**FiGS® CP survey**
– efficient & cost effective CP field gradient survey of structures & pipelines

**INTRODUCTION**

FiGS® CP survey measures the electric field gradient vector and can detect electric currents in seawater. The sensor design allows for highly accurate measurements with a resolution and detection level that surpasses all other field gradient sensors available on the market.

The technology has a wide area of application including, but not limited to:

- Measurement of current output from anodes
- Measurement of current density on pipelines and structures (bare steel, coated steel and concrete)
- Detection of coating holidays / defects on pipelines, including buried pipelines
- Measurement of current drain to buried structures such as piles and wells
HOW FiGS® CP SURVEY WORKS

The sensor measures the electric field gradient FG:

\[ \vec{FG} = \text{grad } \vec{E} = \frac{\partial \vec{E}}{\partial x} + \frac{\partial \vec{E}}{\partial y} + \frac{\partial \vec{E}}{\partial z} \]

FG is a vector field; every point has a value and a direction. Because the geometry and conductivity is known, we can calculate the currents from Ohm’s Law.

FORCE Technology has the mathematical tools and expertise to do these calculations by use of FEM / BEM and empirical equations derived from extensive FEM / BEM modelling of typical geometries.

CAPABILITIES

Pipe integrity
FiGS® CP survey can be used to detect coating defects on pipelines that are exposed, partly buried, buried and rock-dumped. The sensors’ ability to detect very small FG values means that even smaller coating defects can be detected and measured accurately. An area of 10cm² of seawater exposed steel gives an FG value of ~0.4µV/cm, measured 30cm from the pipe. This is 4 times larger than the detection limit of the sensor. This type of coating defect cannot be detected by any other sensor today.

Its ability to measure the direction of the electric field ensures that the detected signal originates from the pipe in question, and not from debris or any other sources of electric noise. Typical cases may be critical 13 Cr pipelines and pipelines exposed to trawling.

The sensor also allows for examination of buried or rock-dumped pipelines. The signal strength gets weaker at longer distance from the pipe, but burial depths of 1 m is tested and feasible. For inspection of buried anodes, measurements can be made for burial depths of 2 m or more.

Pipelines with Direct Electrical Heating (DEH) will have a significant current flowing in the pipe wall and anodes act as discharge points for this current. If a coating damage occurs, this will act as a discharge point, resulting in severe metal loss. The FiGS is ideal for detecting such damages, thereby enabling the operators to take pre-emptive action.

Structural Integrity
FiGS® CP survey can be used to accurately measure current density on coated and uncoated steel, as well as concrete structures. This becomes relevant when the operator plans for lifetime extension, or if regular CP surveys show anomalies. Current density is the most important design factor in CP designs and, in certain cases, the actual values may deviate considerably from the design values. Today, there are no other means of accurately measuring the current density directly on the structure.

The sensor can also be used to measure the current output from galvanic anodes, both on structures and pipelines, which is important data when evaluating remaining lifetime of the anodes.

FiGS® CP survey is also suitable for measurement of current drain to buried structures such as piles and wells. By mapping the seabed around the buried structures, the FiGS data can be used to calculate the amount of current delivered into the seabed.

CASE 1

Jacket lifetime extension
FiGS® CP survey provides considerable cost savings regarding anode-replacement when planning for jacket lifetime extension.

In an offshore jacket-structure fabricated with uncoated steel and sacrificial galvanic anodes, the design-life is 20 years. The jacket has been in service for 18 years and the planned lifetime extension is 15 years, resulting in a total operational lifetime of 35 years.

CP inspections (potential) show -900 mV average potential, and visual inspection estimates 50 % consumed anode mass.

We would typically use CP computer modelling to predict the future performance of the CP-system. A CP model often starts out with a foundation of CP design values. The model is further calibrated by adjusting the current density until the modelled potential fits the inspection data. In this case the current densities are:

- Measured current density: 20mA/m²
- Design current density: 90mA/m²

A retrofit according to design values would require replacement of 60 % of the anodes within 4 years, while a retrofit according to the CP model would require replacement of 15 % of the anodes within 9 years.

A FiGS® CP survey of the jacket will give accurate current density values for both structure and anodes. The actual documented values can be used instead of design values when designing the retrofit solution.

Without a FiGS® CP survey, the operator will typically use current density values between the modelled- and design values. In this case, 50mA/m², which requires replacement of 45 % of the anodes within 5 years. With a FiGS® CP survey, the current densities can be measured and confirmed. The retrofit can now be optimised by using measured current density values in the CP model. In this case a current density of 22mA/m², which requires replacement of 20 % of the anodes within 6 years.

CASE 2

Flexible pipeline lifetime extension
Inspection and examination without excavation of buried pipelines. Maintain integrity with significant cost savings.

Flexible lines (flowlines, jumper lines, etc) are often buried in sediments at 0-0.5 m. The design life of flexibles is limited by coating degradation and corrosion in the strain armour.

Flexibles are normally designed without a permanent CP system, but are connected to the template CP system.

As many flexibles are nearing the end of their design life, examination is required for lifetime extension.

For buried flexible pipelines, the only option today is to excavate the pipe and inspect it visually. The cost of this operation is almost the same as installing a new flexible pipeline.

A FiGS® CP survey can detect seawater exposed steel...
Detectable coating defect size [cm²] as a function of potential [V vs. Ag/AgCl] for a flexible pipeline buried at 0.5 m. The protection potential is negative of ~800 mV. In addition, small coating damages exposing bare steel may pose as a risk due to AC corrosion from the DEH system. The anodes on the pipeline show signs of high consumption. The question is if these anodes deliver current to the pipeline, or to remote structures such as templates and platforms.

Visual inspection shows no sign of coating degradation. Standard CP survey shows typical potentials dominated by the connected structures.

Typical questions regarding the CP retrofit design are:
- What is the current requirement for retrofit?
- Are all the remaining anodes still connected to the pipe?
- What is the lifetime of the remaining anodes?
- When must the retrofit be done?
- What is the coating degradation along the pipe?

A FiGS® CP survey in conjunction with potential measurements will give the answers needed. It will provide data showing how much current is drawn by the pipeline along its entire length. This data can be used along with potential- and coating damage data to document current density values.

By using documented current density values instead of design values in a retrofit design, the retrofit can be optimised with respect to installation-time and cost.

CASE 3

Pipeline survey
A FiGS® CP survey detects small coating damages that cannot be detected by any other method.

This case study is focused on a special case with thermally insulated 13Cr pipelines with direct electrical heating (DEH). The pipelines are partly buried, trenched and rock dumped. Pipelines made from 13Cr stainless steel may be prone to hydrogen induced stress cracking (HISC) when the cathodic protection potential is negative of ~800 mV. In addition, small coating damages exposing bare steel may pose as a risk due to AC corrosion from the DEH system. The anodes on the pipeline show signs of high consumption. The question is if these anodes deliver current to the pipeline, or to remote structures such as templates and platforms.

Visual inspection shows no sign of coating degradation. Standard CP survey shows typical potentials dominated by the connected structures.

A FiGS® CP survey can detect exposed areas smaller than 100 cm² on a 0.5 m buried pipe. This will typically result from a small tear in the outer sheath of the flexible.

By carrying out a FiGS® CP survey, the operator can inspect the buried flexible pipelines without excavating. Any findings from the survey can be combined with CP computer modelling to evaluate the integrity of the flexible pipe.

A FiGS® CP survey can detect small coating damages that cannot be detected by any other methods. In this case, two sensors were used for increased accuracy and confidence. The inspection revealed that most of the stalk joints had coating defects in the order of 50 cm², while the regular pipe joints showed no signs of exposed metal.

The anodes were measured to deliver a total of ~10 A, while the pipeline was measured to draw approximately 5 mA, meaning that the anodes deliver almost all of their current to the connected structures.

None of the detected defects could be seen from the visual inspection. One coating defect was detected in a buried area. Potential measurements cannot detect these defects due to the variation in potential across these defects being in the order of 0.03 mV.

CASE 4

Pipeline survey
Optimising installation time- and cost in retrofit design using documented current density values instead of design values.

A 5 km coated pipeline has had repeated impacts by trawls. Many of its anodes are missing and the coating is severely degraded. A CP retrofit is necessary, but the timeframe and extent is uncertain.

A FiGS® CP survey in conjunction with potential measurements will give the answers needed. It will provide data showing how much current is drawn by the pipe along its entire length. This data can be used along with potential- and coating damage data to document current density values.

By using documented current density values instead of design values in a retrofit design, the retrofit can be optimised with respect to installation-time and cost.

REVOLUTIONARY TECHNOLOGY TO THE MARKET

FORCE Technology is very proud to introduce the FiGS® CP survey, bringing increased integrity and cost savings to the global Oil & Gas market. Major Operators all over the world have already shown great interest. FiGS® CP survey has proven to be a highly cost effective way of inspecting critical subsea installations and infrastructures.

With FORCE Technology on the team, you have skills and expertise from years of training and experience within the field of subsea inspection at hand.

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