need to be collected and analyzed
  - What the appropriate range of pressure for cans is
  - What metrics are used to measure "Teamwork"
  - Pressure data over constant long period of time (at least 1 month) for each pressure filling machine

Stage 2- Data Analysis

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: 37.0508	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

PSI Stage 2 Run Chart (X-Chart)



PSI Raw Data Distribution Stage 1 vs. Stage 2

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

PSI Data One-sample t-test Stage 2

- μ_0: Target CAN pressure = 30 PSI (hypothesized mean)
- n = 124, df = 123
- x-bar = 30.7177 (observed mean), s = 3.0512
- **H_0: x-bar = μ_0, H_a: x-bar ≠ μ_0**
- $t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}}$ = 2.6194
- a = 0.05 (2-tailed critical value = 1.9794)
- Reject H_0

Conclusion: The observed mean and hypothesized mean from Stage 2 PSI data are statistical significant different from each other

PSI Data Two-sample Independent t-test Stage 1 vs. Stage 2

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
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**	

Conclusion: The sample means and variance from Stage 1 PSI data and Stage 2 PSI data are not statistical significant different from each other

PSI Stage 2 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		

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

Conclusion: According to Stage 2 PSI data, we are currently still at 3 sigma level

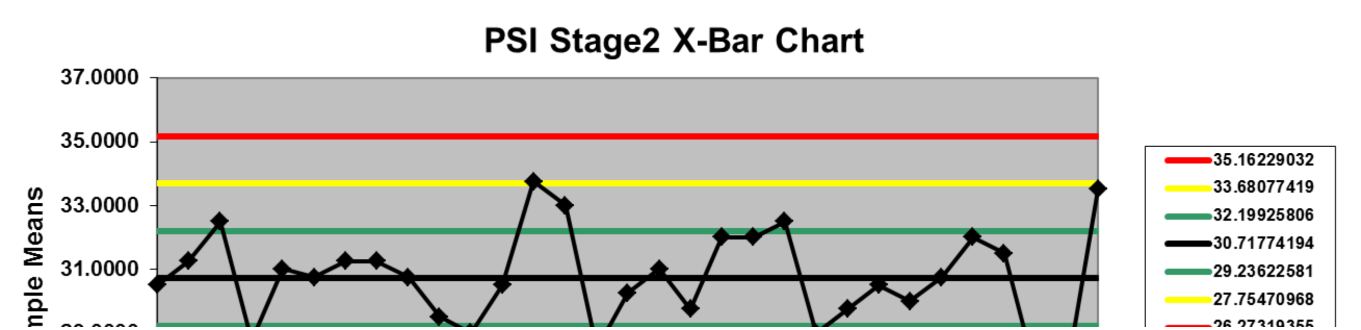
Number and Percent of Observed Values Beyond Specifications		
# Below LSL	# Above USL	# Outside
0	0	0
Percent Below LSL	Percent Above USL	Percent Outside Limits
0.00000%	0.00000%	0.00000%

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

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

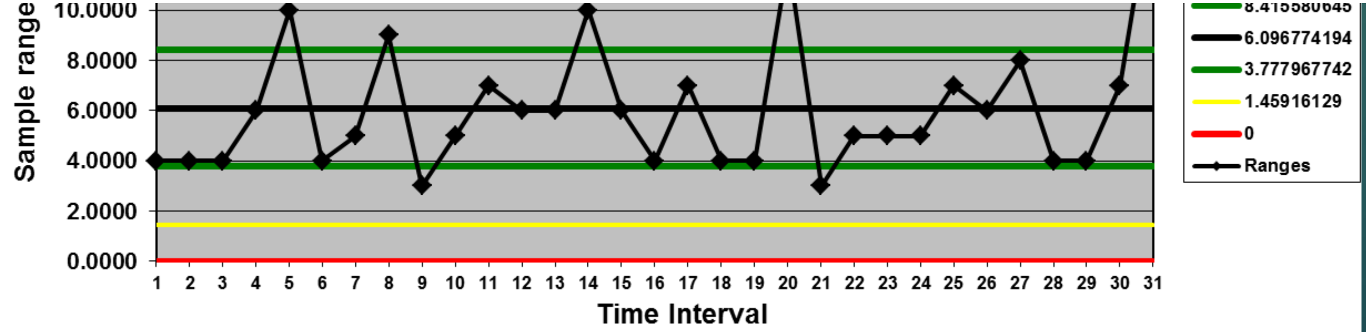
PSI Stage 2 X-Bar and R Charts



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
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

Conclusions:

- The starting time intervals of the days are good
- Poorer results toward the last three intervals of the day
- The last intervals 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 Stage 2 Two-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 Stage 2 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

Conclusion:

There is no statistical significant difference among or between different can samples across different days or different shifts.

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

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

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

Variable Selection (Backward Elimination)

#Coeffs	RSS	Cp	R^2	Adjusted R^2	Probability	Model 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				

Team Greasigma: Stage 2 Conclusions

- **Conclusion 1:** The observed mean and hypothesized mean from Stage 2 PSI data are statistical significant different from each other
- **Conclusion 2**: The sample means and variance from Stage 1 PSI data and Stage 2 PSI data are not statistical significant different from each other
- **Conclusion 3**: According to Stage 2 PSI data, we are currently still at 3 sigma level
- **Conclusion 4:** The starting time intervals of the days are better and results toward the last three intervals of the day are worse
- **Conclusion 5**: There is no statistical significant difference among each sample and between the 4 samples
- **Conclusion 6:** There is no statistically significant difference among or between different can samples across different days or different shifts
- **Conclusion 7:** Unable to identify coefficients statistically significant enough for linear regression modelling

Contributions

- Chen, Qiuye(Roger)- Responsible for slides 8 -10 (Stage 1 Data), slides 14 – 15 (Muda) and most of the data slides. Lead Team Data Analyst
- Lee, Jay – Responsible for Flowcharts on slide 6, and SIPOC Tool overview on slides 19-22
- Shin, Taekyoo – Responsible for Agenda and objective on slide 2, 3, Kaizen tool overview on slides 17-18, and PSI Data One-sample t-test Stage 2 on slide 27
- Wuerth, Daniel- Responsible for slide 5 (C/E Diagram) and slides 11 – 13 (Balanced Scorecards). Slideshow design and compilation
- Yurchenko, Dmitriy- Responsible for slide 4 (PDCA) and slide 16 (5 Whys)
- All team members collaborated fully and worked together to draw appropriate conclusions