Oilfield Production Surveillance as a Management Tool for Environmental Monitoring

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ABSTRACT: Oilfield production surveillance is the effective monitoring of petroleum reservoirs, producing wells, flow station facilities and flow lines. Through surveillance, the production of unwanted effluents (formation water, excess gas, etc.) can be controlled. Production problems such as sand production, emulsion, corrosion, scale formation and wax blockage can lead to disposal problems and poor integrity of facilities and consequent financial losses. This paper presents a system approach for carrying out oilfield production surveillance process. Using case studies it is shown that the process can be used to identify unfavourable conditions such as gas leaks, corrosivity, and unsafe wells. It is further recommended that the frequency of surveillance should be monthly. JASEM

Environmental monitoring methods include health risk assessment and surveillance, baseline exposure evaluation, visual inspection, plant and equipment performance evaluation, process audit, etc. From our experience in Nigeria, it would appear that only the health risk assessment is emphasized in almost all the environmental impact assessment (EIA) reports. Of course, the health of personnel and those in the nearby communities are very important. However, we are of the view that equal emphasis should be placed on the use of appropriate engineering controls. Oilfield surveillance is one of the tools for choosing relevant controls.
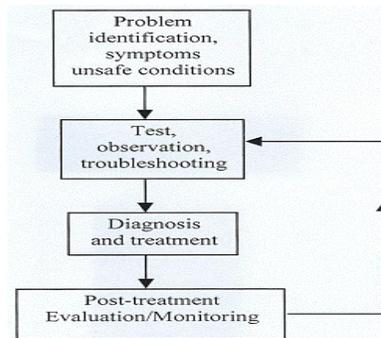
In general, the key strategies for waste management include (a) reducing or minimizing waste generation, (b) recycling the waste and (c) reusing the waste. The objective of oilfield surveillance is to minimize waste generation through systematic monitoring of the production process. Production wastes are mainly effluent water measured in terms of basic sediment and water (BSW), excess gas production measured in terms of Gas-Oil-Ratio (GOR) and sand cut. The effluent water, apart from disposal which is an environmental problem, causes emulsion, corrosion and scale problems. Excess gas production can lead to pressure-related and vibration problems. Sand erodes facilities and causes severe damage. This paper discusses how to monitor and minimize the environmental impact of production activities in the E&P operations using oilfield surveillance as the main tool.

THE SURVEILLANCE PROCESS

The surveillance process involves diagnosing production and facilities problems in a proactive manner before severe damage is done to equipment, personnel and environment. With an effective surveillance process in place, pollution problems such as was the case with Obelle fires (Ajienka and Kuye, 1999) will be avoided. Effective surveillance presumes that the field is well known. Also, a proper balance must be made between producing at minimum cost and minimizing environmental impact. Allen and Roberts (1982) discussed some routines that can be used to handle well problems.

The surveillance process is shown in Fig 1. Every reservoir, every well and every facility is monitored as an entity. Once a problem is identified, tests and/or observations are carried out to ascertain the cause(s). Appropriate remedies are then put in place. After this, it will be necessary to evaluate the effectiveness of the remedies. In some cases, it may be necessary to carry out further tests/observations as can be seen in Fig 1. The outcome of a surveillance process is the report.

Ideally, the frequency of the surveillance is monthly. The monthly surveillance report should comprise:

(a)   Reservoir performance
(b)   Well surveillance / well status summary
(c)   Flow station surveillance and
(d)   Flow line surveillance

In practice, most producing companies mainly concentrate on monthly well surveillance. However, experience has shown that it is necessary to carry out monthly surveillance of the other parameters

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mentioned above. Each of these aspects is discussed further in the remaining sections of this paper.

Reservoir Surveillance: The rate of reservoir pressure decline may have direct impact on productivity and environmental quality. If the reservoir pressure depletes rapidly, it will result in high gas production and water cut. These are production wastes; the disposal of which affects the environment. High pressure drop around the well bore can also cause sand production. Consequently, it is necessary to determine the predominant reservoir drive mechanism and arrest rapid pressure decline. A good

pressure maintenance plan will go a long way in ensuring that this objective is achieved.

Well Surveillance: The production problems that have severe environmental impact potential are:
(a)   Well producing at high Gas-Oil-Ratio (HGOR). Usually, a well is said to produce at HGOR if producing GOR is greater or equal to three times the initial solution GOR (Rsi). This implies wasting reservoir energy that can be used to produce the reservoir. It may also mean wasting the produced gas if there are no facilities for associated gas gathering (AGG) and utilization. Fig 2 gives a flow chart for diagnosing HGOR (Ajienka, 1995)
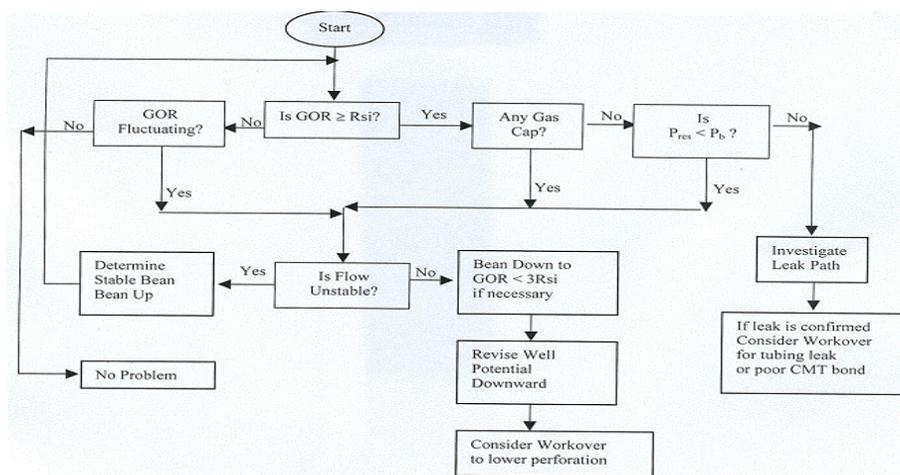

Fig 2. Flow chart for well producing at high HGOR

Wells producing at high basic sediment and water (HBSW) greater than or equal to 50%. When this is the case the well experiences water loading of vertical conduit and therefore inhibits flow. Apart from this, other problems include disposal of formation water, high transportation cost and pipeline ullage problems. Fig 3 gives a flow chart for monitoring HBSW.
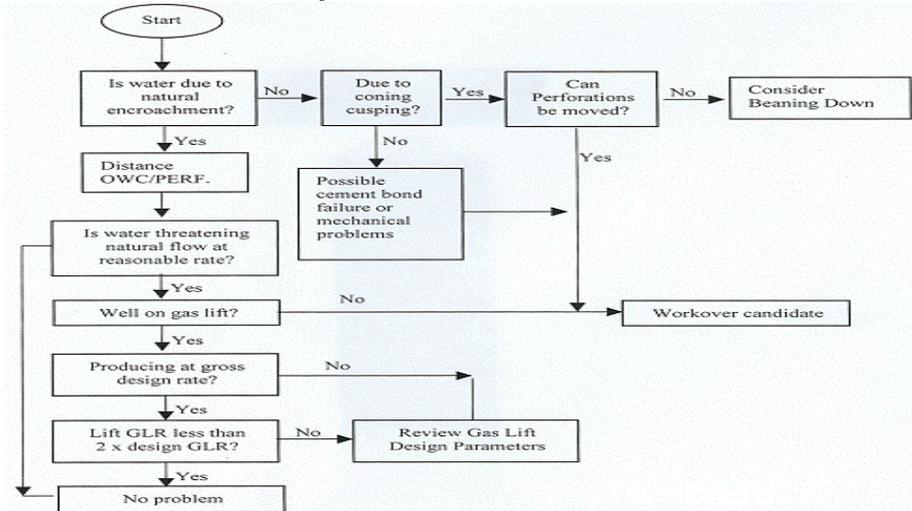
Fig 3. Flow chart for well interval producing at HBSW

(c) Wells with sand cut greater than or equal to 10 lb/mbbl. Fig 4 illustrates a process that can be used to monitor high sand cut. Sand production is a very serious services problem as it can lead to erosion and failure of facilities. It is necessary to monitor the level of the reservoir pressure drop at the well bore since high pressure drop can lead to sand failure.
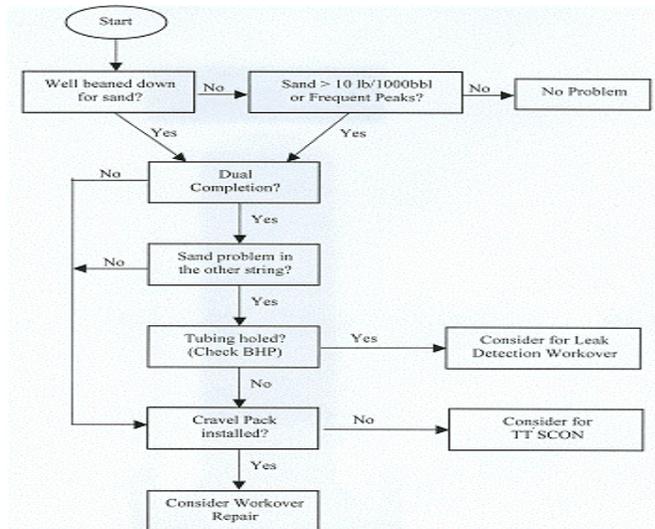

Fig 4. Flow chart for well intervals with sand problems

(d) Other problems include scale formation, corrosivity, unsafe well condition and communication between tubings. Scale formation can lead to reduced well integrity problem. Unsafe wells and communication between tubings are discussed further by Ajienka and Kuye (1999). These problems should be given prominence when carrying out well surveillance.

Flowstation Surveillance: This involves careful monitoring of parameters such as pressure (Fig 5), surge vessels (Fig 6), sand production (Fig 7), gas flaring (Fig 8), corrosion and scaling (Fig 9) and vibration (Fig 10). It should be noted that the major difference between the surveillance that is being suggested here and the usual routine monitoring of facilities, controls, etc is in the reporting of deviations from normal operation. By using Figs 5 - 10, deviations and the remedies proffered should be properly documented. Such reports should be prepared on a monthly basis.
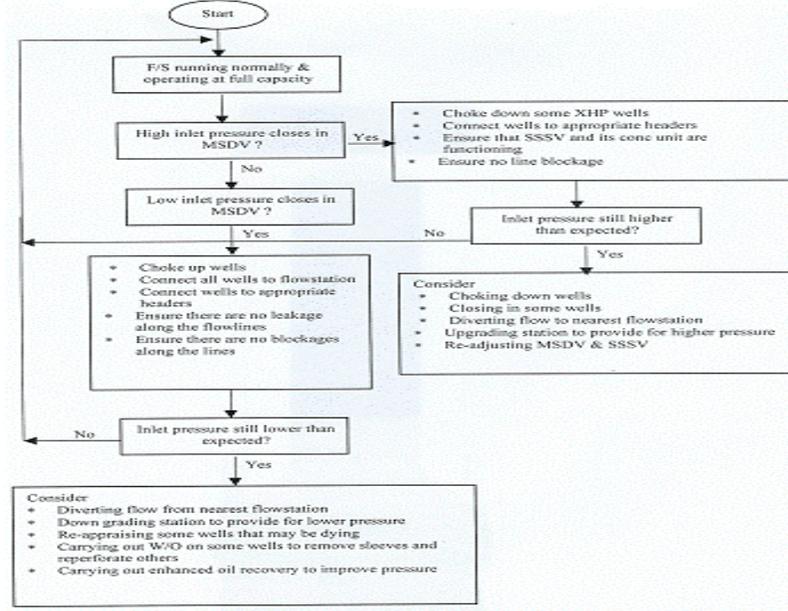
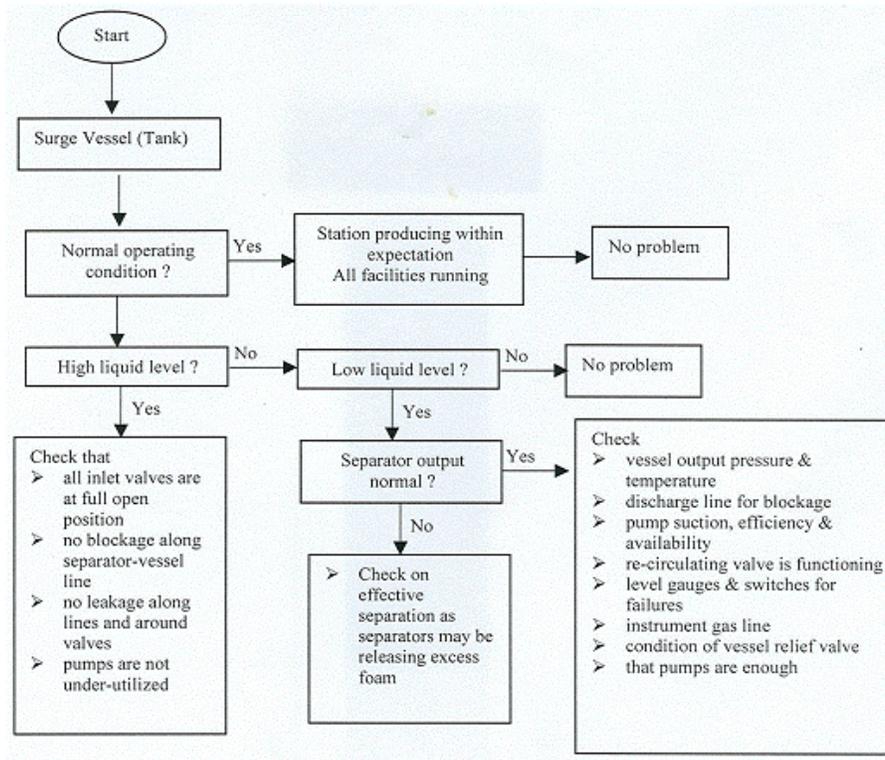Fig 5. Flow chart for pressure surveillance

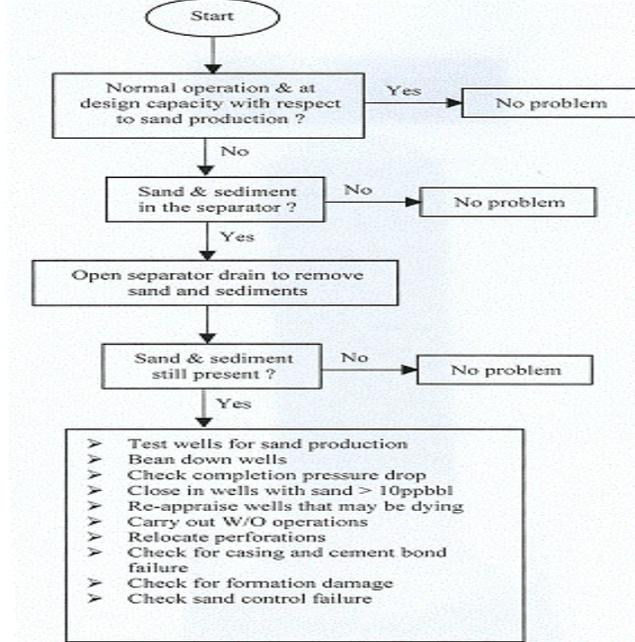Fig 6. Surge vessel performance surveillance

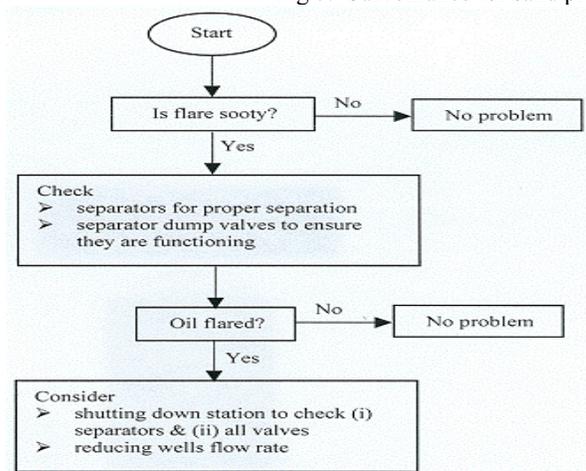Fig 7. Surveillance for sand production from flow stations

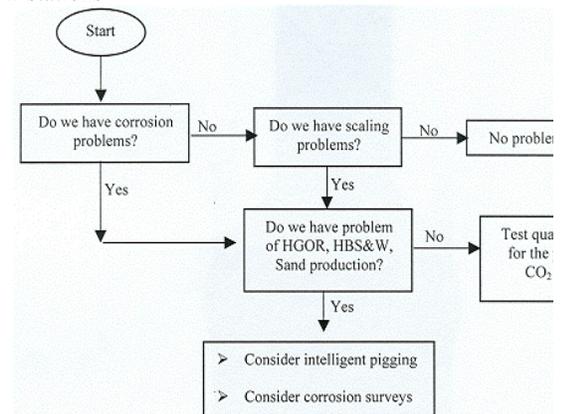Fig 8. Surveillance for gas flares from flowstations

Fig 9. Surveillance for Corrosion and Scaling

Start

Are there vibration problems? — No → Any other mechanical problems like leakage, valve malfunctions? — No → No problem

Yes

Yes

Check
➤ Platforms
➤ Pump installations
➤ Valves fittings
➤ Separator fittings & seating
➤ Surge vessel seating & fitting
➤ Slagged bolts & screws
➤ Pumpline discharge pressure
➤ Pipeline seating & fitting
➤ Platform cement bond

Stop leakages
Repair all valves

Vibration still exist?

Yes

Consider
➤ Diverting flow to nearest F/S to reduce capacity
➤ Total overhauling or upgrading F/S capacity

Flowline Surveillance: This is the monthly monitoring of flowlines for problems which may either block or rupture the lines. These problems include scale formation, wax deposition, corrosion and leakages. Some of the flowcharts given for flowstation surveillance can also be used for flowline surveillance. The effectiveness of flowline corrosion protection system should be carefully monitored. Regular intelligent pigging of flowlines should be conducted. The frequent pipeline rupture within the operational areas of E & P companies in Nigeria is an
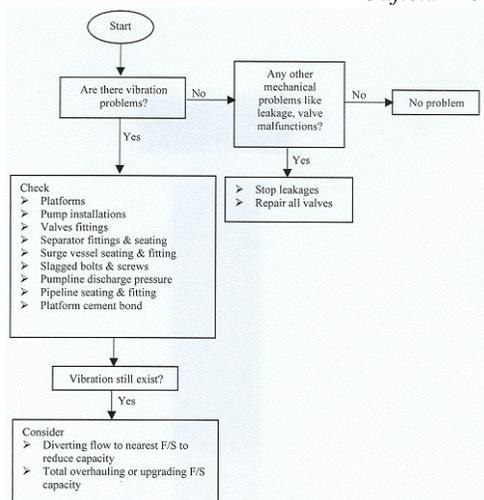
Fig 10. Surveillance for vibration

example of pipeline integrity problem that can be minimised through adequate surveillance techniques.

DISCUSSIONS
The data used for this work were obtained from some E & P companies in Nigeria informally. Consequently, we cannot mention the names of the companies and/or specific fields for legal reasons. Our aim is to subject these data to the surveillance process described in the previous section. The findings are summarized in Tables 1 to 3. Table 1 shows a typical formation water concentration from a Nigerian oil field. Clearly, such aqueous effluent must be subjected to physical, chemical and biological treatment process before disposal (Uhuegbulam and Dala, 1981). Table 1 also demonstrates that production companies should be concerned with the environmental effects of their effluent discharges.

Table 1 Composition of typical produced formation water

Parameter	Concentration mg/litre	Recommended level in Nigeria[a]
Oil & Grease	200	10
Total suspended solids (TSS)	73	30
Total dissolved solids (TDS)	110	2000
Chlorides	61	600
Total organic carbon (TOC)	400	-

[a]Source: FEPA (1991)

Tables 2 and 3 illustrate the output of the surveillance process for wells and flowstation facilities respectively. The four wells and the three flowstations shown in these tables were selected at random from the collected data. Similar outputs can be designed for flowlines. Table 2 indicates that the listed wells have production problems. From Table 3 we observe that flowstation A and C exceeded their liquid capacities while flowstations B and C exceeded

their gas capacities. Capacity constraint could lead to major environmental incidents. For reservoir management reasons, it may be expedient to investigate further causes of HGOR and HBSW rather than closing in as suggested in Table 3. Such investigation may then show that other remedial actions should be taken so as to minimize financial losses.

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Table 2   A typical well surveillance output

Well	Reservoir	Gross Production B/D	GOR SCF/STB	Rsi SCF/STB	BSW %	Sand production lb/Mbbl	Remarks/ Actions
1S	B7.0A	851	3200	932	51	2.1	HGOR Bean down
2L	E3.0F	765	200	578	63	1.4	HBSW, GOR Doubtful Bean down
7L	D7.0C	1009	3400	1541	53	3.0	HBSW, HGOR Bean down
40S	E9.5E	3500	1500	1286	-	5.0	Monitor Sand cut

It should be pointed out that pertinent information (gas composition, pour point, well effluent analysis, etc) should be collected and documented during well completion. Such information can act as the baseline data against which subsequent parameters would be compared. If for instance the gas composition indicates that corrosive gases (CO_2, H_2S, etc.) are present, then it would be necessary to monitor corrosion during surveillance. Also, if the crude oil has high pour point (or high wax content) then it would be important to monitor wax deposition. In addition, high salt content would be a good indication of probable scale formation problem during the life span of the well.

Table 3   Typical flowstation facilities surveillance output

Flowstation	Oil Production BPD	Liquid Capacity B/D		Gas Capacity MMscf/d		Action
		Nominal	Gross	Nominal	Gross	
A	48460	60000	69634	60	59.98	Choke back, close in HBSW producing wells
B	14390	30000	21244	30	32.25	Choke back, close in HGOR wells
C	40876	60000	69463	60	88.69	Choke back, close in on HBSW/ HGOR producing wells

The other pertinent question that has not been addressed is how often should surveillance be carried out. Bearing in mind the level of information required to carry out the surveillance process, we would recommend that the monitoring should be on a monthly basis. Shorter frequencies (daily or weekly) will not be feasible. Longer frequencies (quarterly or yearly) may be too long. This is because by the time the report is ready, the problem may have caused irreparable damage to the environment. By using the flowcharts given in this paper as templates, it should be possible to carry out a comprehensive surveillance on a monthly basis

Conclusion: A surveillance process that can be used for proactive diagnosis of production and facility problems, from an environmental point of view, has been presented. The process can be used to identify unfavourable conditions such as gas leaks, corrosivity, and unsafe wells. It is recommended that the frequency of surveillance should be monthly.

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.NOMENCLATURE

B/D	Barrels per day
BHP	Bottom hole pressure, psi
CMT	Cement
F/S	Flow station
F/S	Flowstation
GLR	Gas liquid ratio, scf/stb
GOR	Gas oil ratio, scf/stb

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HBSW	High basic sediment and water
HGOR	High gas oil ratio
MSDV	Master Shut Down Valve
OWC	Oil water contact, ft
P_b	Bubble point pressure, psi
PERF	Perforation of wellbore, ft
ppbbl	Pounds per barrel
P_{res}	Reservoir pressure, psi
Rsi	Initial solution gas oil ratio, scf/stb
scf	standard cubic feet
SSSV	Subsurface safety valve
stb	Stock tank barrel
TDS	Total dissolved solids
TOC	Total organic carbon
TSS	Total suspended solids
TTSCON	Through Tubing Sand Consolidation
W/O	Workover
XHP	Extra high pressure

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