PETRONAS GAS

PETRONAS GAS BERHAD (101671 H)

PETRONAS GAS BERHAD
KM 8, KG Tok Arun,
Off Jln. Santong
Paka
Dungun Terengganu 23100
Malaysia

To Concept Technologies Inc.
PO Box 72,
Medicine Hat, Alberta, Ca. T1A 7E5

On behalf of PETRONAS GAS BERHAD, Gas Production Plant B Cold Box Team, I would to express how pleased we are with the work executed by Concept Technologies Group during the chemical clean out of our Cold Box Exchanger E5-0408.

It would be no overstatement to say that the task presented to you and your team was a formidable challenge. Getting our cold box E5-0408 to operate within manufacturer specification was next to impossible since commissioning.

Our management and this cold box team appreciates the effort of Concept Technologies at all levels of this project; the preliminary analysis of the contaminants, chemical design and impact analysis, the choice of mechanical systems and the onsite team all came together to ensure that the contaminants were removed from the exchanger's core. Some of the innovations were simple but highly effective in achieving our goals.

We can finally report that after the chemical cleaning conducted by your team on our E5-0408 Cold Box we were able to operate within acceptable parameters.

Congratulations to Concept Technologies Group on and job well done.

Thank you
Sincerely

OPERATION ENGINEERING · MOHD ISHAM B ISA · OEB MANAGER · GPP B

10/1/2013

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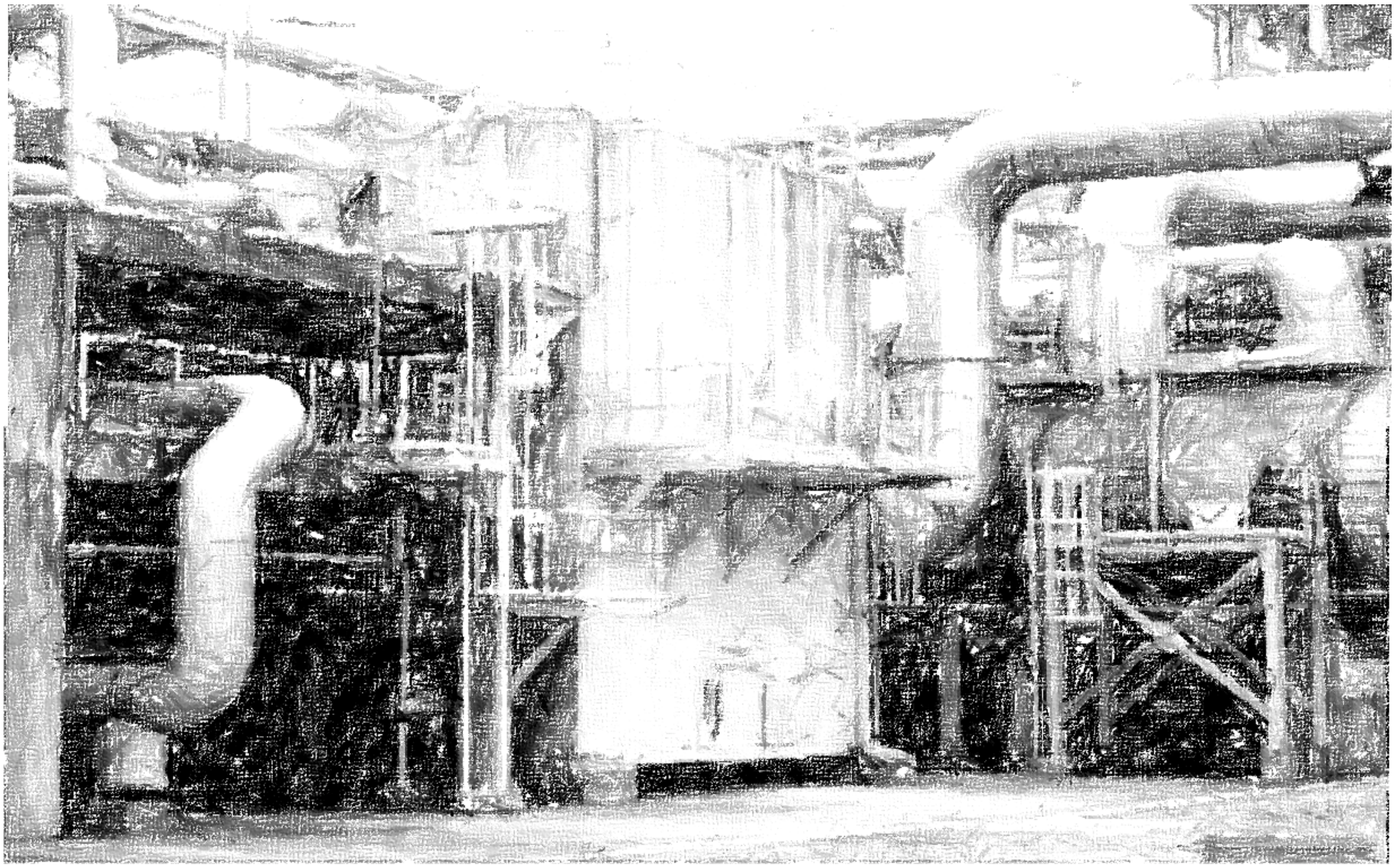
CASE REPORT

File ID: Report-020111-PGB-BAHX.docx



1.0 Introduction

1.1 BAHX – E5-0408 experience higher than designed ΔP since commissioning.

1.2 ΔP kept increasing with increasing plant load and has reached a maximum 13.9 barg in 2010.

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2.0 Equipment Data

2.1 Owner:

- PETRONAS GAS BERHAD GPP-B
- KM 8, KG Tok Arun, Off Jalan Santong, Paka, Dungun, Terengganu 23100 Malaysia.
-

2.2 Exchanger ID Tag / Location

- E5 – 0408 / GPP-B

2.3 Exchanger Details:

- Duty: 48514 kW
- Type: Aluminium (7 Passes)
- Size: 1782 (m^2)
- Design Pressure: 81.7 barg
- Design Temperature: 65°C to - 45°C
- Designed Delta P: 1.9 barg
- Construction Material: Aluminum Alloy AA5083, AA3003, Carbon Steel A333 GR 6, A586, A350, Stainless Steel SS304L
-

2.4 Commissioning Date:

- 1999

Refer to cold box exchanger specification sheet for more details.

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3.0 – Background

3.1 Year 1999:

- GPP5 (E5 – 0408) commissioned.
  - According to GPP5 commissioning report, higher the normal ΔP was experienced at start up.
  - The report suggests that this was due to plugging.
  - This resulted in 28 days downtime.
  - The problem was mitigated by back puffing with nitrogen.

3.2 Year 2000 - 2001:

- GPP5 continues to show higher than normal ΔP when compared with GPP6.
  - ΔP across GPP5 = 4.2 bar at a plant load of 680 t/h
  - Allowable ΔP across E5 – 0408 = 1.9 bar

3.3 Year 2007:

- GPP5 continues to show higher than normal ΔP when compared with GPP6.
  - ΔP across E5 - 0408 = 8 bar at a plant load of 680 t/h
  - Higher ΔP means increased core blockage, thus any plant upset will expedite the ΔP increase.
- Mitigation of ΔP by back puffing in February 2007.
- Mitigation of ΔP by solvent wash was considered in April 2007 using DuPont.
  - This plan was dropped due to no prior success history.
- Mitigation of ΔP by thawing and back puffing in November 2007.
  - Thawing remove hydrates from the system and requires plant shutdown.
  - Back puffing removes dust and other particulates. This requires plant shutdown.
- After thawing and back puffing in November 2007.
  - ΔP across E5 - 0408 = 5 bar at a plant load of 680 t/h

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3.0 – Background Cont'd

3.4 Year 2009:

- GPP5 continues to show higher than normal ΔP when compared with GPP6.
  - ΔP across E5 - 0408 = 9 bar at a plant load of 600 t/h.
  - Plant load reduced due to high ΔP.
- Mitigation of ΔP by thawing in March 2009.
  - Thawing remove hydrates from the system and requires plant shutdown.
  - After thawing in March 2009, ΔP is reduced to 7 bar
- Mitigation of ΔP by thawing and back puffing in May 2009.
  - Thawing remove hydrates from the system and requires plant shutdown.
  - Back puffing removes dust and other particulates. This requires plant shutdown.
  - After thawing and back puffing in May 2009, ΔP is reduced to 5 bar
- In December 2009, ΔP increased sharply and suddenly.
  - This is possibly due to carry over fro S5-0301, changing dust filter online without draining activity.

3.5 Year 2010:

- GPP5 continues to show higher than normal ΔP when compared with GPP6.
  - ΔP across E5 - 0408 = 13.9 bar at a plant load of 600 t/h.
  - Plant load reduced due to high ΔP.
- Mitigation of ΔP by thawing and back puffing in February 2010.
  - Thawing remove hydrates from the system and requires plant shutdown.
  - Back puffing removes dust and other particulates. This requires plant shutdown.
  - After thawing and back puffing in February 2010, ΔP is reduced to 10.5 bar

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3.0 – Background Cont'd

3.6 Summary of ΔP reduction after thawing and back puffing:

- Results from 1999 – 2010 February

When	Before	After
Nov 2007	8 bar	5 bar
Mar 2009	9 bar	7 bar
May 2009	9 bar	5 bar
Feb 2010	13 bar	10.5 bar

3.7 Comments & Discussion:

- Root cause of high of the high ΔP across E5 – 0408 as determined by GPPB Cold Box team are:
  - Accumulation of dust from upstream molecular sieve.
  - Presence of pre commission debris.
  - Hydrate formation.
  - Accumulation of liquid hydrocarbon within the cold box.
  - Design issue.
- Conclusion:
  - Thawing during TA (longer duration and complete depressurized state) has helped to reduce the ΔP of E5 – 0408.
  - Back puffing helped removed some amount of accumulated debris from the core, however the core is not completely cleared.
  - Analysis of samples collected at this point indicated that the debris comprises mostly of iron oxide (magnetic). This is believed to have come from the commissioning period.

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3.0 – Background Cont'd

3.8 Attempts to mitigate increasing high ΔP of GPP5 E5 - 0408:

- April 2007
  - Discussion with DuPont on possible solvent cleaning of cold box.
  - Plan dropped due to no prior success by vendor.
- Consultation with other vendors.
  - GPP5 team reached out to other vendors for help to solve the increasingly high ΔP problem of E5 – 0408.
  - Vendors contacted were namely SUMITOMO, KOBE and CHART INDUSTRIES.
  - The following table represents their response.

No	Issue/Action Items	Findings	Remarks
2	**Reach out SUMITOMO , KOBE and CHART-Ind** **Issues raised :** • Vendor / vendor's client experience on solvent cleaning . • Max DP above design allowable . • Possibility of erosion inside cold box core .	Basically, all three vendors provided similar response i.e. ▪No experience on solvent cleaning. ▪Only efficiency of system affected . No issue as long as inlet pressure does not reach design pressure and stable . ▪Erosion possible due to restriction. But no case of erosion failure yet.	**Not to carry out solvent cleaning for coming shutdown due to :** ➢No vendors or plants has done solvent cleaning. ➢No detailed cleaning procedure from KOBE ➢Choice of solvent / solubility ➢Require competent person – HSE risks ➢Freezing if trapped in cold box during start up ➢Fire hazard ➢High cost ➢Time consuming- critical path ➢Not to introduce new problem to the cold box ➢Spillage

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3.0 – Background Cont'd

3.9 Sample analysis (by SIRIM):

- Back puffing 2007

Table 1: Chemical Composition (%) of the magnetic portions of unknown deposits resulted from SEM-EDX Analysis

Element	Chemical Composition (%)							
	08-014-1M		08-014-2M		08-014-3M		08-014-4M	
Carbon, C	7.86	10.52	5.81	5.42	8.53	12.14	10.83	7.32
Oxygen, O	16.28	22.64	21.43	16.13	21.19	14.14	23.04	22.00
Sodium, Na	0.55	2.12	0.52	0.99	0.91	1.09	1.44	1.27
Magnesium, Mg	ND[2]	0.93	ND	ND	ND	ND	ND	ND
Aluminium, Al	0.36	1.07	0.52	3.10	0.66	1.30	0.91	0.44
Silicon, Si	0.69	1.53	0.70	5.66	1.48	2.36	1.14	0.85
Sulphur, S	1.99	3.27	1.90	0.98	2.76	6.83	6.46	2.82
Potassium, K	0.54	1.20	ND	ND	ND	ND	ND	ND
Manganese, Mn	4.31	1.21	0.90	1.48	0.88	1.22	1.02	1.80
Iron, Fe	67.42	55.51	68.22	66.24	62.82	60.93	55.16	63.51

Table 2: Chemical Composition (%) of the non-magnetic portions of unknown deposits resulted from SEM-EDX Analysis

Element	Chemical Composition (%)						
	08-014-1N		08-014-2N		08-014-3N	08-014-4N	
Carbon, C	87.21	13.44	10.84	16.24	Non-magnetic portion was insignificant to be separated from the magnetic portion for this sample	15.50	84.80
Oxygen, O	7.07	27.80	39.91	31.35		37.79	8.17
Sodium, Na	ND	6.69	0.91	0.70		0.55	0.30
Magnesium, Mg	ND	1.84	ND	ND		ND	ND
Aluminium, Al	0.57	15.00	1.34	1.67		1.60	0.84
Silicon, Si	0.97	20.46	42.91	45.42		42.64	2.50
Phosphorous, P	ND	1.16	ND	ND		ND	ND
Sulphur, S	2.73	1.50	1.22	0.84		0.63	1.90
Potassium, K	0.28	10.27	1.09	1.48		1.29	0.55
Iron, Fe	1.16	1.83	1.77	2.31		ND	0.93

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3.0 – Background Cont'd

3.9 Sample analysis (by SIRIM):

- Back puffing 2009

Table 1: EDX analyses results of the debris

No.	Element	Chemical Composition, wt%					
		S5-301 A/B: Dust Filter	F_{in} Drop Spool	ES 0407	Back Puffing F_{in} Es 0408	Spent Mol Sieve	S5-0302 A/B Activated Carbon
1	Carbon, C	26.14 - 67.68	5.02 - 5.03	22.89 - 41.55	5.47 - 7.91	8.76 - 12.30	79.68 - 80.05
2	Oxygen, O	10.28 - 32.88	16.72 - 16.76	24.37 - 28.94	12.63 - 15.86	30.24 - 32.42	3.13 - 3.44
3	Sodium, Na	0.50 - 0.83	ND	1.39 - 1.68	0.88 - 1.13	4.96 - 5.34	ND
4	Magnesium, Mg	0.31	0.83	0.90 - 1.33	0.68 - 0.94	1.89 - 1.93	ND
5	Aluminium, Al	1.50 - 1.67	1.82 - 1.83	4.27 - 5.32	2.07 - 2.64	12.50 -13.21	0.66 - 0.82
6	Silicon, Si	2.57 - 36.36	3.33	19.48 - 30.24	2.92 - 3.74	16.73 - 18.21	1.37 - 1.68
7	Sulphur, S	0.73 - 8.33	3.26	1.21 - 1.24	2.12 - 3.74	0.23 - 0.38	14.48 - 14.70
8	Potassium, K	0.64-1.39	ND	3.01 - 4.39	0.32 - 0.62	18.05 - 21.12	ND
9	Calcium, Ca	0.52	ND	0.52 - 0.97	0.33 - 0.42	ND	ND
10	Manganese, Mn	ND	2.68	ND	1.22 - 1.83	ND	ND
11	Titanium, Ti	0.39	ND	ND	ND	ND	ND
12	Iron, Fe	6.18	58.50 - 58.52	2.84 - 3.46	49.30 - 63.52	0.85 - 0.87	ND
13	Zinc, Zn	1.11	ND	ND	ND	ND	ND
14	Mercury, Hg	ND	7.80	ND	7.24 - 12.49	ND	ND

ND – Not Detected

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4.0 – CTI 1st Intervention

4.1 May 2010 – Initial Proposal:

- Concept Technologies Inc through its local office Concept Technologies Sdn. Bhd. was invited to submit a proposal to PGB – GPP5 to chemically decontaminate E5 – 0408 and E5 - 0407.
  - The initial proposal was submitted on May 19th 2010.
  - The proposal was based upon the 2009 sample analysis provided by PGB.
  - Also a physical sample from 2009 back puffing was provided to Concept Technologies Inc.
- Project Scope.
  - To completely remove fouling materials (hard fine debris) from the system, by means of chemical decontamination
  - Using CTSB CIP (Cleaning in Place) Unit, a specially formulated treatment solution will be flooded into the cold box exchanger. The exchanger will be divided into three smaller loops; the solution will be circulated through each loop separately until all fouling materials have been removed. This method of flooded circulation of the exchanger loops ensure that the cleaning solution comes into contact with the entire internal surface of the exchanger and associated equipment, reacting and making soluble any contaminants on the surface so that it is easily removed. Once all contaminants have been removed, the exchanger will be rinsed, dried and then turned over for other services.
  - Wastewater will be collected and disposed in accordance with local regulations and PGB guidelines
- Recommended treatment chemical:
  - ART 1000 SC-610, low pH organic salt for removal of iron oxide.
  - WINHIB 1113, corrosion inhibitor specific for aluminum.
  - Methanol as a rinse medium to aid the removal of residual water from the system.

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4.0 – CTI 1st Intervention

4.2 July 2010 – Second Proposal:

- The project scope remained unchanged however the chemical recommendation was modified.
  - It was at first proposed to flood the system with a water based treatment solution.
  - Upon KOBE recommendation using a water-based treatment solution would be detrimental to the metallurgy of the cold box due to the presence of elemental mercury.
  - After discussion with CTI and PGB personnel it was decided to replace water as a diluent with p – Xylene.
  - The object was to dissolve the low pH organic salt in m – Xylene, which would be further diluted with p – Xylene provided by PGB.
- Revise recommended chemical solutions:
  - Urea HCl in m - Xylene, for removal of iron oxide.
  - p – Xylene as a diluent for flooding the system.
  - WINHIB 1113, corrosion inhibitor specific for aluminum.
  - Methanol as a rinse medium to aid the removal of residual water from the system
- Evaluation of chemical treatment solution on metallurgy of the cold box and the contaminants.
  - Corrosion studies by independent 3rd party lab – TD Research, Kingston Ontario. ASTM G31-72, NACE Standard TM0169-76. Metal coupons: AL 5083, AL 3003
  - Concept Technologies Inc. in house lab analysis: the effectiveness of Urea HCl + p – Xylene in the removal of iron oxide.
  - It was shown that the effectiveness of Urea HCl + p – Xylene is significantly reduced when compared to Urea HCl in water. p – Xylene is believed to inhibit the reaction between Urea HCl and iron oxide.

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4.0 – CTI 1st Intervention

4.3 August 2010 – Chemical decontamination with Urea HCl in p - Xylene:

- CIP Unit specification.
  - 120m^3/h system.
  - CIP inlet/outlet is 2"
- Loop modification: It was decided that only 2 loops would be circulated during the GPP5 mini TA.
- E5-0408 Loop 1 Stream 3 (D_{IN} – D_{OUT})
  - Circulation Volume ~ 12 m^3
  - Urea HCl + m-Xylene Blend ~ 1.6 m^3
  - WINHIB + m-Xylene ~ 0.270 m^3
  - p - Xylene ~ 10 m^3
- E5-0408 Loop 2 Stream 1A + 1B (E_{IN} + F_{IN} – $E+F_{OUT}$)
  - Circulation Volume ~ 17 m^3
  - Urea HCl + m-Xylene Blend ~ 2.4 m^3
  - WINHIB + m-Xylene ~ 0.360 m^3
  - p - Xylene ~ 14 m^3
- Refer to Post Job Report: PJR-081310-PGB-BAHX for full account of all onsite activities.

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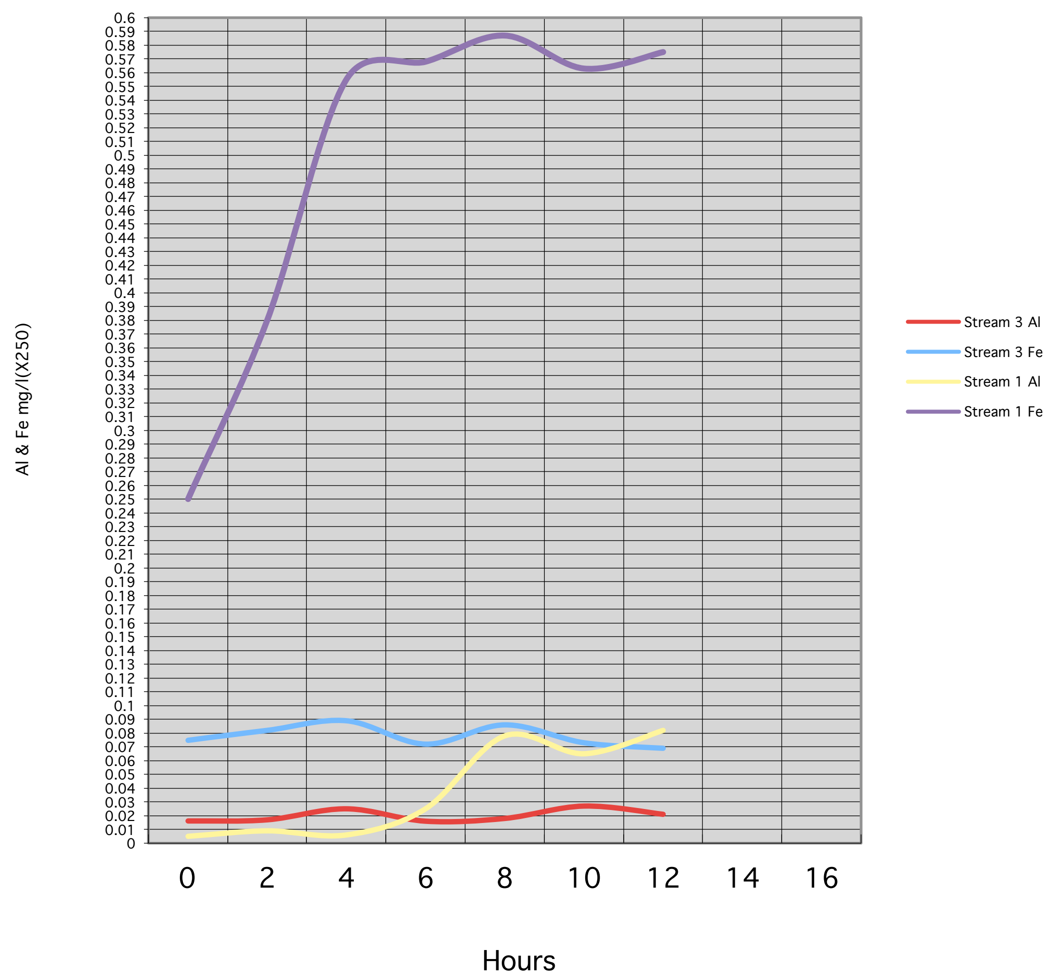
4.0 – CTI 1st Intervention

4.4 August 2010 – Results of chemical decontamination using Urea HCl in p - Xylene:

4.2 Removal of Iron Oxide



4.0 – CTI 1st Intervention

4.5 August 2010 – Results of chemical decontamination using Urea HCl in p - Xylene:

BAHX ID	Treated	Volume of Loop (L)	1st Phase Cleaning Al Removed	1st Phase Cleaning Fe Removed	2nd Phase Cleaning Al Removed	2nd Phase Cleaning Fe Removed	3rd Phase Cleaning Al Removed	3rd Phase Cleaning Fe Removed	Total Al & Fe Removed
E5-0408 Stream 3	Yes	10000	Test Result mg/l	Test Result mg/l	Test Result mg/l	Test Result mg/l	Test Result mg/l	Test Result mg/l	TOTAL Al
			20.5	18.0					0.205 Kg
			Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	TOTAL Fe
			0.205	0.180					0.180 Kg
E5-0408 Stream 1	Yes	14000	Test Result mg/l	Test Result mg/l	Test Result mg/	Test Result mg/l	Test Result mg/l	Test Result mg/l	TOTAL Al
			6.26	143.8					0.875 Kg
			Sub Total Kg	Sub Total Kg					TOTAL Fe
			0.875	2.013					2.013 Kg
			Test Result mg/l	Test Result mg/l	Test Result mg/	Test Result mg/l	Test Result mg/l	Test Result mg/l	TOTAL Al
			Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	TOTAL Fe
			Test Result mg/l	Test Result mg/l	Test Result mg/	Test Result mg/l	Test Result mg/l	Test Result mg/l	TOTAL Al
			Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	TOTAL Fe
			Test Result mg/l	Test Result mg/l	Test Result mg/	Test Result mg/l	Test Result mg/l	Test Result mg/l	TOTAL Al
			Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	TOTAL Fe
			Test Result mg/l	Test Result mg/l	Test Result mg/	Test Result mg/l	Test Result mg/l	Test Result mg/l	TOTAL Al
			Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	TOTAL Fe

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4.0 – CTI 1st Intervention

4.6 August 2010 – Observation / Discussion / Conclusion / Recommendations:

4.6.1 Uncertainties:

1. The amount of iron oxide contaminant inside the BAHX is an unknown for all streams.
2. The exact volumes of both streams were unknown.
3. The size of the particles is an unknown for both streams.
4. Possibility that other types of contaminants are present within the BAHX E5-0408.

4.6.2 Observations/Discussions:

1. The amount of aluminum removed by the treatment solution was at all times below critical threshold value established prior to the chemical treatment. The critical threshold values for both streams are 100 mg/L of aluminum.
   - The amount of Al removed from stream 3 is greater that the amount of iron removed from stream 3.
     i. One reason for this is that the amount of iron oxide present in stream 3 was not significant.

2. Only a minimal amount of iron oxide was removed from both streams 1 and 2.
   - The ineffectiveness of the Urea HCl solution can be attributed to the following:
     i. The amount of Urea HCl present in the system was insufficient to completely react with all the oxide contaminants present.
     ii. Keeping pH of the treatment solution between 4.5 and 6.0 upon recommendation of the BAHX manufacturer. This in effect resulted in a solution that has a very low potential to react with iron oxide.
     iii. Inadequate flow or preferential flow through the loops.
     iv. Interferences caused by p-Xylene inhibit the effectiveness of Urea HCl when compared with water systems.
     v. Large agglomeration of contaminants within the system would require longer circulation times, when the treatment solution is relatively weak.

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4.0 – CTI 1st Intervention

4.6 August 2010 – Observation / Discussion / Conclusion / Recommendations:

4.6.3 Conclusion:

1. There was no significant removal of contaminants from both streams.
2. Reduction in ΔP across E5-0408 was not achieved as expected.

4.6.4 Recommendations:

1. Any subsequent cleaning of the BAHX E5-0408 is carried out with a water medium.
    - Mercury corrosion of aluminum will need to be accessed and a mitigation plan put in place.
    - Since iron oxide is believed to be the fouling material, it is recommended that Urea HCl be used since it is determined that it has the least impact on aluminum. Available corrosion tests and data support this recommendation.
2. Larger inlet/outlet to exchanger be used, at least 4”.
3. Use a higher volume pump system, at least 300 m^3/hr.
    - Velocity ~ 10m/s.
4. Circulation should only be in one direction, opposite the natural flow of the exchanger.
5. Use a thickening agent (POLYGEL CA) to enhance the carrying properties of the water base medium. This will aid in the removal of insoluble and large particles from the exchanger to the inline filter system.

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5.0 – CTI 2nd Intervention

5.1 November 2010 – Proposal for second intervention:

- CTI was invited to submit a proposal by PGB – GPP5 to chemically decontaminate E5 – 0408, Stream 3.
    - The proposal for a second intervention of chemical cleaning was submitted on October 20th 2010.
    - The proposal was based upon the 2009 sample analysis provided by PGB and the recommendations derived from our first chemical cleaning intervention in August 2010.

- Project Scope.
    - To completely remove fouling materials (hard fine debris) from E5-0408 Stream 3, by means of chemical and mechanical decontamination
    - Using GSSB high volume CIP unit, a specially formulated high density, water based solution will be flooded into the stream 3 of E5-0408. This method of flooded circulation of the loop ensures that the cleaning solution comes into contact with the entire internal surface of the exchanger and associated equipment, dispersing and dissolving contaminants from inside the exchanger so that it is easily removed. The thickened liquid gives the fluid its ability to physically transport debris from inside the exchanger to the CIP filter system.
    - Circulation is done in the direction opposite the natural flow of the exchanger.
    - After chemical decontamination the exchanger will be drained, then flushed with methanol.
    - Wastewater will be collected and disposed in accordance with local regulations and PGB guidelines.

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5.0 – CTI 2nd Intervention

5.1 December 2010 – Proposal for second intervention:

- Recommended treatment chemical:
  - ART 1000 SC-610, low pH organic salt for removal of oxides and carbonates.
  - WINHIB 1113, corrosion inhibitor specific for aluminum.
  - Methanol as a rinse medium to aid the removal of residual water from the system.

- CIP Unit specification.
  - 360 m^3/h centrifugal pump.
  - CIP inlet/outlet – 4”
  - Duplex Filter Module with 50 microns filter bags.

- Loop Specification: E5-0408 Stream 3 (D_{IN} – D_{OUT})
  - Circulation Volume ~ 14 m^3
  - Water + POLYGEL CA ~ 10 m^3
  - ART 1000 SC-610 – A ~ 4 m^3
  - WINHIB 1113 ~ 0.35 m^3
- Loop Specification: E5-0408 Stream 1A + 1B (E_{IN} + F_{IN} – E+F_{OUT})
  - Circulation Volume ~ 19 m^3
  - Water + POLYGEL CA ~ 14 m^3
  - BITUSOL SC-615 ~ 4 m^3
  - ART 1000 SC-610 ~ 1 m^3
  - WINHIB 1113 ~ 0.65 m^3
- Refer to Post Job Report: PJR-121510-PGB-BAHX for full account of all onsite activities.
-

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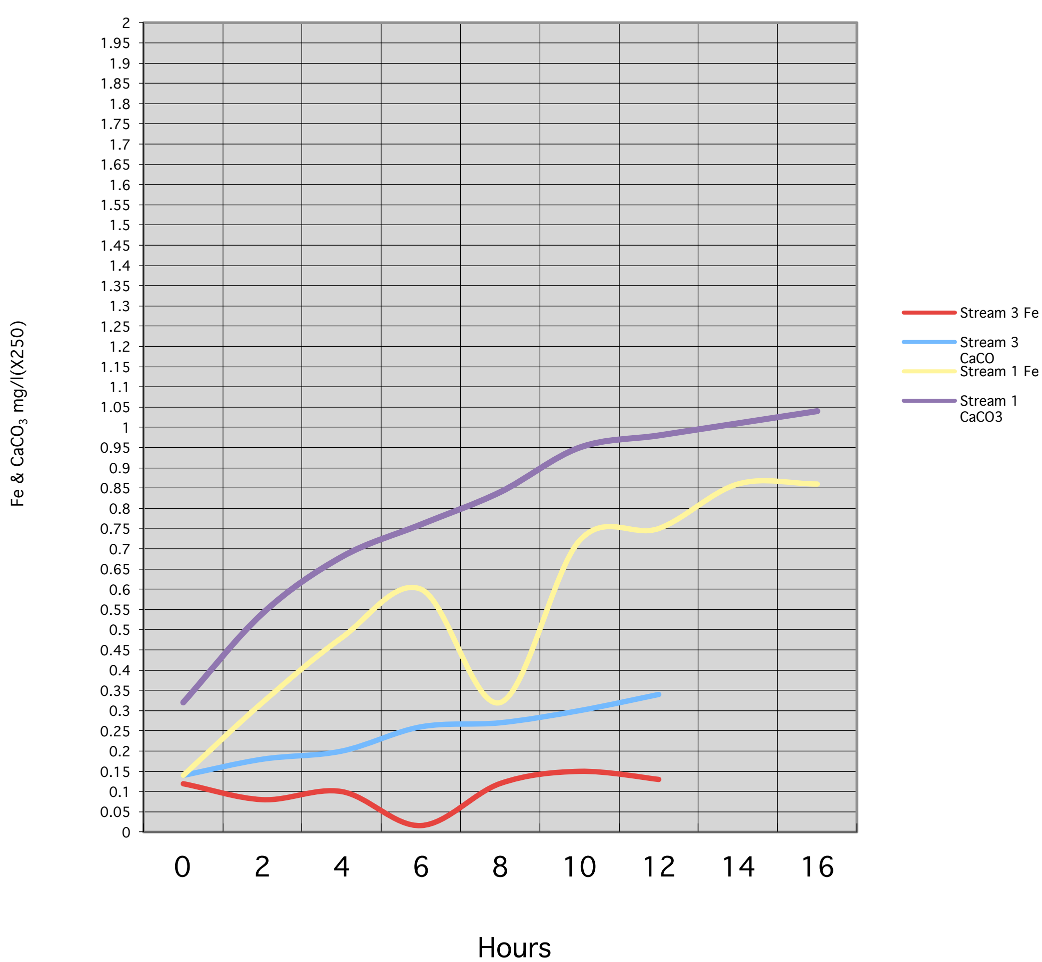
5.0 – CTI 2nd Intervention

5.2 November 2010 – Results of chemical decontamination using Thickened Water, BITUSOL and Urea HCl

5.2 Removal of Iron Oxide & Calcium Carbonate



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5.0 – CTI 2nd Intervention

5.3 December 2010 – Results of chemical decontamination using Thickened Water, BITUSOL and Urea HCl

BAHX ID	Treated	Volume of Loop (L)	1st Phase Cleaning Fe Removed	1st Phase Cleaning CaCO3 Removed	2nd Phase Cleaning Fe Removed	2nd Phase Cleaning $CaCO_3$ Removed	3rd Phase Cleaning Al Removed	3rd Phase Cleaning Fe Removed	Total Fe & $CaCO_3$ Removed
E5-0408 Stream 3	Yes	10000	Test Result mg/l	Test Result mg/l	Test Result mg/l	Test Result mg/l	Test Result mg/l	Test Result mg/l	TOTAL Fe
			55.0	57.5	25	85			0.75 Kg
			Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	Sub Total Kg	TOTAL CaCO3
			0.55	0.58	0.25	0.85			1.40 Kg
E5-0408 Stream 1	Ye Yes ses	14000	Test Result mg/l	Test Result mg/l	Test Result mg/	Test Result mg/l	Test Result mg/l	Test Result mg/l	TOTAL Fe
			180	160	150	260			4.6 Kg
			Sub Total Kg	Sub Total Kg					TOTAL CaCO3
			2.5	2.24	2.1	3.64			5.88 Kg
E5-0408 Stream 3			Solids Removed from Filter (Kg)		Solids Removed from Filter (Kg)				TOTAL Solids
			9		7				16 Kg
E5-0408 Stream 1			Solids Removed from Filter (Kg)		Solids Removed from Filter (Kg)				TOTAL Solids
			13		12				25 Kg

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5.0 – CTI 2nd Intervention

5.4 December 2010 – Observation / Discussion / Conclusion / Recommendations:

5.4.1 Uncertainties:

5. The amount of iron oxide contaminant inside the BAHX is an unknown for all streams.
6. The size of the particles is unknown for both streams.
7. Possibility that other types of contaminants [molecular sieve] are present within the BAHX E5-0408.

5.4.2 Observations/Discussions:

3. The amount of aluminum removed by the treatment solution was at all times below critical threshold value established prior to the chemical treatment. The critical threshold values for both streams are 100 mg/L of aluminum.
4. Iron was removed from both streams 1 and 2.
    - The iron oxide observed in the exchanger could have resulted due to the presence of moisture in the gas, affecting the transition joints.
5. Carbonate compounds were removed from both streams 1 and 2.
6. Significant amount of solids were collected in the Duplex Filter Module from both streams 1 and 2.
    - This is a direct result of the thickened solution carrying ability to transport and carry solids away from the cores.
    - The cores were circulated opposite to the natural flow of the exchanger.
7. Significant amounts of hydrocarbon were removed from the exchanger cores.
    - Solid hydrocarbon particles were observed in the sludge accumulated in the Duplex filter module.
8. Damage strainers can also contribute to particulates accumulating in the cold box.

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5.0 – CTI 2nd Intervention

5.5 December 2010 – Observation / Discussion / Conclusion / Recommendations:

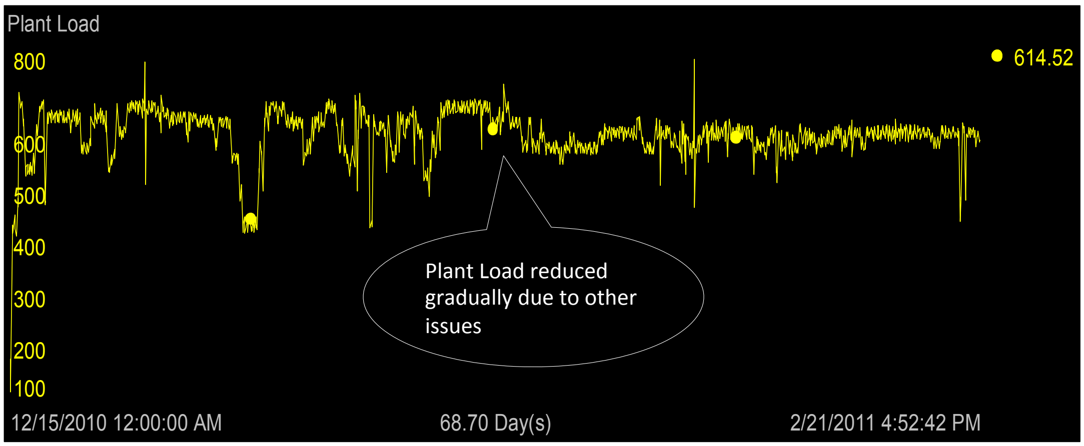
5.5.1 Conclusion:

1. There was a significant removal of contaminants from both streams1 and 2.
2. Reduction in ΔP across E5-0408 was achieved dropping from 13.9 barg to 4.5 barg.
   i. See PGB trending after 2nd chemical cleaning.

5.5.2 Recommendations:

1. Close monitoring of the upstream drying medium and strainers.
   - Significant amounts of molecular sieve dust were observed taken out from the exchanger streams.
2. PGB should look at the upstream process and how it impacts the cold box E5-0408.
3. The cold box E5-0408 should be flushed at least once a year.

E5-0408 Trending after CTI 2nd Intervention



GPP 5 Plant load after second chemical cleaning@ 14th Dec 2010:

- Start of run, the load is 680t/h and gradually maintain low as 614t/h due to business strategy based on availability of feed gas

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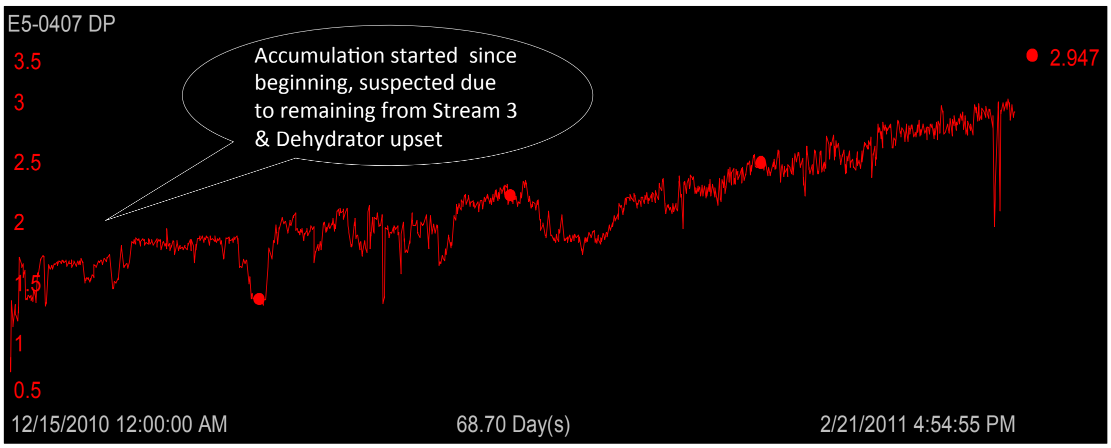
E5-0408 Trending after CTI 2nd Intervention



E5-0407 DP after second chemical cleaning@ 14th Dec 2010:

- Start of run, DP across E5-0407 is 1.8 bar. DP has reached 2.9 bar@620t/h in 2 months time.
- DP increasing at start of run suspected some minor left over from Stream 3 of E5-408 has accumulated at E5-0407 strainer.
- Lower DHU performance also promote the accumulation rate to increase

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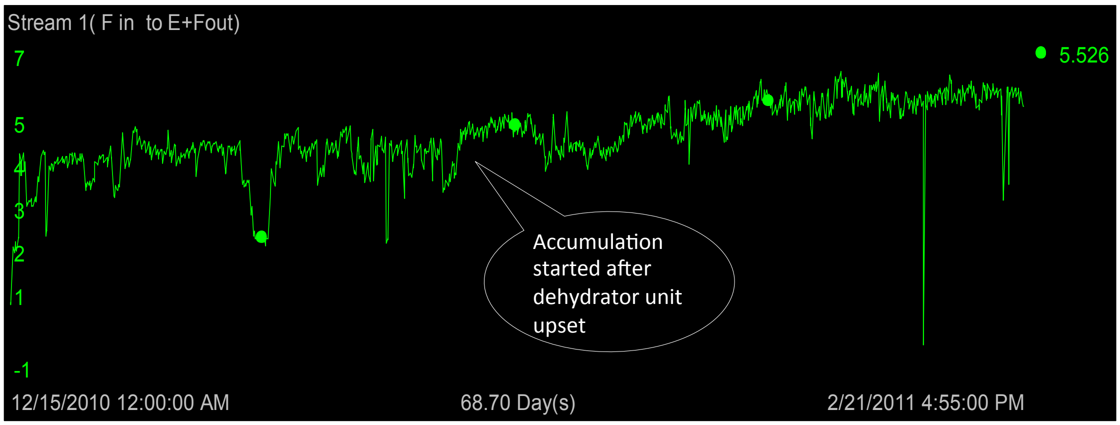
E5-0408 Trending after CTI 2nd Intervention



E5-0408 Stream 1 DP after second chemical cleaning@ 14th Dec 2010:

- Start of run, DP is 4.5 bar. DP has reached 5.5 bar@620t/h in 2 months time.
- Accumulation of DP is suspected due to E5-0407 DP increased.

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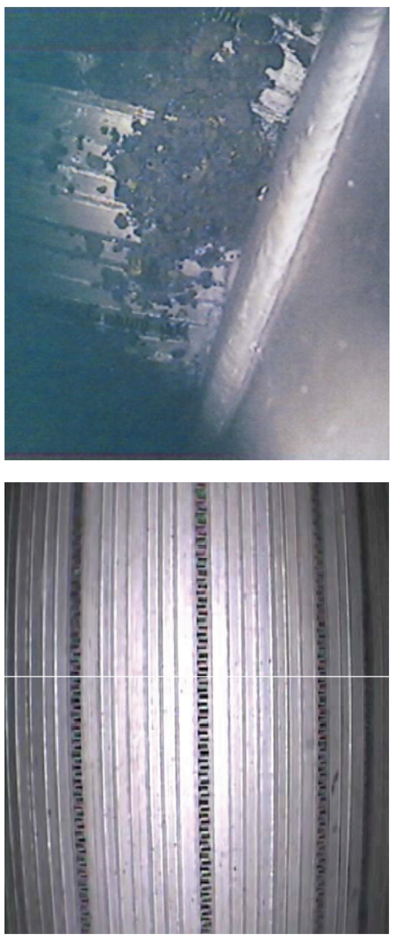
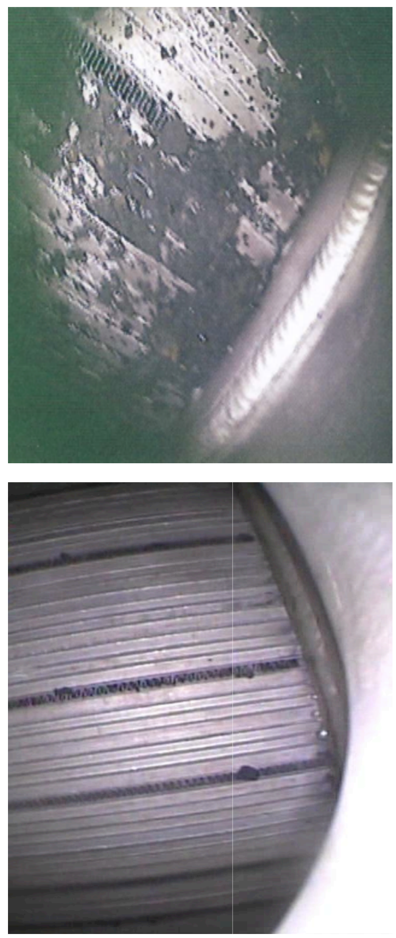
Before & After Pictures

Stream 1 – 4th Nozzle Right 01



Stream 1 – 4th Nozzle Right 02



PETRONAS GAS

PETRONAS GAS BERHAD (101671 H)

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To Concept Technologies Inc.
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Medicine Hat, Alberta, Ca. T1A 7E5

On behalf of PETRONAS GAS BERHAD, Gas Production Plant B Cold Box Team, I would to express how pleased we are with the work executed by Concept Technologies Group during the chemical clean out of our Cold Box Exchanger E5-0408.

It would be no overstatement to say that the task presented to you and your team was a formidable challenge. Getting our cold box E5-0408 to operate within manufacturer specification was next to impossible since commissioning.

Our management and this cold box team appreciates the effort of Concept Technologies at all levels of this project; the preliminary analysis of the contaminants, chemical design and impact analysis, the choice of mechanical systems and the onsite team all came together to ensure that the contaminants were removed from the exchanger's core. Some of the innovations were simple but highly effective in achieving our goals.

We can finally report that after the chemical cleaning conducted by your team on our E5-0408 Cold Box we were able to operate within acceptable parameters.

Congratulations to Concept Technologies Group on and job well done.

Thank you
Sincerely

OPERATION ENGINEERING
MOHD ISHAM B ISA
OEB MANAGER
GPP B

10/1/2013

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