CLAIMS

1. A method for removing a trace amount of mercury in a crude oil feed, comprising:

providing a crude oil having a first concentration of mercury in which at least 50% of the mercury is non-volatile mercury;

mixing into the crude oil an effective amount of a water stream containing at least a water-soluble monatomic sulfur compound selected from the group of sodium hydrosulfide, potassium hydrosulfide, ammonium hydrosulfide, sodium sulfide, potassium sulfide, calcium sulfide, magnesium sulfide, and ammonium sulfide and combinations thereof forming a mixture;

extracting at least a portion of the non-volatile mercury from the crude oil into water as soluble mercury sulfur complexes forming a mercury rich wastewater; and

separating the wastewater containing the soluble mercury sulfur complexes from the crude oil for a treated crude oil having a reduced concentration of non-volatile mercury.

2. The method of claim 1, wherein less than 1% of the non-volatile mercury in the crude oil is extracted from the crude oil as a solid mercury complex.

3. The method of claim 1, wherein the water stream consists essentially of produced water.

4. The method of claim 1, further comprising recovering the wastewater after the separating step for injection into an oil or gas reservoir.

5. The method of claim 3, further comprising treating the recovered wastewater after the separating step for discharge in compliance with relevant regulations.

6. The method of claim 1, wherein the at least a water-soluble monatomic sulfur compound is selected from sodium hydrosulfide, sodium sulfide, and mixtures thereof.

7. The method of claim 1, wherein the crude oil has a first concentration of mercury with at least 65% of the mercury is non-volatile mercury.

8. The method of claim 1, wherein at least 50% of the non-volatile mercury is extracted into the water stream to form the mercury-rich wastewater.

9. The method of claim 8, wherein at least 75% of the non-volatile mercury is extracted into the water stream to form the mercury-rich wastewater.

10. The method of claim 1, wherein the water stream containing at least a water-soluble monatomic sulfur compound has a pH of at least 9.

11. The method of claim 1, further comprising adding a sufficient amount of a base to the mixture of crude oil and water stream containing at least a water-soluble monatomic sulfur for the mixture to have a pH of at least 9.

12. The method of claim 1, wherein the treated crude oil contains less than 100 ppbw of non-volatile mercury.

13. The method of claim 12, wherein the treated crude oil contains less than 50 ppbw of non-volatile mercury.

14. The method of claim 1, wherein the water stream contains at least a water-soluble monatomic sulfur compound for a molar ratio of 1.5:1 to 1000:1 of sulfur to mercury in the crude oil.

15. The method of claim 1, wherein mixing into the crude oil an effective amount of water stream containing water-soluble monatomic sulfur compound comprises mixing a volume ratio of water to crude oil ranging from 0.05:1 to 5:1.

16. The method of claim 1, wherein the method is carried out on a floating production, storage and offloading (FPSO) unit.

17. The method of claim 1, wherein the mixing into the crude oil an effective amount of a water stream containing at least a water-soluble monatomic sulfur compound occurs in-situ in the formation where the crude oil is extracted.

~~18. The method of claim 1, wherein the mixing into the crude oil an effective amount of a water stream containing at least a water-soluble monatomic sulfur compound occurs in a pipeline in the production well from where the crude oil is recovered.~~

~~19. A method for reducing a trace amount of mercury in a crude oil feed, comprising:~~

~~recovering a mixture of produced water and crude oil containing mercury from an underground reservoir, wherein at least 50% of the mercury is non-volatile mercury;~~

~~mixing into the mixture of produced water and crude oil an effective amount of a water stream comprising a base and at least one of sodium hydrosulfide, sodium sulfide, and combinations thereof;~~

~~extracting at least a portion of the non-volatile mercury into produced water as soluble mercury sulfur complexes forming a mercury rich wastewater;~~

~~separating the mercury rich wastewater from the crude oil for a treated crude oil having a reduced concentration of non-volatile mercury; and~~

~~injecting at least a portion of the mercury rich wastewater into an underground reservoir.~~

~~20. The method of claim 19, wherein the treated crude oil contains less than 100 ppbw of non-volatile mercury.~~

~~21. The method of claim 19, wherein the mixing with an effective amount of a water stream containing at least a water-soluble monatomic sulfur compound is for at least 15 minutes.~~

CLAIMS

~~22~~1. A method for removing a trace amount of mercury from a crude oil feed comprising.

extracting a produced fluid containing natural gas, produced water, and crude oil from an underground reservoir via a production well;

separating at least a portion of dissolved natural gas and produced water from the crude oil in the produced fluid to produce a crude oil containing a trace amount of mercury in which at least 50% of the mercury is non-volatile mercury;

combining at least a portion of the separated produced water with a water-soluble monatomic sulfur compound to produce a sulfur-containing produced water solution;

contacting the crude oil containing a trace amount of mercury with at least a portion of the sulfur-containing produced water solution for the mercury to react with the sulfur compound forming a soluble mercury sulfur complex in produced water; and

separating the produced water from the crude oil to generate a treated crude oil having a reduced concentration of mercury and a mercury-containing wastewater stream.

~~23~~2. The method of claim ~~22~~1, further comprising contacting the mercury-containing wastewater stream with a stripping gas to convert the soluble mercury sulfur complex to elemental mercury for removal with the stripping gas.

~~24~~3. The method of claim ~~23~~2, wherein the stripping gas is natural gas having a low mercury content due to prior treatment in a mercury removal adsorbent.

~~25~~4. The method of claim ~~23~~2, further comprising passing the stripping gas containing elemental mercury to an adsorbent bed to produce a natural gas having a low mercury content.

~~26~~5. The method of claim ~~22~~1, wherein the at least a water-soluble monatomic sulfur compound is selected from sodium hydrosulfide, sodium sulfide, and mixtures thereof.

~~27~~6. A method for removing a trace amount of mercury from a crude oil feed comprising.

extracting a produced fluid from an underground reservoir via a well;

separating at least a portion of dissolved natural gas and produced water from the crude oil in the produced fluid to produce a crude oil containing a trace amount of mercury in which at least 50% of the mercury is non-volatile mercury;

combining at least a portion of the separated produced water with a water-soluble monatomic sulfur compound to produce a sulfur-containing produced water solution;

contacting the separated crude oil with at least a portion of the sulfur-containing produced water solution for the monatomic sulfur compound to react with the mercury in the crude oil forming a treated crude oil having a reduced mercury concentration and a mercury-containing wastewater stream containing soluble mercury sulfur compounds;

separating treated crude oil having a reduced mercury concentration from the mercury-containing wastewater stream; and

recycling at least a portion of the mercury-containing wastewater stream for use in producing a sulfur-containing produced water solution.

~~28~~7. The method of claim ~~27~~6, further comprising contacting the mercury-containing wastewater stream with a stripping gas to convert the soluble mercury sulfur complex to elemental mercury for removal with the stripping gas prior to recycling at least a portion of the wastewater stream for use in producing a sulfur-containing produced water solution.