Kuwait 4th Flow Measurement Technology Conference

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Hilton Kuwait Resort
SOLAIMAN A S ALANEZI
Snr. Instrument Maintenance Engineer
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.
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.
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.
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:

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>TORM SARA</td>
<td>17/8/2016</td>
<td>Naptha</td>
<td>53484</td>
<td>53102</td>
<td>53039</td>
<td>445 (Loss)</td>
<td>169,100</td>
</tr>
<tr>
<td>SUVERETTA</td>
<td>27/8/2016</td>
<td>Naptha</td>
<td>75710</td>
<td>75191</td>
<td>75257</td>
<td>453 (Loss)</td>
<td>172,140</td>
</tr>
<tr>
<td>SUVERETTA</td>
<td>22/9/2016</td>
<td>Naptha</td>
<td>50580</td>
<td>50311</td>
<td>50240</td>
<td>340 (Loss)</td>
<td>129,200</td>
</tr>
</tbody>
</table>
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:

<table>
<thead>
<tr>
<th>MTR #</th>
<th>Date</th>
<th>Product</th>
<th>KNPC Metering System Figure (M. Tons)</th>
<th>Tank Dip Figure (M. Tons)</th>
<th>Difference (M. Tons)</th>
<th>Loss in US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>FQI-361</td>
<td>28/9/2016</td>
<td>Gas Oil</td>
<td>6244</td>
<td>6186</td>
<td>58 (Loss)</td>
<td>22,852</td>
</tr>
</tbody>
</table>
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.
The mosaic plot shows the distribution of orientations with respect to change implement status. The table below summarizes the test results:

<table>
<thead>
<tr>
<th>Test</th>
<th>ChiSquare</th>
<th>Prob &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood Ratio</td>
<td>258.222</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>Pearson</td>
<td>267.627</td>
<td>&lt;.0001*</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Term</th>
<th>Number of Splits</th>
<th>G^2</th>
<th>Portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHIP LINE</td>
<td>5</td>
<td>16301.6776</td>
<td>0.6603</td>
</tr>
<tr>
<td>Package</td>
<td>3</td>
<td>6011.6808</td>
<td>0.2468</td>
</tr>
<tr>
<td>ABS(Diff)KNPCM-SHIP</td>
<td>1</td>
<td>1640.4313</td>
<td>0.0674</td>
</tr>
<tr>
<td>ABS[KNPCM-SHIP]@380</td>
<td>1</td>
<td>402.665117</td>
<td>0.0165</td>
</tr>
<tr>
<td>BERTH</td>
<td>0</td>
<td>0</td>
<td>0.0000</td>
</tr>
<tr>
<td>PRODUCT</td>
<td>0</td>
<td>0</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

ABS difference %(KNPCM-Ship)
ABS difference %(KNPCM-Shore)
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