A.C. CORROSION
1989 – 2011
22 YEARS OF RESEARCHES AND EXPERIENCES IN EUROPE

Introduction

In Ceocor International Congresses during the last years many studies have been presented and discussed in the subject of AC corrosion. New findings have been proposed by various authors from many Research Laboratories; field experiences have been reported by many different authors.
It is surely beneficial for CEOCOR Associated Members and useful for the external corrosion scientific world who is facing AC interference phenomena and relevant problems to have in a practical booklet the compendium of his unique, wide experience that CEOCOR has gained during the last 22 Years.
This compendium is unique on its gender,it is difficult if not impossible to find elsewhere such a compilation of knowledge and we are pleased to put it at disposal of a wider world of technicians, corrosionists and any other people interested to this subject.
This Compendium follows the first booklet on a.c. corrosion that CEOCOR has published in 2001:
"**A.C. corrosion on cathodically protected pipelines – Guidelines for risk assessment and mitigation measures".**
In the European Commission for Standardisation (CEN), a first TS (Technical Specification) was issued in Feb. 2007: **"XP CEN/TS 15280 Evaluation of a.c. corrosion likelihood of buried pipelines – Application to cathodically protected pipelines**".
Presently there is an attempt to transform this TS in a full validity Standard.
We are extremely proud to propose this text which includes the results of the last studies, Laboratory Researches and field experiences; it is indeed to be considered the widest experience existing worldwide in this particular and quite intricate field.
We wish that all these information will be beneficial and helpful to those people involved in AC corrosion phenomena both in the industry and in the Standardisation world.

LUCIO DI BIASE

PRESIDENT OF CEOCOR
October, 2011

1996 National Conference 21st – 22nd November, 1996
ROME, ITALY

Corrosion due to alternating current on buried pipelines:

background and perspectives

. **01 – 1996 – ANNEX 2 -AC Corr – APCE – DiB**

Lucio Di Biase – SNAM S.p.A

Synopsis

This document illustrates the real extent of the risks of corrosion due to alternating currents and gives useful ideas for minimising these risks in the simplest, least conflictual and most economic way. It also highlights the need for collaboration and operational co-ordination between the system manager (operator) which creates interference and the manager (operator) of the metallic buried pipelines. The reasons behind the spread of corrosive phenomenon and their growing importance in recent years are illustrated. Some examples of corrosion due to alternating current and their parameters are reported, on the basis of which their typical characteristics can be defined. The operational consequences for the manager (operator) of the metallic buried pipelines and the existing and potential agreements between the various operators are looked at. Current European research in this field is described.

Summary

The influence of alternating currents on metallic buried structures is well known in Europe; it is important for the safety of personnel and plant and for the cathodic protection of metallic buried structures against corrosion. The most common cause derives from the installation of power lines with increasingly high tension and power , and high speed traction systems powered by alternating current. Factors that increase the presence of AC tension on the metallic buried structures and pipelines include: – improvements in materials used for pipeline coating (e.g. three-layer polyethylene); – verification of coating integrity when pipeline laying; – more power lines, higher nominal tension and higher power; – geological reasons behind parallel runs, creating increasingly crowded services channels. To ensure the safety of people working on the metallic buried structures and to enable buried structures to be monitored for cathodic protection, a design with suitable protection devices should be taken into account from the start of pipeline laying. The effectiveness of the protection devices should be verified with periodic maintenance operations. For such end and in the mutual interest of the managers of the structures, the exchange of information and the co-ordination of activities, both planning and operational, are fundamental. Legal requirements and technical standards are becoming increasing In Denmark, Norway and Sweden protocol agreements between the electricity utilities and

the metallic buried structure manager (e.g. gas company) have been drawn up. These are illustrated. In this document the corrosive effects of the alternating current on buried metallic structures, its background and the common studies and search programs in Europe are taken into account.

2000 CEOCOR CONGRESS –2nd ÷ 5th October BRUXELLES, BELGIUM

2001 A02 Alternating current corrosion on cathodically protected steel in soil – A long-term Field investigation

02 – 2000 – Steel in soil – Goran Camitz – Asa Marbe

Göran Camitz1, Charlotte Johansson2 and Åsa Marbe3
Swedish Corrosion Institute, Roslagsvägen 101, Hus 25, SE-104 05 Stockholm, Sweden
Sycon Energy Consultant, Box 616, SE-301 16 Halmstad, Sweden
Sycon Energy Consultant, SE-205 09 Malmö, Sweden

ABSTRACT
An electrical equivalent diagram representing the impedances existing between pipe and remote earth has been proposed for the purpose of modelling the AC-corrosion process. The diagram include static elements like soil- or spread resistance and the charge transfer resistance represented as Volmer-Butler exponential functions with some analogy to diodes. Dynamic elements, i.e. element with frequency dependant impedance, include diffusion (Warburg) impedances and capacitances. The characteristics of the Volmer-Butler function related to iron dissolution and re-depositions along with the DC offset conditions and amplitude of the AC-voltage cleaned from IR-drop is controlling the AC-corrosion rate. The spread resistance plays a major role in controlling the IR-free amplitude of the AC voltage.
KEYWORDS: AC corrosion, equivalent circuit elements, spread resistance, capacitance, diffusion, Volmer-Butler equation, diode analogies, corrosion rate

1. INTRODUCTION
Pipelines provided with high resistant coatings are susceptible to induction of AC voltage from e.g. paralleled high-voltage AC power lines. This AC-voltage may be a source of corrosion at coating defects where the AC current escapes the pipe. It is generally known that severe corrosion can result from AC, but – on the other hand – several pipelines are interfered with AC without experiencing corrosion problems. Yet the question is which conditions are provoking such AC corrosion attach and which conditions are not. To a first approach, it seems plausible to consider electrical factors like the magnitude of the induced voltage (UAC), the magnitude of the AC-current (IAC) running to a coating defect (per unit area of the defect), or the level of CP supplied to the pipe. The latter comprises factors
like the ON-potenial (EON) of the pipe, the OFF-potential (EOFF) of the pipe as well as the DC-current (IDC) running to a coating defect (per unit area of the defect). However, these factors are interconnected by the chemistry and the physics of the soil surrounding the pipeline. Hence, the chemistry and the physics of the soil can be considered to be setting up some kind of elements that are equivalent to electrical elements. The present paper encourages to

setting up such equivalent circuits when dealing with AC corrosion, since they can be helpful in modelling the AC corrosion process, hence lead to a better understanding of the mechanisms behind AC corrosion. Since AC corrosion may not result from one single mechanism, several different equivalent circuits may be applicable, however, in this paper one circuit diagram is proposed, that seeks to comprise the physical and chemical aspects considered to be of relevance in an AC corrosion process.

03-2001 A02 AC corrosion and electrical equivalent diagrams

03 – 2000 – AC corrosion and equivalent circuits

L. Nielsen, METRICOR – P. Cohn, ENERGINET – Denmark

ABSTRACT

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04

2001 A03 Influence of soil composition on the spread resistance and of ac corrosion on cathodically protected coupons

04 – 2000 – Influence of soil composition – Stalder
F. Stalder, SGK – Switzerland

Introduction

In the context of investigations which the SGK conducted on AC corrosion incidences at the gas pipe-line in the Rhone valley the composition of the rust blister and of the circumvening soil were also investigated. It was found that in the vicinity virtually no lime is present in the soil. Apart from α-FeOOH (goethite), larger quantities of sodium carbonate and sodium hydrogen carbonate were found within the rust blister. Furthermore substantial quantities of potassium carbonate and potassium sodium carbonate were detected. Further investigations showed substantial modifications of the spread resistance over time. Modifications up to a factor of 100 were observed. These modifications have been mentioned in investigations by various other authors. The investigations suggested that the soil composition at the fault locations and the area of the coupons are of significant influence.
F. Stalder and D. Bindschedler established a hypothesis which was presented at the CEOCOR conference in Lugano. The hypothesis states that on fault locations in soils with a high lime content high resistivity covering layers develop which cause an increase of the spread resistance. In soils with low lime content however, a decrease of the spread resistance takes place due to the formation of hygroscopic alkaline hydroxides. This hypothesis had to be confirmed by further investigations.
Successively a project was set up which shall demonstrate, among other aspects, the influence of the soil composition on the spread resistance. Under laboratory conditions the influence of various Na+ and Ca2+ ion contents shall be shown by means of artificial soil solutions.

2001 CEOCOR CONGRESS –2nd ÷ 5th October BIARRITZ, FRANCE

05

2001 A02 Detection of a.c. Corrosion

05 – 2001 – Detection of a.c. Corrosion Gregoor-Pourbaix
R. Gregoor – Distrigas, A.Pourbaix, Ph. Carpentiers – Cebelcor, Belgium

ABSTRACT
In the last years, Cebelcor and Distrigas have been actively engaged in the detection of AC corrosion. The result is a system that measures the true potential (with a switch-off method on a coupon) at many instants of the AC period. At the same time, the current density and the phase angle between the current and the electrode potential are measured. This system (Correac) provides useful informations about the instantaneous and local effects of induced AC currents. The details of the method, the equipment, the results of a field survey, the interpretation of the data, the identification of conditions for AC corrosion and some specific features of AC corrosion of passive metals are presented.
Keywords: AC corrosion, passivation, cathodic protection, monitoring, impedance, IR-free potential

RESUME
Ces dernières années, Cebelcor et Distrigaz se sont activement engagées dans la détection de la corrosion par les courants alternatifs et ont mis au point un système qui permet de mesurer le potentiel réel (grâce à une méthode de déconnexion de coupon) à de nombreux moments de la période de courants alternatifs. Parallèlement, la densité de courant et l'angle de phase entre le courant et le potentiel de l'électrode sont également mesurés. Ce système, appelé Correac, fournit des informations utiles quant aux impacts instantanés et locaux des courants alternatifs induits. Ce document présente les détails de la méthode, l'équipement, les résultats d'une étude sur le terrain, l'interprétation des données, l'identification des conditions donnant lieu à la corrosion par les courants alternatifs et quelques caractéristiques spécifiques de la corrosion des métaux passifs par les courants alternatifs.
Mots clés : corrosion par courant alternatif, passivation, protection cathodique, monitoring, impédance, potentiel sans interférence extérieure

ZUSAMMENFASSUNG
Die letzten Jahre haben sich Cebelcor und Distrigas aktiv auf die Erfassung der Wechselstromkorrosion eingelassen. Beide Gesellschaften haben ein System zur Messung des Realpotentiales (über eine Ausschaltmethode auf einem Coupon) an zahlreichen Augenblicken der Wechselstromperiode entwickelt. Gleichzeitig werden die Stromdichte und der Phasenwinkel zwischen dem Strom und dem Elektrodenpotential gemessen. Das System wird Correac genannt und gibt nützliche Auskünfte über die sofortige und örtliche Wirkung der induzierten Wechselströme. In diesem Dokument wird folgendes dargelegt: die detaillierte Methode, die Apparatur, die Ergebnisse einer Feldstudie, die Datenauswertung, die Identifikation der

Wechselstromkorrosionsbedingungen und einige spezifischen Eigenschaften der Wechselstromkorrosion von selbstpassivierenden Metallen.
Stichwörter : Wechselstromkorrosion, Passivierung, Kathodenschutz, Überwachung, Impedanz, IR-freies Potential

06

2001 A06 a.c. corrosion experiences in ENERGINET.DK

06 – 2001 – a.c. experiences Peter Cohn Energinet_PCo

P. Cohn, ENERGINET – Denmark

07

2001 A07 a.c. corrosion – SHREIR Publication – Update of a.c. corrosion
Interaction and Stray-current Corrosion "(MS 156)" for Shreir's Corrosion

07 – 2001 – a.c. Corrosion contribution to SHRIER

L. Di Biase – R. Cigna , Italy – R. Gregoor , Belgium – H.G. Schoeneich, Germany

Index

1 – The phenomenon of a.c. corrosion

The primary factor in alternating current electrolysis is current density. This statement was made in The Engineering Journal, the journal of the Engineering Institute of Canada, and was made in 1927.
A long time has passed since then and a.c. effects have been experienced and investigated in depth.
More recently, since 1986, some instances of corrosion on gas pipelines due to alternating current (16 2/3 and 50 Hz) have been reported in Europe and elsewhere. In all these cases, the cathodic protection values, measured with conventional techniques and instruments, satisfied the conventional criteria.
It is most probable that some previous corrosion failures have not been recognised as being caused by alternating current because cathodic protection personnel have not been made aware of a.c. corrosion risk.
The a.c. influence is referred to as "inductive», «resistive» or «capacitive» interference in technical literature.
In the last decade, quite a number of corrosions have been clearly attributed to a.c. corrosion.

a.c. corrosion is a concern for owners operating long structures (mostly pipelines) running parallel or close to overhead high voltage transmission power lines (typically 15 kV and higher) or a.c. traction systems. The problem also exists in municipal areas (structures near buried a.c. power distribution systems), in reinforced concrete structures (e.g. road bridges also sustaining electricity power lines) and inside tunnels for a.c. electrified railways.
It is not uncommon to measure a.c. voltages in the range of 15 to 100 Vrms on coated pipelines exposed to a.c. influence. This may cause safety hazards to people , malfunction of pipeline equipment and corrosion problems.
In the last two decades, a better knowledge of the a.c. corrosion phenomenon has been gained, thanks to the many studies that mainly gas operators have sponsored or directly performed.
These studies started in the 80ies and are still in progress. Since this period, high quality/high resistance coatings have been used for buried pipelines, thus increasing the effects of a.c. interference.
Very often in the past, a.c. corrosion was not correctly diagnosed because usually Cathodic Protection instrumentation rejects industrial a.c. frequencies and the knowledge of the a.c. corrosion phenomenon itself is still growing every day.

08

2001 A08 HVDC- Projects based on a mutual understanding between involved parties with respect to corrosion protection

08 – 2001 – H. ROSENBERG – HVDC PROJECT BASED ON A MUTUAL
Henrik Rosenberg BALSLEV A/S – DENMARK

ABSTRACT
High Voltage Direct Current (HVDC) transmission systems may cause interaction on long metallic pipelines. It is however possible to avoid conflicts, when taking this into consideration during planning of new energy transport systems.
This approach showed its benefits to all parties as preliminary investigations for the planned North Sea HVDC links were made. 3-D modelling of the electric conductive earth strata was used to describe possible effects on corrosion protection and necessary mitigation efforts.

1. Introduction

Energy transportation is an important issue in the technological developed world. It is equally important whether it is in the one or the other form. The focus in this paper is however only on a transport relation between High Voltage Direct Current (HVDC) and steel pipelines.
The subject is consideration and respect, and I take the liberty to claim, that it is a wise decission to construct and operate energy transport systems with a

mutual technical understanding and respect, and even more detailed – with respect to corrosion protection.
Transport of energy products is often confined to transport corridors. These corridors are relatively narrow, and the proximity between systems may cause interaction. Influence on pipelines from electric railways and high voltage alternating current lines are well recognised factors, that are dealt with when planning new installations or extensions of existing installations. There are however situations, where alternative routes are used, and this is particularly the case, when it comes to HVDC links. Handling the important questions, related to possible effects on corrosion protection from HVDC links, is not every day work. HVDC links in Europe are mainly utilised to connect islands with the main land and as an interconnection between the Western European synchronous ac system (UCPTE) and the Scandinavian synchronous ac system (NORDEL).
Influence from (monopolar operated) HVDC links was hardly recognised by European HVDC operators nor pipeline owners/operators until stray current density levels exceeding cathodic protection current densities were registered. This was particularly the case as well coated pipelines approached the large HVDC links between Norway and Denmark and Sweden and Denmark in the eighties. Since that time, the involved parties have gathered a comprehensive understanding of the nature of the rather complex problems, and this has resulted in a fruitful dialog in advance of new HVDC projects – for example the extension of the Skagerrak link, Kontek link, Baltic Cable, Viking Cable, EuroKabel and NorNed Kabel. The three latter, the North Sea HVDC projects performed an extensive study on possible impacts of stray currents produced by the operation of the three HVDC links. The approach and the results of this study are referred to in this paper.

2002 CEOCOR CONGRESS –30th Sept. – 3rd Oct. ZÜRICH, SWITZERLAND

09

2002 A01 DETECTION OF AC CORROSION. INTERPRETATION OF INSTANTANEOUS IR-FREE POTENTIAL, CURRENT DENSITY AND PHASE ANGLE MEASUREMENTS

09 – 2002 Zurich Detection and Interpretation AC_Eng

R. Gregoor (Fluxys – Belgium) – A. Pourbaix, Ph. Carpentier (CEBELCOR – Belgium)

ABSTRACT
A control system, acting on dc and ac polarization, was developed to keep max and min peak OFF-potentials within preset ranges during long periods of time in different environments. In this way, the absence or occurrence of corrosion has been correlated to potentials varying in immunity, corrosion (Fe2O3, Fe3O4) and passivation conditions, with pH values from 9 to 14. IR-free potential, current density and phase angle were measured on ac interfered coupons, using the CORREAC instrument. The results were

computed as Eoff and I versus time plots, and as Lissajous Eoff-I plots throughout an ac period.
They confirmed the absence of corrosion when the Eoff was below the immunity potential for the relevant pH at every moment of the ac period. Ac currents could impede the formation of protective oxides when the potential oscillates in the passivation domain or between immunity and passivation. This calls for more detailed criteria for the cathodic protection of metals under ac interference.

RESUME

Un système de contrôle, agissant sur la polarisation des courants continu et alternatif, a été mis au point pour maintenir les potentiels OFF de pointe maximal et minimal à l'intérieur de plages prédéfinies, et ce pendant des périodes prolongées et dans divers environnements. Ceci a permis d'établir un rapport entre l'absence ou
l'apparition de corrosion et les variations dans les domaines d'immunité, de corrosion (Fe2O3, Fe3O4) et de passivation, avec un pH allant de 9 à 14. Le potentiel sans chute ohmique, la densité du courant et l'angle de phase ont été mesurés avec l'appareil CORREAC sur des éprouvettes subissant l'influence de courants alternatifs. Les résultats furent présentés en tant que courbes Eoff-temps, I-temps et Lissajous Eoff-I tout au long d'une période de courant alternatif.
Les résultats ont confirmé qu'il n'y a pas corrosion lorsque Eoff est inférieur au potentiel d'immunité pour le
pH concerné à tout moment de la période de courant alternatif. Les courants alternatifs pourraient empêcher la formation d'oxydes protecteurs lorsque le potentiel fluctue à l'intérieur de la zone de passivation ou oscille entre l'immunité et la passivation.
La protection cathodique de métaux soumis à l'influence de courants alternatifs nécessite par conséquent la définition de critères plus détaillés.

ZUSAMMENFASSUNG

Ein Kontrollsystem, das die Gleichstrom- und Wechselstrompolarisation steuert, wurde entwickelt, um die Höchst- und Tiefstspitzenpotenziale OFF während langen Perioden und in unterschiedlichen Umgebungen innerhalb von vorher festgelegten Bereichen zu erhalten. Also konnte ein Zusammenhang zwischen Abwesenheit oder Auftreten einer Korrosion und Potentialschwankungen unter Immunitäts-, Korrosions- (Fe2O3, Fe3O4) und Passivierungsbedingungen, mit pH-Werten zwischen 9 und 14, festgestellt werden.
Das IR-freie Potential, die Stromdichte und der Phasenwinkel wurden mit dem CORREAC-Gerät auf wechselstrombeeinflußten Proben gemessen. Die Ergebnisse wurden als Eoff-Zeit-, I-Zeit-, und Lissajous Eoff-I-Kurven über einer ganzen Wechselstromperiode verarbeitet.
Die Ergebnisse bestätigten, daß keine Korrosion auftrat, wenn Eoff zu

jedem Zeitpunkt der Wechselstromperiode niedriger als das Immunitätspotential für den betreffenden pH-Wert war. Wechselströme könnten die Bildung von Schutzoxiden verhindern, wenn das Potential innerhalb des Passivierungsbereiches oder zwischen Immunität und Passivierung schwankt. Der Kathodenschutz von wechselstrombeeinflußten Metallen erfordert also die Bestimmung mehr detaillierter Kriterien.

10

2002 A02 AC INTERFERENCE OF POWER LINES ON BURIED PIPELINES EVALUATION OF CURRENT DENSITIES.

10 – 2002 lucca_moro1
G. Lucca (SIRTI – Italy) – M. Moro (SIRTISISTEMI – Italy)

Abstract:
The paper considers two examples of electromagnetic interference between a buried pipeline and an A.C. power line in normal operating conditions; due to the inductive coupling, an A.C. current density is exchanged between the pipeline and the soil through the holidays present in the insulating coating with the consequent risk of corrosion; the examples are based on real cases: the first one considers a power line which is, for the moment, only at the design stage whilst the object of the second one are two plants already existing and operating.

1. INTRODUCTION

It is well known that when a pipeline or a metallic duct is under the electromagnetic influence of an A.C. power or electrified railway line, induced voltages and currents appear on it; depending on the level of those quantities, we may have problems of safety for personnel or damages or malfunctioning of apparatuses installed along the pipeline. For such a reason, in many countries suitable standards have been published with the indication of limits to be respected in order to ensure safety for people and correct functioning of apparatuses; nevertheless in the last decades, starting from the field experience, a new problem, againoriginating from the electromagnetic induction on the pipeline, has been recognized: the A.C. corrosion evenon cathodically protected pipelines.Within the community of pipelines corrosion experts, it is commonly accepted that the A.C. current density exchanged between a pipeline and soil through the holidays present in the insulating coating is a meaningful parameter in order to assess the risk of A.C. corrosion; in particular the value of 30A/m2 is considered athreshold that, if exceeded leads, to corrosive effects for any type of soil [1]. Thus, from this point of view,
especially at the design stage of new plants, one can realize the usefulness of predicting the level of current density in different point along the pipeline so that the risk of A.C. corrosion could be assessed. Moreover, also in case of already existing plants, the use of simulation programs can be a complementary tool to be used besides the field measurements. The algorithms on which such simulation tools are based, are strictly related to the ones, succesfully adopted since a long time, to calculate voltages and

currents induced on telecommunication cables and pipelines under the influence of power or electrified railway lines [2], [3], [4]; it is worthwhile to mention that such simulation tools have also been validated by specific field measurements [5], [6]. Before presenting the examples of application, which are the core of our paper, we shall devote the nextparagraph to sketch the basic theory needed to model the pipeline under the influence of power or electrified railway lines.

11

2002 A03 AC CORROSION EXPERIENCES

P. Cohn (DONG – Denmark) – L.V. Nielsen (Technical University – Denmark)

Investigation for AC-corrosion on a Danish transmission pipeline interfered by HVAC lines UsingER-probes

11 – 2002 – a.c. experiences Peter Cohn Energinet_PCo

ILI inspection Coating defect location Fieldinvestigations

Peter Cohn Energinet.dk

12

2002 A04 THE USE OF COUPONS IN THE FIELD OF AC-CORROSION

12 – 2002 Complete Melis_Schoeneich The use of Coupons on AC

M. Melis (SPP – Slovak Republik) – H.G. Schöneich (Rurhgas AG – Germany)

Abstract

At the present, when preventive and mitigation measures are known and mostly successfully applied, relevant fundamentals of a.c. corrosion are still unknown. The effort to describe principles of corrosion induced by a.c. current is not negligible and laboratory and field investigations across Europe are carried out.

Coupons, which are electrically connected to and buried in the vicinity of a high voltage interfered pipeline are commonly used to investigate the a.c. corrosion risk of a pipeline /1/. Results from coupon measurements, which may be transferred to the pipeline, include a.c. and d.c. current densities, a.c. voltage and d.c. potentials, spreading resistance and – at least – the corrosion to be found on the excavated coupon.

This paper summarises results, which were obtained from co-operative a.c. corrosion project supported by Slovenský Plynárenský Priemysel, a.s. (Slovakia) and Ruhrgas A.G. (Germany). Due to big alterations of a.c. interference, which cathodically protected pipelines are exposed to, decision to run test field experiments under controlled conditions was adopted. For that purpose test field with real soil conditions was built. Throughout experiments

that were carried out from 6 to 14 months 24 coupons were exposed in soil and interfered by d.c. and a.c. current maintained at constant level.
To evaluate a risk of possible corrosion attack caused by a.c. current from coupon to soil potential readings, off potential measurements within 2 ms after coupon disconnection from electrical source were taken. Obtained results allow to compare value of applied a.c. and d.c. current density and off potential readings to surface of coupons after their excavation. Corrosion attacks of steel under soil deposits formed on exposed surface of coupon were observed. The first part of paper is dedicated to all above results.
The second part of this paper describes the results from 66 coupons, which were installed for more than two years at a high voltage (50Hz) interfered pipeline at 5 different locations where the average a.c. voltage varied between 3.9 and 36V. The above mentioned measurements had been carried out twice a month. The results indicate that operating conditions strongly interfere the results obtained. Different coupons may behave different from each other at one location. Short term measurements, e.g. of a.c. current density, may give rise to false conclusions concerning the existing a.c. corrosion risk of the pipeline due to the strong dependence of the spreading resistance from soil conditions and cathodic protection parameters. Recommendations concerning the use of coupons and their accuracy will be provided regarding the use of the current density criterion mentioned in /2/, the long term operation of coupons, the interpretation of apparently non reproducible coupon results and their transferability to the high voltage interfered pipeline.

13

2002 A05 EVALUATION OF TECHNIQUES FOR THE DETERMINATION OF THE CORROSION RISK CAUSED BY INDUCED AC-CURRENTS ON CATHODICALLY PROTECTED PIPELINES

13 – 2002 Zurich Buechler, Stalder, Voute
M. Büchler, F. Stalder, C.-H. Voûte (SGK – Switzerland)

Abstract
Different techniques used for the determination of the AC-corrosion risk of cathodically protected pipelines were investigated in laboratory and field tests. The reproducible attack of the AC corrosion was possible within 24hours, by taking into account the specific effect of the soil composition,allowing the test of the different available techniques under laboratory conditions. The AC-Voltage, the AC-current density and the Highspeed measurement proved to be sensitive to the AC-corrosion. Additionally, these techniques were used for the characterization of coupons at 12 different locations in Switzerland. In some cases the different techniques yielded contradictory results regarding the risk of AC-corrosion. After at least 2 years of exposure, the coupons were excavated. On two samples corrosion attack was found, which was

not detected by any of the available techniques used for the evaluation of the AC-corrosion risk. This failure of the available methods was related to the formation of chalk layers covering only a part of the sample surface and fluctuations of the induced AC-power.

Zusammenfassung

Die verschiedenen Verfahren, welche heute für die Beurteilung der Gefährdung von kathodisch geschützten Rohrleitungen gegen Wechselstromkorrosion eingesetzt werden, sind in Labor- und Feldversuchen untersucht worden. Durch Berücksichtigung der Bodenzusammensetzung gelang es Wechselstromkorrosion innerhalb von 24 h reproduzierbar zu erzeugen. Dies ermöglichte die Überprüfung der verschiedenen Verfahren zur Feststellung der durch Wechselstrom verursachten Korrosionsgefährdung im Labor. Die Vorgänge sind komplex, sodass es nicht möglich ist, ein einziges Messverfahren in allen Böden einzusetzen. Die heute verfügbaren Methoden wurden zudem an einer neu entwickelten Messprobe in Feldversuchen getestet. Während mindestens 2 Jahren waren solche Messproben an 12 durch Wechselströme beeinflussten,kathodisch geschützten Rohrleitungen angeschlossen. Nach dem Ausgraben der Messproben wurde festgestellt, dass die in der Schweiz getroffenen Massnahmen zur Verringerung der Gefährdung nur zum Teil wirksam sind. An zwei Stellen wurden Korrosionsangriffe festgestellt. Diese Angriffe konnten mit keinem der eingesetzten Beurteilungsverfahren detektiert werden. Die Abklärungen ergaben, dass das Wechselstromdichte-Kriterium keine Vorhersage erlaubte, da die Messoberflächen teilweise verkalkt waren. Dadurch wird die Wechselstromdichte lokal erhöht. Wie schon die Laboruntersuchungen zeigten, ist die heute zur Verfügung stehende Highspeed-Messung zu langsam und die Ergebnisse sind deshalb nicht eindeutig zu interpretieren.

Résumé

Différentes techniques utilisées pour la détermination du risque de corrosion AC de pipelines dotés d'un dispositif de protection cathodique ont été évaluées à l'aide de test en laboratoires et sur le terrain. Une attaque de corrosion AC sur une période de 24 heures à pu être effectuée de façon reproductible en laboratoire, permettant de tester la réponse des différentes techniques disponibles et ce en tenant compte les effets spécifiques de la composition du terrain. Les mesures de tension alternative, de densité de courant alternatif et les mesures à vitesse élevée se sont révélées sensibles à la présence de corrosion AC. En plus, ces techniques ont été utilisée pour la caractérisation de coupons à 12 différents endroits en suisse. Dans certains cas les différentes techniques ont produits des résultats contradictoires concernant les risques de corrosion AC. Après au moins 2 ans d'exposition, les coupons ont été excavés. La présence d'une attaque de corrosion sur deux échantillons n'a été détectée par aucune des techniques à disposition pour l'évaluation du risque de corrosion

AC. Cet échec des techniques de détection standards peut être expliqué par la présence de couches de craie recouvrant partiellement la surface de l'échantillon ainsi que par des fluctuations de la puissance alternative induite.

2003 CEOCOR CONGRESS –12th – 15th May TAORMINA, ITALY

14

2003 A13 STUDY OF THE EFFECT OF AC-INTERFERENCE AND AC-MITIGATION ON THE CATHODIC PROTECTION OF A GAS PIPELINE

14 – 2003 Taormina Kioupis Columbis
N. Kouloumbi, G. Batis (National Technical University of Athens),
N. Kioupis, P. Asteridis (Public Gas Corp. of Greece – DEPA) – Greece

ABSTRACT
In the present work, an examination was undergone for the effects of the AC-interference and AC-mitigation on the function of the cathodic protection system of a natural gas buried pipeline subjected to 50Hz AC induced by high-voltage power lines. The role of the up-to-this-time operating overvoltage arresters was investigated since their operation disturbed cathodic protection and the AC-corrosion risk was barely eliminated. Thus, this study was directed towards the design as well as on the evaluation of their performance of new specific AC-mitigating electronic devices, named Alternating Voltage Arresters of Continuous Function (AVACF). The installation of AVACF aimed at the minimization of AC-interference and AC-corrosion of the pipeline without detrimental effects on cathodic protection system operation and maintenance, taking into account the very small values of the cathodic protection currents involved. The effectiveness of cathodic protection was assessed through in-situ monitoring of pipeline electrical characteristics before and after the installation of AVACF. The acquired data analysis provided encouraging results. The cathodic protection system function was improved as indicated by the significant decrease of the AC voltage of the pipeline minimizing thus AC-corrosion risk. Furthermore, the reduction of the total cathodic protection current as well as the important diminishing of any low frequency fluctuations and/or deviations of pipe-to-soil potential resulted in reduced general corrosion risk and better reliability of cathodic protection measurements.

INTRODUCTION
Economic reasons as well as crowding of various constructions usually force pipelines to follow routes in close proximity to high-tension power lines. Thus, the pipelines are exposed to AC-interference, which results in perturbation of cathodic protection and AC-corrosion risk. One of the most serious consequences of steady state induced AC is that corrosion can occur even if cathodic protection levels satisfy the standards and despite

the induced AC has been reduced to less than 15V as required by other standards[1].
Theoretical studies of the AC-induced corrosion have been published[2,3]. Also, study of the AC-interference on the DC cathodic protection characteristics has been mainly carried out in the lab or in corrosion coupons/probes. Laboratory experiments on steel specimens have shown that AC causes an increase of the cathodic protection current density and a shift of the open-circuit potential[4-6]. In a pipeline case, the higher the AC probe current density the greater the amount of DC cathodic current density[7]. Moreover, on various corrosion probes DC potential oscillations of the same frequency of the AC voltage (e.g. 50Hz) have been observed and were related to the AC-corrosion susceptibility[8,9]. In-situ long-term monitoring and analysis of the electrical parameters of the cathodic protection of a buried pipeline, which was under AC-interference, has been recently reported[10]. However, further research is generally required for the clarification of the influence of the AC voltage on cathodic protection parameters, mainly in well-insulated pipelines. The presence of alternating voltage and current on buried metallic pipelines can cause malfunctioning or even damage to the Transformer/Rectifier (T/R) units of impressed current cathodic protection. This is particularly valid for T/R units that are not equipped with suitable AC filter and surge protection[11,12].
The induced potentials can be controlled and attenuated by earthing measures. However, a direct earthing of the pipeline counteracts cathodic protection. Therefore, an AC mitigating and DC blocking system i.e. a unit that allows the free flow of AC but effectively impedes the DC discharge has to be installed between pipeline and earthing electrode. The well-coated pipeline under examination poses special requirements for the AC mitigating device. For this reason, such a device was the so-called “Alternating Voltage Arrester in Continuous Function (AVACF)”, which was designed in details, manufactured and installed in the pipeline in question for the goals of this experimental work. There are various AC mitigation systems, such as zinc grounding cells[1], polarisation cells[1,13], AC compensation apparatus[14,15], solid-state DC-blocking devices (e.g. Isolation-Surge Protectors)[16,17], electrolytic capacitors[1] etc. Each type of AC mitigation system should be selected and implemented with great care in order to be effective.

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2003 A15 AC CORROSION ON BURIED PIPELINES: A PROBABILISTIC APPROACH

15 – 2003 AC Corrosion Probabilistic Approach Di Biase-Lucca

G. Lucca (Sirti), L. Di Biase (Snam Rete Gas), M. Moro (Sirtisistem) – Italy

1. INTRODUCTION

Within the community of experts in A.C. corrosion of pipelines, the idea that the current density flowing through a holiday in the insulating coating is a meaningful parameter able to assess the risk of corrosion is commonly accepted; in particular the value of 30 A/m2

is considered a threshold value that, if exceeded, leads, for sure, to corrosive effects for
any type of soil [1]. On the other side, the assessment of corrosion conditions is
only possible when the pipeline has already been laid down in the trench and the current density can be really measured on simulated holidays (usually having 1 mm2 bare surface). These measurements in the field are affected by a possible wide variation of the spread resistance of these simulated holidays, which is connected to complex and not yet completely understood electrochemical reactions deriving from d.c. and a.c. current effects and the chemical composition of the soil contacting the bare steel. It has been demonstrated by laboratory tests that this spread resistance may, during time, increase by as much as 100 times or decrease by as much 60
times (formation of particular layers at the phase boundary). From this point of view, at the design stage of new plants (pipelines from one side and power or railway lines on the other) the only possible approach to the problem is represented by simulation tools able to assess the level of current density exchanged between pipe and soil through the insulating coating holidays. The algorithms on which such simulation tools are based, are essentially the same used to predict the electromagnetic interference (i.e. induced voltages and currents) on pipelines and telecommunication lines by A.C. power and electrified railway lines [2], [3]; thus, from this point of view, the A.C. corrosion can be considered as a particular problem inside the wider set of the power frequency Electromagnetic Compatibility problems.

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2003 A16 CHARATERISTICS OF POTENTIAL MEASUREMENTS IN THE FIELD OF AC CORROSION

16 – 2003 – Caracteristics… Schoeneich etc

F. Stalder (SGK – Switzeland), H.-G. Schöneich (Ruhrgas – Germany)

Abstract

The problems observed in the instantaneous off potential measurement were attributed to a non-sufficient time resolution. By increasing the data acquisition rate up to 2 MHz it was possible to determine the polarization of the metal surface within 2 µs after disconnecting the coupon from the ac and dc power source. This increase in resolution represents an acceleration of the measurement for a factor of thousand compared to the commonly used instruments. However, it was found that the depolarization of the surface is faster than 1 µs in calcium ion free soil solution. As a consequence, the threshold of -0.85 V CSE was not exceeded although ac corrosion occurs on the metal surface. In the presence of calcium ions, however, the threshold is exceeded due to a different depolarization behavior. As the depolarization and therefore the interpretation of the instantaneous off potential measurement depends strongly on the composition of the soil it cannot be recommended for the characterization of coupons in field applications. In order to address the influence of the soil composition and to investigate the chemical processes occurring on the coupon surface, continuous data acquisition was installed in

two locations in Switzerland. The results of the first 6 months of data acquisition are presented. Zusammenfassung
Die bei der sofortigen Ausschaltpotenzialmessung beobachteten Probleme, wurden einer nicht genügenden Zeitauflösung zugeschrieben. Indem die Datenerfassungsrate auf 2 MHz erhöht wurde, war es möglich, die Polarisation der Metalloberfläche innerhalb 2 µs nach der Trennung der Messprobe von der AC und DC Spannungsquelle festzustellen. Diese Zunahme der Auflösung stellt eine Beschleunigung der Messung um einen Faktor von tausend verglichen mit den bisher benutzten Instrumenten dar. Es wurde jedoch gefunden, daß die Depolarisation der Oberfläche in Bodenlösungen ohne Calcium schneller als µs 1 ist. Als Folge wurde der Grenzwert von -0,85 V CSE nicht überstiegen, obgleich Wechselstromkorrosion auf der Metalloberfläche auftrat. In Anwesenheit der Calciumionen wurde der Grenzwert jedoch, aufgrund eines anderen Depolarisationsverhaltens, überschritten. Als die Depolarisation und damit die Interpretation der sofortigen Ausschaltpotenzialmessung in starkem Mass von der Bodenzusammensetzung abhängt, kann deren Einsatz für die Charakterisierung von Messproben in Feldanwendungen aufgrund der vorliegenden Ergebnisse nicht empfohlen werden. Um den Einfluß der Bodenzusammensetzung und der ablaufenden chemischen Prozesse zuntersuchen, wurde in der Schweiz an zwei Standorten eine kontinuierliche Datenerfassung für die relevanten Parameter installiert. Die Resultate der ersten 6 Monate der Datenerfassung werden diskutiert.
Résumé
Les problèmes observés dans la mesure de potentiel à courant coupé instantané ont été attribués à une résolution non-suffisante de temps. En augmentant le taux d'acquisition de données jusqu'à 2 mégahertz il était possible de déterminer la polarisation de la surface en métal à moins de 2 µs après avoir déclanché l'échantillon de la source d'alimentation CA et CC. Cette augmentation de résolution représente une accélération de la mesure pour un facteur de mille comparé aux instruments généralement utilisés. Cependant, on l'a constaté que la dépolarisation de la surface est plus rapide que les µs 1 dans la solution libre de sol d'ion de calcium. Comme conséquence la valeur limite des -0,85 V CSE n'a pas été dépassée, bien que la corrosion de courant alternatif sur la surface de métal apparaisse. En présence des ions en calcium, la valeur limite a été dépassée toutefois, sur la base d'un comportement différent de dépolarisation. Comme dépolarisation et donc l'interprétation de la mesure de potentiel à courant coupé instantané dépend fortement de la composition du sol son application pour la caractérisation des échantillons de mesure dans les applications de champ ne peut pas être recommandée sur la base des présents résultats. Pour examiner l'influence de la composition de sol et des processus chimiques écoulés , une saisie de données continue pour les paramètres pertinents a été installée en Suisse à deux emplacements. Les résultats des 6 premiers mois de la saisie de données sont examinés. Afin d'adresser l'influence de composition de sol et étudier le produit chimique traite l'occurrence sur la surface de bon, acquisition de données continue ont été installés dans deux endroits en Suisse. Les résultats des 6 premiers mois de l'acquisition de données sont présentés.

2003 A17 AC INTERFERENCE EFFECTS ON POLARISED STEEL

17 – 2003 Taormina AC Interference in polarised steel

S. Goidanich, L. Lazzari (Politecnico Milano – Italy)

Abstract

This paper illustrates the results of laboratory tests on the influence of AC interference on carbon steel at different polarisation conditions: anodic polarisation (DC stray current interference and galvanic coupling with copper grounding system) and cathodic polarisation (cathodically protected structures). The environments used for the experiments were sulphate solutions simulating low resistivity soils. AC was overlapped to the testing specimens at different current densities, ranging from 10 to 1,000 A/m2. Cathodic protection level was varied from -0.85 V CSE to –1.5 V CSE as true potential. Anodic polarisation, obtained by galvanic coupling with copper and stainless steels and by external polarisation was ranging from free corrosion conditions to 10 A/m2

.INTRODUCTION

Studies on AC interference grew in the last 30 years, although AC corrosion it was well known since the beginning of the XX century [1]. Today main concern is the frequent parallelism between buried pipelines and AC high tension transmission lines in combination with the use of highly dielectric coatings like extruded polyethylene or polypropylene. However, in the near future, at least in Italy, new interference conditions are expected because of the overlapping of high current AC traction systems (25 kV and 50 Hz) and the traditional DC traction system that have been operating for about a century. For stray direct current corrosion on buried structures, for instance interfered pipelines, there is large agreement on criteria to be used for corrosion mitigation and international standards are available since many years [2]. For AC corrosion, different approaches are used and different pinions still exist. The European approach is the to be measured by means of corrosion coupons (the threshold value so far proposed is 30 A/m2) [3]; others are based on the maximum AC voltage (for instance, 15 V). It is agreed that the AC intensity threshold value obtained in laboratory tests is of the order of 20 to 100 A/m2, and meanwhile, few data are available on the influence of the simultaneous presence of AC and DC current on steel corrosion in soil and in concrete [4]. The results reported in this paper evaluate the effect of AC current on freely corroding conditions, and under cathodic and anodic polarisation in soil simulating solutions.

This experimental research has been co-fund by MIUR (Italian Ministry of School, University and Research) [5].

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2003 A18 AC CORROSION OF CATHODICALLY PROTECTED STEEL IN SOIL/ FIELD INVESTIGATION WITH LOW CONSTANT AC VOLTAGE

18 – 2003 Taormina Camitz

G. Camitz (Swedish Corrosion Institute), C. Persson (Sycon Energy Consultancy) – Sweden

Abstract
Alternating current corrosion has been studied in soil on steel test coupons, which were provided with cathodic protection and exposed to constant AC voltages but to different AC-densities. Three series of tests were performed, one with 5 Vac during 1½ year, one with 10 Vac during almost two years, and a third one with 30 Vac during approx. 1½ year. 16-28 test coupons were used in each test series. This report describes the results from the present 5V-series and they are compared with the results from the earlier 10V- and 30V-series. The 10V- and 30V-series have been reported in detail previously. The corrosion rates (both average and local corrosion) varied widely between the test coupons in all three test series. The measured average corrosion rates in the 5V-test series were, surprisingly, of the same magnitude as those measured in the 10V-series.The average corrosion rates were clearly higher in the 30V-test series. This relationship was the same for the local corrosion in the three series. In the 30V-series some extremely high local corrosion rates appeared. Four coupons showed a local corrosion of 120-285 µm/year. There seemed to be a tendency of increasing local corrosion rate the higher the influ-encing AC-voltage is. The measured corrosion rates at different and constant AC-voltages can be used in the discussion whether a fixed AC-voltage can be used as a measurement criterion for AC-corrosion on cathodically protected pipelines. In spite of a constant alternating voltage throughout the test series, the grounding resistance and thereby also the alternating current density of the coupons varied strongly on short-term up and down between different measurement occasions, due to i.a. weather and seasonal changes in soil resistivity. Long-term changes in the grounding resistances also occurred and it seemed to be a tendency of increasing ground-ing resistance, and decreasing AC-current density, with time. The increase in resistance and decrease in alternating current seemed to be larger for coupons with small exposed steel areas (0,5 and 1 cm2). The observed short-term variations and long-term changes in alternating current densities complicate the use of this parameter as a criterion for AC-corrosion on cathodically protected pipelines.

2004 CEOCOR CONGRESS –15th – 16th June DRESDEN, GERMANY

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2004 A05 DISCUSSION OF CRITERIA TO ASSESS THE ALTERNATING CURRENT CORROSION RISK OF CATHODICALLY PROTECTED PIPELINES

19 – 2004 Dresden Schoeneich
H.-G. Schöneich (Ruhrgas AG – Germany)

Abstract
Buried and cathodically protected pipelines, that are parallel routed with high voltage lines or electrified railways are galvanically or inductively interfered by their operating and fault currents. As a result the pipe/ground a.c.-potential is increased with consequences regarding the safety of the pipeline against hazardous shocks and a.c.-corrosion where the coating is damaged.
This paper adresses the assessment of the corrosion risk of a pipeline due to ac. The state of the art technique is the use of coupons, which simulate a coating fault and which allow to measure the ac-current density and also to evaluate corrosion products and pits. Recently different criteria to assess the ac-corrosion risk have been proposed /1/ that are based on the ratio between ac- and dc-current density or the instantaneous off-potential (high speed off-potential measurement) measured on a coupon. These criteria are discussed on the basis of field experience from coupons and from (ac)-corrosion pits on high voltage interfered pipelines and in the light of the results of laboratory investigations which have recently been carried out.

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2004 A06 ON-SITE MEASUREMENTS OF AC INDUCTED CORROSION RATE : EFFECT OF AC/DC PARAMETERS

20 – 2005 Dresden On site measurements of AC induced corrosion – Effect of AC
Vendelbo Nielsen (MetriCorr), P. Cohn (Gastra) – Denmark

Abstract
Field research activities at AC corrosion monitoring stations along the Danish gas grit system have given successful on-line and real time measurements of AC induced corrosion risk using ER coupons and related instrumentation combined with logging of the electrical data of the coupons.
Studies have given further evidence for the alkalisation mechanisms, and it has been indicated in the field and further proven by laboratory soil box experiments that AC corrosion stops at low CP dosage and accelerates at high dosage of CP.
Field investigations at a site with alternating ground water level have shown that corrosion stops when the water disappears from the coupon’s sphere, and therefore the presence of the groundwater seems crucial. Measurements in pure pore water have on the other hand shown that AC corrosion does not

occur in pure water phase and therefore that the soil particles are necessary requisites in the build up of the hydroxyl accumulation at the coupon surface. Soil texture – grain size distribution – is of less importance.
The base (OH-) neutralising capacity of the soil has been investigated and apparently has no effect on whether or not AC corrosion develops – perhaps rather on the incubation period.
Investigations in laboratory soil boxes have shown that the spread resistance is a function of the OH-
concentration and decreases with increasing DC current (CP) dosage. By obtaining polarisation data, the high pH general corrosion domain has been identified as a result of the OH-production by the CP.
Further activities will include establishment of yet a significant amount of field test stations with the purpose of generating complete evidence that AC corrosion risk will be minimised if the CP is kept low. The effect of DC stray currents on corrosion will be investigated under decreased CP conditions. These field measurements will be sustained by controlled soil box experiments.
Intelligent pigging of the Gastra F-E pipeline has been scheduled with the purpose of evaluating if the critical AC corrosion conditions found at coupons have actually developed attacks in the pipe.
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2004 A07 A NEW ELECTROCHEMICAL METHOD FOR THE DETECTION OF AC-CORROSION

21 – 2004 Dresden Buechler, Stalder, Schoeneich
Büchler, (SGK – Switzerland) F. Stalder, (SGK – Switzerland) H.-G. Schöneich (Ruhrgas AG Germany)

Abstract

Corrosion due to induced ac-voltages on cathodically protected pipelines represents a significant risk to the durability and safety of these structures. To date, the only generally accepted criterion for the determination of the corrosion risk due to ac-currents is based on the use of coupons and the measurement of the ac-current density. However, it was found that the spread resistance of the coupons can significantly vary over time due to formation of chalk layers or the formation of hygroscopic alkali hydroxides in the soil. Moreover, the induced ac-voltage depends on the operation status of the power lines or the train system. Therefore, significant variation of the ac current density can be observed over time resulting in a possible underestimation of the of the corrosion risk in nspection measurements. These problems can be overcome by new electrochemical methods allowing for the detection of ac corrosion. Results of laboratory and field investigations are discussed.

Zusammenfassung

Korrosion aufgrund von induzierten Wechselspannungen auf kathodisch geschützten Leitungen stellt ein bedeutendes Risiko für die Dauerhaftigkeit und Betriebssicherheit dieser Strukturen dar. Bisher ist die Wechselstromdichte,welche an Messproben bestimmt wird, das einzige generell akzeptierte Kriterium zur Beurteilung der Korrosionsgefährdung. Es

wurde jedoch gefunden, dass der Ausbreitungswiderstand von Messproben im Verlaufe der Zeit aufgrund der Ausbildung von Kalkschichten oder der Bildung von hygroskopischen Alkalihydroxiden erheblich variieren kann. Weiter ist das Ausmass der Wechselstromdichte in hohem Masse vom gegenwärtigen Betriebszustand des Beeinflussers ab. Es können daher erhebliche Variationen in der Wechselstromdichte auftreten, welche zu einer möglichen Unterschätzung der Gefährdung beim Zeitpunkt der Messung führen können. Diese Probleme können mit einer neuen elektrochemischen Methode überwunden werden. Ergebnisse aus Labor- und Felduntersuchungen werden vorgestellt.

Résumé

La corrosion due aux tensions alternatives induites sur les lignes cathodiquement protégées représente un risque significatif à la longévité et à la sûreté de ces structures. Jusqu'ici, le seul critère généralement admis pour la détermination du risque de corrosion dû aux courants alternatives est basé sur l'utilisation des coupons et la mesure de la densité du courant alternative. Cependant, on a constaté que la résistance des coupons peut changer dû à la formation des couches de craie ou aux hydroxides d'alcalis hygroscopiques. D'ailleurs, latension alternative dépend du statut d'opération des lignes de puissance ou du système de train. Par conséquent, on peut observer la variation significative de la densité de courant alternative. avec le temps ayant pour résultat une sous-estimation possible du risque de corrosion dans des mesures d'inspection. Ces problèmes peuvent être surmontés par une nouvelle méthode électrochimique tenant compte de la détection de la corrosion courant alternative. Des résultats des investigations de laboratoire et de champ sont discutés.

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2004 A10 AC INTERFERENCE ON A GAS PIPELINE CAUSED BY RBY POWER LINES IN A COMPLEX RIGHT-OF-WAY – COMPARISON BETWEEN MEASUREMENTS AND CALCULATIONS

22 – 2004 Dresden Chistoforidis-Labridis-Dokopoulos

G.C. Christoforidis, D.P. Labridis, P.S. Dokopoulos (Aristotle University of Thessaloniki), N. Kioupis (Public Gas Corporation of Greece) – Greece

Abstract

The interference caused by power transmission lines to buried gas pipelines is under investigation for many years. Situations where a pipeline is influenced by more than one ines are more frequent nowadays, thus making the interaction more complex. Even under normal operating conditions, voltages and currents are induced on the pipeline that may pose danger to working personnel or may accelerate the corrosion of the pipeline's metal. In this paper, a case study taken from the Greek Transmission System is demonstrated. Measurements of the induced voltage at certain locations of a pipeline section are compared with theoretical calculations. These calculations comprise finite element computations and circuit analysis. Results presented show that the induced voltage on the pipeline is heavily influenced on the loading of each of the power lines, which must be known throughout the common route. For an accurate calculation of the induced parameters, it is

recommended that the coupling between all conductors of the problem should be taken into consideration. Furthermore, theoretical calculations presented show the influence of the operation of installed over-voltage arresters, which connect the pipeline to mitigation grounding wires.

Key Words
Finite element methods, gas pipelines, inductive interference, power transmission lines.

2005 CEOCOR CONGRESS 31st May – 3rd June, MALMOE, SWEDEN

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2005 A02 Investigating AC and DC stray current corrosion – A report from the Danish activities

23 – 2005 – Malmoe – Investigating AC and DC – Nielsen

L.V. Nielsen – MetriCorr ApS, Glerupvej 20, DK-2610 Roedovre, Denmark
B. Baumgarten – HNG I/S – Greater Copenhagen Natural Gas Gladsaxe Ringvej 11, DK-2860 Soeborg, Denmark
P. Cohn – Gastra A/S, Bregnerødvej 133D, 3460 Birkerød, Denmark

Abstract

Combined and individual effects of AC and DC stray currents on corrosion of buried pipelines are studied in a research program jointly within the Danish natural gas transmission/distribution companies.
Studies have given evidence for the alkalisation mechanism, and it has been shown both in field and in laboratory soil box experiments that AC corrosion stops at low CP dosage and accelerates at high dosage of CP. Cathodic DC density controls the spread resistance at a coating defect.
In turn, the spread resistance controls the level of AC density – at given AC voltage.
High level of DC density (>3-5 A/m2) in combination with (even rather low >5-10 V) AC voltage gives AC corrosion.
DC density and spread resistance are primary factors in judgment of AC corrosion likelihood.
Combined effect of DC stray currents and AC may cause corrosion both in terms of the alkalisation mechanism that characterises “traditional” AC corrosion, and in terms of the anodic DC peaks occurring in DC stray interference.

Résumé

En conséquence du mécanisme d’alcalisation lié à la corrosion due au CA, il est recommandé de maintenir le potentiel à un niveau faible afin de ménager l’état de la PC et d’éviter un excès de courant de PC. Une question particulièrement intéressante dans ce contexte est l’impact de cette précaution sur l’efficacité de la protection contre les courants vagabonds CC. Cet article inclura les résultats de 2 différentes séries d’expériences avec soil box.
Une série dans laquelle une matrice des conditions CA/CC a été examinée pour connaître les circonstances provoquant une corrosion CA. Une autre dans laquelle une PC faible a été combinée à de fréquentes pointes de

courant anodique afin d'analyser les risques de corrosion par courants vagabonds CC.
Ces observations sont débattues en tenant compte de divers paramètres pratiques pertinents.
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2005 A04 Statistical eva luation of results from a.c. corrosion field tests

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24 – 2005 – Malmoe – AC-corrosion-Stat. Eval. Juhlin-Camitz

L-E. Juhlin * & G. Camitz **
* ABB Power Technologies AB, Dep.PTPS/DC/TSD, PO Box 703, SE-771 80 LUDVIKA, Sweden
** Swedish Corrosion Institute, Kräftriket- Building 23A, SE-104 05 STOCKHOLM, Sweden

ABSTRACT
During some years alternating current (a.c.) corrosion has been studied in soil on steel test coupons, which were provided with cathodic protection, and exposed to constant a.c. voltage. The test site is located in the southern part of Sweden. Three test series with different a.c. voltage exposure have been performed: 30 V during 1½ year, 10 V during 2 years and 5 V during 1½ year. Sixteen test coupons of various area have been used in each series, half of them in clay and half of them in sand. Uniform corrosion and maximum local corrosion have been measured on each coupon. Consequently, te large number of test coupons exposed for a.c. corrosion during very well controlled conditions gives a good possibility to statistically evaluate how the corrosion rate is correlated with measurable parameters such as a.c. voltage level, a.c. current density, coupon area, type of soil (sand or clay), and ratio between a.c current density and d.c. current density. This article presents the results of such a statistical evaluation. There is a clear tendency that the corrosion rate increases with increased a.c. voltage and increased a.c. current density. However, the variations are large, and there seems to be important parameters, which are not controlled. Even in cases, where the preconditions seem to be almost identical, the corrosion rates differ very significantly. Hopefully this analysis can trigger similar statistical evaluations regarding a.c. corrosion correlation based on other test and investigations in Europe. Of special interest is to compare with results from significantly longer exposure.

2005 A03 ALTERNATING CURRENT CORROSION OF BURIED AND CATHODICALLY PROTECTED STEEL EXPOSED TO VARYING A.C. VOLTAGES – AND A NEW MODEL FOR UNDERSTANDING OF A.C. CORROSION

25 – 2005 – Malmoe Perrson
C. Persson (CarlBro – Sweden); A. Marbe (CarlBro – Sweden); R. Lundberg (ES Mätteknik AB – S weden); G. Camitz (Swedish Corrosion Institute – Sweden)

Abstract

During 2003 – 2004 a.c. corrosion has been studied on cathodically protected steel in soil exposed to varying a.c. voltage. The test site is located in the southern part of Sweden. Previously three investigations with constant low, medium and high a.c. voltages have been carried out at the same test site. The varying a.c. voltage has been designed, so that it corresponds to the normal load variations in a high voltage power grid. Thus, the test involves 8 h with high load (30 V) and 16 h with low load (5 V). Test coupons of two different areas (1 and 5 cm2 have been used, placed in clay and in sand respectively. Uniform corrosion and maximum local corrosion have been measured on each coupon after the ending of the exposure. Consequently, test coupons exposed for a.c. corrosion during very well controlled conditions give a possibility to compare how the corrosion rate is correlated with measurable parameters such as a.c. voltage level, a.c. current density, coupon area, type of soil (sand or clay). It is also possible to study the ratio between a.c. current density and d.c. current density. This article presents the corrosion results of varying a.c. voltage. There is a clear tendency that the corrosion rate increases with increased a.c. voltage and increased a.c. current density, despite the high level of a.c voltage occurs during short periods during the day. However, the differences in observed corrosion are large, and there seem to be important parameters, which are not under full control. Therefore, in order to achieve a better understanding of the different parameters that affect a.c corrosion an electrical model has been developed. The electrical model can briefly be described as a rechargeable battery with different re- and discharge circuits. In the model the different chemical processes can be described as different electrical component series. Hopefully this article can trigger similar model evaluations regarding a.c. corrosion correlation based on other tests and studies carried out elsewhere in Europe. Of special interest is a comparison of these results with other studies in hope of gaining more experience in the chemical process of a.c. corrosion.

2006 CEOCOR CONGRESS 31st May – 3rd June
Mondorf les Bains , Luxembourg

26

2006 A01 ASSESSMENT OF A.C. CORROSION UNDER CATHODIC PROTECTION CONDITIONS IN MARINE ENVIRONMENTS

26 – 2006 – ac corrosion of mild steel in marine environments

Dae-Kyeong Kim, Tae-Hyun Ha, Jeong-Hyo Bae, Yoon-Cheol Ha, Hyun-Goo Lee, Kyung-Wha Park
Underground System Group, Korea Electrotechnology Research Institute (Republic of Korea)
Srinivasan Muralidharan – Concrete Structures & Failure Analysis Group, Corrosion Protection
Division, Central Electrochemical Research Institute, Karaikudi (India)
J.D. Scantlebury – Corrosion and Protection Centre, UMIST, Manchester (UK)

Abstract
The influence of alternating current (AC) corrosion of mild steel in naturalsea water was studied systematically under cathodic protection (CP)condition. Electrochemical studies were carried out at the CP protectionpotential namely -780 mVSCE. Corrosion rate determination at the differentapplied AC current densities was carried out by conventional weight lossmethod for the exposure period of 24 hrs. The pH of the test solutions forthe exposure period of 24 hrs was noted. The amount of leaching of iron(Fe) into the solution at various AC current densities was done by usinginductively coupled plasma spectrometry (ICP). Mild steel specimens weresubjected to surface examinations after treatment with various AC currentdensities under CP condition. Optical electron microscopy was used foranalysing the surface of the mild steel. All the studies revealed that mildsteel tends to corrode when applying AC even though it is under CPconditions. The corrosion rates are increased with increasing AC currentdensities. Two to three fold increases in the corrosion rates was obtained at100 A/m2
. Surface micrographs showed the spreading of red rust products onthe mild steel surface after 10 A/m2
. The concentration of Fe was alsofond higher above 10 A/m2. The electrochemical measurements coupleswith surface examination and solution analysis proved to be a very effectivetool by means of characterizing the AC corrosion of mild steel in sea watermedium.
Keywords: AC corrosion, mild steel, cathodic protection, sea water

27

2006 A06 A field study of line currents and corrosion rate measurements in a pipeline critically interfered with AC and DC stray currents

27 – 2006 – on Line and AC – DC stray current (2)

L.V. Nielsen1, B. Baumgarten2, P. Cohn3, H. Rosenberg4.
1) MetriCorr ApS, 2) Greater Copenhagen Natural Gas, 3) Energinet.DK, 4) Balslev Consulting Engineers

Abstract

Based on individual field trials, this paper discusses the following points:
The possibility of detecting corrosion due to DC interference by logging the DC parameters of a coupon in distinct time periods corresponding rush hour and silent periods, and the corrosion rate described as a function of the anodic DC charge in pure DC interference cases.
II. The possibility of detecting corrosion due to AC interference by logging AC and DC parameters and correlating corrosion rate with critical combinations of these parameters.
III. The combined mechanism of AC and DC stray current corrosion showing both critical alkalization and anodic dissolution at threshold AC/DC parameters, and the possibility of diagnosing this combined action.
IV. The possibility of detecting the primary DC-interference source using synchronized line currents and potentials, and the possible recommendations for mitigating the corrosion risk in such cases.

28

2006 A07 Minimising a.c. corrosion risk by AC discharge devices

28 – 2006 – Reduzierung-AC-Gefährdung-K. Riegel

K. Riegel – Fachverband Kathodischer Korrosionsschutz FKKS (Germany)

2007 CEOCOR CONGRESS 9th – 11th May, MALAGA – SPAIN

29

2007 A05 Effect of cathodic protection levels and defect geometry on the a.c. corrosion on pipelines

29 – 2007 – Malaga – Ceocor Buechler ac corrosion final

M. Büchler, C.-H. Voûte and H.-G. Schöneich*SGK, (Switzerland)
*EON-Ruhrgas AG – (Germany)

Abstract

In recent investigations it was found that the level of cathodic protection has an influence on the a.c. corrosion rate observed on coupons. In order to obtain datafor optimizing the cathodic protection parameters, the corrosion

rate was investigated at various On potentials and interfering a.c. voltages. Based on the obtained results it was possible to demonstrate that the corrosion rate can significantly be decreased if the Off potential is more negative than -0.85 V CSEand the On potential is in the range of -1.2 V CSE. Moreover it was possible to demonstrate that the high a.c. corrosion rate on coupons can readily be decreased if the cathodic protection level is adjusted. Hence, the lifetime of cathodically protected pipelines showing high a.c. corrosion rate can be increased by adjusting the On potentials. Interestingly, the geometry of the coupon was found to have a significant effect on the corrosion rate, emphasizing the importance of current distribution and diffusion processes in the soil. The laboratory investigation was completed with the coulometric oxidation in order to determine the degree of corrosion of the coupons and compare these data with the actual degree of corrosion. The comparison of these data with field results allows the conclusion that the coulometric oxidation not only is useful for the determination of the degree of corrosion on coupons but also to monitor thedevelopment of the more general a.c. corrosion situation over time. .

30

2007 A06 a.c. corrosion – Some results of the activities

30 – 2007 – Malaga – ac Corrosion ISPROMA Di Biase (2)

L. Di Biase , R. Cigna, O. Fumei – ISPROMA S.r.L – Italy

Abstract

a.c. corrosion has become a great concern in the last decades, mainly for gas operators, since the use of very high quality coatings (e.g. three-layers polyethylene) have been applied on buried pipelines.

Many studies have been performed in various laboratories in last 15 years by major Gas Operators in Europe and world-wide.

A great effort has been made in Europe by Joint Projects such as the one developed within the GERG (European Group for Gas Researches).

Since the publication of the very first CEOCOR booklet on this subject in 2001, many other experiences have been gained and reported in various studies.

During the elaboration of the European Standards on this subject, which resulted in the final document EN TS 15280, a parallel work in the Standardisation has been developed in the CENELEC, even with some heavy debates. In the framework of the ECDA (External Corrosion Direct Assessment) program, launched by US Authorities and particularly the requirements of DOT (Department of Transportation), has led NACE to elaborating a document on a.c. corrosion, starting with a State of the Art Report, now in a draft phase.

The main needs from a Standardisation point of view, according to the Authors, are the following:

A – which data should be measured

B – where these measurements should be performed

C – how these data should be measured (time duration, frequency etc.)

D – which are the parameters and which are their limits for avoiding a.c. corrosion

Some special Sections of pipelines have been installed by ISPROMA in the training Centre of Riyadh (Saudi Arabia) and elsewhere with the specific scope to answering to some of these questions. Preliminary results have already been achieved and further tests are going on in a reproduced real field conditions.
This paper aims to show some of these results in view of a discussion on this quite tricky subject.

2008 CEOCOR CONGRESS –20th – 23rd May, Starý Smokovec, SLOVAKIA

31

2008 A06 A.C. CORROSION EXPERIENCES IN ENERGINET.DK

31 – 2008 – Slovakia-a.c. experiences Peter Cohn Energinet

P.Cohn – ENERGINET – Denmark

32

2008 A07 A.C. CORROSION – SHREIR PUBLICATION – UPDATE ON A.C.CORROSION

32 – 2008 – a.c. Corrosion contribution to SHRIER

L. Di Biase – R.Cigna, Italia – R. Gregoor, Belgium – H.G. Schöneich, Germany

Interaction and Stray-current Corrosion “(MS 156)“ for the **Shrier’s Corrosion**
Index

MAJOR EVIDENCES FROM FIELD STUDIES AND LABORATORY TESTS
References
Foreword
1 – The phenomenon of a.c. corrosion
The primary factor in alternating current electrolysis is current density. This statement was made in The Engineering Journal, the journal of the Engineering Institute of Canada, and was made in 1927.
A long time has passed since then and a.c. effects have been experienced and investigated in depth.
More recently, since 1986, some instances of corrosion on gas pipelines due to alternating current (16 2/3 and 50 Hz) have been reported in Europe and elsewhere. In all these cases, the cathodic protection values, measured with conventional techniques and instruments, satisfied the conventional criteria. It

is most probable that some previous corrosion failures have not been recognised as being caused by alternating current because cathodic protection personnel have not been made aware of a.c. corrosion risk.
The a.c. influence is referred to as “inductive», «resistive» or «capacitive» interference in technical literature.
In the last decade, quite a number of corrosions have been clearly attributed to a.c. corrosion.
a.c. corrosion is a concern for owners operating long structures (mostly pipelines) running parallel or close to overhead high voltage transmission power lines (typically 15 kV and higher) or a.c. traction systems. The problem also exists in municipal areas (structures near buried a.c. power distribution systems), in reinforced concrete structures (e.g. road bridges also sustaining electricity power lines) and inside tunnels for a.c. electrified railways.
It is not uncommon to measure a.c. voltages in the range of 15 to 100 Vrms on coated pipelines exposed to a.c. influence. This may cause safety hazards to people , malfunction of pipeline equipment and corrosion problems.
In the last two decades, a better knowledge of the a.c. corrosion phenomenon has been gained, thanks to the many studies that mainly gas operators have sponsored or directly performed.
These studies started in the 80ies and are still in progress. Since this period, high quality/high resistance coatings have been used for buried pipelines, thus increasing the effects of a.c. interference.
Very often in the past, a.c. corrosion was not correctly diagnosed because usually Cathodic Protection instrumentation rejects industrial a.c. frequencies and the knowledge of the a.c. corrosion phenomenon itself is still growing every day.
33

2008 A08 – Discussion of the mechanism of a.c.-corrosion of cathodically protected pipelines: The effect of the cathodic protection level

33 – 2008 BUCKLER mb_ac_corrosion_CEOCOR_D

M. Büchler *, C. H. Voûte *, H. G. Schöneich **
* SGK Swiss Society for Corrosion Protection, Technoparkstr. 1, CH-8005 Zürich,
** E.ON-Ruhrgas AG, Huttropstrasse 60, DE-45138 Essen

Summary
In recent investigations it was found that the level of cathodic protection has an influence on the a.c. corrosion rate observed on coupons. In order to obtain data for optimizing the cathodic protection parameters, the corrosion rate was investigated at various On potentials and interfering a.c. voltages. Based on the obtained results it was possible to demonstrate that the corrosion rate can significantly be decreased if the Off potential is more negative than -0.85 V CSE and the On potential is in the range of -1.2 V CSE. Moreover it was possible to demonstrate that the high a.c. corrosion rate on coupons can readily be decreased if the cathodic protection level is adjusted. In order to obtain an understanding of the processes involved and to clarify the influence of alkalinity on the corrosion rate, the effect of cathodic current

density on the pH-value on the metals surface of coupons was analyzed with a new in-situ pH measurement technique. The effect of pH, spread resistance and electrochemical reduction is discussed with respect to the experimentally observed corrosion rate.

2009 CEOCOR CONGRESS 26th – 29th May VIENNA, AUSTRIA

34

2009 A01 The effect of variation of ac-interference over time on the corrosion of cathodically protected pipelines

34 – 2009 – Vienna – Bueckler a.c. Corrosion

M. Büchler *, C. H. Voûte *, H. G. Schöneich **
* SGK Swiss Society for Corrosion Protection, Technoparkstr. 1, CH-8005 Zürich,
** E.ON-Ruhrgas AG, Huttropstrasse 60, DE-45138 Essen

35

2009 A02 HVAC INTERFERENCE ON PIPELINE NETWORKS – MODELING AND OPTIMIZATION OF MITIGATION TECHNIQUES.

35 – 2009 – PaperElsyca

Bortels, J. Parlongue – ELSYCA, Belgium

Summary
In recent investigations it was found that the level of cathodic protection has an influence on the a.c. corrosion rate observed on coupons. In order to obtain data for optimizing the cathodic protection parameters, the corrosion rate was investigated at various On potentials and interfering a.c. voltages. Based on the obtained results it was possible to demonstrate that the corrosion rate can significantly be decreased if the Off potential is more negative than -0.85 V CSE and the On potential is in the range of -1.2 V CSE. Under these optimized cathodic protection conditions various interfering ac voltages and different time dependences were investigated. In addition, the effect of defect geometry, soil composition and soil resistivity were considered. The contribution of these parameters for the durability of the pipeline and their consequence for interference thresholds are discussed. Based on the obtained understanding of the mechanism of a.c. corrosion a new approach to use the cathodic protection technique in order to mitigate a.c. corrosion is proposed.

36

2009 A03 CP REMOTE MONITORING – AC INFLUENCE : ANALYSIS OF TWO FIELD TESTS WITH A NEW DATA LOGGER UNIT

36 – 2009 – paper Tecnosystem
Tecnosystem Group Srl – Pietro Fiorentini Spa
Calvi – Tecnosystem Group Srl – M.H.G. Juinen – Merrem & La Porte

Abstract:
The European technical spefication CEN/TS 15280 is based on a criteria which is founded on the AC current density, and fixes an attention threshold at 30 A/m2, threshold on which there isn't an unanimous consensus among the operators. In Italy, the Politecnico of Milan is leading a study on the subject, to which different companies and associations, interested to the phenomen, took part, study which is arriving at interesting conclusions, among those it is enhanced that the measure or even the estimation of the current density exchanged from a pipe is rather – when impossible – to measure, unless to adopt corrosion samplings, on whose reliability, as for the re-production of real conditions on the pipe (current exchange in correspondence to the coating defects) is legitimate to have doubts.
The potential measure is a way which can be better used with a simpler actuation and interpretation, on which the attention must be posed to individuate the criteria of the upcoming corrosion.
On the basis of these indications, as well as on the pressing and urgent request from operators for a new instrument which allows these kind of verifications, Tecnosystem has developed a new data acquisition unit for the remote monitoring of Cathodic Protection, which allows also the measure and verification of the AC current interference values. We will present, in this Paper, the results of field test effected for few months in the Netherlands, where we have effected remote monitoring measures considering also the alternate current component

37

2009 A04 Simulation of a cathodically protected pipeline with capacitive ac-mitigation devices for the interpretation of the falsification of instant-off pipe-to-soil potential measurements

37 – 2009 – PAPER – Simulation of a c Mitigation Kioupis – Greece
N. Kioupis (DESFA), N .Kouloumbi and G. Batis (NTUA) – Greece
DESFA: Hellenic Gas Transmission System Operator S.A.
NTUA: National Technical University of Athens

Abstract
Several capacitive ac-mitigation devices are usually utilised which connect the pipe to earthing electrodes at various locations along the pipe route, in

order to decrease the induced ac voltage of a cathodically protected pipeline buried in soil. During instant-off pipe-to-soil potential measurements, these devices tend to discharge themselves through the soil. This phenomenon must be taken into consideration since an error in the instant-off potential readings is created by the capacitor discharging currents. It can result to a false view i.e. the pipeline is sufficiently cathodically protected even when it is not.

The aim of the present work is the investigation of the role of the involved parameters with regard to the falsification of instant-off potential readings. For this purpose, an electric circuit simulation of the pipeline with connected capacitive devices is proposed. The key parameters involved are the capacitance value of every ac-mitigation device, the population number of them, the earthing electrodes resistance as well as the pipeline resistance to remote earth. Methods for reducing the error in off potential readings are presented. A modification of the conditions of off potential measurement is suggested aiming at reliable CP potentials readings. Moreover, by taking CP potential measurements under conditions of low ac voltage any impact of high ac interference on the CP parameters is avoided.

2010 CEOCOR CONGRESS 25th – 27th , May BRUGES, BELGIUM

38

2010 C2 03 CP measurement on severely high voltage polluted pipelines

38 – 2010 Blotzki, Quast Ruhrgas
K. Blotzki, M. Quast, – E.ON Ruhrgas AG (D)

Abstract
Due to regulations resulting from regional planing newly constructed transmission pipelines like e.g. high pressure gas pipelines are increasingly laid in common tracks with high voltage overhead power lines. Extended parallel routing partly leads to significant induced a.c. voltages on the pipeline. The following article describes how the limitations in CP measurement technology caused by extreme high voltage interference can be encountered by suitable measurement technology, measurement procedures and grounding technology.
Zusammenfassung
Neue Rohrfernleitungen werden aufgrund raumordnerischer Anforderungen zunehmend in gemeinsamen Trassen mit Hochspannungsfreileitungen verlegt. Durch die lange Parallelführung werden teilweise erhebliche Wechselspannungen in die Rohrleitungen induziert. Im Folgenden wird beschrieben, wie den durch die Hochspannungsbeeinflussung hervorgerufenen Beschränkungen bei KKS-Messungen mit geeigneter Messtechnik und Messverfahren sowie mit spezieller Erder-Schaltungstechnik begegnet werden kann.

39

2010 C2 04 Development of a time dependant numerical model for the quantification of AC corrosion phenomena

39 – 2010 – Offerte_AC_Corrosion_Model
B. V.d. Bossche, L. Bortels, J. Parlongue – ELSYCA NV (BE)

1. Introduction
The phenomenon “a.c. corrosion” was investigated very detailed since the observation of the first corrosion damages induced by a.c. corrosion on cathodically protected pipelines in the year 1988 [1, 2]. Soon the a.c. current density was identified as a critical parameter [3-5]. Later the contribution of the d.c. cur-rent density to the corrosion rate was reported [7-10]. However, a profound understanding of the detailed mechanism was lacking for years. Only in recent investigations it was possible to develop a model capa-ble of explaining the empirically obtained experimental data [11]. Based on this concept, the a.c. corrosion rate can be decreased to insignificantly low values, if the d.c. current density is limited. Preferably the value should be below 1 A/m2

. This should be achievable if the on potential is in the range of -1.2 V CSE and the off potential is below -0.85 V CSE [11]. Under these conditions, th driving force for d.c. current flow is minimized, resulting in minimal possible d.c. current densities.

2011 CEOCOR CONGRESS 17th – 20th May Menthon-Saint-Bernard, (ANNECY), FRANCE

40

2011 C2 04 Practical case of measures to reduce the stray current impact on a 40 km long natural gas pipeline caused by intersecting High Voltage transmission lines.

40 – 2011 – EDWALL Measures to reduce stray currents

Hans-Erik EDWALL (E.ON Gas AB, Sweden)
Klas MALMBORN (Reducta, Sweden)

Cas pratique de mesures visant à réduire l'impact sur une canalisation de gaz naturel de
40 km de long du courant vagabond dû au croisement de lignes haute tension
Une canalisation de gaz naturel est affectée par des interférences galvaniques générées au croisement de deux lignes de transport de 400 kV et d'une ligne de 130 kV. Les courants induits dans les lignes aériennes augmentent les gradients de potentiel du sol autour de lignes haute tension via les pylônes/mises à la terre. Le courant traversant le sol, combiné à une résistivité élevée, fera que les gradients de potentiel dans le sol s'étendront aussi très largement. En introduisant plusieurs joints isolants dans la section de canalisation de gaz naturel de 40 km de long, le niveau de courant alternatif permanent a été réduit sur tout l'itinéraire de la canalisation. Nonante-cinq pour cent de tout l'itinéraire de la canalisation respecte désormais le critère de 10 VCA.
Praxisfall: Maßnahmen zur Verminderung der Auswirkungen von Streustrom – verursacht durch kreuzende Hochspannungsleitungen – an einer 40 km langen Erdgasleitung
Eine Erdgasleitung wird durch ohmsche Beeinflussung beeinträchtigt, die von zwei kreuzenden 400-kV-Leitungen und einer 130-kV-Leitung verursacht wird. Induktionsströme in den Oberleitungen erhöhen die Potentialgradienten im Boden rund um Hochspannungsleitungen über die Masten/Fundamente. Der Strom, der im Boden fließt, führt in Kombination mit einem hohen Leitungswiderstand dazu, dass die Potentialgradienten im Boden ebenfalls sehr groß werden. Durch den Einbau mehrerer Isolierstücke in die 40 km lange Erdgasleitung konnte die Größe des ständigen Wechselstroms an der gesamten Leitungstrasse vermindert werden. 95 % der gesamten Gasleitungstrasse liegen jetzt unter dem Schwellenwert von 10 VAC.
Practical case of measures to reduce the stray current impact on a 40 km long natural gas pipeline caused by intersecting High Voltage transmission lines A natural gas pipeline is affected by ohmic interference caused by two intersecting 400 kV transmission lines and a 130 kV transmission line. Electromagnetic coupling from the transmission lines induces currents in the

sky wires which flow to ground through the towers/groundings and increase the soil potential gradients around the high voltage power lines. The current passing through the ground, in combination with high resistivity soil, results in potential gradients in the soil that occur across a wide area. By intoducing several insulating joints into the 40 km long section of the natural gas pipeline, the permanent AC level has been reduced on the entire pipeline route. 95 % of the entire pipeline route is now below the criterion of 10 VAC.

41

2011 C2 05 Considerations on measurements and measurement techniques under AC/DC interference conditions

41 – 2011 Paper NIELSEN

Lars NIELSEN (MetriCorr , Denmark)

ABSTRACT

This paper gives a general outline and discussion of measurements and measuring techniques relevant for studying, assessing, or monitoring AC corrosion. The techniques cover the parameters AC voltage, DC potential (in the “ON” mode or IR compensated), AC and DC current densities through a coating defect, Spread resistance of the coating defect as well as direct corrosion rate measurements on coupons.

The paper is a conglomerate of a contribution given to the CEN committee as suggestions and justifications to cover “Measurements Techniques” included in the merging standard on AC corrosion.

42

2011 C2 06 AC stray current due to ohmic interference

42 – 2011 SANDBERG AC Corrosion Mitigation

Bertil SANDBERG (Swerea KIMAB AB Stockholm, Sweden)

Abstract

When planning new pipelines, careful calculations are being performed concerning inductive interference due to parallel routing with three-phase, high-voltage overhead power lines. The ohmic interference due to the vicinity of overhead power line pylons is less considered. Often a minimum distance of just a few meters is requested. In most areas in Sweden, the bed rock is only covered by a thin layer of soil, which to 70% consists of moraine. These poor conditions for grounding result in many cases in extensive gradient fields around pylons giving long term interference on adjacent pipelines. These problems have been identified first when the pipeline is installed. Before installing new pipelines this ohmic interference will be taken into account by combination of field measurements and interference calculations.

Zusammenfassung

Bei der Planung neuer Pipelines werden sorgfältige Berechnungen zur induktiven Beeinflussung durch parallele Trassenführung von dreiphasigen Hochspannungshochleitungen durchgeführt. Die ohmsche Beeinflussung aufgrund der Nähe von Hochspannungsmasten wird seltener berücksichtigt. Oftmals wird nur ein Mindestabstand von wenigen Metern gefordert.

In den meisten Gebieten Schwedens ist das Grundgestein nur von einer dünnen odenschicht bedeckt, die zu 70 % aus Moränen besteht. Diese Fließbedingungen für die Erdung führen in vielen Fällen zu intensiven Gradientenfeldern rund um Masten, die benachbarte Pipelines langfristig beeinflussen. Diese Probleme wurden erstmals festgestellt, als die Pipeline verlegt wurde. Vor dem Verlegen neuer Pipelines wird diese ohmsche Beeinflussung durch eine Kombination von Feldmessungen und Interferenzberechnungen berücksichtigt.

Résumé

Lors de la planification de nouvelles canalisations, des calculs minutieux sont réalisés à propos des interférences par induction dues à l'acheminement parallèle à des lignes aériennes de courant triphasé à haute tension. Les interférences galvaniques dues à la proximité des pylônes électriques sont moins prises en considération. Souvent, une distance minimale d'à peine quelques mètres est requise.

Dans la plupart des régions de Suède, le substrat rocheux n'est couvert que d'une fine couche de sol, qui consiste pour 70 % en de la moraine. Ces mauvaises conditions de mise à la terre résultent dans bien des cas en des champs de gradient étendus autour des pylônes, ce qui produit des interférences à long terme sur les canalisations adjacentes. Ces problèmes ont d'abord été identifiés quand la canalisation est installée. Avant d'installer de nouvelles canalisations, ces inteférences galvaniques seront prises en compte par une combinaison de mesures sur place et de calcul des interférences.

43

2011 Field Investigation of a.c. corrosion

43 – 2011 Field investigation of a.c. corrosion

BÜCHLER, C.-H. VOÛTE and D. JOOS (SGK Zürich, Switzerland)

Abstract

Based on laboratory studies and model concepts, a profound understanding of the involved processes in a.c. corrosion and the required limits has been obtained in the last years. But there is no information whether these thresholds can be effectively applied to pipelines or whether operational constraints make their implementation impossible. Therefore, an extensive field test with seven pipeline operators in Germany was carried out. Thereby the relevance of the laboratory tests for field application was investigated.

Zusammenfassung

Aufgrund von Laboruntersuchungen und Modellvorstellungen besteht ein vertieftes Verständnis über die bei Wechselstromkorrosion ablaufenden Prozesse und die erforderlichen Grenzwerte. Es gibt aber keine Informationen ob diese effektiv auf Rohrleitungen angewendet werden können oder ob betriebliche Randbedingungen deren Umsetzung verunmöglichen. Es wurde daher ein umfangreicher Feldversuch mit sieben Rohrleitungsbetreibern in Deutschland durchgeführt. Dabei wurde die Releanz der in den Laborversuchen gewonnenen Erkenntnisse überprüft werden.

Résumé

Ces dernières années ont permis d'acquérir une profonde compréhension des processus impliqués dans la corrosion par courant alternatif et des limites requises pour l'éviter en se basant sur des études en laboratoire et des modèles. Mais il n'y a aucune information indiquant si ces seuils peuvent effectivement être appliqués à des canalisations ou si des contraintes opérationnelles rendent impossible leur implémentation. Par conséquent, un essai *in situ* de grande envergure a été mené en Allemagne avec sept exploitants de canalisations. La pertinence des essais en laboratoire pour les applications de terrain a ainsi été investiguée.