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Case Study: Flow Measurement Accuracy Loss-Gain

WHAT WAS THE PROBLEM?

- In previous years, KNPC had potential loss of approximately half million US dollars during ship loading at Oil Pier on selected meters in performance analysis.

- The root causes of the loss were investigated and identified, and remedial causes were implemented.

SOLVING THE PROBLEM

- The Oil Pier metering system was replaced with a system based on international API standards.

- New procedures/recommendations based on the analysis were followed taking into consideration several contributors including fluid properties. This resulted in an accurate representation of the fluid quantities dispatched.

CHALLENGES

- The Standard Metering Loading Reports are not been officially used by oil account, However TANK DIP METHOD AND Manual Calculations OF SP.GR. @ 60 F, was still used to issue the final loading/accounts calculations Certificates for Customers.

- Based on management directives a team was formed including all concerned Members. to analyze the performance of the new oil pier metering system. (121 liquid meters + 17 LPG meters) and come-up with recommendations.

CHALLENGES

- Team reviewed the complete system and observed that LPG meters (LP#1/2) are not calibrated/proved due to valves passing and ice formation in provers.

- Based on above, team decided to separate the review into two portions one as liquid and other as LPG. LPG portion was reviewed later after the valves repair.

ANALYSIS

- AFTER REVIEW OF LIQUID METERING SYSTEM, TEAM SELECTED SKID # 416 (NAPTHA) FOR PERFORMANCE ANALYSIS.

- THERE WERE THREE BATCHES/LOADING CONDUCTED ON SKID # 416, THE ANALYSIS DATA FROM METERING/SHIP/SHORE ARE AS FOLLOWS:

Ship Name	Date	Product	KNPC Metering System Figures (M. Tons)	Ship Figures (M. Tons)	Shore Figures (M. Tons)	Difference (M. Tons)	Loss in US $
TORM SARA	17/8/2016	Naptha	53484	53102	53039	445 (Loss)	169,100
SUVERETTA	27/8/2016	Naptha	75710	75191	75257	453 (Loss)	172,140
SUVERETTA	22/9/2016	Naptha	50580	50311	50240	340 (Loss)	129,200

ANALYSIS

- FOR LAND LOADING, TEAM SELECTED METER # 361 (GAS OIL) FOR PERFORMANCE ANALYSIS.

- THERE WAS ONE BATCH/LOADING CONDUCTED ON METER # 361 (SUBIYAH-MEW), THE ANALYSIS DATA FROM METERING/TANK ARE AS FOLLOWS:

MTR #	Date	Product	KNPC Metering System Figure (M. Tons)	Tank Dip Figure (M. Tons)	Difference (M. Tons)	Loss in US $
FQI-361	28/9/2016	Gas Oil	6244	6186	58 (Loss)	22,852

RECOMMENDATIONS

TEAM HAS THE FOLLOWING RECOMMENDATIONS:

- OPERATIONS SHIFT SHALL ACT AS SINGLE METERING FOCAL POINT FOR COORDINATION BETWEEN OPERATION AND OTHER RELATED DIVISIONS. (OIL ACCOUNTS/INST. MAINT./PROCESS CONTROL/LAB).

- MAKE PROCEDURE/GUIDELINES FOR STARTING BATCH / SAMPLING / PROVING / END BATCH / LAB DATA / OBTAIN OFFICIAL FINAL REPORT.

- SET STANDARD CALIBRATION / PROVING INTERVAL AS BELOW:

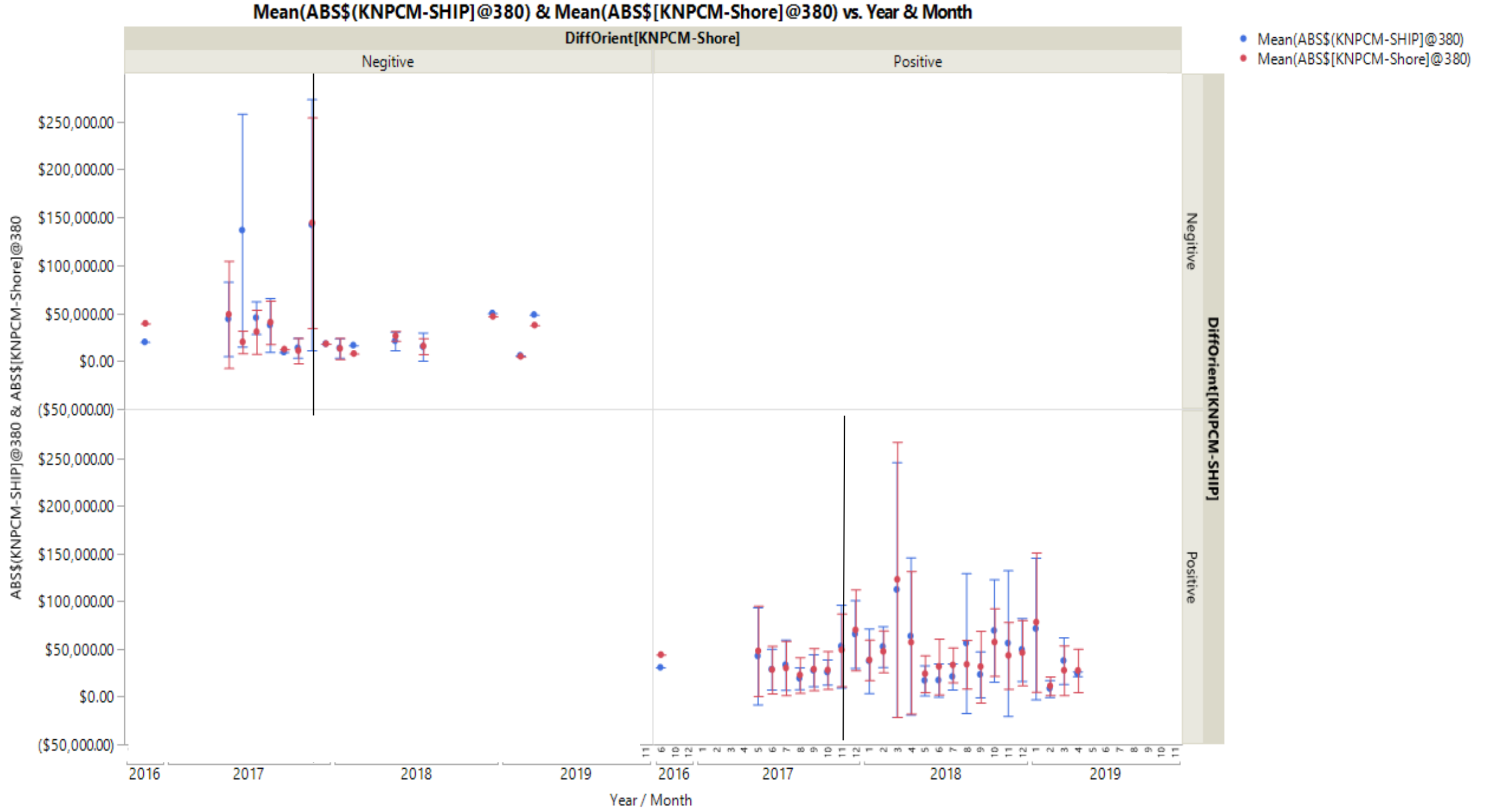
✓ EXPORTS METERS CALIBRATION/PROVING SHALL BE EVERY QUARTER.

✓ LAND LOADING METERS CALIBRATION/PROVING SHALL BE EVERY SIX MONTHS.

IMPLEMENTATION AND VALIDATION ANALYSIS

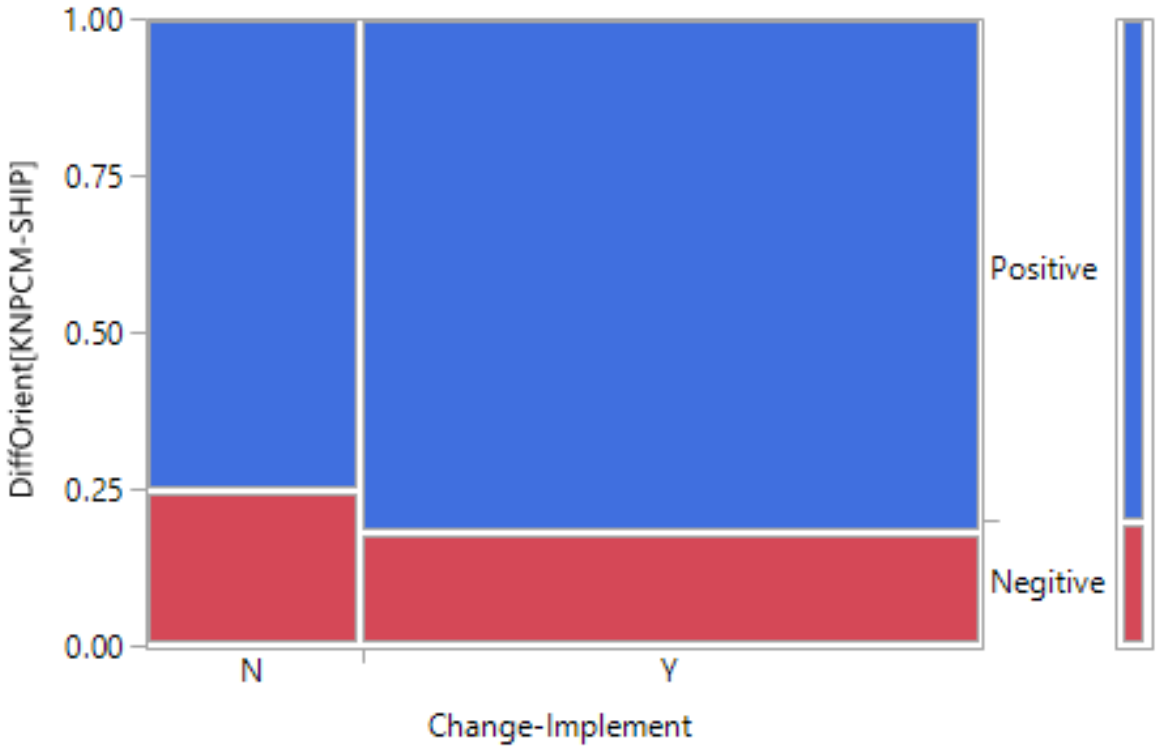
- All the recommendations were implemented.
- Loss was recovered however there will be always room for improvement.
- Analyzing the data and building statistical models helps to find the gap in the system and to validate the reading of meters.

Graph Builder



Each error bar is constructed using 1 standard deviation from the mean

Mosaic Plot



Tests

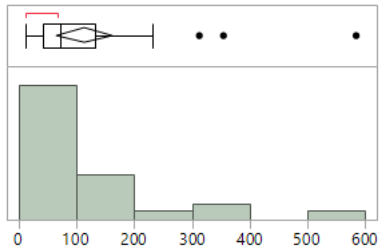
N	DF	-LogLike	RSquare (U)
49838	1	129.11082	0.0052

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	258.222	<.0001*
Pearson	267.627	<.0001*

Fisher's Exact Test	Prob	Alternative Hypothesis
Left	1.0000	Prob(DiffOrient[KNPCM-SHIP]=Positive) is greater for Change-Implement=N than Y
Right	<.0001*	Prob(DiffOrient[KNPCM-SHIP]=Positive) is greater for Change-Implement=Y than N
2-Tail	<.0001*	Prob(DiffOrient[KNPCM-SHIP]=Positive) is different across Change-Implement

Distributions Change-Implement=N, DiffOrient[KNPCM-SHIP]=Negitive

ABS[KNPCM-SHIP]

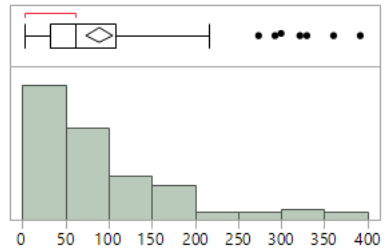


Quantiles		
100.0%	maximum	586
99.5%		586
97.5%		586
90.0%		317.2
75.0%	quartile	132
50.0%	median	72
25.0%	quartile	40.25
10.0%		14.9
2.5%		10
0.5%		10
0.0%	minimum	10

Summary Statistics	
Mean	113.75
Std Dev	125.79219
Std Err Mean	23.77249
Upper 95% Mean	162.52712
Lower 95% Mean	64.972879
N	28

Distributions Change-Implement=N, DiffOrient[KNPCM-SHIP]=Positive

ABS[KNPCM-SHIP]

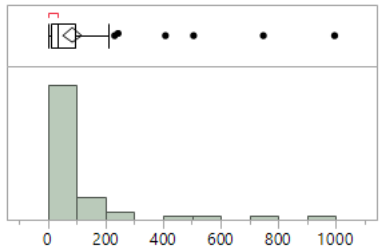


Quantiles		
100.0%	maximum	392
99.5%		392
97.5%		338.525
90.0%		195.3
75.0%	quartile	108.5
50.0%	median	62
25.0%	quartile	31.5
10.0%		12.9
2.5%		3.725
0.5%		2
0.0%	minimum	2

Summary Statistics	
Mean	89.592593
Std Dev	82.45509
Std Err Mean	7.9342447
Upper 95% Mean	105.32131
Lower 95% Mean	73.863878
N	108

Distributions Change-Implement=Y, DiffOrient[KNPCM-SHIP]=Negitive

ABS[KNPCM-SHIP]

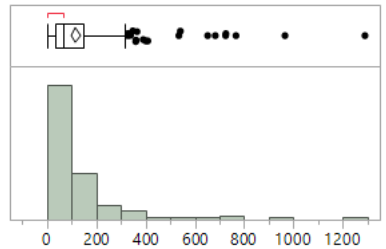


Quantiles		
100.0%	maximum	997
99.5%		997
97.5%		742.925
90.0%		194
75.0%	quartile	92
50.0%	median	33.5
25.0%	quartile	8.5
10.0%		3.1
2.5%		1
0.5%		1
0.0%	minimum	1

Summary Statistics	
Mean	83.6125
Std Dev	154.55346
Std Err Mean	17.279602
Upper 95% Mean	118.00669
Lower 95% Mean	49.218312
N	80

Distributions Change-Implement=Y, DiffOrient[KNPCM-SHIP]=Positive

ABS[KNPCM-SHIP]



Quantiles		
100.0%	maximum	1291
99.5%		1193.5
97.5%		667.5
90.0%		276
75.0%	quartile	148
50.0%	median	68
25.0%	quartile	32
10.0%		10
2.5%		3.5
0.5%		0.3
0.0%	minimum	0

Summary Statistics	
Mean	116.94208
Std Dev	156.08344
Std Err Mean	9.6985529
Upper 95% Mean	136.04049
Lower 95% Mean	97.843681
N	259

READING MAIN CONTRIBUTOR FACTORS

The decision tree model

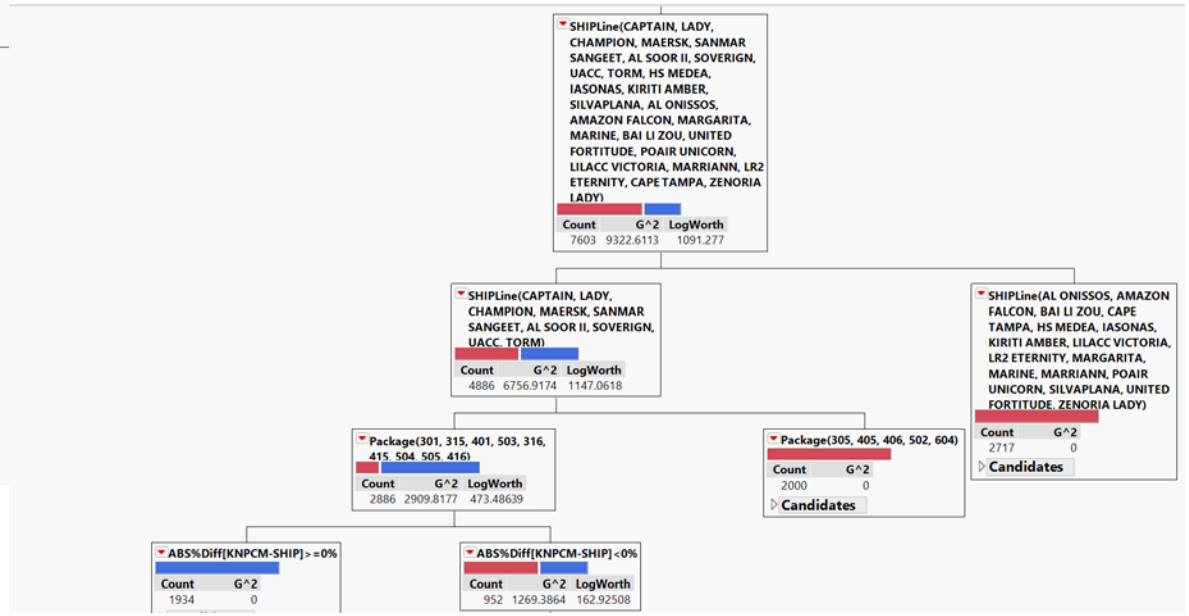
- SHIP LINE
- BERTH
- METER PACKAGE
- PRODUCT
- ABS difference %(KNPCM-Ship)
- ABS difference %(KNPCM-Shore)

The decision tree model
- It is useful for exploring relationships without having a good prior model
- It handles large problems easily
- The results are interpretable.

Column Contributions

Term	Number of Splits	G^2	Portion
SHIPLine	5	16301.6776	0.6693
Package	3	6011.68088	0.2468
ABS%Diff[KNPCM-SHIP]	1	1640.4313	0.0674
ABS$(KNPCM-SHIP]@380	1	402.665117	0.0165
BERTH	0	0	0.0000
PRODUCT	0	0	0.0000

EXPERIMENTAL MODEL APPROACH



The decision tree model can identify opportunities such as which ship liners would take a shore reading to verify!

For some ship liners the model would indicate that we be better to take a shore reading [Red versus Blue].

Meter packages play a lesser role in % difference!

CONCLUSION

- Obtain confident flow measurements, with defined, repeatable and reproducible figures against certain conditions of measurement like fluid properties, distribution of velocity etc. which in return helped gain client accreditation.
- The statistical data analysis helped us Deeper understanding of Flow meter reading which, in turn, increased KNPC profitability.

THANK YOU