General Information about Pipe Current Mapping (PCM)

Why Use Pipeline Current Mapping

Pipeline Current Mapping (PCM) provides an accurate evaluation of the condition of the coating of a section of pipe and, by incorporating multiple simultaneous inspection parameters, reduces false indications and thereby minimises unnecessary excavations. In addition to negating the need to excavate pipelines in areas where no reason exists to assume the coating is not in good condition, the system thus acts as a screening tool to focus any required remedial work which reduces operational and maintenance costs. From an asset management perspective, this approach significantly speeds up survey and inspection times and provides a more effective approach to maintaining a pipeline's integrity.

Traditional coating surveys only measure the voltage potential of the pipe with respect to the earth around it to show that the pipe is protected against corrosion (CIPS-only surveys). Some pipes, due to coating degradation or damage have low protection voltages and are at risk of increased corrosion damage. Ohms law shows that adding more current will cause more voltage, however higher output voltages have been shown to speed the degradation of coatings. Furthermore, higher current flow can cause embrittlement of the pipeline material leading to premature (and possibly catastrophic) failures.

The PCM system enables a pipeline inspector to overcome the limitations of existing techniques used in evaluating the effectiveness of pipeline coatings and/or cathodic protection. In principal, a current flowing on a buried conductive structure produces a magnetic field directly proportional to the magnitude of the applied current. By resolving components of the magnetic field from the surface, the original current can be precisely determined. **'Mapping' the current enables shorts caused by contact between the pipeline and other metallic structures or 'earthing' resultant from coating defects to be identified.**

Additionally, the PCM system will also perform a Close Interval Potential Survey (CIPS); an inspection methodology based upon the principle that current flow and voltage potentials are directly related and can be measured in unison to determine whether any other factors are present which are affecting this relation. **When performing a PCM (CIPS) survey an experienced inspector can directly and swiftly pinpoint coating defects across large spans of buried pipeline (up to 30km) with the elimination of the laborious and time—consuming requirement to perform 'current spans' and manual current calculations during the survey.**

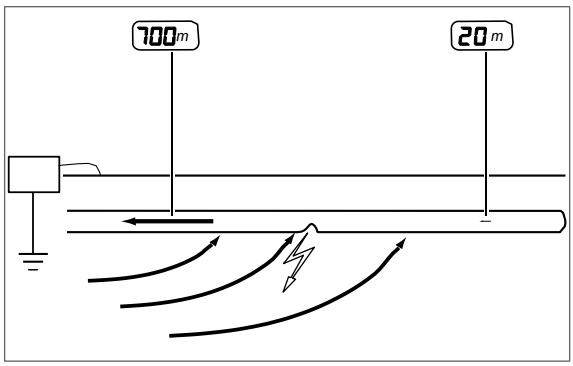
How Pipeline Current Mapping Works

The PCM system consists of a portable transmitter and a handheld receiver. **The transmitter applies a unique near-DC signal to the pipeline which the receiver locates from the surface and displays the signal's current magnitude and direction without connection to the pipeline.** The system provides a current profile and current direction which permits accurate location and mapping of the pipeline even in areas where there is contact with other metallic structures, interference, or congestion.

A pipeline's electrical characteristics of current attenuation and distribution at the very low operational frequency of the PCM transmitter enable the precision, high-performance sensors (known as magnetometers) within the PCM receiver to remotely detect and measures the very low frequency magnetic fields being generated. Advanced signal processing technology provides push button current measurement (and direction) of the near DC signal at incremental points along a pipeline, which when plotted against precise GPS-coordinates enables graphical interpretation and data analysis of current loss against distance to be performed by an experienced inspector.

Combined analysis of data gathered in one or more survey modes means an inspector can classify signal discontinuities, exclude 'known features', and accurately establish the location of any potential coating defects. Figure (a) shows a simplified diagram of a typical PCM inspection situation; Figure (b) displays resultant PCM data for analysis and classification by the inspector. When combined with a secondary CIPS inspection, the location accuracy and estimated defect severity can be significantly refined. It must however be remembered that the PCM technique is a screening tool to identify potential defect locations based on external coating degradation and cannot be used to give precise 'sizing' of defects or accurate estimations of remaining wall thickness.

Figure (a), the effect of current leakage resultant from coating breakdown



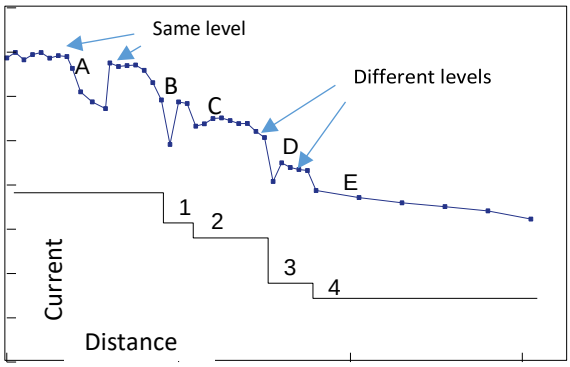


Figure (b), graphical representation of primary data gathered over a PCM survey

Performing Pipeline Current Mapping

Ordinarily, the PCM inspector should initially conduct a visual survey of the entire pipeline to be inspected and from this determine the preferential locations to attach the PCM transmitter at the surface. **Standard protocol is to take readings over the complete site as a general survey before concentrating on any particular area.**

Very little surface preparation is required for testing using PCM; at the transmitter surface connection point, if no existing connection leads are available, direct connection to the pipe wall will need to be made (typically at flange fastenings or by removing a 10mm area of the pipeline's coating). In addition to selecting the optimal survey mode, an experienced inspector needs to determine the best current output for a pipeline by balancing the the local environment conditions, signal detectability, and safe power/voltage limits of the equipment.

The handheld receiver unit is used to locate the pipeline, and, utilising a combination of 5 magnetometers, makes the required calculations to provide the inspector with a continual measurement of depth, current strength, and direction of the signal. This inspection method provides 'live' data to accurately pinpoint metallic contacts and/or locate areas with coating defects.

The time that it will take to inspect a section of pipe varies depending on the number of features present and accuracy desired. Typically, after equipment configuration and set up, it takes around 5-10 minutes to locate the pipeline and perform each survey log using the receiver. Dependent upon the spacing between data log locations and the overall length of pipeline to be inspected, PCM surveys can take anything from a couple of hours to several days or weeks. **If suspected coating degradation is found, the area is usually examined in multiple modes and by incorporating a PCM A-Frame CIPS (ACVG) survey.** This process is used to better classify the extent and precise location of the indication and can take several hours at each identified location.

Sensitivity of Pipeline Current Mapping

Pipeline Current Mapping (PCM) and Close-Interval Potential Surveys (CIPS) are screening tools to identify potential defect locations based on external coating degradation. **Identified discontinuities in the gathered data represent fluctuations in the signal received from an area of the pipeline relative to the pipeline in general.** As such PCM data analysis is a relative comparison to indicate areas with low coating resistance (breakdown/thinning/defects), the presence of which is directly correlated with the probability of external pipe wall corrosion or damage. Consequently, PCM and CIPS survey results cannot be used alone to give precise 'sizing' of coating defects or accurate estimations of remaining wall thickness for the pipeline itself.

In practice survey accuracy is determined principally by the GPS coordinates of the test log locations which can only be considered precise to within a couple of metres, beyond this it is the ability of the technician to identify and pinpoint the buried pipeline using the tracing components of the equipment. In addition to GPS coordinate tolerance, PCM results rely heavily on accurate depth measurement as this forms a fundamental component of the post-survey data analysis. Furthermore, local ground resistivity can fluctuate dramatically dependent upon recent weather and or the activity of other electrical services.

Typically, for a pipeline in average condition buried at a nominal depth up to 3m and within an uninterrupted range of 20km from the transmitter, a combined PCM CIPS survey would identify current discontinuities indicative of coating defects to a detection accuracy to 0.01mA. General location accuracy (including depth) for identifying coating defects in these conditions is within 50mm. Note that performance related parameters resultant from varying factors may have a significant effect on these figures.