RÉSUMÉ Raymundo Case

MATERIALS AND CORROSION ENGINEER / SCIENTIST

KEY COMPETENCIES AND SKILLS

- Dynamic, team-spirited Materials and Corrosion Engineer, with a strong orientation towards corrosion science.
- Development of materials selection criteria based on fitness for service to minimize the corrosion impact in industrial infrastructure.
- Research and development of the control of corrosion phenomena associated with the oil and gas production industry.
- Application of fracture mechanics for the understanding of environmentally assisted cracking phenomena in metallic materials.
- Advanced expertise in failure analysis due to corrosion, in exploration production and refining industries.
- Bilingual English / Spanish

ACADEMIC QUALIFICATIONS

1998 – 2002 *PhD Corrosion Science*
UMIST, Manchester United Kingdom

1992 –1994 *M. Sc. Physical Metallurgy*
Universidad Central de Venezuela, Caracas Venezuela

1991 –1992 *Specialization in Materials Selection*
Universidad Central de Venezuela, Caracas, Venezuela

1983 – 1989 *B Sc. Materials Science and Engineering*
Universidad Simon Bolivar, Caracas, Venezuela.

EMPLOYMENT/ PROFESSIONAL EXPERIENCE

From December 2008 to August 2016: Conoco Phillips Bartlesville Technology Center, Staff Scientist, Production Assurance Technologies.

Responsibilities:

- Conduct scientific research in the field of localized corrosion modelling with the objective of provide reliable risk assessment criterions for oil & gas producing facilities.
- Evaluate the material's performance in oil & gas producing conditions to assess failure causes.
- Provide expert analysis and evaluation to support technological development projects for the different business units of COP.

From June 2006 to December 2008: Petrobras Energia Argentina S.A.

Senior Team Leader in Corrosion and Chemical Treatment, Department of Production Engineering.

Responsibilities:

- Technical supervision of corrosion control projects in upstream and surface facilities within Petrobras assets In Argentina.
- Development of technological strategies for corrosion control and chemical treatment for organic and inorganic scale deposition of surface facilities, within the Petrobras assets in Argentina.
- Senior consultancy for reconditioning and recompletion of wells in special services (deviated, tight gas, etc.).
- Provide fitness for service and Risk based Inspection criteria applicable to reliability assessment for upstream and associated surface facilities.
- Supervision of the staff (3 senior professionals and a senior information support technician) and project portfolio management for the Corrosion and Chemical Treatment sector within the Production Engineering department.
- Advanced technical consultancy in corrosion prediction and control for Petrobras Energia assets at corporate level.

From September 2005 to May 2006: Petrobras Energia Venezuela S.A.

Senior Specialist in Corrosion and Chemical Treatment. Department of Production Engineering.

Responsibilities:

- Technical supervision of Corrosion control projects in upstream and surface facilities within Petrobras assets in Venezuela.
- Development of Technological directives for Corrosion control and chemical treatment of surface facilities.
- Senior consultancy for reconditioning and recompletion of wells in critical service.
- Provide fitness for service and Risk based Inspection criteria applicable to reliability assessment for upstream and associated surface facilities.

From October 2003 to 2005, Carabobo University, Faculty of Engineering,

School of Mechanical Engineering. Valencia, Venezuela.

Lecturer in Materials Science and Engineering, **Department of Materials Engineering.**

Responsibilities:

- Preparing and delivering lectures in Materials Science and Engineering at Undergraduate level.
- Lecturer in Fracture Mechanics at Post graduate MSc. in Mechanical Engineering course
- Responsible for the direction of the Department of Materials science and Manufacturing Processes of the School of Mechanical Engineering.
- Development of research activities within the Materials department.
- Tutoring of students in the development of research activities associated with graduate and postgraduate theses.

From September 2003 to September 2005: CMPC Engineering Consultancy, C.A, Caracas, Venezuela.

Corrosion Consultant, Course Facilitator:

Responsibilities:

Production and teaching of high level courses for technical staff training for oil and gas producing companies.

From May 2003 to September 2005: ST3I Soluciones Tecnologicas, Caracas Venezuela
Corrosion Consultant:
Responsibilities:

- Determination of corrosion risk in oil and gas wells under critical service conditions.
- Modelling of CO_2 / H_2S corrosion in producing oil wells.
- Assessment of failure causes and determination of reliability in oil and gas wells and surface installations.

2001– 2003 PDVSA/ Intevep. Dept of Infrastructure Technologies, Caracas Venezuela
Advanced Project Leader:
Responsibilities:

- Consultancy to the Excellency Centre in Drilling and Completion design at PDVSA corporative level. In the area of materials selection for completions in corrosive environments.
- Introduction of state of the art selection criteria for metallic completion materials, adjusted to the ISO-15156, at corporate and operational level at PDVSA.
- Identification of technological areas of interests that lead to savings in capital investment (CAPEX) in the development of traditional and new, oil and gas fields.

1998 – 2001 UMIST, MANCHESTER, U.K.
PhD Candidate, under supervision of Prof. Dr. Roger Newman

1989 – 1998 PDVSA/ Intevep. Dept of Materials Technology, Caracas Venezuela
Research and Development Engineer
Responsibilities:

- Responsible for the direction and management of Dynamic Flow Corrosion Field Tester (DFT) project, requiring commissioning on a new site and design of research project goals on flow assisted corrosion.
- Assurance of the technical aspects for the South Maracaibo Lake materials selection programme with the goal of selecting completion tubular adequate for the specific environmental conditions, and achieving 50% savings in capital expenditure with

minimization of corrosion damage risks.

- Management of the technical responsibility to the Support to Surface installations business unit within PDVSA/ Intevep. Responsible for supervision of the joint project with Sumitomo industries, and the materials selection programme with Shell.
- Providing corrosion control solutions services in the different areas from oil and gas production, transport refining and petrochemical industries.
- Study and implementation of corrosion control, methodology in oil and gas drilling environments, for reduction in costs associated drilling operations.
- Responsible for the Basic research on the flow effects in the CO2 corrosion of carbon steels in oil and gas transport conditions. Conceptual design of a laboratory flow loop, supervising research agreement with Tulsa university
- Support of Basic Oriented Research: Study of the Sulphide stress cracking, and the suitable methods to quantitatively assess the susceptibility to cracking.
- Development of test methods for assessing stress corrosion cracking susceptibility by CO_2 / H_2S.
- Study of corrosion control in actual amine gas scrubber systems, achieving a reduction of corrosion costs in actual operations. Contributing to estimation of risk for phase 2 and 3-remnant life assessment.

APPENDICES

TECHNICAL EXPERIENCE

- Sur del Lago Field – Localized in the Maracaibo lake basin, Western Venezuela, Materials selection study was performed in order to evaluate a suitable alternative to expensive duplex steel tubing used in the well's completion for this high pressure high temperature, formation which produces sour oil and gas. This required extensive analysis of the geochemistry of the produced fluids, as well of the mechanical design of the well and its completion arrangement. A testing protocol based on assessing fitness for purpose was devised in order to evaluate and qualify candidate steels and suppliers
- Cogollo Field – Located in the Maracaibo Lake basin in western Venezuela. Materials selection study was performed in order to evaluate a suitable CRA alloy that would minimize corrosion problems, for these sour wells. A fitness for purpose procedure was designed based on fracture mechanics evaluation and localized corrosion behaviour at the simulating the specific critical environmental parameters identified
- La Victoria Field – Located in south-western Venezuela. An extensive evaluation of the corrosion problems found within the production tubing in these wells was performed by means of failure analysis. The identification of the failure causes prompted an extensive modelling of the CO_2 corrosion behaviour associated with the production scheme used. Suitable materials alternatives were recommended
- San Joaquin Field – Located in Anaco, Eastern Venezuela. Identification and analysis of the corrosion risks associated with new gas wells completed with standard 13 Cr (L-80) steels. Based on the study of the formation's geochemistry and its history, as well the proposed mechanical designs for the completions, material alternatives were implemented and a NDT inspection protocol recommended.
- Pirital Field – Located in El Tejero, Eastern Venezuela. Identification of the impact of the corrosivity of the drilling fluids used in the expected useful life of drilling stem and tool joints. Extensive failure analysis of specimens together with corrosion monitoring was used to support an inspection protocol devised to reduce fishing costs.
- Furrial Field – Located near El Furrial, Eastern Venezuela. Evaluation of the corrosion problems associated with increased water cut in the produced fluids together with souring of the reservoir. Evaluation of the chemistry of the produced fluids together with failure analysis was used to identify the severity of the sour environment. The analysis of the wells completions was used to assess cracking risk in the completion tubing and the producing casings.
- Member of the team responsible for the evaluation of well construction and completion practices at PDVSA's corporate level. With the specific role of identifying present and future corrosion severity scenarios for the main producing areas, and indicate the relevant technologies that can be used to control its impact minimizing cost and optimising capital expenditure.

- Assessment of corrosion profiles in gas sweetening plants, by means of the development of a novel method based on the electrochemical evaluation of the actual amine system used within the system determining the corrosivity impact of the degradation products.
- Introduction of a new approach towards the assessment of the risk to environmentally assisted cracking in OCTG used in the construction and completion of wells. Based on the fracture mechanics behaviour of the steels used and the fitness for purpose criterions.
- Assessment of the risk of CO_2 corrosion, in gas / condensate producing wells, located in Quiriquire (northern Monagas area), operated by Repsol/YPF. This study was accomplished by means of predictive modelling. Results were corroborated by failure analysis of tubing.
- Analysis of CO_2 corrosion severity in gas lift producing wells in the San Tome field, operated by Teikoku oil of Venezuela. Resulting in the implementation of materials replacement protocols in order to reduce failure incidence.
- Development of a prediction methodology for CO_2 corrosion damage distribution, applicable for the assessment of the survivability of susceptible wells with deviated completions or artificial lifting systems. The methodology was used in: the Oritupano oilfield in Venezuela (operated by Petrobras Energia), Puesto Hernandez (PESA, Argentina), Kuparuk (Alaska, Conoco Phillips) to define the number of wells that could require workovers, in order to develop a preventive maintenance intervention scheme.
- Definition of a pipe integrity programme for a critical 16" OD conduction line for the Block 31 operated by Petrobras Energia Ecuador. This programme was produced considering risk based methodologies and the assessment of corrosion damage distribution by stochastic simulation methodology. This was done in order to minimize the likelihood of failure with optimised construction (CAPEX) and maintenance costs (OPEX) in the environmentally sensitive area of the Amazon where the Block 31 is located.
- Assessment of the causes and relative severity of the salt plugging experienced in the deep gas wells of the Punta Rosada field (operated by Petrobras Energia Argentina) located in the Neuquen basin (Argentina). Using mechanistic modelling coupled with simulation for this tight gas (low permeability) reservoir.
- Optimisation of the scale control costs by the assessment of the effect that the production parameters used in the operation electro submersible pumps deployed in wells, have on the inorganic scale deposition rate, under the conditions found in the Maria Ines and Puesto Peter fields operated by Petrobras Energia Argentina.
- Development of a performance based strategy for the implementation of contracts for the chemical treatment required in the several producing oilfields operated by Petrobras Energia in Argentina. The objective was to devise operating service contracts consistent with the maintenance, optimisation and long-term prevision to production scenarios in the mature reservoirs operated by Petrobras Energia.
- Assessment of the Fitness for service condition for the substandard piping fittings in place at Ekofisk (COP Norway BU) offshore platforms. The evaluation based on the fracture mechanics model and electrochemical testing of the localized corrosion behaviour showed that no significant risk to actual failure could be expected in a reasonable time, allowing to extent the operation until the planed turn around.

- Development of a method for assessing stress corrosion cracking susceptibility for stainless steels exposed in H_2S containing brines based on the transient analysis of the currents recorded from constant potential electrochemical tests. The methodology was used to define cracking risk in the Lost Cabin gas plant (Lower 48 BU COP).
- Evaluation of the impact of chemical inhibition on the chemical storage tanks fitness for service at Bohai FPSO (Bohai Bay, China BU, COP), by assessing the effect of chloride ion in concentrated acetic acid solutions on the pitting resistance of steel used in the construction (316L) and its associated welds.
- Development data analysis algorithms to evaluate K_{Ith} and J_{Ith} for environmentally assisted cracking from notched tensile tests performed the using slow strain rate method. The methodology is used to evaluate Hg cracking susceptibility of nickel steels.

PUBLICATIONS

LIST OF PUBLISHED PAPERS IN PEER REVIEWED CONFERENCES

CORROSION CONTROL IN CO_2 /H_2S CONTAINING ENVIRONMENTS

1) MARCANO, S.; CASE, R.; VILORIA, A. "Study of the corrosion in gas sweetening systems". Primer Congreso Región Latinoamericana NACE. Maracaibo. Noviembre 1994.
2) R. Bisbal, M. Staia, M. Ledezma, R. Case, A. Viloria. "Corrosion behaviour of the A-515 Gr 70 Carbon Steel in Monoethanol amine solutions Saturated with H_2S" (in Spanish). 1ºNACE Latin.American Corrosion Conference, 2 (1994).
3) R. Case, A. Viloria, B. Luciani, "Corrosion profile in a Gas Sweetening Plant". CORROSION 98, Paper 98404, (Houston TX: NACE International 1998).
4) A.Valdes, R. Case, M. Ramirez, A. Ruiz. "The effect of small amounts of H_2S on CO_2 corrosion of carbon steel" CORROSION 98, Paper 99022, (Houston TX: NACE (International 1998).
5) R. Case, M. Carpio, "Assessment of CO_2 corrosion damage - likelihood of failure in deviated wells by deterministic and stochastical modelling", SPE 107839, X LACPEC, Buenos Aires, 2007.
6) R. Case. **"**Assessment of CO_2 corrosion damage distribution in oilwells by deterministic and stochastical modelling", CORROSION 2008, Paper 08541, (Houston TX: NACE International 2008).
7) R. Case. "Estimation of the Replacement time interval due to CO_2 Corrosion in Oil wells by Random Process Modelling". CORROSION 2010, Paper 10366, (Houston TX: NACE International 2010).
8) R. Case. "The Stochastical approach applied to CO_2 Corrosion Modeling". CORROSION 2012, Paper C2012-0001463 (Houston TX: NACE International 2012).
9) Case, R., Stochastic Approach to the Modelling of CO_2 Corrosion. Corrosion, 2014. 70(11): p. 1080-1089.
10) Case, R., et al. Evaluation of Corrosivity of Produced Fluids during SAGD Operations. in CORROSION 2014. paper No 4273. San Antonio, TX: NACE International, 2014.

11) McIntyre, D.R., et al. Impact of Corrosion Inhibition on the Mitigation of Preferential Weld Attack in Sea Water Injection Pipelines. in CORROSION 2014. paper No 3847. San Antonio, TX: NACE International, 2014.
12) Case R. et al. High Temperature Corrosion Studies in Simulated SAGD Produced Fluids, CORROSION—Vol. 71, No. 4, 2015.
13) Case R., M. Achour, J. Daniels Evaluation of Preferential Weld Corrosion Susceptibility and its Mitigation in Slightly Sour Conditions in CORROSION 2015 Paper 5640, NACE International, 2015.
14) Case R. M. Achour, J. Ning Effect of Corrosion Inhibition on the Mitigation of Preferential Weld Corrosion in Seawater Transport Systems in CORROSION 2015 Paper 5641, NACE International, 2015

LOCALIZED CORROSION IN PASSIVE ALLOYS

1) R. Case, R.C. Newman, S. Olsen, G. Rorvik. " Pit Growth behaviour of modified 13 Cr Steel in Sour Environments", EUROCORR 2000, London, The Institute of Materials, 2000.
2) Raymundo P. Case, Sudhakar P.V. Mahajanam, Hernan E.Rincon, Dale R. McIntyre. Tom McWalter. "Effect of intermetallic content on the pit stability and propagation kinetics of duplex stainless steel exposed to CO_2 saturated production brine", EUROCORR 2010, Moscow, The Institute of Materials, 2010.
3) Raymundo P. Case, Hernan E. Rincon, Dale R. McIntyre, "Analysis of Pit Stability in 316L Stainless steel exposed to H_2S saturated dilute chloride solutions above the Critical Pitting Temperature", CORROSION 2011, Paper 11252, (Houston TX: NACE International 2011).
4) Raymundo P. Case, Hernan E. Rincon, Dale R. McIntyre, "Analysis of Pit Stability in 316L Stainless steel exposed to H_2S saturated dilute chloride solutions above the Critical Pitting Temperature", Corrosion, The Journal of Science and Engineering: March 2012, Vol. 68, No. 3, pp. 035004-1-035004-12.
5) Raymundo P. Case, Dale R. McIntyre, "Effect of Inhibition on the Pitting stability and Growth kinetics of 316 Stainless Steel in an Acetic Acid storage tank". CORROSION 2011, Paper 11273, (Houston TX: NACE International 2011).
6) Raymundo P. Case, Dale R. McIntyre, "Effect of Inhibition on the Pitting stability and Growth kinetics of 316 Stainless Steel in an Acetic Acid storage tank". MATERIALS PERFORMANCE NACE International, Vol. 51, No. 4. April 2012
7) Sudhakar P.V. Mahajanam, Raymundo P. Case, Hernan E. Rincon, Dale R. McIntyre, Mike W. Joosten, Stig Gjesdal, Henning Monsen," Effect of Sigma Phase on the Corrosion and Stress Corrosion of 2205 and 2507 Duplex Stainless Steels", CORROSION 2011, Paper 11173, (Houston TX: NACE International 2011).
8) Xuanping Tang, Hernan Rincon, and Raymundo Case, "Prediction of the Temperature Effect on Pit Stability using Stochastical Modeling of the Pit Localised Dissolution Kinetics". CORROSION 2012, Paper C2012-0001329, (Houston TX: NACE International 2012).
9) Hernan Rincon, Xuanping Tang, and Raymundo Case," Determination of the Critical Pitting Temperature of Stainless Steel using Electrochemical Testing Techniques" CORROSION 2012, Paper C2012-0001334, (Houston TX: NACE International 2012).
10) Engelhardt, G. R., Case, R. P., & Macdonald, D. D. (2016). Electrochemical

Impedance Spectroscopy Optimization on Passive Metals. Journal of The Electrochemical Society, 163((8)), C470-C476.

STRESS CORROSION CRACKING

1) A. Viloria, R. Case y J. Vera, "Susceptibility to stress corrosion cracking of A-515 carbon steel in gas sweetening plants ", IX Jornadas Técnicas GPA – Capítulo Venezuela, Valencia, 1991.

2) M. Kermani, R. Macguish, J. Smith, R. Case, J. Vera. "The effect of Environmental Variables on Crack Propagation of Carbon Steels in Sour Media". Oil and Gas Production and Refining, International Corrosion Conference (ICC), Houston 1993.

3) R. Case, J. Vera, A. Viloria, M. Staia, "Effect of the Environment on the Sulphide Stress Cracking in High Strength Steels by Fracture Mechanics" (in Spanish). 1ºNACE Latin American Corrosion Conference, 2 (1994), paper 94100.

4) R. Case, J. Vera, C. Sequera, "The Use of ACPD Technique in Assessing Cracking Propagation and K_{ISSCC} in High Strength Steels OCTG Materials in Sour Media". CORROSION 97, Paper No 97046. (Houston TX: NACE International 1997).

5) R. Case, J. Vera, A. Castro, "The Relationship between Hydrogen Permeation and Sulphide Stress Cracking Susceptibility of OCTG Materials at Different Temperatures and pH Values". CORROSION 97, Paper 97047, (Houston TX: NACE International 1997).

6) R. Case, A. Valdes, "Selection of Completion Material for a Sour Oil field using Fracture Mechanics Concepts and Stress Corrosion Cracking Testing". CORROSION 98, Paper 98111, (Houston TX: NACE International 1998).

7) H. Rincon, S. Hernandez, J. Salazar, R. Case, J Vera. " Effect of the Water/oil Ratio on the SSCC Susceptibility of High Strength OCTG Carbon Steel." CORROSION 99, Paper 99602, (Houston TX: NACE International 1999).

8) R. Case, Dale R. McIntyre, "Mercury Liquid Metal Embrittlement of Alloys for Oil and Gas Production and Processing" CORROSION 2010, Paper 10294, (Houston TX: NACE International 2010).

9) R. Case, H. Rincon, , Dale R. McIntyre," Chloride Limits for Pitting and Cracking of 300 Stainless Steels Series in an Acid Gas Removal Plant" ,CORROSION 2011, Paper 11174, (Houston TX: NACE International 2011).

10) Sudhakar P.V. Mahajanam, Raymundo P. Case, Hernan E. Rincon, Dale R. McIntyre, Mike W. Joosten, Stig Gjesdal, Henning Monsen, "Study of Environmentally Assisted Cracking of Duplex Stainless Steels Due to Presence of Sigma Phase", Corrosion, The Journal of Science and Engineering: December 2011, Vol. 67, No. 12, pp. 125002-1-125002-14.

11) Dale McIntyre, Chris Dash, Raymundo Case, Jay Murali and Probjot Singh," Evaluation of the Stress-Corrosion Cracking Susceptibility of Carbon Steel in High pH Glycol Solutions Simulating Oilfield Pipeline Heaters", CORROSION 2013, Paper 2259, (Houston TX: NACE International 2013).

12) Dale R. McIntyre, Raymundo P. Case, Tom Ballantyne, Steve Woodward," Environmentally Assisted Cracking of Nickel Steels In Liquid Mercury, Hydrogen and Methanol", CORROSION 2013, Paper 2701, (Houston TX: NACE International 2013).

13) Raymundo P. Case, Hernan E. Rincon, Dale R. McIntyre, Shanen R. Hernandez, "Pit

Metastability and Stress Corrosion Cracking Susceptibility Assessment of Austenitic Stainless Steels in Sour Gas Service Conditions", CORROSION 2013, Paper 2235, Houston TX: NACE International 2013).

14) Mahajanam, S., et al. Evaluation of Cracking and Corrosion Susceptibility in High pH Scale Dissolver CO2-Containing Environment. in CORROSION 2014. paper No 3983. San Antonio, TX: NACE International, 2014.

15) D. McIntyre, R. Case Environmental Effects on Fitness-for Service Parameters For 1% Nickel Steel Pipe Welds with Preferential Weld Corrosion Damage in CORROSION 2015 paper 5820, NACE International, 2015.

16) Mahajanam S. R. Case et al Corrosion Studies of Scale dissolver in Carbon Dioxide Containing Environment, MATERIALS PERFORMANCE VOL. 54, NO. 5.

17) Case, R. P., McIntyre, D. R., & Rincon, H. E. (2016). *Effect of Brine Ionic Strength on Sulfide Stress Cracking Resistance of High Strength Low Alloy Steel*. Paper presented at the CORROSION 2016, Vancouver,2016.

RESEARCH AREAS OF INTEREST

1.**Corrosion damage distribution model for low alloy steels is CO_2/H_2S containing environments**:

The starting point for this model is the stochastical algorithm used in the CO_2 corrosion damage distribution model already published, which has been validated by actual field applications.
However, the stochastical algorithm used is based on two hypotheses which have not been explicitly proved. These are associated with the underlying interpretation of a general corrosion as a Poisson stochastical process and the $FeCO_3$ deposition as Bernoulli random process that leads to a Binomial distribution.

2.Corrosion damage distribution model for stainless steels and CRA's in CO_2/H_2S containing environments:

There is a lack of systematic studies on the effect of H_2S in the pit stability and propagation. Particularly in the alloys of interest to production environments such as 13% Cr family, Duplex and Ni Base alloys.
Once the general pit stability conditions can be defined from the temperatures within the typical deployment envelopes of H_2S and chloride content, a pit propagation model can be established from the theoretical description available in the literature based on the establishing of an aggressive anolyte environment within the pit cavity.
The model is proposed to be based initially on a non-Homogeneous Markov random process since it's the simplest mathematical route to establishing a consistent representation of the physical situation that will provide a verifiable probability distribution for discrete pit depths.

3.Study of the elemental sulphur distribution on the pit growth kinetics and stability in corrosion resistant alloys (CRA).

The interaction between the elemental sulphur and the passive layer has been the subject of extensive coverage in the related literature, particularly the role played by the sulphur and its compounds incorporated to the passive layer via inclusions present in the steel.
However, in relation of the role played by the form by which the elemental sulphur is distributed in the associated environment is only mentioned in relatively small fraction of the available literature. In these the sulphur is distributed via mechanical dispersion or mixing, where the associated increase of pitting susceptibility is attributed to the in surface occurrence of the sulphur reduction reaction to H_2S.

However, experiments carried out using remelted sulphur in solution show that the increase in the cathodic reaction kinetics can occur without apparent physical contact between the elemental sulphur particle and the working electrode surface. This behaviour is explained (partially) by the thermodynamically feasibility of adsorbed elemental sulphur in Fe, Cr and Ni at pH values where their respective passive oxides exists.
In relation to this effect the presence of colloidal sulphur in solution is important to sustain the sulphur reduction reaction as viable cathodic reaction that can support pitting.
Based on the previous considerations, a set of comparative experiments are suggested in order to differentiate the effect that the distribution form of the elemental sulphur can have on the susceptibility of pitting in CRA steels and Ni based alloys.

4.Study liquid metal embrittlement (LME) of CRA and High strength Ti by exposure to metallic Hg.

The presence of metallic Hg in oil and gas production operations is cause of concern in relation to the possibility of liquid metal embritlement (LME) of structural metallic alloys since it has the potential to produce extensive cracking.
The phenomenon of LME although widely reported in the literature is notable due to the lack of a comprehensive mechanistic model that can explain its occurrence in quantitative way. Therefore, the susceptibility must be assessed for each particular alloy considered.
In this sense a way forward is the use of a fracture mechanics approach which will yield information that both in mechanistically relevant and susceptible to be used for engineering purposes.
Based on the previous considerations, an experimental evaluation program for the susceptibility of commonly deployed CRA's and high strength Ti to LME by Hg is proposed. The focus of this is based on the application of Fracture Mechanics in order to assess the degree of embrittlement by means of quantitative parameters.