DC VOLTAGE GRADIENT TECHNOLOGY & SUPPLY LTD

GLOBAL LEADERS IN DCVG / CIPS EQUIPMENT ECDA + SURVEY SOFTWARE

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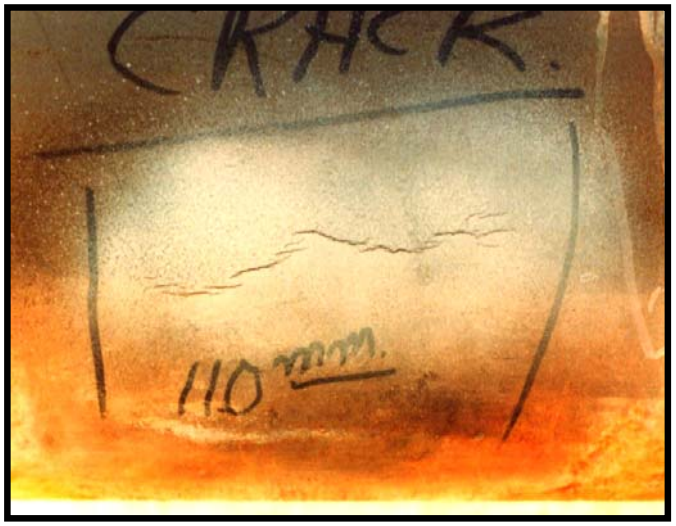
Stress Corrosion Cracking (SCC) Studies

SCC is the most insidious, and often the most unexpected form of pipeline failure that can involve no metal loss and must not be confused with wall thinning rupture. Whilst there is a fair understanding of the types and causes of SCC, the prediction and location of SCC cracks on Operational Pipelines is not so well developed. However, the location and removal of SCC Cracks before the pipeline bursts uncontrollably is vital for safe Operations.

Rupture of a 20" Tape Coated Gas Pipeline.



A large crack close to its Critical Crack Length

Looking for Stress Corrosion Cracks

SCC can occur in both Gas and Liquid pipelines but is more common and catastrophic in Gas Pipelines. DCVG Ltd offer a proven technique of locating external pipeline SCC through a combination of high quality data gathering and detailed analysis of combined data sets from a variety of pipeline parameters and survey techniques.

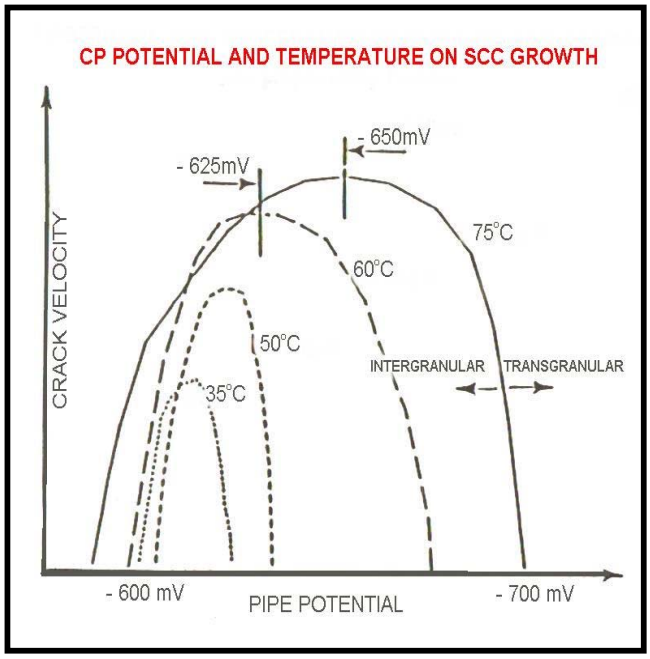
This approach is proven to be 40 to 50% accurate at locating Carbonate/Bicarbonate SCC, an accuracy unmatched by others. In other words if you dig ten holes to expose a pipeline at predicted locations four or even five of them of them should have pipe showing SCC. Such studies do not stop there, an analysis of the Operating Conditions of the pipeline allows recommendations to be made to reduce the risk of SCC recurring or developing.

Types and Causes of Stress Corrosion Cracking.

The two common forms of SCC are Low pH and Carbonate /Bicarbonate. Both forms require a coating fault exposing the steel pipe to the local soil environment where conditions conducive to SCC must exist. SCC has been observed on pipeline coated with Tape, Coal Tar and Bitumen. All pipeline steels are susceptible but most failures to date have been on X52 Pipe, which together with the above coatings have been the most widely used pipe and coatings of sufficient age to show SCC.

External Conditions Needed to Develop Carbonate/Bicarbonate SCC.

1. Stress levels in the pipe generally greater than 45% SMYS, and slow cycling of that stress.
2. A coating fault exposing steel to the soil.
3. Polarised potentials on the steel surface at coating fault typically between –600 to –720 mV wrt Cu/CuSO4 half-cell as result of applied CP to pipelines with poor coating, often disbonded.
4. A local soil environment containing Carbonates and Bicarbonates, by-products of the Cathodic reaction on the exposed steel pipe surface.
5. Elevated temperature from hot fluid being transmitted through the pipe, as crack growth is thermally controlled.
6. Crack Morphology -- Intergranular



External Conditions Needed to Develop Low pH SCC.

1. Stress levels in the pipe generally greater than 45% SMYS, and slow cycling of that stress.
2. A coating fault exposing steel to the soil.
3. Coating typically disbonded at fault location.
4. Low pH in surrounding soil at coating fault.
5. No apparent correlation with pipe temperature.
6. Variable correlation with pipe polarised potential. Generally the CP has to be weak.
7. Crack Morphology – Transgranular.

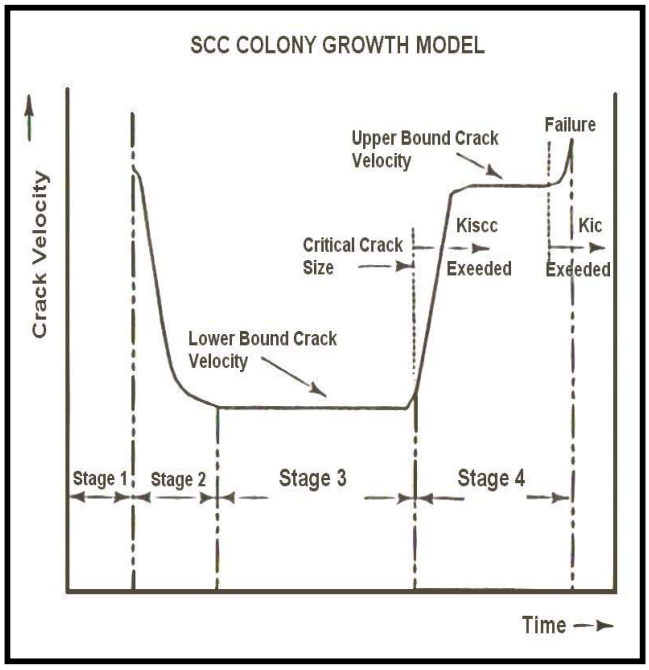


Diagram ⟶

Kic = Steel Fracture Toughness.
Kiscc = The minimum Stress Intensity Factor for rapid rate SCC propagation.

Techniques Available to Find SCC.

The methods employed to locate SCC are Hydrostatic Testing, Acoustic Emission Testing and examination of Operating and Environmental Parameters followed by Excavation and Magnetic Particle Inspection. There are also SCC Inline Inspection Tools but they detect what we consider to be relatively large cracks but can have their interpretation improved by combining inspection data with data from the Operating and Environmental technology recommended here.

Hydrostatic Testing.

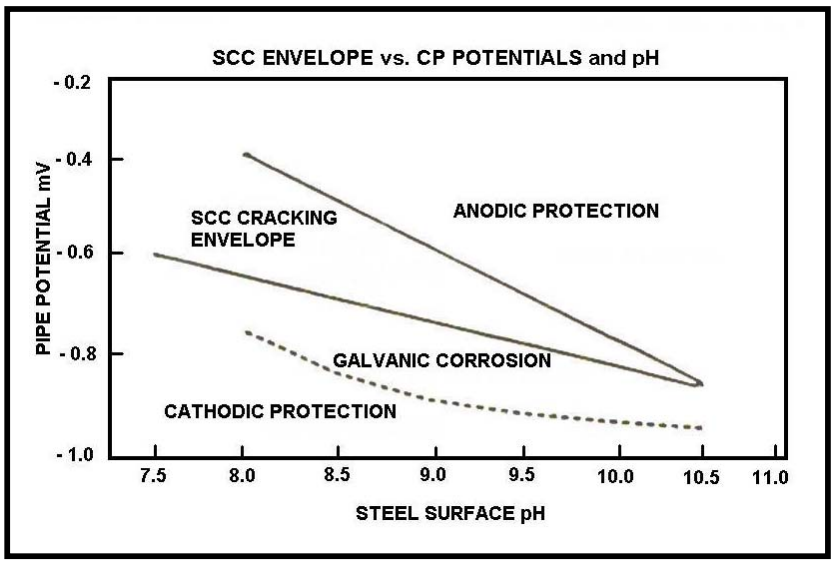
Hydrostatic testing is a useful technique for locating metal loss areas or SCC at or near to the point of failure. Unfortunately the pipeline has to be taken out of service, also finding and repairing leaks and re-testing is expensive. In addition there is no guarantee that cracks below the critical crack length will not fail during testing but will continue to grow and rupture shortly after recommissioning.

Acoustic Emission.

This is a technique more suited to liquid rather than gas pipelines. It has been found that in gas pipelines, because of rapid attenuation there is little difference in signal energy between different defect types, e.g. pitting, laminations, gouges, SCC and background noise. Combining with coating surveys to locate sensors at defects sites improves the accuracy of the technique.

Operating and Environmental Parameters. (DCVG Methodology)

DCVG's unique approach is to integrate metallurgical, operational and environmental parameters to quantify the possibility of and locate SCC. Studies of the stress level and its relation to pressure and temperature fluctuations plus various parameters of the steel pipe allow a number of factors to be calculated. For example, the %SMYS, the critical crack length, the SCC threshold stress for the onset of SCC, the temperature and stress profile of the pipeline. From samples it is possible to determine factors such as crack velocity and prediction of time to failure. Having determined the risk of SCC failure, the most likely locations are then determined from combined survey data sets.
Studies of the pipe coating system, the level of cathodic protection at individual coating faults, the corrosivity factor which is related to the formation of protective magnetite films on the steel surface, soil resistivity, soil conditions and composition and the pipeline history are some of many additional inputs to a computer program used to select SCC locations. These locations are then excavated and inspected using Magnetic Particle Techniques to identify SCC.



Gathering Quality Data for SCC Location Prediction.

Garbage data will only give a garbage analysis output from any computer program. Hence to get a Quality Analysis it is essential to have only Quality Data gathered by experienced and well trained surveyors from the pipeline and its right of way. To meet this requirement it is essential to have in place the following:-

1. **Properly Qualified and Trained Surveyors to Gather the Data.**
   All DCVG Surveyors have to undergo Training Courses in the Technologies used and pass a 90-minute written Exam.
2. **Well-Defined Method Statements for the Techniques to be Applied to Gather Data.**
   Very detailed Method Statements many being 30 pages long are available for all techniques used.
3. **The Right Equipment Well Maintained and Calibrated.**
   DCVG Ltd manufacture and calibrate regularly the surveying equipment used to gather data. **NOTE**. Beware of Scam DCVG Techniques that are CIPS with an extra half-cell.
4. **A Proper Understanding of the Errors and Limitations of Each Survey Method.**
   Many years of Research into the survey techniques and equipment by DCVG personnel have identified all significant errors in the equipment and survey techniques used. Many Technical Articles published on the technologies.
5. **Methods to Correct Data for Errors.**
   DATA MUST BE ERROR CORRECTED BEFORE ANALYSIS
   Having recognised the errors in the survey technologies from our Research work, suitable elimination or correction techniques have been developed. For example DCVG data must be corrected for soil resistivity, depth of cover, closeness to rectifier etc errors. CIPS for attenuation, depassivation, half-cell location etc. errors**.** **NOTE**. CIPS on its own is a useless technique when applied to SCC studies as data is not coating fault specific.
6. **Techniques for Matching Data Sets.**
   MUST HAVE CORRECT PROCEDURES WHEN GATHERING DATA
   DCVG is unique in pioneering techniques to match data sets taken from different technologies at different times. These techniques using GPS technology have been tried and tested for the last 10 years.
7. **Appropriate Computer Programs to Analyse the Vast Amounts of Data.**
   DCVG have developed the most advanced and extensive program to analyse and compare data sets for the determination of Pipeline Integrity and SCC. This program is already used by a number of major Oil and Gas companies and operated by staff Qualified to PhD level in Stress Corrosion Cracking.

DCVG Ltd is unique by having in house all the necessary methods, equipment, computer programs and technology for Stress Corrosion Cracking Studies. WE do not have to sub-contract any part of a study and so can ensure that only Quality Data is gathered and analysed.