Challenges in Managing Mercury in Field Development and Production

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Targeted Mercury Removal in Raw Condensate: A Phased Approach from Analysis to MRU Optimization

M Erwani B Aziz[a], M Farizal N M Nor Azli[a], Roslydia Akma Bt Rusli[a], Norfaiz Izzat Bt Rusly[a]

Tg M Uzaini B Tg Mat[b], Safwan B A Salam[b], ChM Dr Sharizal B Mohd Azam Shah Wong[b], Suriani Bt Hj Yaakob[b]

[a]PETRONAS Carigali Sdn. Bhd.,

[b]Petronas Research Sdn. Bhd.

Introduction

- Current MRU configuration to treat mercury in condensate stream at receiving terminal is not optimized and having operational issues such as fouling and underperformed.
- This led to high frequency of the filter elements replacement and pressure drop issues across mercury adsorbers – thus putting the MRU on idle.
- Effective solutions to decrease mercury down to acceptable levels;
  - Modifications of the filters/coalescers arrangement
  - Selection of mercury adsorbent are considered
- Advantage of current approach – lower cost, shorter testing duration and lower risks compared to commercial trial.

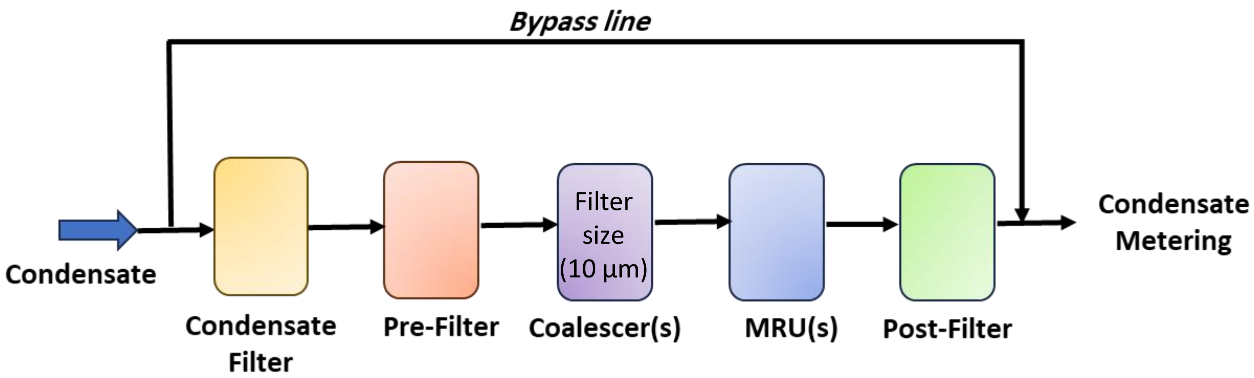

Figure 1: MRU configuration

Methodology

Lab-test adsorbent pre-qualification			
Sampling of condensate at site	Mercury grouping & particle size analysis	Adsorbent characterization	Adsorbent performance test

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Validation of mercury groups via onsite measurement

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Reduced-scale testing configuration to validate selected adsorbent	
Identical LHSV to actual MRU	Appropriate filtration size

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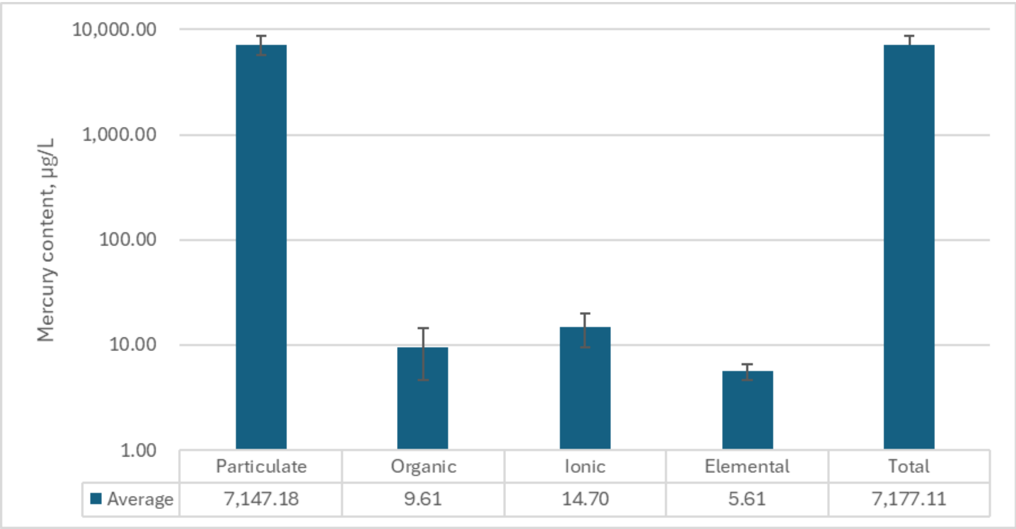
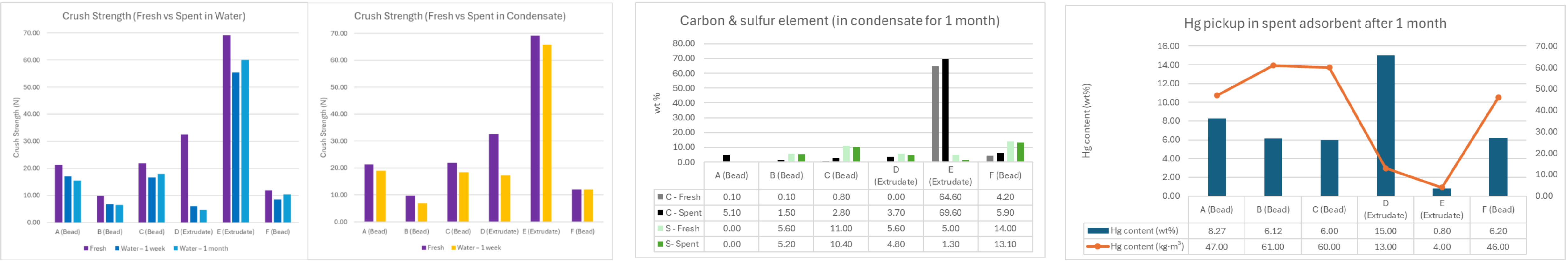
Lab-test adsorbent testing

- Condensate collected at site indicated more than 99% is particulate and remaining are elemental, organic and ionic Hg,
- 6 adsorbents were tested for a duration of 1 month
- Selection criteria of adsorbent:
  - Good stability over time,
  - Good mechanical resistance,
  - Limited fines formation,
  - Acceptable mercury pick-up.
- Adsorbent C & Adsorbent F are selected for onsite performance test.



	Particulate	Organic	Ionic	Elemental	Total
Average	7,147.18	9.61	14.70	5.61	7,177.11

Figure 2: Mercury grouping for condensate collected from site (n=3)



Carbon & sulfur element (in condensate for 1 month)

	A (Bead)	B (Bead)	C (Bead)	D (Extrudate)	E (Extrudate)	F (Bead)
C - Fresh	0.10	0.10	0.80	0.00	64.60	4.20
C - Spent	5.10	1.50	2.80	3.70	69.60	5.90
S - Fresh	0.00	5.60	11.00	5.60	5.00	14.00
S- Spent	0.00	5.20	10.40	4.80	1.30	13.10

Hg pickup in spent adsorbent after 1 month

	A (Bead)	B (Bead)	C (Bead)	D (Extrudate)	E (Extrudate)	F (Bead)
Hg content (wt%)	8.27	6.12	6.00	15.00	0.80	6.20
Hg content (kg·m^3)	47.00	61.00	60.00	13.00	4.00	46.00

Figure 3: Evaluation on adsorbents (i) crush strength in water and condensate (ii) Carbon and sulfur changes (iii) Mercury pickup

Validation of mercury groups via onsite measurement

- Condensate sampling was done at 70-85 bar in sampling cylinder and moved to a temporary laboratory;
- Sample depressurized – gas collected in Tedlar bag whilst stabilized liquid collected prior to grouped according to UOP 938 method.

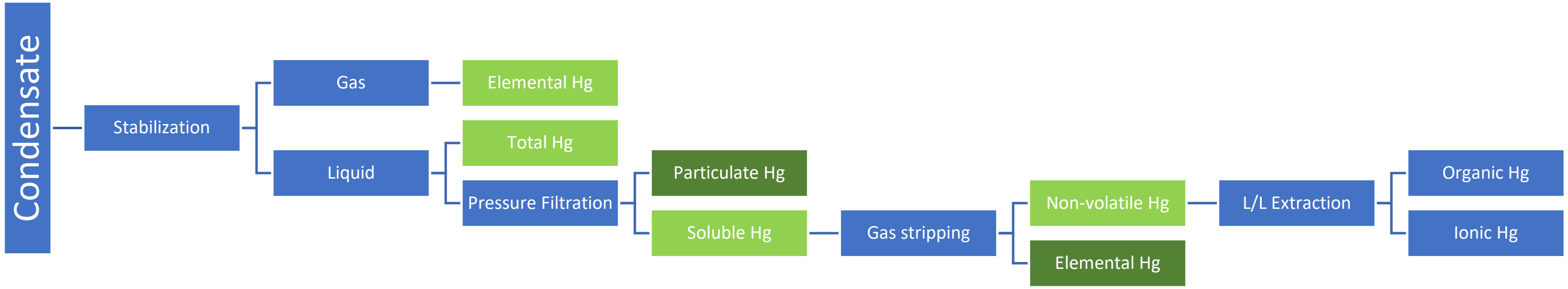


Figure 4: Adopted UOP 938 method for condensate grouping

- Findings;
  - Gas/Liquid Fraction: 85 wt% stabilized liquid
  - High fluctuation shown for samples collected, subjected to the incoming feed from offshore.
  - Higher elemental Hg in condensate measured vs. in lab.

Speciation, µg/L	Lab	On-site
Total	5,790 – 10,200	1,154 – 14,281
Particulate	5,758 – 10,093	772 – 14,273
Elemental	5 – 71	5 – 604
Organic	4 – 15	0 – 37
Inorganic	11 – 20	0 – 24

Table 1: Comparison of Hg grouping done in lab vs. onsite

Reduced-scale testing configuration to validate selected adsorbent

- Mobile test skid was developed based on the actual configuration with reduced flow and capable of testing different mode of operation.
- Duration of 10 days, operating pressure ~ 90-95 bar, LHSV: 0.9 h^{-1}
- Gas/liquid fraction observed ~ 80wt%, slightly lower during previous phase.
- Total mercury reported ranging from 300 – 70,000 µg/L, with more than 90% predominantly particulate

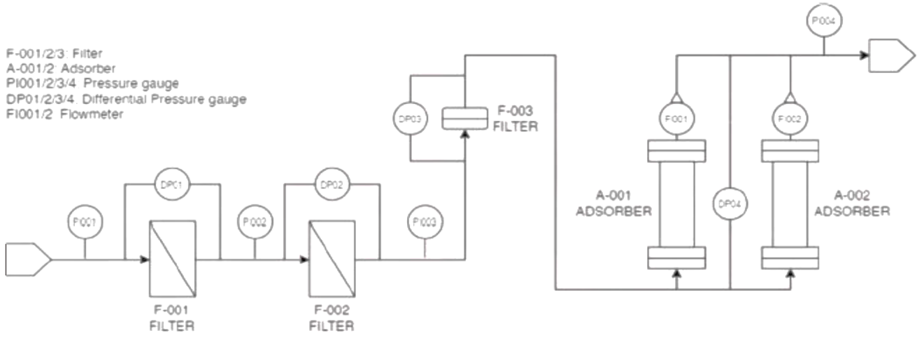


Figure 5: Side stream setup for filtration and adsorbent performance test

Layer	Ads C (gram)	Ads F (gram)
#5	446.4	330.4
#4	223.2	165.2
#3	111.6	82.6
#2	55.8	41.3
#1	27.9	20.6

Figure 6: Loading diagram of Adsorbent C & F

Performance of Hg removal via filtration

- At 10 µm, the particulate were inconsistent, mainly due to higher inlet Hg concentration (not shown). 2 samples shown < 40% removal efficiency. Additionally, > 200 µg/L Hg content observed post 10 µm filter,
- With addition of 2 µm filter, it helped to consistently maintain removal above 90%. Higher removal observed for 0.2 µm, but this resultant in higher dP.

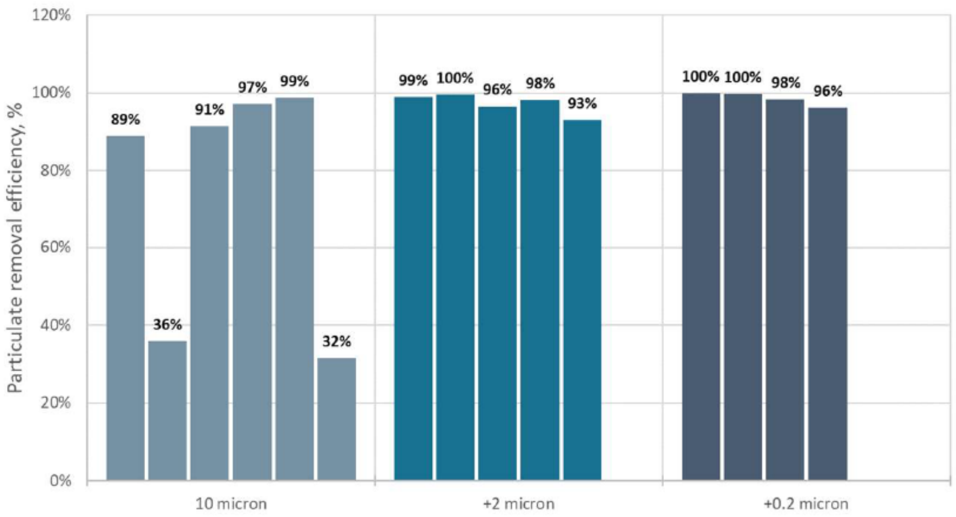


Figure 8: Particulate removal efficiency post filters

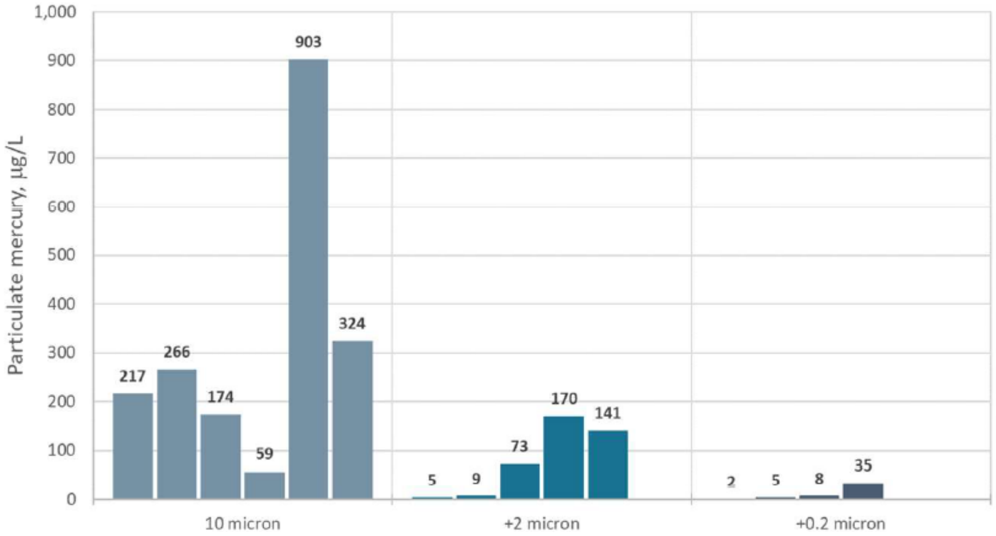


Figure 9: Hg particulate removal

Performance of Hg removal via adsorbent

- Adsorbent targeted to remove elemental mercury, < 0.1 µg/L observed whichever upstream filter arrangement.
- Spent adsorbent analyses shown the mercury contamination at the beginning the bed height – identical performance for both adsorbents.
- Mechanical resistance for both products dropped to about 70% of the fresh product value.

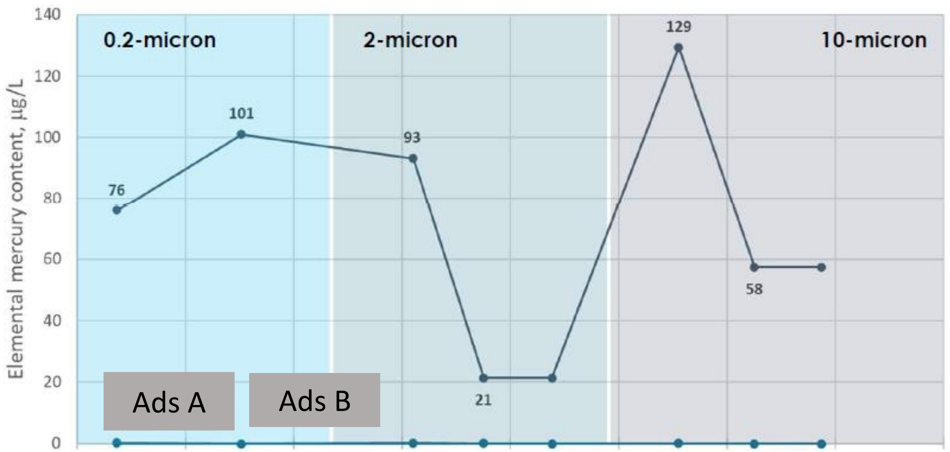


Figure 10: Removal of mercury via Adsorbent A & B

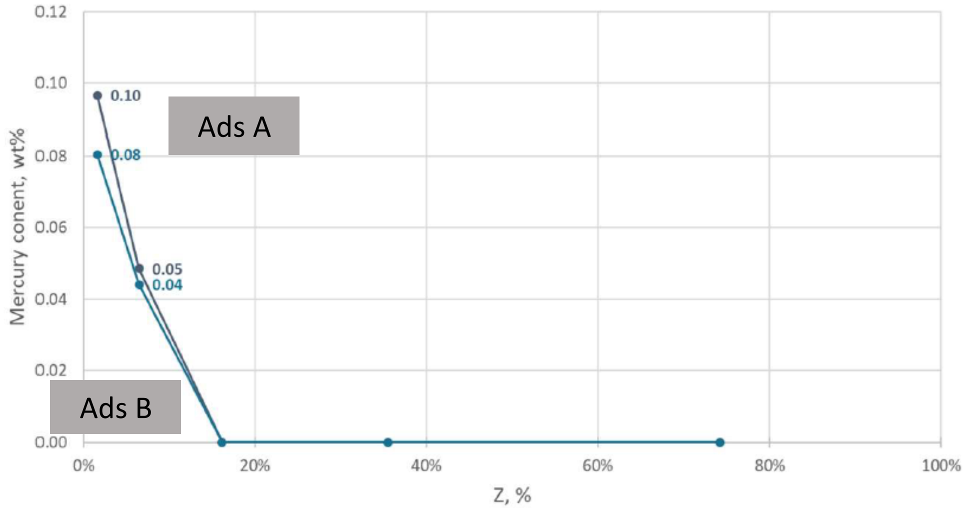
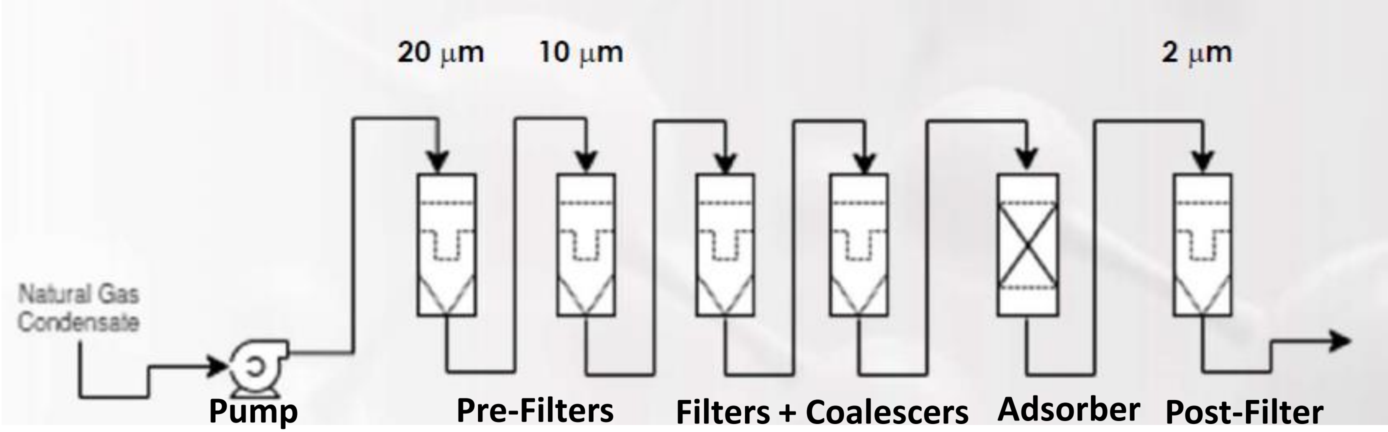


Figure 11: Spent adsorbent A & B mercury content

Conclusion and Recommendation

- Stepwise filtration is proposed to remove particulate Hg efficiently.
  - 20 – micron filters may serve as core removal of the particles and prevents overloading of the smaller size filters
  - 10 – microns shall complete the passed particulate
  - Optional - 2-micron is proposed to be installed post filter downstream of adsorbers
    - Drawback: More frequent filter change-out
- The adsorption evaluation suggested the following basis of design to be considered for optimum MRU design
  - Hg elemental : 250 µg/L, Q = 50 m^3/h
  - Partial loading with bed life of 4 years; short loading of 50%, loading tonnage of 20 tonnes with Hg loading of 2-2.5 wt%



Thank you