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Communication Systems for Pipeline Protection in Nigeria Niger Delta Region *(pp.213-222)*

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Abstract: Environmental leaks, flow assurance and tempering with pipelines continue to persist as major pipeline issues in the Nigeria Niger Delta region. As a mature, cost - effective technology that can effectively address these issues, The Fiber Optic cable (FOC) and Supervisory Control and Data Acquisition (SCADA) systems are well designed for wide spread adoption among the pipeline operators in this region. These systems will provide advanced warning, which will allow the pipeline operators to take deliberate and strategic actions to prevent or mitigate any damage of the pipeline.

Key words: initial injection station, compressor/pump stations, partial delivery station, block valve stations, regulator stations, final delivery station

1 INTRODUCTION

Pipeline is an efficient means of transporting fluids over long distances, from production locations to the markets. The safe and continuous operation of hydrocarbon pipelines requires the pipeline operator to have the most up-to-date information to hand regarding the condition of his pipeline. It is clear from a number of surveys that the most common cause of pipeline failure is third-party external damage, caused by activity such as ploughing of buried lines, or the impact of trawl gear against (unburied) sub-sea lines. Furthermore, in many areas in the Niger Delta region of Nigeria, the effects of sabotage or vandalism must also be considered.

In locations where the pipeline is relatively inaccessible, the principle and theory of standby of visual inspection is not an easy option to implement, and grate damage may go undetected for considerable periods of time. The continued operation of upstream oil and gas pipelines in these often rather inaccessible locations requires the ability to monitor the line condition remotely (Russell and Gordon 2001).

The main elements that constitute a pipeline system are the Initial Injection Station, Compressor/Pump Stations, Partial Delivery Station, Block Valve Stations, Regulator Stations and Final Delivery Station. In general, pipelines can be classified in three main categories depending on its main purpose, such as Gathering pipelines or Flow lines, Transportation Pipelines or cross country pipelines and Distribution Pipelines. All these facilities face several daily vandalisation due to lack of proper protection system by the operating companies.

2 METHODOLOGY

A visit to various pipeline construction sites within the Nigeria Niger delta region were carried out to access the necessary principles and theories that are employed toward the implementation of pipeline protection. Similarly, we visited various damaged sections of some pipeline within this region and ascertained the causes of the damages and the most likely reasons behind the operating companies not been able to identify the causes of the damages in time and invoke a preventative measures. Finally, a comprehensive study on various pipeline communication systems and how they could be employed for pipeline protection were carried out, and two main systems were selected from this study.

However, managing a pipeline system, for an effective protection is an all round-the-clock, complex operation that involves continuous monitoring. Hence, we need a highly reliable, simple and dependable way to give supervisory control over the pipeline systems. These could only be achievable, where there is an effective communication system between the various points linking the pipeline system. In the course of carrying out this study, two most effective communication systems within the pipeline network system have been identified to be very reliable and effective toward the protection of the pipeline systems from damages, ruptures, leaks and third party damages.

2.1 Threats to Pipeline Systems in Nigeria

Effective pipeline communication system is a model utilized to lower pipeline operating costs, improve performance, create effective efficiencies and as well as providing the most needed protection of the pipeline from third party damages (encroachment). During our study, it was discovered that most of the pipeline damages were caused by external forces, which is a combination of a gouge and dent. Gouging damages the surface of the pipeline creating hard and brittle surface layers that have low resistance to crack initiation. Denting changes the contour of the pipe, thereby creating local areas of high strain. Our interaction with the operating companies of these pipelines indicated that third party strikes represented the greatest rupture threat and that rupture rates were typically highest in the river line and swampy areas of the Niger Delta. They also opined that most obvious means of preventing failures due to encroachment is to prevent the encroachment, which is much easier said than done. Several efforts have been exerted by the operating companies in this direction by the installation of post warning signs, improve marking of pipeline right-of-ways, increase public awareness, especially within the host communities of these pipelines, and promotion of one-call notification system through the provisions of the company hot telephone lines, etc. But irrespective of all these measures, encroachment damage continues uncontrollably within the pipeline right-of-way and has proven as the single most common cause of pipeline failures.

Weather related phenomena were also discovered as one of the major threat to pipeline system in the Niger Delta of Nigeria, especially with the gas pipelines. Failures related to cold weather, earth movement, heavy rains, floods and lighting. Cold weather failures cover those caused by thermal stresses.

Thus, there is need to install alongside the pipeline and between the starting point and the terminating point, a communication system that transmit signals between the pipeline right of way and the control room which defines various happenings along the pipeline. Two of the most commonly used communication system in a pipeline, which we considered suitable in Nigeria Niger Delta scenario, are:

- Fiber Optical Cable (F.O.C.) System and
- Supervisory Control And Data Acquisition (SCADA) SYSTEM

2.1.1 Fiber Optical Cable

Pipelines often cross hazardous environmental areas from the point of view of natural exposures such as landslides and earthquakes, and from the point of view of third-party influences such as vandalism or obstruction. These hazards can significantly change the original structural functioning of the pipeline, leading to damage, leakage and failure with serious economic and ecologic consequences. Furthermore, the operational conditions of the pipeline itself can induce additional wearing or even damage.

The structural and functional monitoring can significantly improve pipeline management and safety. Providing regularly with parameters featuring the structural and functional condition of the pipeline, monitoring can help achieve the following (Daniele and Branko, 2007).

- Prevent the failure,
- In time, detect the problem and its position and
- Undertake maintenance and repair activities in time.

Thus the safety is increased, maintenance cost optimized and economic losses decreased. Typical structural parameters to be monitored are strain and curvature while the most interesting functional parameters are temperature distribution, leakage and third-party intrusion. Since the pipelines are usually tubular structures with kilometric lengths, structural monitoring of full extent is an issue itself. The use of discrete sensors, short- or long gauge is practically impossible, because it requires installation of thousands of sensors and very complex cabling and data acquisition systems raising the monitoring costs. Therefore, the applicability of discrete sensors is rather limited to some chosen cross-sections or segments of pipeline, but not extended to full-length monitoring.

Recent developments of distributed optical fiber strain and temperature sensing techniques provide a cost-effective tool allowing monitoring over kilometric distances. Thus, using a limited number of very long sensors it is possible to monitor structural and functional behaviour of pipelines with a high measure and spatial resolution at a reasonable cost.

Optical fiber (or "fiber optic") refers to the medium and the technology associated with the transmission of information as light pulses along a glass or plastic wire or fiber. Fiber optic Cables is the most advanced early warning pipeline security monitoring system available, which detects and locates intrusions and third Party Interference, tempering, and illegal tapping attempts any where along thousands of kilometres of buried pipeline, in real time before actual pipeline damage occurs.

Fiber optic cable is usually buried above the pipeline, and it has the ability to transmit a laser beam, which will be accompanied with a return signal, which will be automatically monitored and analysed for disturbance. This returned signal is also intelligently processed to minimise nuisance alarms, while still detecting and reacting to real time events.

Figure 1: Fiber optical Cable Laying on a typical Pipeline in the Niger Delta.

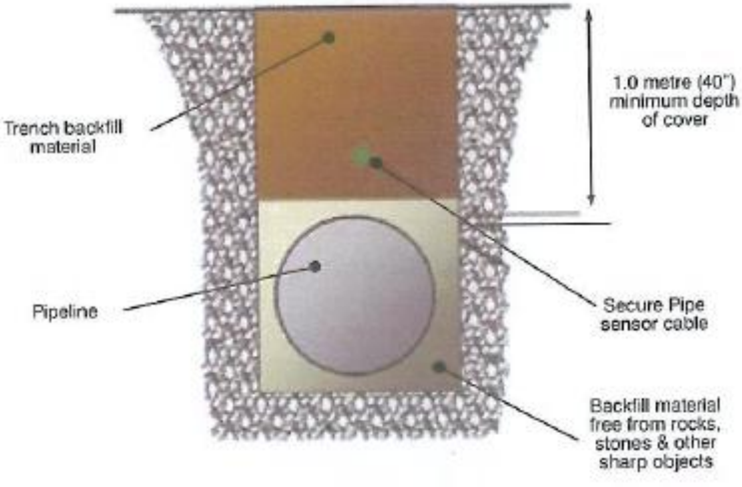

Figure 2: Fiber Optic Cable Installation.

Fibers can be made out of transparent plastic, glass or a combination of the two, the fibers used in long distance pipeline communication applications are always glass, because of the lower optical attenuation. Optical fiber carries much more information than conventional copper wire and is in general not subject to electromagnetic interference and the need to retransmit signals. Fibers are used instead of metal wires because signals travel along them with less loss.

Light is kept in the “core” of the optical fiber by total internal reflection. This causes the fiber to act as waveguide. Thus, the primary aim of installing a fiber optic cable alongside our buried pipelines is to provide warning signs which will aid in preventing accidental third-party damage. This objective can be achieved by the optic fiber cables, because, they generate detection systems which will sense and transmit signals to the control room, whenever an outside force damage or construction equipment is near the pipeline. Upon detection, the system would automatically initiate alarms and notification to the pipeline operators.

Figure 3: Optic Fibers

Some of the advantages of fiber optic cables are that it provides the capacity to monitor the entire pipeline in real time to detect treats from illegal operations, physical damages from excavations or stream scour. It has the ability to provide information relating to the exact location or point where the threat occurs and where to dispatch security staff or maintenance teams before environmental damage occurs.

To bring this objective to its fullness, the fiber optic cable (which is similar to the telephone cables as shown above) will be buried above the underground pipeline and periodically, light pulses may be sent down the optical cable, and this in turns are reflected back to the source, whenever a construction equipment or any other foreign undesirable element or force are present within the buried pipeline, because the weight and size of the equipment causes the optical properties of the fiber to change. These properties make it possible for the actual location of the damage to be known, because it allows for easy measurement of the time for the reflected light pulse to return.

Thus, in general, the system can provide 24 hours per day, seven days per week of policing the pipeline from a single point, by alerting the pipeline operator that construction equipments are moving close to its pipe, and in cases where there were no previously granted permit to work, efforts are immediately mobilised to stop the un approved excavation and potential damage to the pipeline. It could as well be used for detecting leakages in pipelines. Optical fibers can also be used as sensors to measured strain, temperature, pressure and other parameters. The small size and the fact that no electrical power is needed at the remote location gives the fiber optic sensor an advantage over a conventional electrical sensor in certain applications.

2.1.2 SCADA System

SCADA is an acronym for Supervisory Control and Data Acquisition. SCADA systems are used to monitor and control Pipeline or a plant or equipment in industries such as Pipeline operating companies, telecommunications, water and waste control, energy, oil and gas refining and transportation. These systems encompass the transfer of data between a SCADA central host computer and a number of Remote Terminal Units (RTUs) and/or Programmable Logic Controllers (PLCs), and the central host and the operator terminals. A SCADA system gathers information (such as where a leak on a pipeline has occurred), transfers the information back to a central site, then alerts the home station that a leak has occurred, carrying out necessary analysis and control, such as determining if the leak is critical, and displaying the information in a logical and organized fashion. These systems can be relatively simple, such as one that monitors environmental conditions of a small office building, or very complex, such as a system that monitors all the activity in a nuclear power plant, or in between, such as one that monitors a pipeline system. Traditionally, SCADA systems have made use of the Public Switched Network (PSN) for monitoring purposes.

SCADA systems consist of (Fonsah, et al; 2004):

- One or more field data interface devices (which form the “eyes” and “ears” of a pipeline SCADA system), usually RTUs or PLCs, which interface to field sensing devices and local control switchboxes and valve stations.
- A communication system used to transfer between field data interface devices and control units and the computers in the SCADA central host. The system can be radio, telephone, cable, satellite or any combination of these.
- A central host Computer Server or Servers (sometimes called a SCADA Center, Master Station or Master Terminal Unit (MTU).
- A collection of standard and/or custom software (sometimes called Human Machine Interface (HMI) software or Man Machine Interface (MMI) software) systems used to provide the SCADA central host and operator terminal application, support the communications systems and monitor and control remotely located field data interface devices.

The Figure below shows atypical SCADA system.

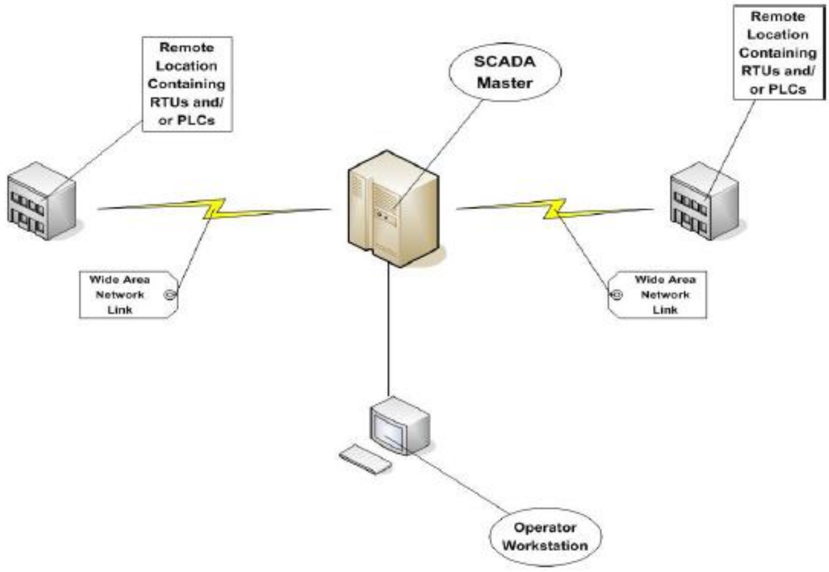

Figure 3: Typical SCADA System

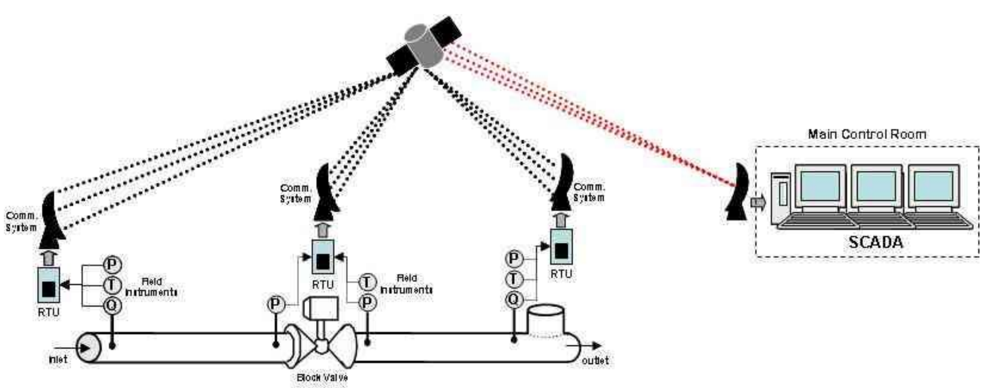

Figure 4: Overview of SCADA system for pipelines

Field devices are basically instrumentation, data gathering units and communication systems. The field instrumentation includes flow, pressure and temperature gauges/transmitters, as well as other devices to measure the relative data required to operate. These field instruments are installed along the pipeline on some specific locations, such as injection or delivery stations, pump stations (liquid pipelines) or compression stations (gas pipelines), and block valve stations.

The SCADA System has its main functions as;

- Automatic control (from the main control system) of the emergency shut-down valves (ESD) of various pipeline
- Metering data – pressure, temperature, Gas composition, Density etc.
- Used for monitoring of gas leak detection

The information measured by the various field instruments is then gathered in local Remote Terminal Units (RTU) that transfer the field data to a central location in real time using communication systems such as satellite channels, micro wave links or cellular phone connection. Pipelines are then controlled and operated remotely, from what is commonly know as the control room. In this specific centre all the data related to field measurement is consolidated in one central data base. The data is received from the multiple RTUs installed along the pipeline. The SCADA system also includes a PC – based system which has increased the leak detection capability of a pipeline system, thereby facilitating the dispatch of a repair solution as needed. Thus, with the SCADA system, we can monitor and control our pipeline systems along side with the pumping stations for our oil pipelines as well as oil tanks in different tank farms along the extensive pipeline. This is usually made possible through its ability to be integrated with the intranet and internet- based large network applications. This eventually makes it possible for the SCADA system to provide a means for monitoring and controlling the overall operations of the pipeline system from a single location. These various advantages can be made possible in various international languages as switching from one language to another is made very easy, thereby bringing about a great reduction in transmission cost as long as the SCADA system is a web based system, as this will support the ability to view trends and alarms anytime, anywhere, through the web. The SCADA system at the main control room receives all the field data and presents it to the pipeline operator through a set of screens. The operator can monitor the hydraulic conditions of the line, as well as remotely manipulate pumps, compressors, valves, deliveries, etc. Sending operational commands (open/close valves, turn on/off compressors and pumps, change set points, etc) through the SCADA system to the field. To optimize and secure the operation of these assets, installation of the “Advance Pipeline Applications” which are software tools installed on top of the SCADA system, that provide extended functionality to perform leak detection, leak location, batch tracking (liquid lines), pig tracking, composition tracking, look ahead modelling, operator training and more is recommended.

3 CONCLUSION

Ruben (2010), in his presentation, opined that our conventional approach to pipeline instrumentation and control has left significant gaps that cost time, money and product. These gaps include:

- Errors due to cluttered data displays, causing operator confusion or misinformation
- Errors due to nuisance alarms, un prioritized alarms, or flurries of alarms, leading to slow or omitted response to field conditions.

- Errors related to lack of training of controllers responsible for pipeline and SCADA system operation.
- Property damage, product loss and equipment loss due to vandalism and other trespass at pipeline facilities including compressor stations.

Since oil and gas pipelines represent one of the most important assets for the current economic and social development of Nigeria, it has been required either by government regulations or internal policies to ensure the safety of the assets as well as of the population and the environment where these pipelines run across. Some of effects of unsafe pipelines include; Loss of life and property, Direct cost of lost products and line down time, Environmental cleanup cost and possible fines and legal suits.

It is for these reasons that, it becomes necessary to have an integrity monitoring system for our pipelines, because the cost of fitting and operating damaged pipeline system is often insignificant when compared with the cost of failure of the line.

Most of the oil and gas companies operating in the Niger Delta region of Nigeria are still operating behind these technologies, as their pipeline networks are operating without any Fiber Optic cable or a SCADA system. This has resulted in the continuous and un interrupted damages of the pipelines within this region, without it being notice, which has eventually lead to several ruptures and consequent pollution of the environment. Several issues need to be addressed, especially in the area of vulnerabilities associated with computer usage and the communications within SCADA systems and the Fiber Optic Cable. To facilitate SCADA systems' ability to support the Pipeline systems in the Niger Delta region, the following are recommended:
The Federal Government of Nigeria through its agency, the Directorate of Petroleum Resources (DPR) should monitor the development, and make contributions when appropriate, of the SCADA and Fiber Optic systems, and make them a compulsory installation within our pipeline system, for an effective protection of our pipeline systems from external damages.

The Federal Government of Nigeria through its agency, the Directorate of Petroleum Resources (DPR) should Monitor and participate, as appropriate, in the preparation of the standards process as it relates to SCADA and Fiber Optic cable systems, especially in security features or requirements with SCADA/Fiber Optic Cable Standards.

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