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Quantity and Fate of Mercury in Crude Oil



Content

Objective:

- Why should we be paying more attention to mercury in oil?

Answering the questions:

- How much mercury are we talking about?
- Where is the mercury going?
- What data do we have?
- Where data is lacking, can we make reasonable estimates?



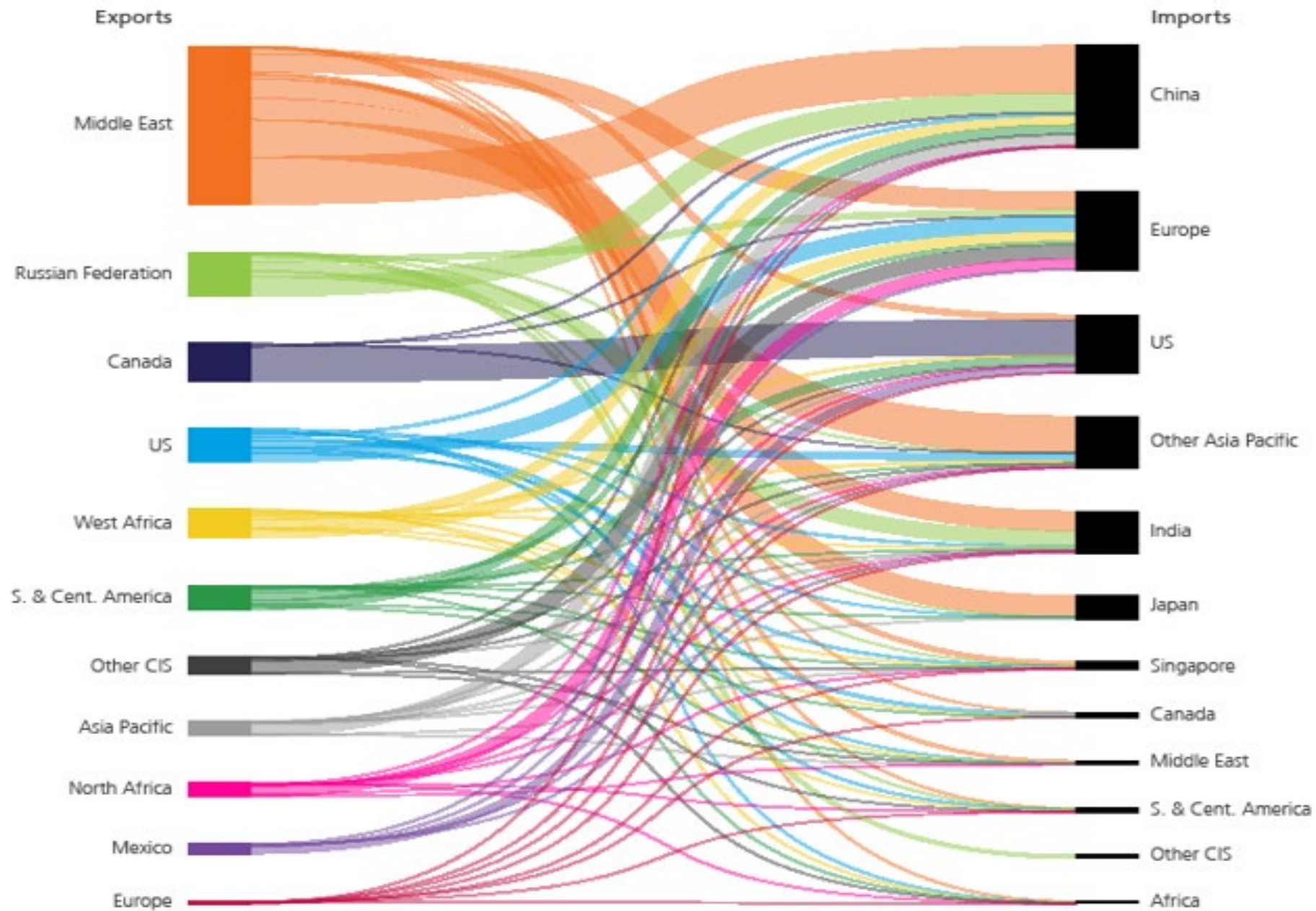
Why should industry be concerned?

Some of the risks of Hg in oil and gas include:

- corrosion of process equipment
- potential exposure of maintenance workers, esp. during “hot work”
- Hg “poisoning” of precious metal catalysts such as platinum or palladium
- potential liabilities resulting from mercury-contaminated product streams
- difficulty and/or expense of disposing of mercury contaminated equipment
- waste management issues (e.g., incineration or landfilling of some Hg wastes)
- decommissioning challenges (pipelines, storage tanks, etc.)
- increasing regulatory requirements (e.g., flaring, methane emissions)



Crude oil trade 2023



Mercury fraction in fossil fuel samples

Hg Fraction	Coal	Natural Gas	Gas Condensate	Crude Oil
Hg ⁰	<1%	>50%	>50%	>50%
(CH ₃) ₂ Hg	–	<1%	<1%, 10–50%	<1%, 10–50%
HgCl ₂	10–50%	ND	10–50%	10–50%
HgS	>50%	ND	Particulate	Particulate
HgO	<1%	ND	ND	ND
CH ₃ HgCl	–	ND	<1%	<1%

ND – Not detectable.

Elemental mercury, dimethyl mercury, mercuric chloride, mercuric sulfide, mercuric oxide, methylmercury chloride.

Source: Wilhelm SM, Kirchgessner D. Mercury in U.S. Crude Oil: A Study by U.S. EPA, API and NPRA. SPE/EPA/DOE Exploration and Production Environmental Conference. San Antonio, Texas: Society of Petroleum Engineers; 2003:7.

Gases -	metallic (elemental) mercury
Condensate / Oil -	volatile mercury (elemental) soluble ionic mercury soluble non-ionic mercury particulate mercury (> 0.2 μm)
Waters -	volatile mercury (elemental) soluble ionic mercury soluble non-ionic mercury particulate mercury (> 0.2 μm)

Ref. Qa3, Sheet Reference: INF15, Mercury in the Oil and Gas Industry, Document for the UNEP Global Mercury Partnership



Selected references for Hg in oil & gas

- Wilhelm et al., Mercury in crude oil processed in the United States, 2004.
- IPIECA, Mercury management in petroleum refining, An IPIECA Good Practice Guide, 2014.
- Johnson Matthey. Handling mercury in gas processing plants, 2017.
- Wood Environment & Infrastructure Solutions UK Limited, Best Available Techniques Guidance Document on upstream hydrocarbon exploration and production: Final Guidance Document, European Commission, February 2019.
- Maxson, Mercury in natural gas, presentation at ICMGP 2019, Krakow, Poland, 12 September 2019.
- Qa³, Unconsidered Mercury Emissions from the Oil and Gas Industry, 2020.
- Qa³, Sheet Reference: INF15, Mercury in the Oil and Gas Industry, Document for the UNEP Global Mercury Partnership.
- UNEP Global Mercury Partnership Advisory Group, Latest draft study report on mercury from oil and gas, United Nations Environment Programme (Economy Division), UNEP/Hg/PAG.12/5, 8 March 2022.
- AMAP/UN Environment. Technical Background Report for the Global Mercury Assessment 2018. Arctic Monitoring and Assessment Programme, Oslo, Norway/UN Environment Programme, Chemicals and Health Branch, Geneva, Switzerland, 2019.



Ave. Hg in crude by region

Continent / Region	Annual Production*			Estimated Average Mercury Concentration [#]			Estimated Annual Mass of Mercury Produced (tonnes)	Estimated Annual Mercury Emission Assuming 30% Losses (tonnes)
	NG (Bm ³)	CO (Mt)	LPG (Mt)	NG (µg/m ³)	CO (µg/kg)	LPG (µg/kg)		
Europe	236	149	13	6	12	60	4.0	1.2
North America	1128	927	188	15	15	90	48	14.3
Latin America	174	289	11	25	20	120	11	3.4
CIS	847	711	10	15	10	100	21	6.2
Asia Pacific	672	350	19	140	110	1000	152	45.6
Africa	238	394	15	30	25	150	19	5.8
Middle East	695	1321	119	20	15	90	44	13.3
TOTALS	3989	4141	377	-	-	-	300	90

* Based upon data collected by BP – ‘Statistical Review of World Energy 2020, 69th edition’

Based upon Qa³ project experience, observations and available literature

NG – Natural Gas, CO – Crude Oil, LPG – Liquefied Petroleum Gas



World oil production & Hg content, 2023 (A)

	Production(1) thousand bbl/day	Production(1) million metric tons	Multiplier '000 bbl/d per MMT	Ave. Hg concentration(2) micrograms/kg	Hg mobilized metric tons	
North America						
total oil*	27050	1207.5	22.40	15	18.1	100%
crude & condensate**	19737					73%
natural gas liquids***	7313					27%
S. & Cen. America						
total oil*	7368	378.1	19.49	20	7.6	100%
crude & condensate**	7029					95%
natural gas liquids***	339					5%
Europe						
total oil*	3225	152.1	21.20	12	1.8	100%
crude & condensate**	2944					91%
natural gas liquids***	281					9%
CIS						
total oil*	13868	675.2	20.54	10	6.8	100%
crude & condensate**	13317					96%
natural gas liquids***	551					4%



World oil production & Hg content, 2023 (B)

Middle East							
total oil*	30362	1413.9	21.47	15	21.2	100%	
crude & condensate**	26274					87%	
natural gas liquids***	4088					13%	
Africa							
total oil*	7228	341.5	21.17	25	8.5	100%	
crude & condensate**	6719					93%	
natural gas liquids***	509					7%	
Asia Pacific							
total oil*	7275	345.7	21.04	110	38.0	100%	
crude & condensate**	6737					93%	
natural gas liquids***	537					7%	
Totals							
total oil*	96376	4514			102	100%	
crude & condensate**	82757					86%	
natural gas liquids***	13618					14%	



World oil production & Hg content, 2023 (C)

Sources and notes:

- 1) Energy Institute Statistical Review of World Energy 2024
- * Includes crude oil, shale oil, oil sands, condensates (lease condensate or gas condensates that require further refining) and NGLs (natural gas liquids – ethane, LPG and naphtha separated from the production of natural gas).
- Excludes liquid fuels from other sources such as biofuels and synthetic derivatives of coal and natural gas. This also excludes liquid fuel adjustment factors such as refinery processing gain.
- ** Includes crude oil, shale/tight oil, oil sands, lease condensate or gas condensates that require further refining. Excludes liquid fuels from other sources such as biomass and synthetic derivatives of coal and natural gas.
- *** Includes ethane, LPG and naphtha separated from the production of natural gas. Excludes condensates.
- LPG has two origins: approximately 60% is recovered during the extraction of natural gas and oil from the earth, and the remaining 40% is produced during the refining of crude oil. The intention here is to identify the LPG that has not already been included in the natural gas analysis, i.e., LPG from refineries, and the estimated mercury content of that LPG.
- 2) Unconsidered Mercury Emissions from the Oil and Gas Industry, Qa³ Ltd., 2021. Data based upon Qa³ project experience, observations and available literature.



Oil production Mercury (metric tons)	Mercury mobilized (metric tons)
Oil (100-105)	Crude & condensate (50-65)
+ Associated nat'l gas (20-25)	Natural gas liquids (40-55)
	Associated nat'l gas (20-25)
	Drilling muds (2-5)

Est. mercury mobilized globally by oil production

Oil production Mercury (metric tons)	Mercury mobilized (metric tons)
Oil (100-105) + Associated nat'l gas (20-25)	Crude & condensate (50-65)
	Natural gas liquids (40-55)
	Associated nat'l gas (20-25)
	Drilling muds (2-5)



Est. mercury remaining when it gets to the refinery

Refinery	Post refinery
Mercury (metric tons)	Mercury (metric tons)
Crude & condensate (20-30)	Products (15-20)
LPG (10-15)	



Methane (trace Hg) emission sources from oil

The Climate and Clean Air Coalition (CCAC) Oil & Gas Methane Partnership (OGMP) is focused on some “core” sources of methane emissions:

1. Natural gas driven pneumatic controllers and pumps.
2. Fugitive component and equipment leaks.
3. Centrifugal compressors with “wet” (oil) seals.
4. Reciprocating compressors - piston seal/packing vents.
5. Glycol dehydrators.
6. Unstabilized hydrocarbon liquid storage tanks.
7. Well venting for liquids unloading.
8. Casing head gas venting.

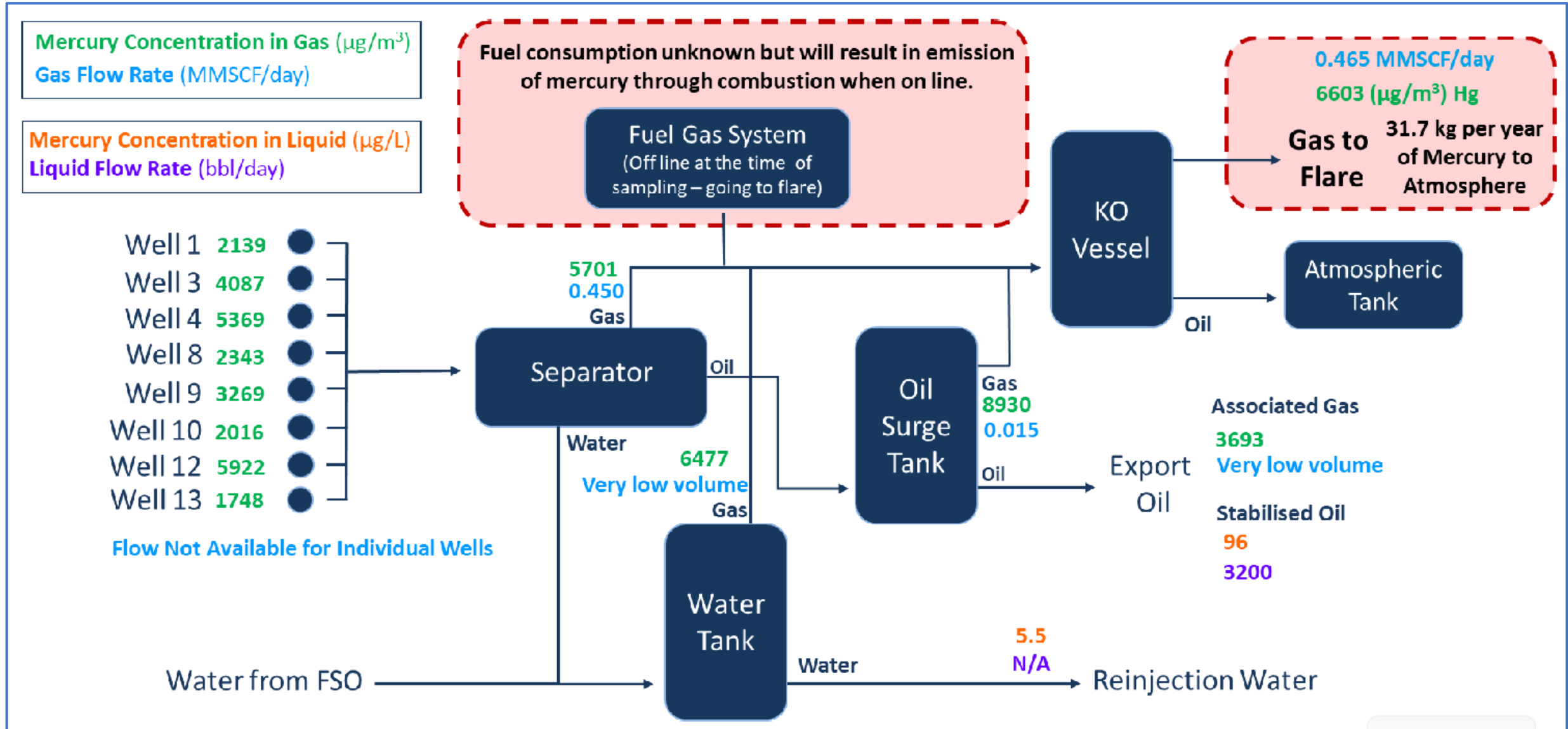


Other examples of oil process Hg releases

- Flaring activity (any mercury in gases or liquids sent to flare is released to the atmosphere).
- Using untreated gas as fuel (where the mercury is released during combustion) in O&G processing.
- Mercury absorbed during normal operation of process units (amine, glycol, molecular sieve) is released during the regeneration cycle, and may go to venting/flaring.
- Discharge of mercury contaminated water.
- At end of life, mercury adhering to the internal surfaces of process equipment, piping (process, subsea, etc.) and storage tanks may be liberated during dismantling and recycling (esp. smelting).
- Subsea equipment decommissioned or abandoned in-situ releases mercury to the marine environment as equipment decays.
- Mercury particulates and solids on filters are released if not recycled properly.
- Sludge from pigging activities or accumulated in storage tanks is often high in mercury which may be released if not recycled properly.



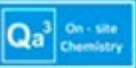
Gas/oil/water separation process – S.E. Asia example




Ref. Qa3, Sheet Reference: INF15, Mercury in the Oil and Gas Industry, Document for the UNEP Global Mercury Partnership



O&G sources of unconsidered emissions (ref. Qa³)

 Summary of Unconsidered Emissions		
Emission Source	Observed / Estimated % Removal	Common Emission Route
Dehydration - (Glycol Contactor)	OBSERVED 10 – 60%	Venting direct to atmosphere
Dehydration - (Mol Sieve)	OBSERVED 10 – 99%	Via water and possible flaring
Acid Gas Removal - (Amine Contactor)	OBSERVED 10 – 60%	Flaring or contaminated sulphur
Pipework and Equipment	OBSERVED 10 - 99%	Smelting at end of life
Waste Solids and Sludges	OBSERVED 10 – 60%	Hydrocarbon waste disposal routes
Flaring	OBSERVED 1 – 80%	Direct to atmosphere
CO ₂ and N ₂ Removal	ESTIMATED 1 – 5%	Vent to atmosphere
Effluent Water	OBSERVED 0.1 – 2%	Directly into sea / waterway
Venting of Cargo Tanks	ESTIMATED 1 – 2%	Direct to atmosphere

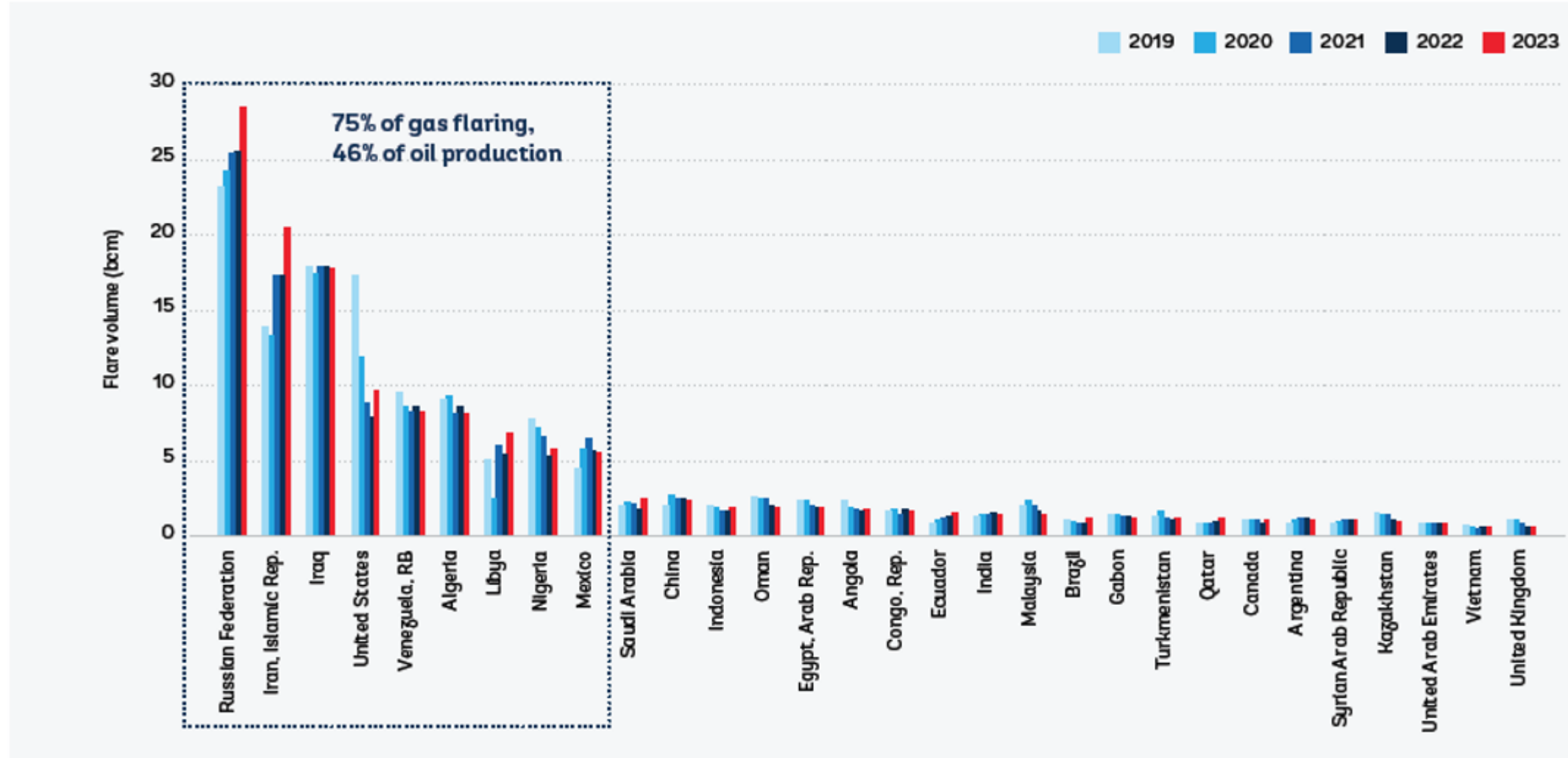


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Global flaring, 2023

Figure 1. Flare volumes in the top 30 flaring countries, in order of 2023 flare volume with the top 9 flaring countries indicated, 2019–23



Source: Payne Institute and Colorado School of Mines, National Oceanic and Atmospheric Administration (NOAA), World Bank.
Note: bcm = billion cubic meters.



Intermediate mercury recovery and losses

Separation, stabilization, etc.	
Mercury (metric tons)	
MRUs, gas dehydration & other Hg removal systems (55-65)	
Crude storage tank sludges & scales (4-6)	
Tanker & pipeline transport sludges & scales (4-6)	
Process equipment (8-12)	
Flaring, venting, fugitive emissions (8-12)	
Process and effluent water (1-2)	



Median mercury (metric tons) pathways from oil production

	Separation, stabilization, etc.	Refinery	Post refinery	Total
Safe disposal (or resale)	46	11	0	57
Air emissions	17	3	13	33
Releases to water	2	1	0	3
Releases to soil	9	2	0	11
Accumulated for later decision	17	5	2	24
Total	91	22	15	128



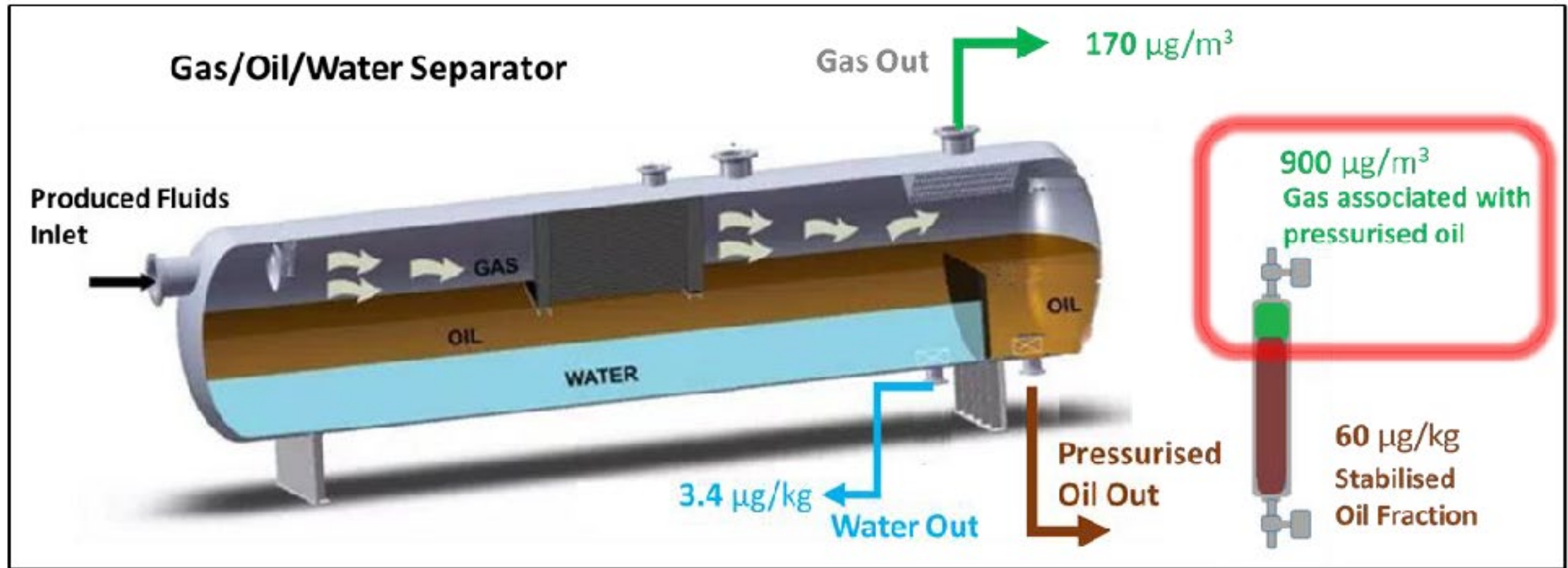
Sincere thanks to colleagues (especially Stuart Baker at Qa³) who generously contributed to this analysis!

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Gas/oil/water separation



Ref. Qa³, Sheet Reference: INF15, Mercury in the Oil and Gas Industry, Document for the UNEP Global Mercury Partnership.

