A Conceptual Underwater Diving System for Pipeline Repairs in Nigerian Muddy Water Niger-Delta Oil and Gas Locations

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Abstract— Inspection and repair of leaking underwater pipeline in muddy water is generally difficult to perform in line with relevant engineering and construction standards. This is basically due to the requirement to closely and visually inspect the problem and then developing best strategy to fix it. It is therefore obvious that when the problem or the leak area or location is inadequately examined due to muddiness of the water mass, strategizing for re-pair becomes a trial and error operation. The consequence is re-pair-leak-repair cycle observed in most cases. Unfortunately, the poor visibility of un-derwater conditions is not a global problem. It is local to Swamps and Estuaries of Delta, and in the case of the Niger Delta of Nigeria to a depth of about 20m. The essence of this paper is to point out this local problem that requires a special engineering stand. A system of plume-detector-led manned motorized hyperbaric bell is suggested as a system that satisfies that leaking pipeline installed in a muddy water can be identified, close-visually in-spected and re-paired adequately in line with global best practices. Indeed, this suggestion is an extrapolation of something that already exists (the bell diving) but has now been modified for possible deployment to offer solution to repair of pipelines in muddy water to meet international standard.

Index Terms— Pipeline Repair, Underwater poor visibility, Muddy Water, Close Visual Inspection

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1 Introduction

An underwater operation in clear water is obviously not same when poor underwater visibility condition exists. Poor underwater visibility is a condition where the ability to see through in the water is impaired. In this paper, such condition is termed a muddy or unclear water condition. Field practice has shown that no matter how good one is at working with Remotely Operated Vehicles (ROVs), the ROVs are not good for inspection in limited visibility conditions. It is noted that in those cases, even a working diver has to carry out the inspection by 'touch'. These challenges do not imply that it is not possible to inspect and repair pipelines installed in muddy water. The main concern is that the visual inspection is inadequately done and once the affected pipeline cannot be retrieved to surface, the proper repair becomes unguaranteed. Unfortunately, this is the case with Nigerian most Niger Delta Shallow water and Estuaries with depth up to 20 meters. The reasons for the underwater poor visibility are well discussed in Agbakwuru J., 2012, Arumala J.O., 1987 and Agbakwuru et al., 2012. .A typical sample of muddy water of Nigerian Niger Delta is shown in Figure 1.

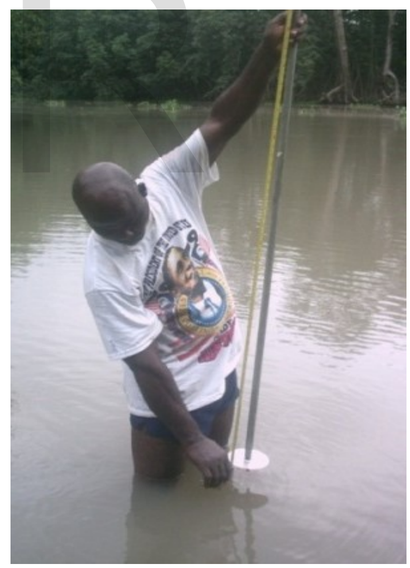

Figure 1: Picture showing a flowing river in Ekpan Effurun, Delta State of Nigerian Niger Delta area

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2 Existing Methodologies for Pipeline Inspection and Repairs

The most suitable method for pipeline repair depends on the extent and mechanism of the damage and location of the damage [4]. This can mostly be defined by adequate close visual inspection. Close visual inspection is a close-range detailed inspection that practically involves the use of human eyes. The standard practice of pipeline repair requires the performance of close visual inspection prior to implementation of repair strate-

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gy. Close visual inspection and repair of a pipeline in line with [5] requires a high standard of cleaning. The purpose of the inspection generally, is to establish detailed information of the specific area of interest. When the leaking point on a structure is in unclear water conditions, close visual inspection cannot be conducted by a diver without a special technique. Repair by divers immersed in muddy water would be a trial and error effort .

Table 1 shows a review on various existing methods of leak inspections and the suitability of use in poor underwater visibility. The classification done by the authors is based on the mode of operations.

The consideration of the numerous technologies of Table-1 clearly point to the inadequacies of repairing underwater pipelines in unclear water conditions in line with appropriate standards such as [5]. The reason for this inadequacy in the authors' opinion is that the muddy or unclear water characteristic is peculiar to Nigeria Niger Delta in particular. As could be obviously noted, the International Oil Companies are gradually re-selling off these facilities to Indigenous Oil Companies. As the pipelines are ageing and not quickly replaced, it will, in the near future, become an indigenous engineering concern that must be addressed indigenously. This is a major point of this paper. This paper attempts to establish that new methodologies have to be developed to manage the maintenance and repair of the pipelines to minimize the disastrous consequence of loss of containment in muddy marine environment.

Furthermore, the consequences of not innovating policies and methods for repair of pipelines in muddy water cannot be overemphasized. Aged pipelines are numerous in Niger Delta swamps and estuaries with unclear water mass. Many of these pipelines were installed in the 1970s by the International Multinational Companies. As discussed earlier, majority of these pipelines have recently being transferred to indigenous oil companies in Nigeria. Due to the aged pipelines, In-Line inspection using Intelligent or Smart pigs are often regarded as risky and therefore undone, especially for many pipelines in which piggability was not designed for. The consequence is that pipeline operator is not in control of the pipeline structural integrity. This implies that the operator barely waits for visible leaks from the pipelines before attending to the pipelines. The reactive approach is not the concern but the fact that the repair will not be properly executed due to unavailability of suitable technologies to deal with the underwater poor visibility challenge.

Furthermore, due to volatility of the region, there is also heavy cost associated with constructing new pipelines to replace the aged pipelines. This ranges from community demands, youth restiveness, engineering and installation costs. (It is largely believed that the first two are part of the reasons the International Oil Companies are re-selling off their facilities in these areas). The pipeline operators have therefore been comfortable in continued use of the aged pipelines. In the authors' perspective, it is important to state clearly that no existing state of the art technology is available to deal with the pipeline repairs in muddy water in-line with available standards. It could be spillage 'galore' when the limits of depreciation in the aged pipelines are exceeded.

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TABLE 1
UNITS FOR MAGENTIC PROPERTIES

Method	Examples of tools/systems that use the Method	Leak point identification possibility?	External inspection to Identify and guide ROV to leaking point on Pipeline in muddy water condition?
Laser Scanning	Electron Laser scanning	Yes	No. ROV is difficult to guide in water
Sound systems	Intelligent pigging, Automatic ultrasonic tester, TOFD, Ultrasonic probe testers, Acoustic Leak detector ,Sonar hydrophones, Electromagnetic Acoustic Transducers (EMAT), Phased array, Infrasonic testers, UT scanners etc.	Yes	Yes as In-Line inspection systems and as point sensors
Fibre Optics	Optical sensors (for leak, strain, fatigue and ground movement detection), Optic scanners, etc	Yes. As point sensor	No
Visual (Optical) Inspection	Use of human eye, full dive, Inspection light, Robotic crawlers, Camera, Videos, Bubble solution, Flourometry etc	Yes	ROV is difficult to guide in unclear water Diver's can feel.
Magnetic flux leakage (MFL) method, Eddy current	Magnetic flux leakage pigs, Remote eddy current testing etc.	Yes. MFL pigs Yes. Remote field eddy current possible but with limited range	No.MFL not used in water.
Inventory accounting	Negative pressure wave detectors, Pressure losses, mass balance.	No	No
Hydro-Carbon Leak detection sensors	Hydro-chemical detectors, Methane sniffers, Capacitance method, Bio sensors, Halide touch,	Yes	Possible. As point sensors.
Infra-red / Temperature based sensors	Temperature based sensors (specially used in water injection pipelines), infra-red thermal imaging	No	No. Infra-red is absorbed in water.

3 THE INNOVATIVE METHOD

A proposal in this work is made as combination of diving and some leak point tracking instrumentations using hyperbaric bells. This will be discussed in details in Section 3.1
Muddy water condition implies that it is impossible to optically visualize object immersed in the water. It is noted that the only probable technique to observe object clearly under a muddy water condition is to replace or displace the muddy water with air or clean water. Otherwise, a diver can merely feel situations with his hands to assess the object of interest. The technique of muddy water displacement was first used in 1977 for visual inspection of repaired corroded concrete bottom of a stilling basin of Webbers Falls Dam in Sallisaw, Oklahoma. For this particular case, visibility was zero even with diving light [6]. This technique is now modified in the present work for application in pipeline visual inspection in muddy water. It is therefore a proven method. However, unlike the steel plate inspection, prior to the performance of any close visual inspection on a leaking pipeline, locating the point of leak is required. Recent work has also developed a method of using the exiting plume as a tracking medium [7]. The principle is to optically follow the track of the plume in the muddy water to the originating point. The origin of the plume is exactly the broken point on the pipeline. This method is a new technique for pipeline leak point identification but has been demonstrated in the laboratory under muddy water condition. It may therefore be ranked as TRL 6 in the technology readiness level.

The use of the methods presented in Table 1 for identification of the leaking point of pipeline section in muddy water could have the possibility of misleading the tracking tool. Such mislead of remote vehicles could be very costly and unsafe. The inadequacy or the cause of the mislead is the inability of the remote operator or the ROV pilot to obtain clear visual signal directly leading to the point of leaks due to attenuations, poor visibility, effect of surface waves and currents. The tendency for mislead is avoided with the use of emerging plume. The plume is the physical disturbance observed in water due to leaking oil or gas.

3.1 The Plume Detector-Led Manned Motorised Hyperbaric Bell

The procedure for the use of the suggested innovation, here referred to as the Plume Detector-led manned motorized hyperbaric bell system is as follows with reference to Figures 2, 3 and 4 shown below: Minimal pressure is introduced in the pipeline to generate observable plume on the surface of the water. The working vessel (51) approaches the pluming area and lunches the bell system (Figures 3 and 4). The bell is rigged to the lifting frame (53) and lifting chain/ wire (54). The inflatable body (66) on the top of the bell is in deflated position as the bell goes into the water with divers (60) and (61). Air is suggested to be supplied from the surface through hoses (56) & (57) but could alternatively be generated by equipment mounted in the bell. A communication and power cable (59) is provided from vessel (51). Observation, supervisory and control of the divers are managed from the surface (52). A camera (22) is mounted inside the bell and lamps (68) and (69) are available for illumination in the bell. Once the bell is in the water, one diver (61) feeds in the plume detector (67) and the other diver (60) drives the bell gently towards the

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plume. The transparent glass (64) provides a window view of outside of the bell, should the water condition permit some visibility. Electrically operated thrusters (70) are controlled using the joy-stick (63). The plume signal is observed from the TV monitor (65). The sticks (62) located in slots (74) enable the diver (61) to pull-out or feed-in the detector, depending on the signal on the monitor (65). The detector is described in section 1.0. As the bottom is approached, the pressure in the pipeline is further reduced to zero as would be advised by the divers (till the pluming base is minimal). The bell is now closest to the leaking point and diver (60) drives the bell above the pluming pipeline. At this point, the divers confirm the alignment of the pipeline (59) in relations to the bell's slot (75). The surface crane operator is advised by the divers to assist to maneuver the bell (if necessary) to enable the pipeline to sit in the slot (75). The inflatable system (66) is then inflated and the surface crane operator removes tension from the bell. Divers (60) and (61) clear the bottom area of the pipeline and fix the pipeline to seal between the slots. The sealing brackets are then tightened to minimize loss of pressure when the bell is on full pressure to empty the bell. The bell is then pressurized in full to expose the section of the pipeline to be inspected and repaired. Close visual inspections and repair of the damaged pipelines is then carried out and supervised by the surface engineers and experts on the vessel (51) via the installed camera (72) and communication line (59).

The divers are anchored in the bell till all the operation is completed. The divers do not leave the bell. The light top and bottom heavy condition of the system enables the bell to always stand erect during the inspection and repair process without any tension from the surface crane and irrespective of the softness of the seabed. Thus, this invention reduces the risk of surface wave effects on the bell and the pipeline system when the pipeline is fitted and sealed in the slots.

When the process is completed, the sealings are removed, the surface crane takes tension and the inflatable system is deflated for the bell to be returned to surface.

4.0 Conclusion

There is an absolute need to prepare for repair and maintenance needs of, especially, aged and non-piggable pipelines in muddy water of the Niger Delta of Nigeria. The pipelines referred to in swamps and estuaries are majorly spaghetti and criss-crossed that the solution of lifting the pipeline above water to fix may fail in many cases. The paper has demonstrated that despite the muddy water situations, pipeline repairs can still be carried out adequately in line with global best practices of first closely and visually inspecting the problem and then carefully strategizing and fixing the problems professionally and adequately.

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