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Proposed Method Statement for Cleaning Storage Tanks Online at Cairn Energy Mangala

1. Introduction

Cairn Energy has several storage tanks at the Mangala Production Facility in which there is a primary problem of a substantial build up of sludge and solids. The sludge consists of a mixture of hydrocarbon waxes, crude, polymer inorganic salts and solids which have precipitated out of the crude and produced water in the system.

Cairn Energy wishes to remove the bottom sludge and from within the structure of individual tanks, whilst the tanks remain online to avoid any interruption to production during the procedure. Cairn Energy has already expressed a desire to carry out a survey of the condition of each tank to determine the amount of sludge and its distribution within individual tanks to prioritise and create a schedule for cleaning.

Cairn Energy has provided details of two tanks and analyses of the sludge deposits within them as representative examples to use as the basis for this proposal.

Pipeline Maintenance International (PMI) in conjunction with Schlumberger can offer a procedure which will meet the requirements of Cairn Energy, namely to remove the sludge whilst maintaining the tank as operational.

2. Pipe Maintenance International Ltd (PMI)

PMI is a supplier of a range of specialist, proprietary chemicals designed for use in the Oil and Gas Sector. PMI has its Commercial Headquarters in the UAE with its Manufacturing Facilities and Technical Centre in the UK.

In December 2017 PMI signed a Global Supply Agreement with Schlumberger under the terms of which they will provide all field services on a worldwide basis.

Schlumberger's role is to carry out all physical field work.

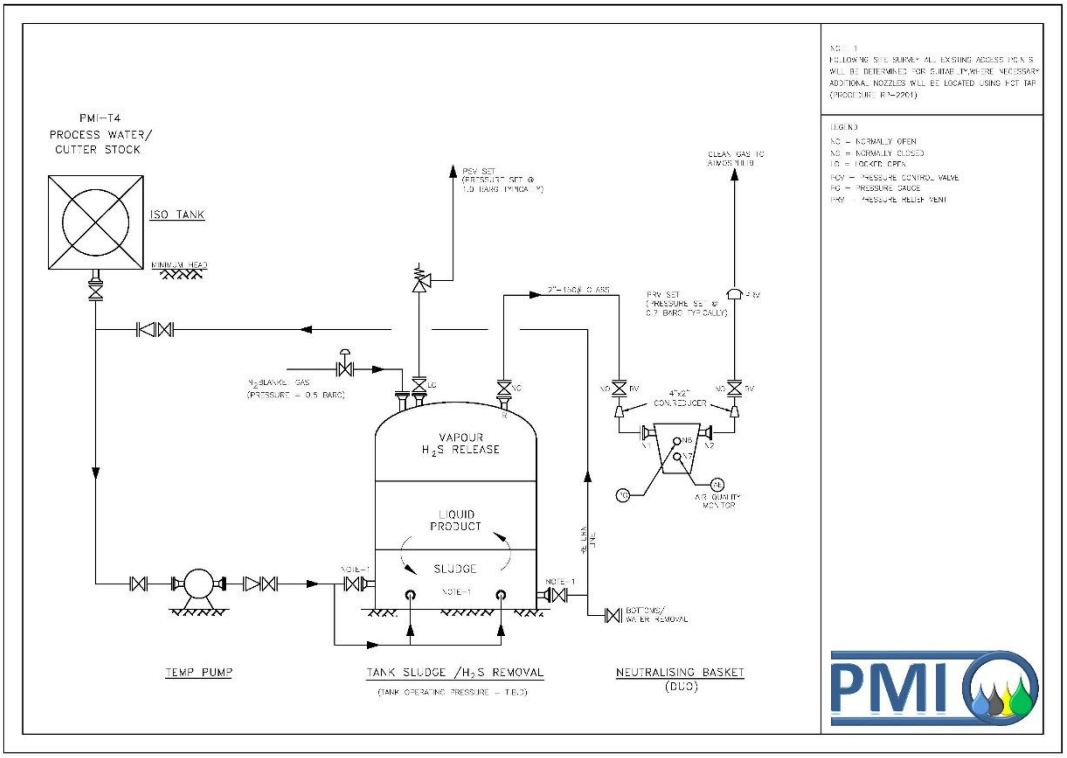
3. PMI-107 Product Description

PMI-107 is a multi-faceted chemical, with exceptional capabilities for highly effective wax and corrosion inhibition, legacy sludge deposit removal and drag reduction. Its variant, PMI-107FA has a non-toxic additive which completely neutralises H_2S at source. PMI-107 is an amphiphilic compound formed of nano-particles. PMI-107 is applied directly into the oil flow on a continuous low-level dosing regime, whilst the system is online, so there is no disruption to production. PMI-107 requires kinetic activity to be effective, so static testing is inappropriate to measure the product's performance.

The intrinsic feature of PMI-107 is its ability to retain all the elements in the flow of produced crude as a homogenous stream whilst keeping the droplets of water separate from the droplets of oil. This results in all the impurities (such as carbonates, salts, sulphur, waxes, asphaltenes, among others) whether they be dissolved in water or entrained in oil, remaining combined as an integrated stream whilst the whole remains in motion. This is inherent in the chemical structure of PMI-107.

In situations where legacy accumulations containing hydrocarbons and inorganic salts and particulate matter are present, PMI-107 will be applied at elevated levels for a short period during which it will re- suspend such materials in the production flow and carry them on downstream to their ultimate destination

PMI-107 is an organic substance which offers a further benefit. There is the natural tendency for organic materials to be adsorbed onto steel surfaces. As a result, once PMI-107 is applied to the system it immediately forms a protective film on steel contact surfaces which prevents the onset of corrosion, wax accretions and reduces drag.



SLUDGE REMOVAL COMBINED WITH H2S NEUTRALISATION

4. Sludge Analysis

The analysis provided by Cairn Energy of the sludge in both tanks demonstrates that it is made up to a very large extent of hydrocarbons and polymer. Much of the inorganic solid content is mixed in with the hydrocarbons. The hydrocarbons, polymers, inorganics mixed with hydrocarbons and any free inorganics will all be re-suspended and passed into the transportation pipeline as a result of our process.

5. Tank Data

Cairn Energy has provided information on two tanks - 224 and 114. The design and size of the tanks will lend themselves perfectly well to our recommended procedure. Depending on the configuration of any injection points, we would connect to these as appropriate to create the required circulation pattern during the process to re-suspend the accumulated sludge.

Where possible, we would inject through existing injection ports, although we have the capability to create new ports of entry by using our own hot tapping/tank tapping, procedures.

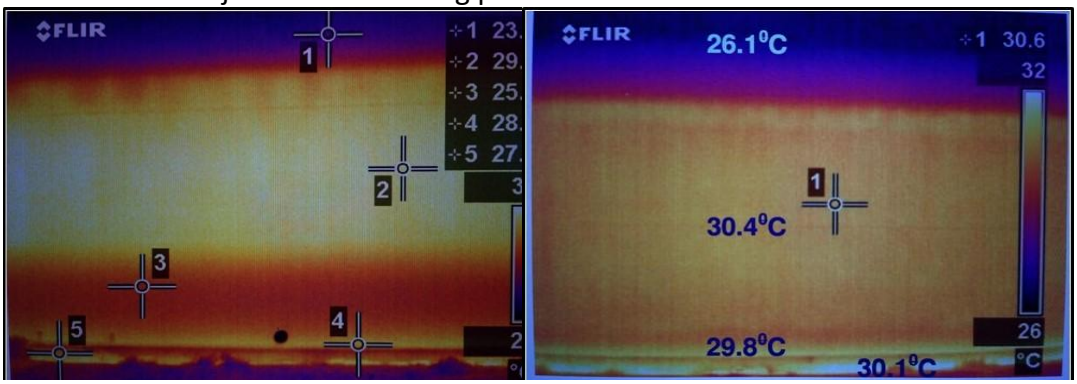
6. Proposed Tank Cleaning Method.

a. Stage 1 - Thermal Imaging

6.a.Stage 1 (i). Preparatory Evaluation

As required by Cairn Energy, the first part of the whole procedure will be to carry out a survey of all the tanks which could be candidates for cleaning. This will be carried out by our team using thermal imaging technology. The objective will be to establish the level and distribution of BS&W in each tank.

The information gathered will enable prioritisation of the order in which the tanks should be cleaned and the period over which the programme should be implemented.
Thermal imaging would also be used to monitor progress of cleaning in real time in each tank as it becomes subject to the cleaning procedure.



THERMAL IMAGE BEFORE TREATMENT THERMAL INAGE AFTER TREATMENT
NOTE THE SLUDGE LEVEL BEFORE IN DARK AMBER COLOUR

6. a. Stage 1 (ii) On-going Monitoring Procedure

We would monitor progress in real time by comparing thermal images before, during and after treatment. We have all the equipment necessary to undertake that task.

b. Stage 2. - Removal of existing deposits of BS&W

6.b.Stage 2 (i) preparatory Steps

Prior to the commencement of injecting PMI-107, the level of the contents of the tank should continue to be exported so as to reduce to a level as close as possible to that of the sludge consistent with considerations of safety and continuous operation. This action should be taken irrespective of which method outlined below is selected. At that point, import of crude would be reinstated and injection of PMI-107 at a rate of 1,000ppm would be initiated. This procedure immediately introduces the chemical into the sludge mixed with fresh crude input. The flow of crude with the entrained chemical creates the kinetic energy to agitate the sludge and enable re-suspension to take place.

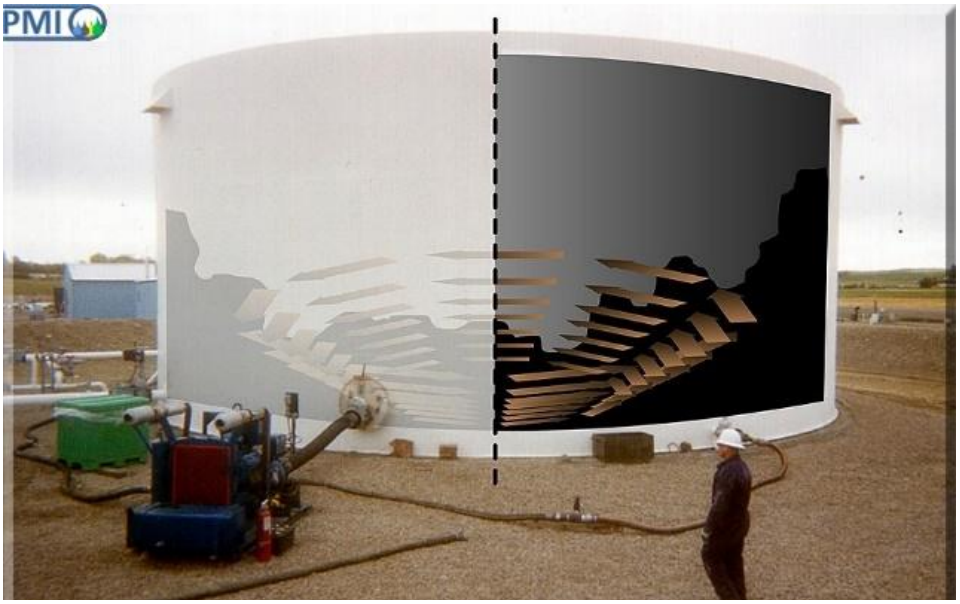
6.b. Stage 2 (ii). Preferred Method

This preferred procedure is to inject PMI-107 into the existing inlet/import pipeline that feeds the tank. Once the export of the existing crude down to the safe level above the sludge level is complete, the injection system is turned on as the tank fills naturally. This method ensures consistent mixing of PMI-107 with the fresh crude as it enters the tank. As the crude/PMI-107 contacts the sludge, the natural re-suspension of these solids takes place. The hydrocarbon rich, high calorific, waxes/asphaltenes are automatically resuspended into the crude.

This preferred option provides a very natural process. It might be necessary to export the tanks more than once for complete re-suspension into the oil phase. This method requires no man entry, is very safe and not harmful within the context of all HS&E considerations. It is also extremely efficient compared to alternative methods of sludge removal. The whole procedure is completed on-line so that full production and productivity are never compromised.

6.b. Stage 2 (iii). Alternative Method

In the event that the preferred option is not available or practicable, there is an alternative method that can be employed to achieve re-suspension. This procedure involves injecting PMI-107 by means of high pressure injection pumps through an existing port directly into the bottom sludge. The effect of this application method is to create circulation with a vortex. Depending on the configuration of the tank one or more pairs of ports would be used for circulation. If necessary, we would create our own ports by means of our own hot tapping/tank tapping procedure, (API RP 2201 Safe Hot Tapping Practices). Extraction would be by means of the natural flow from the export outlet. This method meets all HS&E safety standards.



HIGH PRESSURE PUMP WITH JET NOZZLE

PMI-107 attaches to each molecule or water and hydrocarbon and in so doing separates the water droplets from hydrocarbon droplets. Inorganic materials and polymer residues which are water soluble will be captured in the water phase and the waxes and any asphaltenes captured in the oil phase. Any salts or solids which are bound into the hydrocarbons within the sludge will automatically be released into suspension. These substances will all remain in suspension for as long as the body of the liquid remains in motion. A small proportion of heavy inorganic residues, (for example up to 8% in tank 224 or 1% in 114 of the original sludge content), could remain behind. This would still mean 98% + effectiveness of the total tank. If necessary de-sander units can be employed to remove this remaining inorganic material.

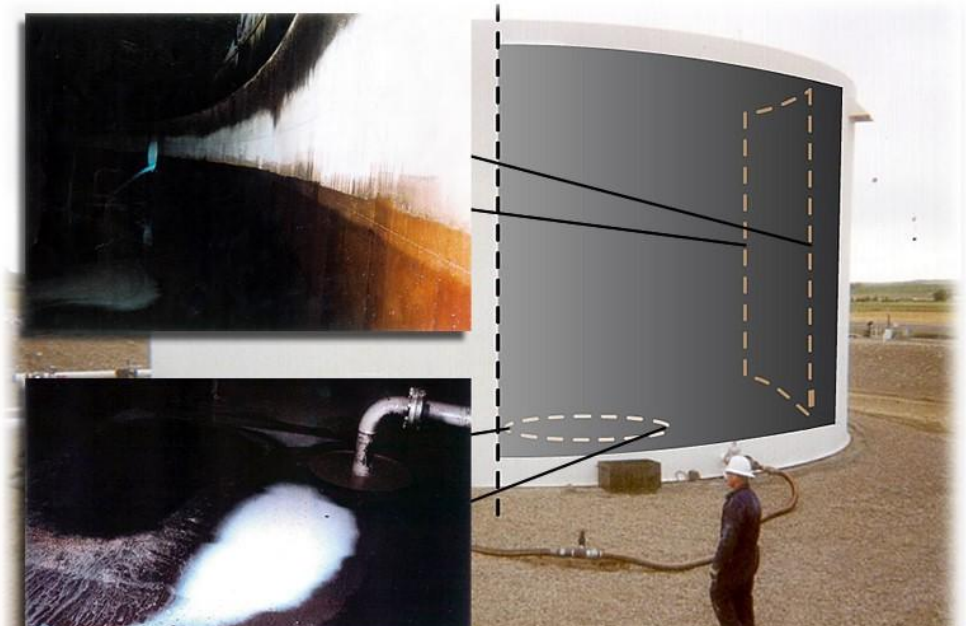
The re-suspended solids are despatched from the tank through the normal production flow and they will remain in suspension until they reach their ultimate destination and all motion has ceased. At that point the aqueous portion and hydrocarbons will separate into two discrete phases. The residual PMI-107 will be contained in the aqueous phase and the high calorific waxes which formerly were the main constituents of the BS&W will be available for refining.

c. Stage 3 – Ongoing prevention

Stage 3 should actually be run concurrently with Stage 2.

At the same time as the injection into the bottom sludge is in progress, PMI-107 needs to be injected into the production flow up stream of the tank. PMI-107 should be injected into the oil flow by standard dosing pumps at a predetermined maintenance concentration (which we would expect to be in the range of 50-100ppm) to inhibit future build up of BS&W. The upstream injection will maintain all the re-suspended impurities (wax, asphaltenes, bi-carbonates, other water-soluble inorganics and salts), which previously formed the sludge solids, in suspension. The upstream injection will retain the integrity of the fresh crude and inhibit future BS&W formation. Once the crude reaches its ultimate destination all

inorganic and water soluble impurities drop into the water phase together with the residual PMI-107, leaving a stabilised and high-quality oil phase without the need for further separators.



THIS WAS A HIGH LEGACY SLUDGE BUILD UP TANK
THIS COMPLETED SOLUTION USED ONLY PMI-107

7. Summary

The issue with build-up of solids in storage tanks, is exactly what PMI-107 was designed to solve. Our processes will remove virtually all existing deposits, (up to 98%), and ongoing maintenance-level dosing will eliminate recurrence. The fact that the process can be applied whilst the facility is online saves costly downtime and removes the requirement for manual intervention.

EXPORT LINES BEFORE TREATMENT EXPORT LINES AFTER TREATMENT

4th March 2018