Challenges in Managing Mercury in Field Development and Production

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Enhancing Mercury Mitigation with Advanced Chemical Formulations in Condensate Streams

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Risk associated with high mercury level

Consequence: Temporary Shutdown or Production Halted

Why do we need a chemical for Mercury Scavenging?

unexpectedly high concentrations

- Inaccurate measurement
- Start up of new reservoirs
- Change in operating conditions

MRU

time

capex/opex

logistics

Target: Reliable Removal of Mercury from hydrocarbon to bring it on-spec before it gets to the refinery

Mercury Speciation

Mercury Species	Characteristics	Challenges
Elemental (Hg^0)	Oil-soluble, volatile, accumulates in cold zones	Causes metal embrittlement, corrosion, critical in Al-based cryogenic systems
Inorganic (Hg^+, Hg^{2+})	Water-affine, soluble in polar solvents	Leads to scaling, difficult to separate from water streams
Organic (DMM, MeHg)	Partitions between hydrocarbon/water phases	Hard to remove, reduces adsorption efficiency
Particulate-bound (HgS)	Insoluble, forms deposits in pipelines	Requires specialized filtration and chemical treatments

Approximate Natural Abundance of Mercury Compounds in Hydrocarbon

	Coal	Natural Gas	Gas Condensate	Crude Oil
Hg°	T	D	D	D
(CH3)2Hg	?	T	T, (S?)	T,(S?)
HgCl2	S?	N	S	S
HgS	D	N	Suspended	Suspended
HgO	T?	N	N	N
CH3HgCl	?	N	T?	T?

Abundance

D(Dominant) - greater than 50% of the total

S(Some) -10 to 50 percent

T (trace) - less than 1 percent

N (None) - rarely detected

? - data not conclusive

Mercury exists in multiple forms

High solubility in Hydrocarbons

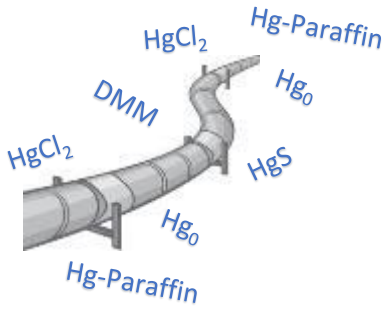
Standard processes In upstream (e.g. separation) and refinery (e.g. desalting) not efficient

CHEMICAL

- access the hydrocarbon matrix
- complex the various species
- upstream/midstream environment

Scavenging Mechanism Key Parameters

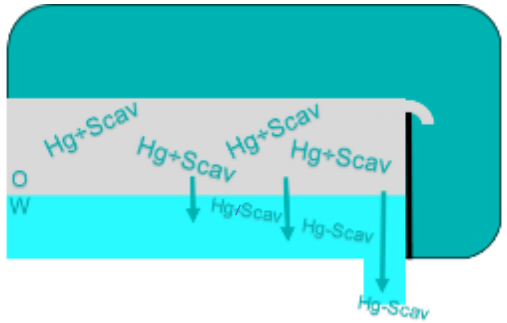
- pH ➔ Solubility
- Phases ➔ Partitioning
- Water ➔ Removal
- Temperature ➔ Kinetics



Hydrocarbon containing Hg in various species and other components to which Hg can be bound

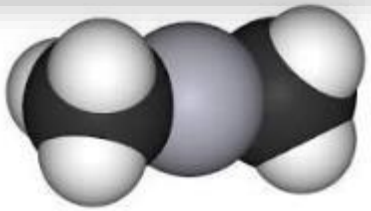
Hg Scavenger (Wellhead, Upstream Separator, etc)

3-phase separator



After the Hg scavenger is injected and the reaction occurs, the new water-friendly complex is separated in the three-phase separator and treated as waste

Laboratory Setup



- 🔬 Simple Analysis
- 🎯 Selective Effectiveness
- ⚖️ Accurate Dosing
- ⚙️ Field-Like Simulation
- 🧪 Final Validation

✅ Validation

1 **Standard Addition**	Known amount of **methylmercury chloride** (e.g., 1 ppm) added
2 **Phase Separation**	Mercury distributes between **aqueous** (complexed) and **oil** (residual) phases
3 **Oil Mineralization**	Organic matrix eliminiated to **isolate** residual mercury
4 **Phase Analysis**	Hg measured in **water + oil**
5 **Consistency Check**	Sum (water + oil) ≈ standard added. If mismatch → **analytical error detected**

Results

Elemental Mercury (Hg^0)

Contaminant	Complexing agent	Hg Scav vs. Contaminant	Time	Temper.	% Hg in hydrocarbon	% Hg in water
Hg0	Water	/	120 min.	70° C	97	3
Hg0	Active 01	50 : 1	120 min.	70° C	22	78
Hg0	Active 01	100 : 1	120 min.	70° C	19	81
Hg0	Active 01	50 : 1	30 min.	100° C	12	88
Hg0	Active 01	50 : 1	60 min.	100° C	11	89

A high extraction efficiency was achieved. In these tests, the effect of temperature was investigated, revealing that extraction capacity increases with rising temperature, reaching its peak around **100°C**

Results

RESULTS – Organic Mercury

Contaminant	Complexing agent	Hg Scav vs. Contaminant	T (°C)	% Hg in crude oil	% Hg in water
$Hg(CH_3)_2$	Blank (H_2O)	---	70	99	1
$Hg(CH_3)_2$	Active 02	50 : 1	70	97	3

Dimethylmercury remains entirely in the oil phase and does not transfer into the aqueous phase with any of the tested products

Its strong affinity for the oil phase prevents migration, even under highly acidic conditions (pH 1-2)

Results

RESULTS – Organic Mercury Partially Ionic

Contaminant	Complexing	Hg Scav vs. Contaminant	T (°C)	% Hg in crude oil	% Hg in water
$(CH_3)HgCl$	Blank (H_2O)	---	70	90	10
$(CH_3)HgCl$	Active 03	10 : 1	70	76	24
$(CH_3)HgCl$	Active 03	20 : 1	70	54	46
$(CH_3)HgCl$	Active 03	50 : 1	70	23	77
$(CH_3)HgCl$	Active 03	100:1	70	9	91

Methylmercury Chloride, taken as a representative compound of the monoalkylmercury species
The partial ionicity of the compound allows good extraction capacities, which exceed 90% (in the ratio 100 :1)

Real condensate testing

	BASELINE	Case n°01	Case n°02	Case n°03	Condensate washing
Water content (%)	20	20	20	20	5
Dosage (chemical/Hg)	200:1	500:1	500:1	500:1	500:1
Injection temperature (°C)	90	90	70	70	70
Retention time (hours)	4	4	4	8	4
Removal (%)	**40**	**71**	**64**	**68**	**81**

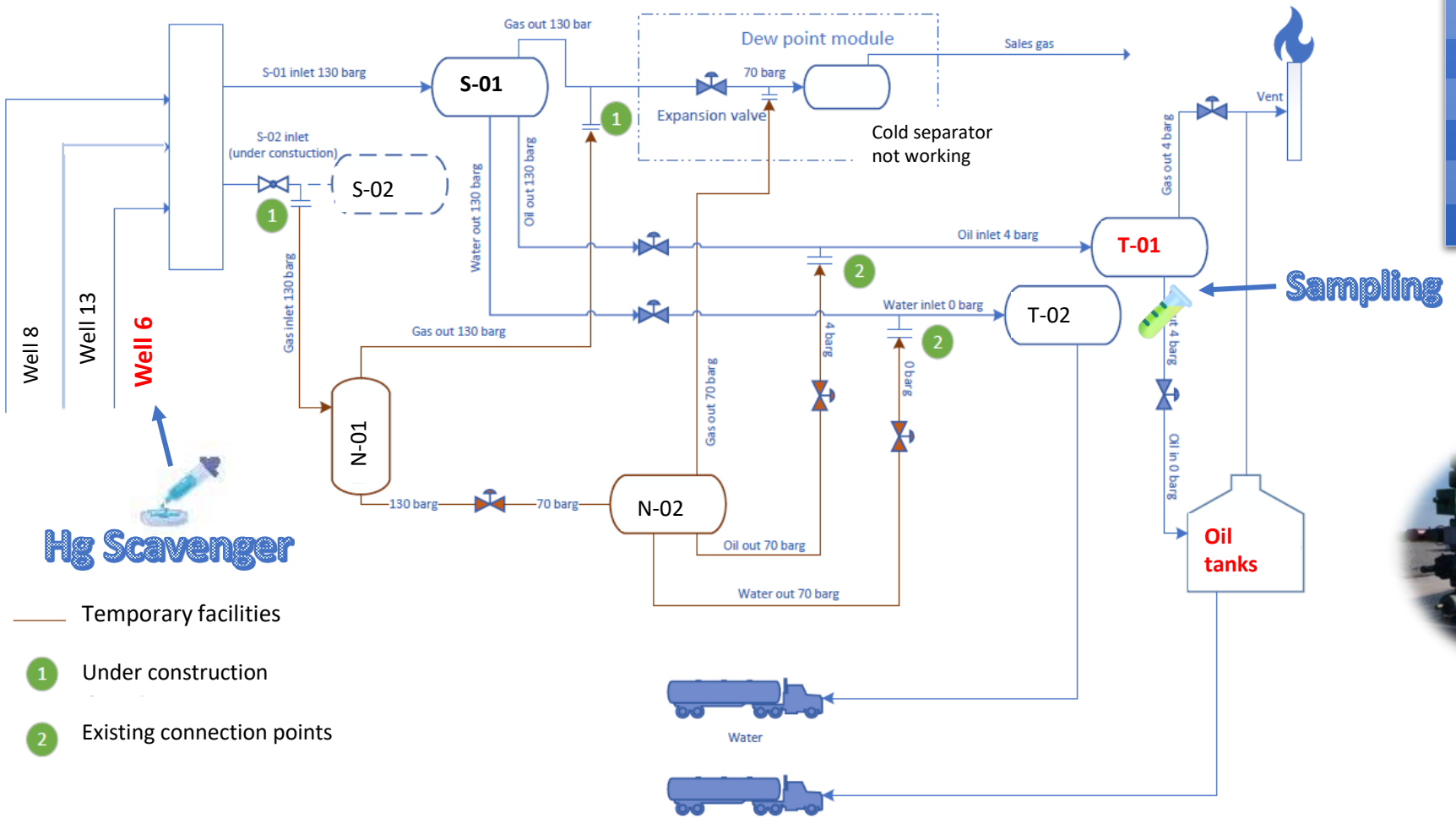
⚫ **Stratification**: Black interface layer indicates partial Hg reaction; not all mercury transfers to water

💧 **Water Cut Effect**: Better performance at lower WC — suggests dosing before water addition in washing systems

🧪 **Product Improvement**: Limited mercury access highlights need for optimization

Multiphase Mercury Removal

Parameter	Value
Condensate rate	2500 bopd
Wellhead Pressure	58 bars
Wellhead Temperature	78°C
Water Cut	20-25%
Initial Mercury Level	400 ppb (total Hg)
Temp at injection point	65°C
Initial Scavenger Dosage	30 L/day
Scavenger Dosage Ratio	200 x Hg content



INJECTION

Well-6

SAMPLING

Separation stages

- ⏰ **Maximize contact time**: about **10 hrs**
- 💧 **Mercury removal:** through water separation
- 🧪 **Condensate** sampled: **2nd stage**
- 🎯 **Requested KPI**: **< 100 ppb**

Results

Day	Total Hg (ppb)
1	**400**
2	36
3	1474
4	942
5	2720
6	152
7	255

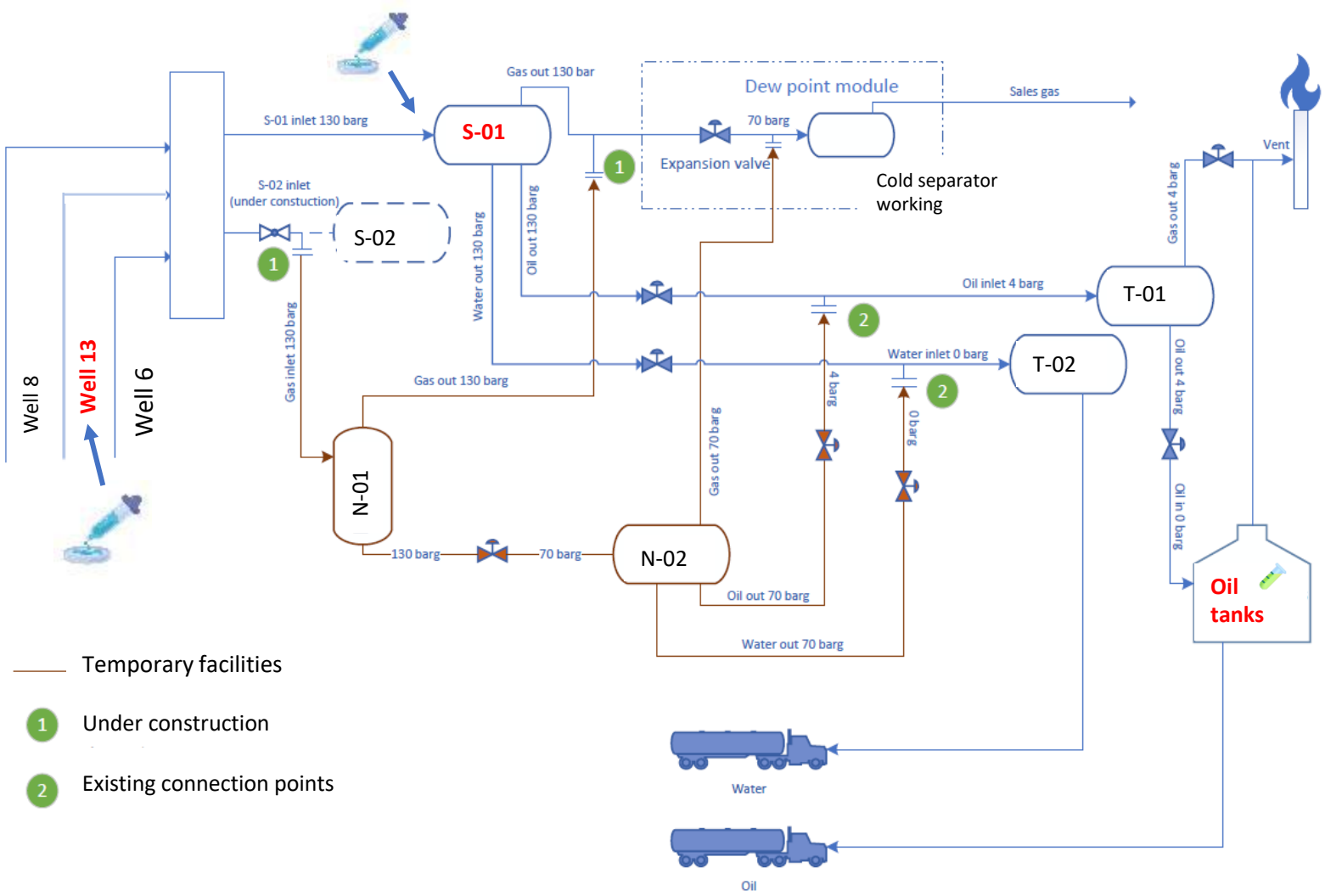
Shut-in well-6

✅ **Effectiveness confirmed**: HG SCAVENGER reduced mercury content in the condensate

🌡️ **Temperature Effects**: Injection at higher temperature effectively activated the scavenger

⚠️ **Some instability**: due to well shutdown and transient conditions (Well 6)

Second field trial



🌡️ **DPCU modifies thermal profile**:

significant impact on system temperature

❄️ **Air coolers installed:**

at each wellhead to lower stream temperatures

⬇️ **Inlet temperature reduced** by **20–25°C:**

at three-phase separator compared to Aug 2023

🧪 **Condensate** sampled: **storage tank (average top-bottom)**
⏰ **Contact time**: about **6-8 hrs**

Results

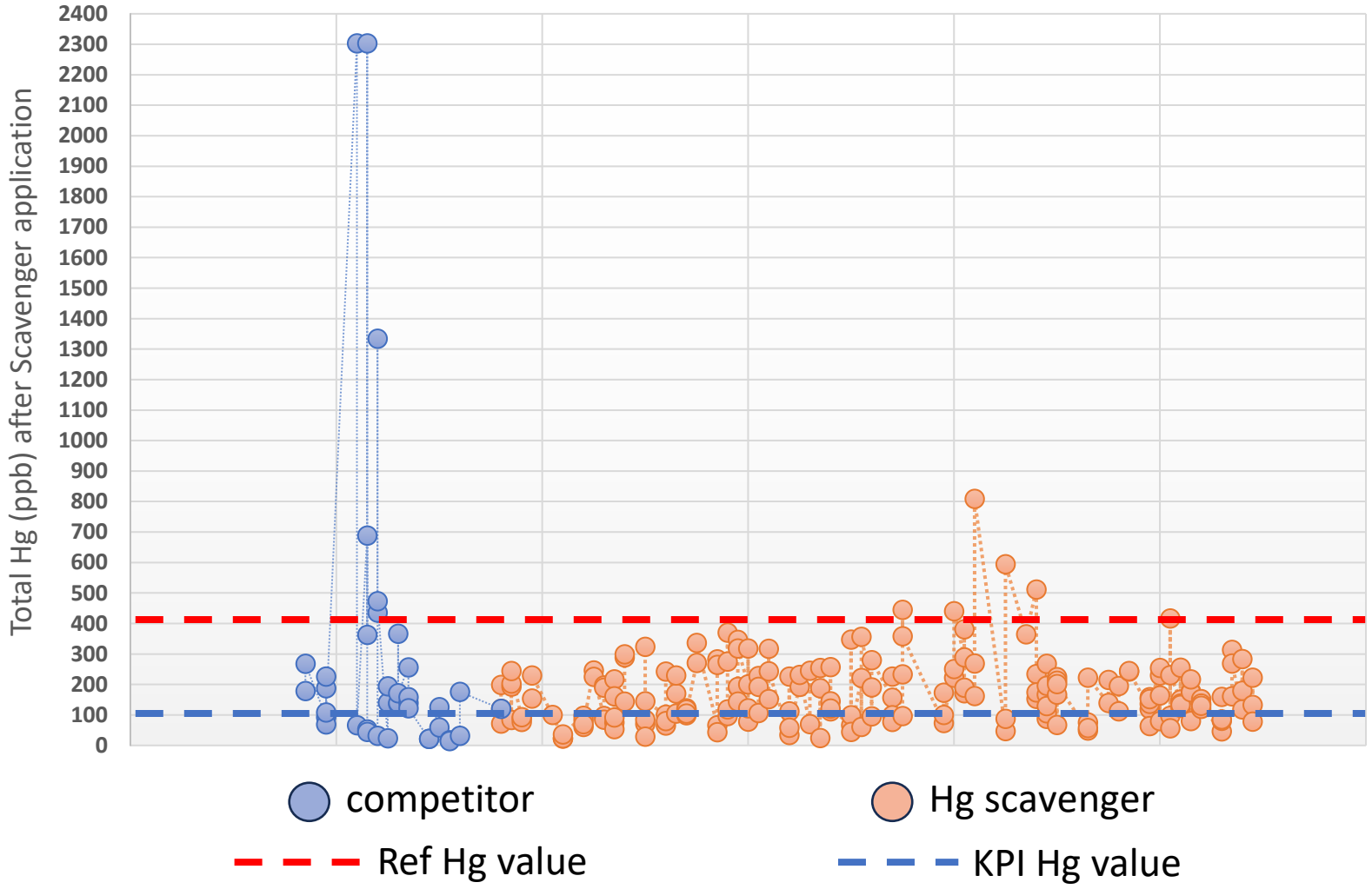
Day	Location	Total Hg (ppb)	Total Hg (ppb_MVI)
1	Gathering Station	400	
2	Gathering Station	822	
3	Well 13	139	105
4	Well 13	180	119

🌡️ **Temperature**: Cooling after DPCU reduced scavenger performance due to slower reaction kinetics

💧 **Water Cut**: Low water content shifted the system to monophasic, decreasing scavenger efficiency

⏱️ **Retention Time**: 8-hour retention improved mercury removal, confirming the need for sufficient contact time

Extended trial phase



✅ **Proven Performance**: Hg Scavenger consistently reduced mercury levels

📊 **Effective Testing**: Trials from April to May 2024 confirmed removal efficiency

🔁 **Strategic Injection**: Dual-point injection (wellhead + tank loading) guaranteed uniform distribution

👓 **Reliable Monitoring**: Continuous analysis highlighted key roles of temperature and retention time

🌡️ **Thermal Support**: HX and boiler maintained 40°C, enhancing scavenging effectiveness

🚨 **System Safeguard**: Excess mercury in tank bottoms was managed via slope drainage to maintain integrity

Conclusions

- A chemical solution easy and flexible to implement is available to scavenge Hg on gas condensate
- Acts by complexing Hg and transferring it to the water
- Works with most of the mercury species, not with organic Hg
- Monitoring is a key point for making a solid baseline and assess the scavenging efficacy

Way Forward

Product Improvements

No Sulphites ✅

Solubility ✅

Particulate

Chemical Pigging

Thank you!

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