



CORROSION DEPARTMENT INCL. FRENCH CORROSION INSTITUTE

Research in Progress 2025

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Introduction

Our mission is to utilise the depth and breadth of our corrosion knowledge to guide our partners and customers to achieve sustainable solutions to material problems. With over 60 years of experience and over 100 specialists within corrosion and corrosion protection, we collaborate with industry and society in research projects and consultancy assignments worldwide. Our laboratories include Kista and Borås in Sweden, as well as in France at Brest, St Etienne and Lyon. We also have a many test sites located strategically in order to offer corrosion testing relevant to industry. These include atmospheric weathering sites (Bohus Malmön, Brest, Gällivare), natural seawater facilities (Brest and Kristineberg), soil exposure sites (France and Sweden) and mobile testing on trucks (Sweden).

Through our Member Research Consortia, MRC, over 150 companies participate and contribute to the progress within corrosion science. Our MRC's bring together companies which may otherwise just be competitors, in order to share the cost of R&D work and solve common issues saving money, time and resources. The projects initiated within the 14 different MRC's are formulated from direct industry need and are carried out in collaboration with our member companies. Membership in our MRC's means increased possibilities, expanded networks and access to the most recent knowledge and know-how in corrosion. All our MRC's are open to new members.

The purpose of this Research in Progress publication is to give you an overview of our work, to spread the information of

the areas we are working on. The projects shown here are financed by industry through cost-shared programs, membership through collective programs, European programs, or National and regional agencies. You will also find information about our different MRC's, as well as a list of our publications for 2024.

We hope you will find this Research in Progress brochure interesting and inspiring. Should you find any project of particular interest, please contact the project leader for more information.

Yours Sincerely,

Andrew Gordon,
Department Manager, Corrosion department

Our membership companies are governed by two different non-profit Associations, one established in Sweden (IKI) and the other in France (ARCOR).

For more information on the membership associations, please contact:
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Erwan Diler erwan.diler@institut-corrosion.fr for ARCOR.

Being member of our associations implies joining one of the following Member Research Consortia (MRC).

MRC AUTOMOTIVE CORROSION

Aluminium Duffel BV	Nissan Motor Corporation
Aperam	NOF Metal Coatings
ArcelorMittal	Novelis Switzerland SA.
Auson	Outokumpu Stainless AB/ARC
Baoshan Iron & Steel CO., Ltd	Porsche AG
Chemetall GmbH	POSCO
Constellium	PPG
Daimler Truck AG	Provexa
Dörken Coatings GmbH & Co. KG	Q-LAB
Ford Motor Company	Renault
General Motors LLC	Robert Bosch -GmbH
Gestamp HardTech AB	Scania CV AB
Gränges Sweden AB	Schlötter Svenska AB
Honda Motor Co., Ltd.	Speira
Hydro Extruded Solutions	SSAB EMEA AB
Hyundai Motor Company	Stellantis
Hyundai Steel	Toyota Motor Corporation
Jaguar Land Rover	UACJ Corporation
JFE Steel Corporation	Valeo Thermal Systems
Mercedes-Benz AG	voestalpine
Metalsa S.A.P.I. de C.V.	Volvo Car Corporation
Nemak Linz GmbH	Volvo Technology AB
Nippon Steel Corporation	
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MRC AEROSPACE INDUSTRY

Airbus	Henkel Technologies
Airbus Helicopters	Liebherr
AkzoNobel Car Refinishes	PPG Industries Ltd
Boeing Company	Safran
Constellium	SOCOMORE
DGA	
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MRC SURFACE TECHNOLOGY

ArcelorMittal Global R&D (AC&CS)	SSAB EMEA AB
BASF Coatings GmbH	ProCoat Tecnologias S.L.U.
Becker Industrial Coatings Ltd.	TopAnalytica
Hydro Extruded Solutions	voestalpine Stahl GmbH
Scania CV AB	Volvo Car Corporation
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MRC COIL COATED STEEL MATERIALS

AkzoNobel Hilden GmbH	SNCZ
ArcelorMittal Global R&D (AC&CS)	SSAB EMEA AB
Becker Industrial Coatings Ltd.	TataSteel NL
Bluescope Steel	Ternium Siderar
Chemetall GmbH	The Sherwin Williams Company
Henkel Technologies	VM Building Solutions
Hyundai Steel	voestalpine Stahl GmbH
PPG France Business	
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MRC CORROSION AND CATHODIC PROTECTION IN SOILS

ArcelorMittal R&D Gent (OCAS)	Nippon Steel
ArcelorMittal R&D Esch/Alzette	Nordion Energi AB
BAC Corrosion Control	Storengy
BS Coatings	Tata Steel NL
EDF	Terega
GRTgaz	TotalEnergies One Tech
JFE Steel Corporation	
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MRC CORROSION PROPERTIES OF POLYMER

Aliaxis Research & Technology	Kemira Kemi AB
Amiblu Technology AS	Lubrizol Advanced Materials BV
AOC (Aliancys) Nederland B.V.	Nordpipe Composite Engineering Oy
DOW Deutschland Anlagengesellschaft mbH	Plasticon Germany GMBH
Georg Fischer DEKA GmbH	Polynt Composites Norway AS
Glencore Nikkelverk AS	SABIC Innovative Plastics B.V.
INEOS Composites Germany GmbH	SIMONA AG
INOYIN Manufacturing Belgium SA	
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MRC BRASS ALLOYS

ESBE AB	ISIFLO A/S
FM Mattson Mora Group AB	LK Systems AB
IMI Hydronic Engineering AB	Nordic Brass Gusum AB
ISIFLO AB	
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MRC CORROSION IN PULP AND PAPER INDUSTRY

Billerud Skog & Industri AB, Gävle	Stora Enso AB/ Skoghall Mill
Billerud Sweden AB, Skärblacka Bruk	Södra Skogsägarna ek. för. (Södra Cell Mönsterås)
Billerud Sweden AB, Karlsborgsverken	Södra Skogsägarna ek. förening (Södra Cell Värö)
SCA Obbola AB	Valmet AB
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MRC CORROSION PROTECTION

Carboline Norge A/S	SSAB EMEA AB
DACAR AB	Stockholm Stad, Trafikkontoret
International Färg AB /AkzoNobel	Tikkurila Sverige AB
Hempel A/S	Trafikverket
Hilti Aktiengesellschaft	Zinc Info Norden AB
Hitachi Energy Sweden AB Components	Zingametall BV
NKT HV Cables AB	
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MRC MARINE CORROSION

AB Volvo Penta	Industeel, Arcelor Mittal
Alleima	National Oilwell Varco
Aker Solutions/OneSubsea	Outokumpu Stainless AB
Aker BP	Petrobras
Aperam	Saipem
DGA	TechnipFMC
EDF	Thales DMS
EQUINOR	TotalEnergies One Tech
Grundfos Holding	Vallourec
Harbour Energy	voestalpine Böhler Edelstahl
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MRC PAINT AND LINING FOR STEEL

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AkzoNobel	Orano TN
DGA	Peintures Maestria
EDF	TotalEnergies One Tech
Thalès Group	
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MRC HYDROGEN

Alleima	Schlumberger
Airbus Operation SAS	SHELL
Akzo Nobel UK	Storengy
Aperam	Subsea7 France
Ascometal	Tata Steel NL
Baker Hughes	Technip Energies
DGA	Technip FMC Subsea France
GE Power Conversion	Tenaris
Geostock	Terega
GRTgaz	TotalEnergies One Tech
Industeel, ArcelorMittal	Trapil
NV Bekaert	UGITECH
National Oilwell Varco	Vallourec
OCAS / ArcelorMittal R&D Gent	voestalpine Böhler Edelstahl
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MRC BIOREFINERY

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Aperam	TotalEnergies One Tech
IFPEN	Valmet AB
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MRC CCUS AND H₂S

Alleima	Saipem
Aperam	Subsea7
ArcelorMittal / OCAS	Technip Energies
TechnipFMC-FlexiFrance	TotalEnergies One Tech
National Oilwell Varco	Vallourec
Outokumpu Stainless AB	voestalpine Böhler Edelstahl
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MRC BRINE AND WATERS

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MRC NAVAL PAINT

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TRANSPORT

Project Title: Development of a robust and reliable accelerated corrosion test in the aerospace industry II		Acronym: CorrTestAero II
Research area: Transport, Aerospace	Project period: 01/01/2023 – 01/01/2025	
Research leader: Fabienne Peltier fabienne.peltier@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Aerospace Industry	
	Keywords: Aerospace, corrosion test, aluminium	

It is often considered that aluminium alloys exhibit good resistance to atmospheric corrosion due to the presence of a fine oxide passivating layer. Nevertheless, these alloys are not immune to corrosion which can take the form of localised corrosion like pitting or intergranular corrosion (such as exfoliation corrosion). Thus, the assessment of corrosion behaviour under atmospheric conditions is a major topic for many applications including the aerospace industry. In this context new alloys have been developed in the last decades as alternative to AA 2024. Moreover, in the last decades, new environmental regulations have led to major changes for aluminium corrosion protection. So, by limiting or prohibiting some chemicals (CrVI), the European regulation REACH (Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals) has induced major changes in some finish processes of aluminium alloys (chromate conversion, chromic acid anodizing, chromate sealing).

Hence, from the above, there is a need to qualify new materials and surface finishes for different applications in the aerospace industry (including both exterior and interior applications and maintenance aspects). One major difficulty in this task is the lack of robust and reliable corrosion test(s) in this field. Today salt spray (e.g. ISO 9227) is widely used and it is not representative to service conditions and thus not adapted to new developments (alloys and surface finishes). Another problem is that long term corrosion data under atmospheric conditions for these new alloys are, for the moment, rather limited. Some data on outdoor corrosion of new alloys surface finishes are available but they are restricted to exposure performed at 45° angle in a very few numbers of sites (which normally not favours intergranular corrosion).

In the first project iCorrTestAero devoted to the development of new accelerated corrosion tests, materials with known behavior were selected to be critical on results obtained with the new tests and to determine if the developed test is representative of service conditions. The data have also been correlated to data from field exposures in a marine atmosphere (36 months) to design testing conditions that show the best correlation to the field data.

Based on the results from the matrix of experiment and experience, accelerated tests were selected to be validated in a second phase with different materials with less known behavior.

Project aims:

- To obtain the long-term behaviour of painted materials after 5 years of exposure.
- To implement or validate a test (designed in the first project) which correlates with field exposures on painted materials.
- To study the repeatability and the reproducibility of the test for a standardization of the test in aerospace industry.

TRANSPORT

Project Title: Investigation of the corrosion performance of indoor REACH materials		Acronym: PerfpaintAlu
Research area: Transport, Aerospace	Project period: 31/12/2022 – 31/12/2025	
Research leader: Fabienne Peltier fabienne.peltier@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Aerospace, REACH materials	

Aluminum alloys are relatively low cost, light weight alloys and can be heat treated and loaded to relatively high levels of stress. However, as they are not immune to corrosion, it is important to assess their corrosion behavior under atmospheric conditions. To limit the corrosion of aluminum alloys, paints are generally applied on the materials. The corrosion protection in aerospace consisted mainly in CrVI-paint (primer, topcoat ...) However, new environmental regulations have led to major changes for aluminum corrosion protection. By limiting or prohibiting some chemicals as for instance CrVI, the European regulation REACH (Regulation on Registration Evaluation, Authorization and Restriction of Chemicals) has induced major changes in some finish processes of aluminum alloys (chromate conversion, chromic acid anodizing, chromate sealing).

Various projects have been carried out by the French Corrosion Institute on the corrosion performance of new surface finishes (CrVI free) but they were mainly used for exterior applications.

In view of the literature and the experience acquired on Cr-free coatings, it appears more and more that interesting alternatives to CrVI were highlighted but these studies mainly provided knowledge and confidence for outdoor coatings applications. Consequently, there is a lack of knowledges on protection performance of indoor coatings applications since the conditions (e.g., condensation...), the type of corrosion or the modes of failures (galvanic corrosion, crevice corrosion...) encountered inside the plane cannot be compared to those observed at the exterior of the aircraft (rinsing conditions...).

Hence, from this background, there is a need to investigate the performance and the mechanisms of protection of new REACH systems for indoor applications in the aerospace industry.

Project aims:

- To define a testing protocol for indoor Cr free coatings.
- To assess the long-term durability and corrosion performance of indoor REACH systems.
- To understand the mechanisms of protection of selected systems.

TRANSPORT

Project Title: Solutions for Corrosion Optimized and Prediction with Efficient Network of Environment Sensors		Acronym: Scorpenes
Research area: Transport, Aerospace	Project period: 01/01/2023 – 31/12/2026	
Research leader: Nathalie LeBozec & Johan Becker nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: Public Funding (EDA)	
	Keywords: Aeronautic, condition-based maintenance, sensors	

Degradations due to corrosion are a major concern in aeronautic and related issues can appear along the service life of aircraft and helicopters. Although materials and protective coatings are carefully selected to prevent onset of corrosion, exposure to harsh environments, e.g. to marine conditions or decontamination agents may still conduct to corrosion of structural parts. Evidence of corrosion is usually assessed during scheduled maintenance operations which are not considering in-service conditions (exposure to salt contaminants, high relative humidity levels, temperature variations ...) of helicopters and aircraft. This type of maintenance may be therefore inadequate being too extensive or insufficient. Developing solutions enabling to trigger maintenance operations is therefore of great interest and would significantly reduce costs and increase the availability of aircraft and helicopters.

The main objective of the project is therefore to build a condition-based maintenance solution related to corrosion management on aircraft and helicopters and to improve the corrosion testing reliability. This will be achieved through developments and tests of environmental sensors, corrosion monitoring techniques and assessments on specimens aiming to reproduce real helicopters/aircraft assemblies. The design of an accelerated corrosion test to better reproduce in-service conditions will be also investigated.

Project aims:

- To understand, model and simulate the aging of sensors in variety of environmental conditions representative of flight conditions.
- To identify, understand and simulate representative level of corrosion of structures to implement adequate maintenance solutions.

TRANSPORT

Project Title: Investigation of the corrosion performance of indoor REACH materials		Acronym: GalvanIC
Research area: Transport, Aerospace	Project period: 01/07/2023 – 01/07/2025	
Research leader: Fabienne Peltier & Johan Becker fabienne.peltier@institut-corrosion.fr johan.becker@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Aerospace, galvanic corrosion, sensors	

The development of new materials in the aerospace industry creates more risks for serious galvanic corrosion, stress corrosion cracking and fatigue-corrosion issues. The galvanic corrosion between dissimilar materials is a primary cause of structural failure of aircraft (asfor example, cracks), commonly initiated from galvanically driven corrosion pits around fastener holes. The presence of corrosion damage also reduces the fatigue life of components to a severe extent. Corrosion analyses have demonstrated that galvanic corrosion risk is determined by the corrosion current between two pieces made of dissimilar materials, which is a function of surface chemistry and electrochemical reactions that vary with surface treatments and service environments. At the same time, environmental regulations require that long-standing protective coatings containing cadmium and hexavalent chromium must be replaced with alternative materials, which may not perform as well as their predecessors. Thus, to make good design and maintenance material choices for future aircrafts, there is a growing need to predict and quantify galvanic corrosion risk at material interfaces.

The objective of this project is to build a database on the risks of galvanic coupling under atmospheric corrosion conditions for various materials and paint systems. A specific setup developed at the French Corrosion institute to follow galvanic coupling for up to 60 specimens in parallel under accelerated corrosion tests is used under opened and confined conditions for the selected combinations of materials. In addition, commercially available corrosion sensing solutions will be used to monitor in real-time the self-corrosion and response of the painted aluminum substrate.

Project aims:

- Build a database on the risks of galvanic coupling under atmospheric corrosion conditions for various materials and paint systems.
- Evaluate the galvanic coupling under both opened and confined conditions.
- Monitor in real time the self-corrosion and response and aluminum substrate based on ER sensor.

TRANSPORT

Project Title: Instrumentation and Standardization of accelerated corrosion test		Acronym: INSTANT
Research area: Transport, Aerospace	Project period: 01/08/2024 – 01/08/2028	
Research leader: Fabienne Peltier & Johan Becker fabienne.peltier@institut-corrosion.fr johan.becker@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Accelerated corrosion tests, bare alloys, painted aluminium alloys, sensors, Al	

Aluminum alloys are not immune to corrosion which can take the form of localized corrosion. Thus, the assessment of the corrosion behavior of aluminum alloys under atmospheric conditions is a major topic for the aerospace industry. One major difficulty in this task is the lack of robust and reliable accelerated corrosion test(s) in this field. Indeed, several tests such as the Neutral Salt Spray Test (ASTM B117) are used to assess the general corrosion resistance of aluminum, but these tests were not developed specifically for the aerospace industry and are not representative of service conditions.

Other tests have been developed in the automotive industry and have been used in a multi material concept to test steel-based materials and aluminum alloys (mostly from the 3000,5000 and 6000 series). However, the experience with aerospace materials in cyclic corrosion tests is rather limited. This project aims therefore to deepen the understanding of the corrosion processes of bare and painted aluminum alloys in more representative cyclic corrosion tests. This will be conducted through i) the assessment of the performances of different systems in terms of resistance to cyclic corrosion tests in recently developed and standardized cyclic corrosion tests, ii) comparisons with the behavior of similar systems in field conditions (Brest and Mumbai) and iii) the development of a statistical and physical model builds from electrical resistance (ER) corrosion sensor data, galvanic current and from material characterizations.

Project aims:

- Deepen the understanding of the corrosion processes of bare and painted aluminum alloys in more representative cyclic corrosion tests.
- Standardize of an accelerated cyclic testing method for aerospace applications.
- Develop a statistical and physical model builds from both sensor data and material characterizations.

TRANSPORT

Project Title: Environmental Induced Cracking Susceptibility in Aluminium Alloys for sustainable Electrification of Heavy-Duty Vehicles		Acronym: EICAL
Research area: Transport, Automotive	Project period: 01/04/2022 – 31/12/2025	
Research leader: Salil Sainis salil.sainis@ri.se +46 73 084 16 65	Source of funding: Public funding (Swedish Energy Agency)	
	Keywords: Aluminium alloys, Al-Si, Al-Mg-Si, VDA atmospheric corrosion, fatigue, SSRT, 4-point bend strain, mobile truck exposure, localized corrosion, microstructure, SEM, SKPFM	

This project investigates the sensitivity to environmentally induced cracking of recycled aluminium when combining stress and corrosion that may lead to a reduced technical lifespan. Cast aluminium alloys (Al-Si type) investigated contains higher recycled content. Also included are forged (Al-Mg-Si type) alloys used for truck wheel rims. Corrosion and fatigue studies are carried out both in the lab and for the mobile road condition to be compared the outcome to understand their relations.

Lab tests simulate the corrosive situation adding stresses (strain and fatigue) to mimic field road situation but also mechanistically understand the effect of chlorides, pH, and temperatures. Results from such static stress and/or dynamic loads (fatigue) test situations of corrosion exposed aluminium samples will be evaluated.

Laboratory atmospheric corrosion test for automotive parts using VDA233-102 test standard will produce corroded samples. For the forged (Al-Mg-Si type) we modified this test applying a special corrosive mud for better acceleration effect corresponding closer to road conditions. These sequentially tested samples with corroded defects are run through a resonant fatigue test machine to understand reduction compared to nominal samples. Stress cracked surfaces will be studied by SEM.

Furthermore, a combined in situ corrosion fatigue test using low frequency fatigue set-ups inside a corrosion lab chamber while running the VDA test will be studied. In this way we can compare results to the sequential fatigue test data to understand if these two approaches differentiate or not.

A deeper understanding of corrosion mechanisms related to microstructure using SKPFM electrochemical technique will support us in understanding how microstructure-corrosion-stress related effects to aluminium alloys in the project are related. Results in the above lab tests will finally be compared to both free- and strained aluminium samples exposed to the road environment when fit to truck trailers for a period of two years.

Project aims:

- Understand the effect of road conditions on aluminium corrosion and how this impacts fatigue life, both for primary and recycled alloys used for heavy transport vehicles.
- Develop a more rapid methodology to test the stress-load perspective of road conditions.
- Determine whether recycled alloys are more susceptible to corrosion and applied stresses.
- Describe and evaluate the corrosion mechanisms of these alloys in greater detail looking at microstructures and impact of chlorides, pH and temperature.

TRANSPORT

Project Title: Development of an accelerated corrosion test that better mimic field conditions		Acronym: MRC-AC 21
Research area: Transport, Automotive	Project period: 01/01/2024 – 31/12/2025	
Research leader: Bo Rendahl bo.rendahl@ri.se +46 10 228 4858	Source of funding: MRC Automotive Corrosion	
	Keywords: Accelerated corrosion testing, Mobile on-vehicle exposure	

The studies performed on the corrosivity in road environment have shown that approximately 90% of the corrosion takes place during the winter period when there is frequent use of de-icing salt on the roads but also rather low temperatures.

When looking into the OEM's different accelerated corrosion tests, all of them increase the corrosivity of the test with high temperatures. The corrosion mechanism taken place at these higher temperatures will probably not be the same as what will be found in the field. An accelerated test at lower winter temperatures might thus better mimic the corrosion observed in the field.

The activities within the project are to perform a series of cyclic corrosion tests with selected automotive materials together with atmospheric corrosion sensors at lower temperatures. The new tests at lower temperatures will have a considerably lower acceleration factor compared with the OEM's cyclic test used today and therefore the exposure period will become much longer.

Project aims:
From the obtained results and together with existing field data try to develop an accelerated corrosion test that better mimics the corrosion observed in the field.

TRANSPORT

Project Title: Warm Press-Formed Zinc-Coated Third Generation Advanced High Strength Steels with High Crash and Corrosion Resistance and Mini-mized Microcracking		Acronym: WarP-AHSS
Research area: Transport, Automotive	Project period: 01/10/2023 – 31/03/2027	
Research leader: Dominique Thierry & Christophe Mendibide dominique.thierry@ri.se christophe.mendibide@institut-corrosion.fr +33 676 80 66 76	Source of funding: European funding (RFCS)	
	Keywords: Medium manganese steel, Automotive corrosion, LME, hot stamping	

Steel sheets at automakers are formed in different ways (e.g. cold forming, hot forming, roll forming etc.) for use in car bodies. Hot stamping (or hot forming or hot pressing or press hardening) is one of the forming methods for automotive components which is growing rapidly in Europe. The major process steps for producing sheet steels at the steelmaker and their processing at the automaker using the hot forming process. Hot stamping allows manufacturing of complex parts with minimal spring back, which is not possible by cold stamping process, while simultaneously achieving ultrahigh strength levels in service.

“Medium manganese steels” (MMnS) are candidate materials for the 3rd generation advanced high strength steels. These steels typically contain 3-12 wt.% Mn, along with low C in a ferritic and/or martensitic matrix. The broad possibility of changing the heat treatment of these steels can lead to a wide spectrum of final mechanical properties (Rm ~ 800-1500 MPa and A ~ 10-45%) that can be achieved. Interestingly, the relatively high amount of Mn additions in MMnS decreases the ferrite-to-austenite transformation temperature (Ae3) in these steels. Although MMnS are usually intended for cold stamping applications, their low Ae3 can allow lower reheating and hot stamping temperatures if used for hot stamping leading to a “warm stamping” process. This possibility can ensure that during the warm stamping of Zn-coated sheet steel no Zn-rich liquid phase is in contact with the steel substrate minimizing the risk of LME and associated coating degradation.

Project aims:

- To develop “warm pressed” medium Mn steel products that will use significantly lower processing temperatures enabling the use of Zn-coated sheet steels for warm stamping parts.
- To avoid the occurrence of LME and other coating and surface degradations during warm stamping.

The consortium is formed with the following partners: Tata Steel (Coordinator), Steel Institute (IEHK) of RWTH, RISE, CSIC-CENIM and Volkswagen.

TRANSPORT

Project Title: Comparison of different automotive accelerated corrosion standards		Acronym: MRC-29
Research area: Transport, Automotive	Project period: 01/05/2023 – 31/12/2025	
Research leader: Clara Linder clara.linder@ri.se +46 70 562 47 04	Source of funding: MRC Automotive Corrosion	
	Keywords: Accelerated corrosion testing, bimetallic corrosion	

Most of the OEM's have their own accelerated corrosion test with their own knowledge about the correlation to the field data. Important parameters for the corrosivity of the test are among others, salt concentration, droplet size, frequency of spraying, and temperature and relative humidity e.g. wet and dry phases.

The MRC Automotive corrosion projects often use the German standard VDA 233-102 (DIN 55635) but its correlation to other standards is not always well known.

Six different standardised accelerated corrosion tests have been chosen to be a part of the project. The test matrix includes samples such as:

- Cosmetic panels of CRS, GI60, ZM60 and AA6016 with both thin-film and phosphate pretreatment.
- Creviced samples in GI60, ZM60, PHS (AISI) and bimetallic samples with the combinations GI60-AA6016 and GI60-PHS(AISI).
- Reference panels of CRS and Zn.
- Zn-flake and Zn-Ni coated fasteners in combination with cast aluminium.

Project aims:
The aim with the project is to include materials and sample designs of interest to bench mark the OEMs test methods.

TRANSPORT

Project Title: Galvanic coupling of die cast Aluminum and coated steel fastener		Acronym: MRC-32
Research area: Transport, Automotive	Project period: 01/01/2024 – 31/12/2025	
Research leader: Bo Rendahl bo.rendahl@ri.se +46 10 228 4858	Source of funding: MRC Automotive Corrosion	
	Keywords: Mega casting, die cast aluminum, Zn flake fasteners, galvanic corrosion, mobile exposure, accelerated corrosion test	

The transition towards e-mobility and the need to lower the weight of vehicles has entailed higher use of lightweight materials. The amount of aluminum in vehicles is increasing due to the combined properties of low weight, high strength, and good corrosion resistance. The environmental impact of new production of aluminum is huge and it will be necessary to use more and more recirculated materials. Recycled or secondary die cast aluminum can contain higher amount of impurities e.g. Cu and Fe resulting in the risk of lowering the corrosion resistance of the material. The risk of galvanic corrosion when assembling coated steel fasteners towards die cast aluminum in accelerated corrosion tests and in the severe road environment will be studied.

Project aims:
Learn more about contact corrosion behavior of representative aluminum alloys coupled with coated fasteners e.g. Zn flake, ZnNi, ZnFe, ZnSn, Stainless steel (or EPDM sealings) to be able to provide recommendations for corrosion avoidance and material choice.
Primary and secondary die cast aluminum combined with different types of coated steel fasteners will be exposed to different types of accelerated corrosion tests as well as during mobile on-vehicle exposures.
A methodology to measure the galvanic current between the fasteners and the aluminum during the different phases in the accelerated corrosion tests will be established. The result from the galvanic measurements will be compared with the findings of corrosion attack on fasteners and on the aluminum material.

In a second phase the methodology will be used for measuring the galvanic corrosion in a field exposure.

TRANSPORT

Project Title: Field survey		Acronym: MRC-30
Research area: Transport, Automotive	Project period: 01/04/2023 – 31/12/2025	
Research leader: Bo Rendahl bo.rendahl@ri.se +46 10 228 4858	Source of funding: MRC Automotive Corrosion	
	Keywords: Real-life performance	

RISE has performed several surveys of the corrosion resistance of the car body. Parts of the car body have been collected from dismantling plants from collision damaged vehicles. The last survey was reported 2014 and included inspection of more than 1900 crevice surfaces of year models 2006 to 2009. A follow up project but in a minor extent is run within the MRC Automotive corrosion.

The project has two focus areas whereas the first one is focusing on thin-film technology as a replacement to phosphating. Thin-film technology have been used by some OEMs for more than 10 years, it is thereby possible to get access to vehicles that have been in service for a long period of time.

The second focus is to investigate the effect of design, adhesives and sealers by collecting hem-flanges and spot-welded joints from chosen car models. The parts will be opened, documented and, if interesting, evaluated with respect to corrosion.

Project aims:

- Investigate the performance of vehicles pre-treated with thin-film technology after 5 to 10 years in service in one of the most corrosive road networks in the world.
- Evaluate and compare the corrosion resistance of the car body of some recent models and to evaluate the effects of design as well as adhesives and sealers.

TRANSPORT

Project Title: Influence of the composition of recycled cast aluminum alloys on their corrosion and fatigue corrosion performance		Acronym: ReCalCor
Research area: Transport, Automotive	Project period: 01/05/2023 – 31/12/2026	
Research leader: Flavien Vucko & Bo Rendahl flavien.vucko@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Cast Aluminum, recycling, fatigue	

In the automotive industry, the transition towards global e-mobility to fulfill current and future CO2 emission regulations is quite challenging. Extensive research and developments are done to improve the efficiency of electric engines and to reduce the weight of batteries. However, the decrease of the weight of the vehicle itself is of key importance for its energy efficiency and carbon footprint. In addition to this, the use of recycled materials, in particular aluminum alloys, can even further improve the environmental impact the vehicle manufacturing.

To lighten future vehicles, multi-material concepts are necessary, and aluminum alloys are of high interest due to their versatile properties combining lightweight, high strength and good corrosion properties. Die-cast aluminum alloys is a material of choice for complex geometries. The current trends towards mega-casting will make it even more important. Indeed such technique allow to improve profitability by reducing assembly time, length of the assembly line, but need further developments in terms of component design to optimize their weight. Mega-casting also helps to increase the material utilization as well as the use of secondary aluminum.

For the integrity of the cast components, both pitting and intergranular corrosion are particularly risky in case of high or cyclic loads as both could act as crack initiation sites. Combination of mechanical stress and corrosive environments could also lead to environmental assisted cracking or fatigue-corrosion mechanisms that would even further reduce the lifetime of the component.

As a conclusion, the corrosion behavior of secondary cast aluminum and its impact on mechanical and fatigue behavior must be investigated to anticipate the risk of failure under service conditions.

Project aims:

- Investigate the influence of Cu and Fe content on the corrosion properties of various commercially available cast alloys.
- Investigate the properties of model cast alloys to mimic successive recycling operations.
- Quantify the impact of corrosion on the mechanical properties and fatigue/fatigue-corrosion performance of the cast alloys.
- Gives recommendation in terms of material selection and design of cast parts made of secondary alloys.

TRANSPORT

Project Title: Assessment of Corrosivity Towards Automotive Materials in Road Environments		Acronym: ACTAM
Research area: Transport, Automotive	Project period: 01/06/2024 – 31/05/2028	
Research leader: Bo Rendahl bo.rendahl@ri.se +46 10 228 4858	Source of funding: Industrial funding	
	Keywords: Mobile exposure, Corrosivity, Road environment	

In the last decade, there have been a strong focus in the automotive industry on lowering the weight of the vehicles with the aim to reduce the emissions. Extended research has been carried out to facilitate the use of lightweight materials in vehicles. The latest transition, going from vehicles with combustion engine to introducing hybrid and electric vehicles has been made over a short period of time. This introduces new challenges with respect to corrosion, with one being linked to the battery housing. OEMs have different solutions to cover and protect the battery, for example by a battery housing produced in cast or extruded aluminium or coated or uncoated steel with E-coating etc. Other transitions are the use of more environmentally friendly pre-treatments to replace the phosphating process and the use of E-coatings with lower curing temperatures due to the increased cost for energy. The aim to lower the carbon footprints has put a lot of attention on the increased use of re-circulated materials, in specific aluminium alloys both as sheet materials and the forecasted higher use of cast aluminum materials. The changes in the climate, with more extreme weather conditions as well as an increased global average temperature, might have an impact on the corrosivity in the road environments and this study aims to give valuable data to map the road environment in different areas of the world.

The project is divided into 5 work packages dedicated to assessment of corrosivity in selected areas.

WP1 - Selection of exposure areas

WP2 - Material selection and specimen preparations

WP3 - Evaluation methods to assess corrosivity

WP4 - Monitoring and analyses of road environments

WP5 - Analyses of corrosion products

Project aims:

- To assess the corrosivity towards different materials, coatings, and configurations used within the automotive industry, in selected areas of the world.
- To establish correlation between the relative corrosivity of different materials and environmental data at different exposure locations (composition of road mud, temperature, relative humidity).
- To gain more knowledge in terms of environmental parameters affecting the corrosion of materials used for automotive applications.

TRANSPORT

Project Title: Plastics in electric machines: Ageing mechanisms and the development of new sustainable solutions		Acronym: InElect
Research area: Transport, Automotive	Project period: 01/01/2022 – 31/12/2026	
Research leader: Andrew Gordon andrew.gordon@ri.se +46 10 228 48 55	Source of funding: Public funding (Swedish Energy Agency)	
	Keywords: Electrical vehicle, EV, plastic, aging of plastic insulation, cable insulation, electrification	

The transition to a society with electrical vehicles requires improved power and long-term reliability of the electrical machine. A key component to improve is the plastic insulation around copper wires and other electrical components. The project aims to study aging mechanisms in plastic insulation under conditions like real service life.

A more sustainable society combatting climate changes requires that more and more vehicles are driven with battery. For a complete change the power of the motor needs to be increased, and the reliability and long-term properties also needs to be improved. A bottleneck in the performance of the motor, and to reach higher power, is the properties of the plastic insulation covering the copper wires and other plastic parts in the machine. During service, especially the insulation is exposed to high temperature, oxygen, moisture and oil, which leads to component ageing through oxidation and/or hydrolysis. A failing insulation leads to corrosion of the copper wire and eventually electric short cuts.

To be able to improve the wire insulation and improve the machine performance, knowledge needs to be obtained on how the local environment affects and age the insulation as well as other plastic parts. This is an important part of the project, which will enable an optimized choice of the plastic components, oil-additives and cooling system. Part of the project will be to set up a lab scale equipment that allows for efficient and accelerated testing of the plastic components (including the wire insulation) in relevant machine environments. The project will also involve scale-up testing in a small machine/prototype motor. A specific work package will focus on involving biobased plastic and oil in the future electric machine.

Project aims:

- To develop understanding of aging and breakdown mechanisms of cable insulation in EV.
- Increase the efficiency of electrical machines to higher voltages (800 and 1200 V).
- Increase the sustainability of the insulation material, other plastic machine components and oil/lubricant by increasing the bio-based content.
- Improve the reliability of the e-machine and decrease the failure rate. Electrical insulation is one of the most critical functions in the e-motor/machine system.

TRANSPORT

Project Title: Hydrogen Embrittlement and Corrosion Resistant Coatings for Ultra High Strength Automotive Steels		Acronym: HyCoat
Research area: Transport, Automotive	Project period: 28/10/2024 – 30/06/2025	
Research leader: Smita G. Rao smita.gangaprasad.rao@ri.se +46 10 228 47 87	Source of funding: Public funding (Vinnova)	
	Keywords: Hydrogen Embrittlement (HE), Ultra-High Strength Steels (UHSS), Corrosion-Resistant Coatings	

The HyCoat (Hydrogen Embrittlement and Corrosion Resistant Coatings for Ultra High Strength Automotive Steels) project focuses on developing novel corrosion-resistant coatings to enable the safe use of ultra-high strength steels (UHSS) in the automotive sector.

As the industry aims to reduce CO₂ emissions by decreasing vehicle weight, martensitic UHSS—with strengths exceeding 1500 MPa—offers an ideal solution. However, these steels are highly susceptible to hydrogen embrittlement (HE), especially when coated with conventional zinc (Zn) coatings applied through electro galvanizing (EG), which can promote hydrogen formation and absorption during corrosion.

The HyCoat project explores alternative aluminum (Al)-based coatings deposited using Physical Vapor Deposition (PVD) as a means to reduce the risk of HE while maintaining strong corrosion protection. These coatings will be directly compared with traditional EG Zn coatings to assess their performance in real-world conditions.

RISE conducts a range of corrosion and electrochemical tests under simulated service conditions. This includes open circuit potential (OCP) and linear polarization (LP) measurements to assess the pitting resistance of the Al-based coatings, as well as cyclic corrosion tests following industry standards (e.g., VDA233-102) to simulate real-world exposure. RISE also examines the impact of coating damage and applied strain on corrosion behavior, providing insights into the long-term durability and protective performance of the coatings. This work is critical for ranking the coatings and identifying the most promising solutions for further development in a full-scale project.

This work is performed under collaboration with Swerim in Sweden. Swerim AB is the coordinator of the HyCoat project and main responsible in evaluation the susceptibility of the UHSS with various coatings to hydrogen embrittlement (HE). Assessment to HE susceptibility Swerim AB is carrying out through establishing correlation between the mechanical performance of the coated UHSS in simulated corrosive environment through performing a step load testing (VDA 238-201) and analysis of hydrogen level and trapping using thermal desorption spectroscopy coupled with mass spectrometry (TDMS). Moreover, to establish link between the HE sensitivity and coatings type Swerim AB also contributes with in depth characterization of the coatings in aspect of microstructure, morphology chemical composition, thickness, elemental depth distribution and adhesion of the coatings using Scanning Electron Microscopy (SEM-EDS) and Glow-Discharge Optical Emission Spectroscopy (GDOES).

Project aims:

- Develop new coatings for UHSS.
- Evaluate corrosion and hydrogen embrittlement performance of new coatings.
- Lay a foundation for a full-scale implementation.

TRANSPORT

Project Title: Renewable Advanced high strength steels for Vehicle Efficiency and Sustainability		Acronym: RAVES
Research area: Transport, Automotive	Project period: 01/01/2025 – 31/12/2027	
Research leader: Flavien Vucko & Salil Sainis flavien.vucko@institut-corrosion.fr salil.sainis@ri.se +33 298 05 15 52	Source of funding: European funding (RFCS)	
	Keywords: Steel Circularity, Advanced High Strength Steels	

As steel remains the dominant material in the automotive sector—accounting for 16% of the global 1.85 billion tons annual steel production—it also contributes to nearly 30% of global industrial CO₂ emissions. Traditional steelmaking processes have limited capacity for scrap steel integration, while alternative methods allow for significantly higher scrap utilization, offering substantial potential for carbon reduction.

The RAVES (Renewable Advanced High Strength Steels for Vehicle Efficiency and Sustainability) project aims to look into these alternative methods and develop strategies to produce advanced high strength steels (AHSS) from end-of-life vehicles (ELV).

The project focuses on defining acceptable residual levels in future steels, understanding the impact of contaminants on AHSS microstructures, and optimizing thermo-mechanical treatments to ensure desired properties. It also investigates the risk of defects like cracking and embrittlement due to contaminant interactions, building a comprehensive database linking composition, microstructure, and performance.

Using advanced techniques such as atomic force microscopy (AFM) for detailed microstructure analysis and scanning kelvin probe Force microscopy (SKPFM) to study the electrochemical properties of inclusions, combined with accelerated corrosion testing under simulated real-world conditions, RISE contributes to the project by investigating how contaminants influence material performance. RISE also aims to lead in-situ corrosion studies using synchrotron-based ambient pressure X-ray photoelectron spectroscopy (AP-XPS) to analyze surface changes during exposure. These contributions help develop robust, high-quality secondary AHSS, supporting a more sustainable and circular automotive industry.

Project aims:

- Enhance steel circularity.
- Understand contaminant impact of AHSS properties.

TRANSPORT

Project Title: Towards Zero emission 3D printed copper electrical motor Windings		Acronym: Z-3D-Windings
Research area: Transport, Automotive	Project period: 01/09/2024 – 01/09/2027	
Research leader: Andrew Gordon andrew.gordon@ri.se +46 10 228 48 55	Source of funding: Public funding (Swedish Energy Agency)	
	Keywords: Electrification, copper, additive manufacturing	

This Z-3D-Windings project aims to transform the manufacturing of electric motor windings using advanced additive manufacturing (AM) by evaluating the technical challenges and environmental impact of the process.

These more flexible designs that can be made with AM should i) reduce some harmonic losses in the motors, ii) create more efficient space utilization for copper in the motor, iii) allow for more efficient and built-in cooling, iv) increase the power/efficiency of the motors, v) improve the recyclability of the motors at the end of their lifetime. This project aims to increase the speed of this innovation to be used in the electric vehicle market, resulting in improved performance and durability.

Project aims:

- This project aims to create and evaluate more efficient motor designs with improved field factors and reduced environmental impacts, by exploiting the use of additive manufacturing.

TRANSPORT

Project Title: Hydrogen effect on the formability of 3rd generation advanced high strength steels to be used for future vehicle designs		Acronym: H₂FORM₃G
Research area: Transport, Automotive	Project period: 01/07/2024 – 31/12/2027	
Research leader: Flavien Vucko flavien.vucko@institut-corrosion.fr +33 298051552	Source of funding: Public funding (RFCS)	
	Keywords: 3rd generation AHSS, hydrogen embrittlement, formability	

Understanding the effect of hydrogen on the formability of 3rd generation AHSS is crucial to fully exploit their great potential as cost-effective and sustainable lightweight solutions for future mobility. Therefore, the main objective of H2FORM3G is to provide the necessary tools to prevent the risk of cracking during the manufacture of automotive components and reduce the risk of delayed fracture after forming. To reach this goal, the project aims to generate a comprehensive understanding of the interaction between hydrogen and the microstructure of quenching and partitioning (Q&P) steels during the process of forming to ensure its safe application in the manufacture of lightweight automotive parts at affordable costs. The project includes the development of new characterization methodologies and predictive models that will contribute to accelerate the design and optimization of new automotive components made of 3rd Generation AHSS with reduced weight (10 - 20% with corresponding savings in CO₂ emissions) and improved crash-safety performance. The application of these new methodologies and models will 1) reduce the time to market of new high performance steel products by reducing the time and cost of prototype validation, 2) reduce the number of failed parts during production due to more accurate determination of risk of cracking during forming, and 3) reduce the amount of material waste (estimated 25% reduction in scrap and failed parts compared to the current situation and 20% GHG emission savings based on machine usage/time reduction) by limiting the use of trial and error methods and encouraging the use of digital predictive models. H2FORM3G solutions are expected to strengthen the technological competitiveness of the EU steel and automotive industry (accounting for 6.1% of total EU employment), crucial for Europe's prosperity (the automotive industry alone represents over 7% of the EU's gross domestic product).

Project aims:

- To establish a relationship between hydrogen content, microstructure evolution (phase transformation of austenite to martensite) and the mechanical behaviour of 3rd Gen steel grades.
- To better understand the hydrogen embrittlement mechanisms by the development of a microscopic scale model based on a crystal plasticity constitutive law coupled to a hydrogen diffusion model.
- To determine an appropriate failure criterion thanks to the full characterisation of the forming limit curves on as-received and hydrogen charged materials.
- To evaluate the risk of hydrogen-assisted cracking during manufacturing and the risk of delayed fracture after forming.
- To quantify the environmental impact of the proposed solutions.

SURFACE PROTECTION

Project Title: Recycled aluminium alloy coatings with chemically tailored electro-chemical potential for safe protection of steel structures		Acronym: ALCOAT
Research area: Surface protection, Automotive	Project period: 01/09/2023 – 28/02/2028	
Research leader: Dominique Thierry dominique.thierry@ri.se +33 676 80 66 76	Source of funding: European funding (RFCS)	
	Keywords: Metallic coatings, high strength steel, galvanic protection, Aluminium, Hydrogen embrittlement	

Although currently indispensable in steel corrosion protection, zinc coatings have several drawbacks, including lower corrosion resistance in marine environments, the risk of hydrogen embrittlement when applied to high strength steels, and a relatively low recycling rate. The only economically viable alternative metallic coating material, aluminium, is cheaper, lighter, widely available, and more corrosion resistant. However, it is unable to provide sufficient protection to steel in defects, leading to red rust formation, and thus it is used only marginally.

Project aims:

To solve these shortcomings, this project will develop two new families of aluminium alloy coatings for protection of wind towers, ships, and other structures exposed to sea water and atmosphere, and steel sheet products for automotive, building, and home appliance industries. The coating composition and microstructure will be designed using advanced computational and molecular modelling. A novel, ground-breaking chemically-tailored potential difference concept will be developed and applied to precisely tailor the potential difference between the coatings and steel substrate in relevant environments. Application of this revolutionary concept will ensure that the corrosion potential of the coatings is more negative than that of steel guaranteeing thus sacrificial protection of steel in defects and protection against red rust formation, and still more noble than that of zinc, which is in a range where the risk of hydrogen embrittlement exists.

The new coatings will be more sustainable than zinc coatings due to lower corrosion rate, lighter due to lower specific mass of aluminium, ensure savings of primary raw materials due to use of iron-contaminated aluminium scrap, and improve the safety of steel constructions due to no risk of hydrogen embrittlement.

The consortium comprises the following partners: University of Chemistry and Technology Prague (Coordinator), RISE, Výzkumný a zkušební ústav Plzeň, Tata Steel Nederland Technology B.V., Catalan Institute of Nanoscience and Nanotechnology, RMIT Europe, RMIT University, Pyrogenesis SA.

SURFACE PROTECTION

Project Title: Elyfog - Testing and development of long-term reliable electrical contacts		Acronym: Elyfog
Research area: Surface protection, Automotive	Project period: 15/09/2023 – 15/09/2026	
Research leader: Karin Törne karin.torne@ri.se +46 8 674 17 01	Source of funding: Public funding (Vinnova)	
	Keywords: Electric vehicles, contact resistance, aging	

In electric powertrains, fast charging and discharging of batteries and high voltages, current, and power levels and other stresses make the characteristics of the electrical contacts critical for the basic functions of the vehicles as well as for lighting, window lifts, infotainment, etc. In other words, faulty or inferior contacts will cause unnecessary energy losses, non-functioning or at worst inoperative vehicles. It is therefore critical for EV OEMs to ensure they are using highly reliable electrical connection concepts, designed to withstand the higher voltages and temperatures sustained in these environments. Depending on the mounting location of the electrical connection also environmental exposure and corrosion resistance needs to be considered as well.

The project will analyse how different materials, surface treatment, concept, and assembly affect performance and long-term properties. Properties to evaluate are primarily: mechanical joint strength and electrical contact resistance (structural and functional characteristics) in correlation to the chosen configuration (geometry, surface properties, materials, fasteners, assembly parameters). Changes of the parameters during exposure to mechanical, electrical and environmental loads will also be evaluated.

Project aims:

- Development of a test rig allowing for simultaneous application of two or more stresses and online measurement of electrical contact resistance over the runtime of the experiment.
- Evaluation of at least 3 established material combinations and surface treatment for electrical contacts and development of at least 3 optimized combinations for a comparative study.
- Instructions and guidelines for testing, material selection and assembly to improve connection lifetime and guidelines for re-using connection parts and the use of recycled materials in electrical connections.

SURFACE PROTECTION

Project Title: Respirometry technique for corrosion studies		Acronym: Respirometer
Research area: Surface protection, Automotive	Project period: 16/11/2023 – 30/04/2025	
Research leader: Dominique Thierry & Smita Gangaprasad Rao dominique.thierry@ri.se +33 676 80 66 76	Source of funding: Public funding (Hugo Carlssons stiftelse)	
	Keywords: Oxygen reduction, hydrogen evolution, corrosion monitoring	

The mobility/transportation sector has high targets in reducing the CO₂ emissions from vehicles. To achieve this, reducing the weight of the vehicles is required. Utilization of steels with strength over 1500 MPa known as ultra-high strength steels (UHSS) are potential candidates for such applications. However, UHSS are susceptible to hydrogen embrittlement (HE). Hydrogen embrittlement is a metal's loss of ductility and reduction of load bearing capability due to the absorption of hydrogen atoms or molecules by the metal. The result of hydrogen embrittlement is that components crack and fracture at stresses less than the yield strength of the metal.

During corrosion the oxidation of the metal releases electrons which must be consumed to ensure electrical neutrality. This is why one or more reactions of reduction of oxidizing chemical species present in the aqueous phase necessarily happen simultaneously at the interface. The most common cathodic reactions are the reductions of dissolved oxygen and H₃O⁺ and water. Hydrogen can thus be produced during the corrosion reaction both in aqueous and atmospheric environments. Hydrogen can then enter and diffuse through steel even at room temperature. This can occur during various manufacturing and assembly operations or operational use (e.g. during the corrosion process).

Recently a new technique, so called “respirometry” that allows to quantify in-situ the rate of O₂ reduction reaction (ORR) and H₂ evolution reaction (HER) has been developed and applied to corrosion science. The technique can be used to monitor the amount of hydrogen produced and consumed oxygen during exposure to aqueous/atmospheric conditions.

Project aims:

- To build a respirometry equipment at RISE in Stockholm.
- To use the equipment to quantify HER/ORR for HSS under different atmospheric conditions.

SURFACE PROTECTION

Project Title: Cleaning and pre-treatment of Al-alloys		Acronym: CAROL
Research area: Surface protection, Automotive	Project period: 01/08/2025 – 01/08/2026	
Research leader: Karin Törne karin.torne@ri.se +46 8 674 17 01	Source of funding: MRC surface technology	
	Keywords: pre-treatment, cleaning, painted aluminum alloys, contaminates	

This project will primarily focus on surface treatments of aluminum alloys and the effect of Cu and Zn contamination. When recycling aluminum the amount of contaminant may increase. Cu will separate into intermetallic or particles in the microstructure. In a previous project the potential difference between Cu inclusions and surrounding matrix was found to induce localised corrosion.

In this project the effect of Cu intermetallics on surface pre-treatment prior to painting will be investigated. The surface of samples after surface treatment, alkaline etching, acid etching and thin film pre-treatment will be characterized by SKPFM, SEM/EDS, and FTIR. Painted samples will be exposed to different weathering conditions and evaluated for filiform corrosion.

Project aims:

- Improve the fundamental understanding of the effect of Cu and Zn in aluminum alloys during
- Alkaline etching
 - Acid etching
 - Alkaline and acid etching

SURFACE PROTECTION

Project Title: Novel approaches for investigating local corrosion and mechanical degradation of multiphasic alloys		Acronym: LoCoMecha
Research area: Surface protection, Medical implants	Project period: 01/01/2023 – 31/12/2026	
Research leader: Michel Prestat & Flavien Vucko michel.prestat@institut-corrosion.fr +33 298 05 15 52	Source of funding: Public funding (ANR)	
	Keywords: Titanium implants, stress corrosion cracking, additive manufacturing, materials modelling	

Titanium and its alloys are among the most widely used non-biodegradable materials for implants in the human body. The corrosion resistance of titanium is mainly attributed to the presence of a thin passive layer on its surface that degrades in the presence of oxidizing species, such as oxygen peroxide (H₂O₂), leading to the device degradation and release of its constituents in the surrounding tissues. H₂O₂ is produced by the immune system during inflammatory episodes and is also utilized by surgeons for tissue disinfection during operation. A recent study of the French Corrosion Institute revealed that Ti6Al4V, a popular α+β alloy, exhibits a phase-specific degradation in H₂O₂-containing solution with a thick oxide layer growing on the α phase and a dissolution of the β phase, leading to the formation of undesired cracks.

By combining experimental and modelling approaches, the LoCoMecha project ambition is to gain insights into the processes at play in the degradation of Ti6Al4V without and with external mechanical load (stress corrosion cracking).

This project is carried out in collaboration with the Laboratoire de Réactivité de Surface (Université Paris Sorbonne, France), the Institute of Computational Physics (Zurich University of Applied Sciences, Switzerland), the Thermomechanical Metallurgy Lab (Swiss Federal Institute of Technology Lausanne, Switzerland).

Project aims:

- Understanding the phase-specific mechanisms of Ti6Al4V corrosion in H₂O₂-containing physiological electrolyte by using global and local electrochemical methods.
- Assessing the impact of β phase cracks on the mechanical properties of the alloy.
- Modelling and predicting stress corrosion cracking and fatigue corrosion by using virtual materials testing.
- Investigating the effect of the various microstructures prepared by additive manufacturing on the Ti6Al4V corrosion behavior.

BUILDING AND INFRASTRUCTURE

Project Title: Crevice Corrosion Mitigation Technology		Acronym: CCMT
Research area: Building and infrastructure, Coatings	Project period: 01/06/2022 – 01/06/2025	
Research leader: Björn Tidbeck bjorn.tidbeck@ri.se +46 72 734 08 17	Source of funding: MRC Corrosion Protection	
	Keywords: Life extension of painted steel, Maintenance strategy	

The stretch goal of this project is to extend the life of existing steel structures and reduce future maintenance needs for new steel structures. Bridges with an expected lifespan of 120 years, generally needs to be repainted or repair-painted at least three times during their lifespan. During such maintenance work, the entire steel surface of the bridge is often treated as per the current due diligence praxis. However, we know from experience that crevice corrosion in bolted connections, riveted web constructions, bridge bearings and stay cables often constitute weak points with increased risk of corrosion.

The initiative to this project is to investigate if the bulk of such maintenance work can be reduced by focusing on the above-mentioned problem areas. The methodology of this study is to perform a state of the art focusing on prevention of crevice corrosion on low alloyed steels, including weathering steels, treatment of ongoing crevice corrosion on existing steel and proactive maintenance on structures susceptible to crevice corrosion.

The study explains theoretical treatment options and surveys alternative treatment options that have been employed by asset owners outside the Swedish market. The study also includes a collection of case studies where alternative treatment protocols have been tested and can be evaluated after exposure on infrastructural assets in field after up to 30 years in service.

The planned continuation of this project includes corrosion testing of promising alternative corrosion protection strategies. And proof of concept studies of new ideas for proactive maintenance that this study has resulted in.

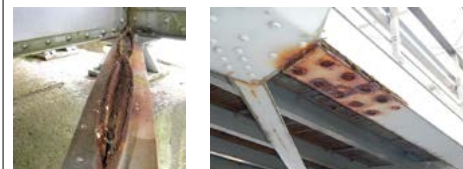


Figure 1. To the left: cross sectional beam with pack rust and ongoing crevice corrosion. To the right: edge beam with shot out rivet heads.

Project aims:

- Evaluate technology to extend technical life of existing structures with crevice.
- Reduce future maintenance need for both new builds and existing steel structures.
- Perform corrosion testing and follow up case studies with crevice corrosion.

BUILDING AND INFRASTRUCTURE

Project Title: Data base on the corrosion performance of coil coated steel materials		Acronym: CoilDataBase
Research area: Building and infrastructure, Coil Coating	Project period: 01/01/2017 – 31/12/2025	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Coil Coated Steel Materials	
	Keywords: Database, coil coated steel, field test, laboratory tests	

A large number of research projects on the degradation of coil coated steel products have been conducted at the French corrosion institute. However, a direct comparison of results within these different programs is difficult as different products have been selected (e.g. pretreatment, primer, top coat etc.). Hence, it is rather difficult to build a database from the results of these projects. In order to overcome this issue, it has been decided to select 10 to 12 systems that will be used as references in future projects for the next 5-10 years. This will allow us to build a database on these different reference materials and to model the results for instance with respect to environmental parameters.

Project aims:

The aim of the project is to build a database on reference coil coated materials and in the future to use this database to predict the corrosion behavior of coil coated steel materials. This includes field exposures as well as exposure in various corrosion testing or weathering tests. Electrochemical Impedance Spectroscopy (EIS) measurements with focus on water uptake and stability, Delamination studies using for instance Cathodic delamination test and/or Kelvin probe will also be conducted.

BUILDING AND INFRASTRUCTURE

Project Title: Influence of distance from the sea on degradation of coil-coated materials		Acronym: SealDis
Research area: Building and infrastructure, Coil Coating	Project period: 01/01/2017 – 31/12/2025	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Coil Coated Steel Materials	
	Keywords: Coil coated steel, chloride deposition	

Airborne salinity plays a relatively significant role in the degradation of metallic infrastructures. Empirical relationships have been found between chloride deposition onto surfaces and corrosion rates [1]. The deposition of marine aerosols is the primary source of chlorides which concentration and deposition rates tend to decrease rapidly when increasing the distance to the seashore. Aerosols concentration and corrosion rates depend on the nature of the aerosol sources being very high close to surf and moderate near calmer waters of bays and estuaries. Other factors influencing the aerosol concentration are the intensity and direction of prevailing wind, the topography of the land.

If the effect of chloride deposition is rather well documented on the corrosion of bare metals such as pure zinc, no systematic study on the influence of the distance to the sea on the degradation of coil coated steel materials has been carried out, especially when it concerns Zn-Mg-Al metallic coating as well as new chrome-free technologies commercially available. From an on-going project at Institut de la Corrosion where the outdoor performance of some coil-coated steel materials (prepared in laboratory) was assessed at various distances from the seashore, it was shown that the edge creep increased with decreasing distance to the sea and increasing chloride deposition.

Project aims:

The goal of the project is thus to assess the degradation of a large number of commercially available coil coated materials as a function of chloride deposition and distance from the seashore. In addition, the performance of identical coil coating systems applied on various metallic coatings will also be studied.

BUILDING AND INFRASTRUCTURE

Project Title: Outdoor Corrosion Performance of Prepainted Galvanised Steel – A long term field exposure		Acronym: WorldCoil 3
Research area: Building and infrastructure, Coil Coating	Project period: 01/04/2023 – 31/03/2026	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Prepainted steel, outdoor exposure, marine atmosphere, distance to the sea	

Long term outdoor exposures have to be conducted to fully evaluate the corrosion performance of prepainted materials upon corrosivity classes since thin organic protective layer must withstand very harsh conditions in various outdoor applications. This is particularly true with the evolution of coating technology for example those with a reduced environmental impact, such as coatings with reactive biorenewable diluents, but also any changes in the process of coil-coating as well as in the coating formulation.

Two large field exposure programmes of prepainted galvanised steel materials have been conducted at the French Corrosion Institute (FCI) since 2007. The first project that was performed over 8 years e.g. between 2007 and 2015 included 7 sites worldwide with marine temperate, marine industrial, marine tropical and acid rain sites. Conventional prepainted galvanised steel Zn-0.2Al, Zn-5Al and Zn-55Al materials were selected, most of them including chromated pre-treatments and primers. With the development of new zinc-alloy coated steel and the transition from chromate-based systems to fully chrome-free solutions, a second outdoor exposure programme including a new set of commercially available coil coated materials was started in 2015 for a total duration of 6 years. Most of the systems were fully chrome-free and included Zn-Al-Mg coatings in addition to conventional Zn-0.2Al and Zn-55Al substrate. Valuable data were obtained from these exposure programmes. In particular, the second project highlighted the need to take into consideration the quality of the backcoat that was highly degraded in some sites influencing thus the corrosion of the front side. It was also concluded that a larger number of prepainted systems (based on Zn-0.2Al which is commonly produced by the Coil-Coater) should be carefully selected and tested in outdoor sites, allowing a larger statistical analysis of the data. Moreover, the distance to the seashore in a similar geographical location without change in elevation shall also be considered to assess how the chloride load affects the degradation of the materials (e.g., all sites being at the seawater level).

Project aims:

- To test the long-term durability and corrosion performance of prepainted galvanised steel materials in various atmospheric sites in marine environment.
- To study the influence of the distance to the seashore.
- To better understand the role of different climatic parameters and corrosiveness in the degradation of coil coated material and to a provide a full statistical analysis.

BUILDING AND INFRASTRUCTURE

Project Title: Testing the durability of repair solutions for prepainted steels		Acronym: RepairCoat
Research area: Building and infrastructure, Coil Coating	Project period: 01/01/2020 – 31/12/2025	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Coil Coated Steel Materials	
	Keywords: Coil-coated steel, Repair solution, outdoor exposure, accelerated tests, mechanisms	

Prepainted steel materials are widely used in the construction of building industry. During service life, their durability is affected by weathering conditions in particular when exposed to marine and/or industrial environments. This may result in noticeable underpaint corrosion at defects in the paint such as cut-edges or scribes, for examples. These degradations will obviously propagate with ageing time at a rate that will depend upon the system e.g. metallic coating, surface treatment and organic paint, and the corrosiveness of the environment. Repair solutions are available at paint suppliers for treating such damages and thus improving the life durability of the materials. However, the efficiency of such solutions is not well-known. Thus, there is a need to test them under different conditions including laboratory test and field exposure, as well as to better understand their mechanisms of protection.

Project aims:

- To test the durability of repair solutions on various prepainted steel materials in laboratory test and field exposure.
- To compare the efficiency of the repair solution upon the metallic coating.
- To compare the efficiency of the repair solution upon the chemical nature of the organic coating.
- To better understand the mechanism of protection of the repair solutions.

BUILDING AND INFRASTRUCTURE

Project Title: Degradation of coil-coated materials under extreme conditions		Acronym: CoilXtreme
Research area: Building and infrastructure, Coil Coating	Project period: 01/01/2021 – 30/06/2026	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	Keywords: Prepainted materials, weathering degradation, extreme outdoor conditions

The degradation of coil-coated materials in field is a complex process depending on the panel orientation, the atmosphere at a given field site, the coating thickness, the paint chemistry and physical properties (such as type and thickness of the metallic coating, pretreatment, anticorrosive pigment formulated in the primer etc...). Each atmospheric exposure site has a unique blend of environmental stresses. It should also be noticed that each material will answer differently to a given environmental factor. The sites differ in the amount of ultraviolet light (UV), overall temperature, daily temperature cycles affecting the time of wetness, relative humidity, precipitation, deposition rates of atmospheric contaminants such as chloride, SO₂, and dust etc. Although the effect of some of these parameters on the corrosion of coil-coated materials is known, there are many unclear aspects. In addition, trustable data on microclimate conditions are missing. Several exposure programs have been conducted at FCI in the last 15 years. Worldcoil I and Worldcoil II were conducted at different sites worldwide. The focus of these projects was on edge creep and creep from scribe rather than on degradation due to weathering. Even if these projects gave important information on the degradation of coil coating materials in different climatic conditions, sites of extreme conditions (related for instance to weathering and/or extreme temperature) were not covered in these studies. In another project conducted at IC, the mechanisms of blistering have been studied and compared to field data. Even though cut-edge creep and blistering are the most common defects when considering coil-coating materials performance, it is also important to take into account the weathering of the paint system. Weathering is a joint action of ultraviolet radiation, heat, oxygen, humidity and chemicals species. These agents can induce physical and chemical changes in the polymer. Indeed, the weathering of the paint can affect the paint properties and thus changes water or electrolyte transport through the organic coating and consequently the tendency to blistering. It should also be noticed that the different weathering parameters can also induced stresses in the top coat and thereby largely influence the transport properties of for instance water.

Project aims:

- To expose and test different coil coated materials in different weathering sites (with high UV, humidity and pollution).
- To perform different laboratory test commonly used to evaluate the performance to weathering of coil coated materials.
- To compare the results of the laboratory test and field tests.
- To better understand the role of different climatic parameters in the degradation of coil coated material with the final aim to design more appropriate testing conditions for simulation of weathering conditions.

BUILDING AND INFRASTRUCTURE

Project Title: Corrosion performance of new emerging and energy saving curing technologies for coil coating		Acronym: EnSaveCoat
Research area: Building and infrastructure, Coil Coating	Project period: 01/01/2023 – 31/12/2026	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Coil Coated Steel Materials	Keywords: Curing technology, Energy saving, Radiation curing, UV, E-Beam

Due to the actual situation on the energy sector linked to the war in Ukraine, there is a request from the EU and national authorities to save energy. This is crucial with respect to the rising cost of gas and electricity. Energy is highly consumed in surface treatment processes used in coil coating in a variety of ways such as process solution heating and cooling, paint curing, drying of the part.. etc. It is believed that the new request in term of energy saving will lead to new products or/and new processes that would need to be characterized and tested regarding their corrosion properties for instance.

In the field of coil coating industry, several ways of saving energy can be identified by using: Radiation curing techniques (for instance UV, E-beam..), Induction and IR or NIR curing techniques, Low PMT paints.

In this project, several energy saving technologies will be identified and used to cure the coatings applied on galvanised steel substrate. The materials will be characterized in both laboratory conditions and outdoor exposure to assess their performance versus conventionally thermal cured systems.

Project aims:

- To identify energy saving curing technologies of interest.
- To characterize the corrosion performance of energy-saving-cured systems in laboratory tests.
- To assess the long-term performance of energy-saving-cured systems in field exposure.
- To compare the corrosion performance of energy-saving-cured systems to thermal-cured prepainted steel.

BUILDING AND INFRASTRUCTURE

Project Title: Corrosion in agriculture environments		Acronym: FARM
Research area: Building and infrastructure, Coil Coating	Project period: 01/01/2018 – 31/03/2026	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Ammonia, coil coating	

There are many potential causes of corrosion in animal buildings. Animals exhale large quantities of moisture into the air and create high relative humidity in the building if the moisture is not properly vented. High humidity increases the potential for condensation. In addition ammonia may be found in large quantities in animal buildings. Ammonia is released from manure and urine, especially during storage and decomposition. Levels could exceed 50 ppm with lowered winter ventilation rates and reach 100 to 200 ppm in poorly ventilated buildings. Additional corrosive agents are acids, and salts (from silage and feed residues, cleaning agents, fertilizers, and preservatives), mechanical destruction and bacteria causing microbially induced corrosion.

Project aims:

- To study the material performance of metallic coating in both liquid and atmospheric environments in a selected animal farming.
- To evaluate new coil coating materials with respect to these environments.

BUILDING AND INFRASTRUCTURE

Project Title: Accelerated Corrosion Test for Coil Coated Aluminum		Acronym: ACT-AI ECCA
Research area: Building and infrastructure, Coil Coating	Project period: 01/03/2018 – 30/06/2027	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Coil-coated aluminum, Accelerated tests, marine atmosphere	

The development of prepainted metal products for the building and construction market usually requires prolonged exterior exposure studies in order to validate product performance. An accelerated corrosion test that correlates with exterior exposure studies would enable the coil coated industry to shorten their development time for new products and reduce the cost of their research programs.

During the last 10 years, some efforts have been made by the Steel Industry for developing better reliable corrosion test for prepainted steel products in order to replace the conventional neutral salt spray test that is known to fail in reproducing real degradation. A project sponsored to ECCA is on-going at the French Corrosion Institute (FCI) to optimize the testing conditions on the basis of the so-called Test 1A.

Considering coil coated aluminum products, there is also a need to develop accelerated testing conditions that simulate service conditions in better way than the acetic salt spray test (ASST) currently used by the industry. Since 2008, some projects under the frame of ECCA were conducted at SINTEF in particular with the aim to develop an accelerated corrosion test for coil coated aluminum. The resulted test was able to reproduce similar degradations e.g. filiform corrosion from scribes or cut-edges. They were some limitations to the work carried out in this program and it was agreed that further development activity was required.

ECCA: European Coil Coated Association

Project aims:

The aim is to develop an accelerated corrosion test for prepainted aluminum products that correlates with exterior weathering performance. The test must be able to be used in commercially available equipment and would become the standard for the coil coated aluminum industry.

BUILDING AND INFRASTRUCTURE

Project Title: Data base on the corrosion performance of coil coated steel materials		Acronym: Coildatabase 2
Research area: Building and infrastructure, Coil Coating	Project period: 01/01/2025 – 31/12/2027	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Coil Coated Steel	Keywords: Database, coil coated steel, outdoor exposures, corrosion tests, weathering tests

Valuable data were obtained in CoilDatabase 1 project during the period 2017-2025 on a set of 13 commercial prepainted galvanised steel and zinc materials including 8 Z275, 1 Z100, 1ZM, 1AZ, 1 AM and 1 Zn substrates. Data from various laboratory tests (corrosion, weathering, blistering) and long-term outdoor exposures in marine and rural environments in temperate region as well as in marine-tropical atmosphere were collected and summarized in a previous project, constituting a unique database on commercially available products from 2017.

Since 2017, new products have obviously been developed at coil coaters and are available on the market. Thus, it was decided to select newly available prepainted materials to build a new database on 2025 commercial products. A larger number of materials will be selected for the new project.

Project aims:

The aim of the project is to build a new database on a set of commercial coil coated materials from 2025 based on results from field exposures as well as exposure in various corrosion testing or weathering tests. This database may be used to predict the corrosion behavior of coil coated steel materials.

BUILDING AND INFRASTRUCTURE

Project Title: Development of measurement method to determine the risk of necking on steel piles		Acronym: BBTPILE
Research area: Building and infrastructure, Corrosion in concrete	Project period: 01/09/2023 – 01/08/2026	
Research leader: Jonas Engblom jonas.engblom@ri.se +46 72 546 2171	Source of funding: Industrial funding /Public funding (Swedish Road Administration)	Keywords: Corrosion in soil, Infrastructure, Material efficiency, Piling

Steel pilings are, after concrete pilings, the most used type of piling in Sweden. The most common method of preventing corrosion to ensure the technical lifetime of the piling is through the use of a corrosion allowance, which means an over-dimensioning of the pilings. This over-dimensioning is based on empirical values from exposure studies, from which the corrosion rate has been extrapolated. When high corrosion rates have been recorded, these has been limited to a vertically restricted area, a phenomenon commonly referred to as "necking". Despite this, the corrosion allowance for the entire piling has been based on the corrosion rate of this small area. In a previous project, a method for assessing the risk of occurrence of necking has been developed and compared with long time exposures with good results. In the planned project, the method will be further developed to improve practical use as well as the scientific value. The ambition is to enable a method that already in the planning stage of a construction project can assess if there is a risk of necking or not. If there is a risk, additional corrosion protection, or increased corrosion allowance, can be applied to the critical part of the piling. Dimensioning the corrosion allowance based on the need contributes not only to safer construction, but also to potential material savings. These material savings are planned to be calculated using LCA in the end stage of the project.

Project aims:

- Validation of a new type of sensor designed to detect small aeration cells (necking).
- Determination of proper field application, such as installation time, time of the year for installation, temperature fluctuations, etc.

BUILDING AND INFRASTRUCTURE

Project Title: Partial repairs of concrete structures - Methodology to ensure extended service life		Acronym: BBTCORR
Research area: Building and infrastructure, Corrosion in concrete	Project period: 01/06/2023 – 31/03/2026	
Research leader: Bror Sederholm bror.sederholm@ri.se +46 73 512 78 44	Source of funding: Industrial funding /Public funding (Swedish Road Administration)	
	Keywords: Corrosion, concrete structures, chloride environments, repair materials	

Both in Sweden and Norway, the Swedish Transport Administration and the National Road Administration have drawn attention to the fact that concrete damage caused by reinforcement corrosion occurs locally. The problem has also come to the fore within the nuclear power industry in, among other things, cooling water ways. This has meant that the question of the choice of suitable repair methods has become relevant to minimize traffic disruptions at the Swedish Transport Administration and operational disruptions within the nuclear power industry. It will be important to avoid traffic and operational disruptions in above all road tunnels and cooling waterways where local repairs are and will be a used repair method for concrete structures. According to the Swedish Transport Administration, local repairs are made to bridge piers, bridge slabs, retaining walls and edge beams and retaining walls. There is uncertainty regarding the choice of repair material and methodology to avoid damage in the transition zone between repaired and original concrete. Previously carried out local repairs on, among other things, Öland's bridge, have proved to be not permanent.

In the project, it is planned to test the corrosion protection ability of different repair materials using a laboratory method that was previously developed. In connection with the testing, the chloride-binding properties of the repair materials and the resistivity of the repair material are also analyzed. The properties are considered important to achieve a permanent repair.

The chlorides can be transported from the old chloride-contaminated concrete to the boundary layer between repair and old concrete, which can be one of the reasons why new corrosion can start. It is therefore important that the repair is carried out in the right way to prevent the chloride levels from increasing in certain places along the reinforcement.

Project aims:

- The aim of the project is to develop suitable repair materials to avoid corrosion in the existing concrete structure using permanent local repairs.
- The goal of the project is to show which types of repair materials are most suitable to be used to permanently repair localized concrete damage caused by reinforcement corrosion in chloride-containing environments.

BUILDING AND INFRASTRUCTURE

Project Title: Study of 100 mV criteria efficiency in soils		Acronym: 100 mV
Research area: Building and infrastructure, Corrosion in soil	Project period: 01/12/2022 – 01/07/2025	
Research leader: Erwan Diler erwan.diler@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Soil, cathodic protection, carbon steel, moisture level, current demand, corrosion sensors	

According to the ISO 15589-1 standard, the protection potential E_p corresponds to a potential in where the corrosion rate is less than $10 \mu\text{m}/\text{y}$. This rate of corrosion is low enough for corrosion to be allowable for the rated life. The E_p values for such materials depends on the temperature and soil resistivity. In field, if E_p cannot be achieved, a minimum lowering of cathodic potential of 100 mV is another acceptable method to reduce the corrosion rate. However, the ISO 15589-1 standard also mentions that a residual corrosion rate of less than $10 \mu\text{m}/\text{year}$ may not be achievable. This can be assessed with the use of electrical resistance (ER) corrosion sensor.

In soil, the local environment, i.e. initially polarized or not, as well as the moisture level can have a strong impact on the open circuit potential (OCP), oxygen diffusion, resistivity, active surface and depolarization kinetic. This environment can thus affect the efficiency of the 100 mV method, explaining that under certain cases rather high residual corrosion might subsist. The understanding of such mechanisms is crucial to ensure as much as possible the efficiency of such method.

Project aims:

The overall objective is to better understand and quantify the degree of the actual protection when the -100mV is applied, depending on the soil environment, as well as:

- To assess the efficiency of the 100 mV criteria under unsaturated soil conditions both in terms of uniform and localized corrosion.
- To investigate the relation between the Open Circuit Potential of carbon steel and the moisture level for different soils.
- Assess the electrical resistance method to obtain the residual corrosion under CP at low moisture level in soils (higher risk of localized corrosion).

Assess the electrical resistance method to obtain the residual corrosion under CP at low moisture level in soils (higher risk of localized corrosion).

BUILDING AND INFRASTRUCTURE

Project Title: Coating ageing of buried structures in environments chemically affected by the cathodic protection – effect of alkaline interface		Acronym: Coatage II
Research area: Building and infrastructure, Corrosion in soil	Project period: 01/01/2024 – 31/12/2026	
Research leader: Krystal Pélissier & Erwan Diler krystal.pelissier@institut-corrosion.fr erwan.diler@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: FBE, 3LPE, Liquid Epoxy, cathodic protection, EIS, water uptake, Glass Transition temperature	

The corrosion of buried structures is usually mastered by the combination of organic coatings and cathodic protection (CP). However, detrimental interaction between these two protections can be observed on site either by the induced cathodic disbondment or by the chemical aging of the coating due to the local environment (induced by the CP).

In soil, under CP, the limited species diffusion and the possibly high current demand can lead to pH as high as 14 at the vicinity of the defect. Such environment also containing oxygen radicals might be particularly severe for organic coatings. In a study performed at IC, old disbonded coatings (hydrocarbons and Fusion Bonded Epoxy) were characterized by electrochemical impedance spectroscopy (EIS). The obtained results show that with time the coating resistance strongly decrease. This behavior was reproduced under CP simulated conditions in laboratory on industrial coatings. Additional work performed at IC have demonstrated the significance of taking into account alkaline ageing of coating when considering the overall performance of the coating when considering LE, FBE and 3LPE.

In this project, industrial coatings will be exposed during several months to environment representative of CP in soils. The coating resistance and/or aging will be characterized by a combination of methods: EIS and water uptake on free membrane and coated steel. In addition, coating delamination susceptibility to alkaline ageing will be assessed on specimens with unprotected edges and on coating with circular defects.

Project aims:

- To study the kinetic of coating degradation as a function of the pH and the temperature.
- To assess coating delamination due to alkaline ageing on coated steel.
- To better understand degradation and disbondment mechanisms due to alkaline ageing.
- To propose a representative accelerated tests for organic coating development and qualification, more resistant to alkali-induced cathodic protection environment.

BUILDING AND INFRASTRUCTURE

Project Title: Worldwide exposures: Determination of corrosion in soil		Acronym: Worldsoil
Research area: Building and infrastructure, Corrosion in soil	Project period: 01/01/2022 – 31/12/2027	
Research leader: Abdelkader Meroufel & Dominique Thierry abdelkader.meroufel@ri.se +46 73 047 2263	Source of funding: Industrial funding	
	Keywords: Corrosion in soil, worldwide exposure, metallic coatings, stainless steel	

The corrosion of ferrous metals in soils is a major problem for owners and managers within the infrastructure and energy sectors, such as water, sewerage, oil and gas distribution systems, solar energy parks etc.

The study of the corrosion of buried pipes has a long and substantial history. Soil is a complex environment involving solid particles, gas and liquid phases. Corrosion in soils is a multiscale process and it is believed to be controlled both by the microenvironment (film/droplet formation, diffusion/migration of water, oxygen, and other species) and the macro environment (rain and temperature).

In addition, due to the large number of parameters that influence corrosion in soil, it is rather difficult to fully simulate field conditions at the laboratory scale. Hence, the present project will focus on field exposures of materials in soils with different characteristics. The project will include sites with high and moderate temperatures and high and low moisture content. The project will focus on condition where cathodic protection is not applied. Following the initial results of 2 years exposure, the project will continue to obtain longer time corrosion data and materials behaviour.

Project aims:

- To evaluate the performance of different materials and coatings used for soil applications.
- To assess the risk of preferential soil corrosion attack on ZnAlMg coatings.
- To generate data on a worldwide basis that could be used as input data in modelling.

BUILDING AND INFRASTRUCTURE

Project Title: Differential soil corrosion of zinc alloy coatings		Acronym: DiffcellCorr-MRC soil
Research area: Building and infrastructure, Corrosion in soil	Project period: 01/10/2024 – 30/02/2026	
Research leader: Abdelkader Meroufel abdelkader.meroufel@ri.se +46 73 047 2263	Source of funding: MRC Soil	
	Keywords: Zinc coatings, Corrosion, soil, differential cell	

The use of Zinc based coatings for buried support structure increased in terms of use for different applications including solar support structures. The performance of these materials in different soil types is an industrial need to get their performance versus traditional materials such as steel and pure zinc. In parallel to the determination of those materials performance in different soils, the need to assess their behavior in the case of differential soil cells is considered in the present project. Indeed, galvanic coupling which develop for those materials crossing different soil layers with variable properties represent a non-explore area for the reliability of buried structures.

In this initial step, two Swedish soil types are considered i.e. saturated clay and unsaturated sand with different pH, resistivity and chemical properties. The corrosion rates will be explored for different zinc alloy coatings and reference materials carbon steel and hot dip galvanized steels. Weight loss, thickness loss and electrochemical data will be determined for one year for defined cathode/anode area ratio.

Project aims:

- Assess the differential soil corrosion rate of different zinc-based coating in laboratory controlled exposure conditions.
- Determine the galvanic current and potential differences for the same material between saturated clay and unsaturated sand.

BUILDING AND INFRASTRUCTURE

Project Title: Development of accelerated laboratory soil corrosion testing method		Acronym: AccelabCorr
Research area: Building and infrastructure, Corrosion in soil	Project period: 01/01/2024 – 31/12/2027	
Research leader: Abdelkader Meroufel & Dominique Thierry abdelkader.meroufel@ri.se +46 73 047 2263	Source of funding: Industrial funding	
	Keywords: Soil corrosion, sensors, laboratory exposure, metallic coatings	

The use of Zinc based coatings for buried support structure increased in terms of use for different applications including solar support structures. The performance of these materials in different soil types is an industrial need to get their performance versus traditional materials such as steel and pure zinc. In parallel to the determination of those materials performance in different soils, the need to assess their behavior in the case of differential soil cells is considered in the present project. Indeed, galvanic coupling which develop for those materials crossing different soil layers with variable properties represent a non-explore area for the reliability of buried structures.

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Project aims:

- To develop a reliable and representative method to study soil corrosion in short time to overcome the limitation of long field exposures in natural soils.
- To generate laboratory corrosion data in natural soils with different representative conditions.
- To develop a mathematical/statistical model to manage soil corrosion data obtained in both accelerated lab method and field data from Worldsoil project.
- To validate the laboratory method through a round robin test via the involvement of different partners upon the availability of facilities.
- To propose a testing method that could be the first step in a recognize international standard to test metallic materials in soil under controlled laboratory conditions.

BUILDING AND INFRASTRUCTURE

Project Title: Worldwide exposure of metallic coated steel panels		Acronym: Worldcoat 2
Research area: Building and infrastructure, Construction	Project period: 01/01/2017 – 31/12/2027	
Research leader: Nathalie Le Bozec nathalie.lebozec@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Zinc coated steel, field exposure	

In 2011, a project was initiated at the French corrosion institute with the aims to define the corrosion behavior of hot-dip galvanized steel, ZnAl and ZnAlMg coated steel at 14 different field stations worldwide. 1, 2, 4- and 6-years data have been collected.

In addition, analyses of corrosion products have been performed after 2 and 4 years of exposure.

As indicated before although the project has generated very valuable results, they are still questions that remain. For instance, as the corrosion was highly localized on all metallic coatings, the measurements of mass loss are questionable and may not reflect the localized corrosion observed on all coatings.

In addition, new metallic coatings with addition of Al and Mg have been introduced recently on the market and were not included in the first investigation.

Project aims:

- To obtain the long-term (e.g. up to 10 years) behavior of ZnAl and ZnAlMg coated steel (in particular with respect to red rust) and compare it with hot-dip galvanized steel.
- To obtain a full picture of the performance of ZnAl and ZnAlMg coated steel worldwide.

BUILDING AND INFRASTRUCTURE

Project Title: The International Co-operative Programme on Effects on Materials including Historic and Cultural Monuments		Acronym: ICP Materials
Research area: Building and infrastructure, Cultural Heritage	Project period: 01/01/1987 - Undefined	
Research leader: Johan Tidblad johan.tidblad@ri.se +46 10 228 48 78	Source of funding: Public funding(UN and The Swedish Environmental Protection Agency)	
	Keywords: Air pollution, Atmospheric corrosion, Atmospheric soiling, Atmospheric degradation, Cultural heritage	

The International Co-operative Programme on Effects on Materials, including Historic and Cultural Monuments (ICP Materials) started in 1985. It was initiated in order to provide a scientific basis for new protocols and regulations developed within the Convention on Long-range Transboundary Air Pollution.

Project aims:

- Perform a quantitative evaluation (dose-response functions) of the effects of multi-pollutants such as S and N compounds, O₃ and particles as well as climate parameters on the atmospheric corrosion and soiling of important materials, including materials used in objects of cultural heritage.
- Describe and evaluate long-term corrosion and soiling trends attributable to atmospheric pollution in order to elucidate the environmental effects of pollutant reductions achieved under the Convention and in order to identify extraordinary environmental changes that result in unpredicted materials damage.
- Use the results for policy purposes for the benefit of the Convention by i.a. mapping areas with increased risk of corrosion and soiling and for calculation of cost of damage caused by deterioration of materials.

BUILDING AND INFRASTRUCTURE

Project Title: Plastic Free Corrosion Protection for CX -environments		Acronym: PFCX plastic free
Research area: Building and infrastructure, Paint	Project period: 01/01/2021 – 31/12/2027	
Research leader: Björn Tidbeck bjorn.tidbeck@ri.se +46 72 734 08 17	Source of funding: MRC Corrosion Protection	
	Keywords: Environmentally sustainable coatings, Microplastics	

During 1972-1973, NASA carried out an extensive investigation comprising 200 different coating systems based on zinc rich coatings. One of the conclusions from the study was that zinc rich coatings perform better without topcoats. One possible mechanism explaining this result may be that water ingress into the zinc primer may degrade the primer prematurely in multicoat systems. And a better approach may be to use a topcoat with higher water permeability, see Figure 1.

In this study, alternative topcoats for zinc silicates will be trialed in an attempt to develop a completely inorganic, two coat CX system. It is envisioned that such a system would not attribute a source of microplastics whilst offering increased durability, lower VOC emissions, less chemical hazards, and less risk of fire compared to traditional systems based on epoxy and polyurethane.

The project has been preceded with a study on microplastic emissions from marine coatings. Initial trials have been very promising, see figure 2. This project includes more extensive evaluation by both accelerated and outdoor corrosion testing in CX environments.

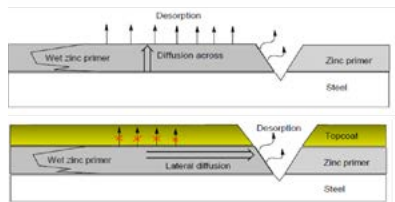


Figure 1. Drying of a zinc silicate without topcoat vs a Zinc silicate with topcoat

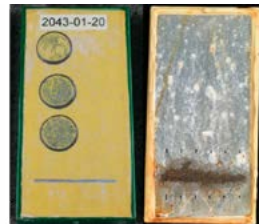


Figure 2. Initial trails after CX testing
To the left: silicate topcoat
To the right: reference

Project aims:

- To develop a plastic free coating system for CX/ offshore environments.
- To develop a CX coating system with reduced cost
To develop a CX coating system with reduced VOC emissions, chemical hazards and Risk of fire.
- To develop a CX coating system with reduced cost.

BUILDING AND INFRASTRUCTURE

Project Title: New Generation Lead-Free Brass Alloys		Acronym: NewLeaf
Research area: Building and infrastructure, Water distribution	Project period: 18/05/2022 – 18/02/2025	
Research leader: Charlotta Obitz charlotta.obitz@ri.se +46 73 088 7675	Source of funding: Public funding (Vinnova)	
	Keywords: Brass, lead-free, corrosion, drinking water, alloy development	

The Swedish brass industry has built up a system where most of the production is based on recycled material. During the last few years, low-lead alloys have been developed and optimized through several research projects, to replace the traditional alloys containing 2-3% lead. Most efforts have been put on improving machining and productivity, as well as investigating methods to refine melt from lead. However, more stringent EU directives on lead and lead release to drinking water implies that the newly developed alloys risk not being accepted, which poses a serious threat to the brass industry. This project will focus on developing and modifying lead-free alloys adapted to the revised lead directives, using the learnings and outputs of the previous projects performed (e.g., the need for further developments regarding castability) as well as new studies to understand the relationship between corrosion mechanisms, alloys composition and microstructure and lead release to drinking water. Refining of brass melt from lead will also be further implemented through pilot-testing to ensure a circular approach. Finally, an analysis of carbon footprint for the different alternatives and production routes (LCA), of today's and tomorrow's regulatory requirements, of cost consequence for the different alternatives and of testing capacities available will ensure an overall system perspective, allowing to look beyond silos and have a holistic approach in choosing the alloys and production routes to be implemented.

Project aims:

- Maintain the circular Swedish brass industry while meeting revised EU directives and regulations and secure material supply for a lead-free future.
- Concepts for different alloys suitable for the different production routes of the project partners will be available for evaluation in approval processes and for future standardization.
- Plans about how a controlled transition to lead-free industry in Sweden without a significant increase in demand of new raw materials can be achieved.

BUILDING AND INFRASTRUCTURE

Project Title: Network for materials and Products in contact with drinking water		Acronym: Drinking water network
Research area: Building and infrastructure, Water distribution	Project period: 01/01/2025 – 31/12/2025	
Research leader: Charlotta Obitz charlotta.obitz@ri.se +46 73 088 7675	Source of funding: Industrial funding	
	Keywords: Drinking water, Materials, Products, Legislation	

This network gathers relevant actors along the drinking water chain, such as manufacturers, industry associations, drinking water suppliers, authorities, and researchers, who are interested in the topic of materials and products in contact with drinking water.

The network offers the opportunity to exchange knowledge about current legislation, up-to-date research, industrial challenges as well as material and product development. The network maintains close contact with the European Commission and national authorities on the new legislation and approval systems for materials and products in contact with drinking water. We also regularly invite other European stakeholders to present at our seminars (RTOs, industries, water suppliers) and exchange ideas and best practices in the field.

Our members get the opportunity to meet annually through two seminars. We also send a newsletter every year where essential information regarding materials and products in contact with drinking water is given. The network raises members' questions and needs in the area of materials and products in contact with drinking water.

Project aims:

- Have up-to-date information about legislation, regulations, industry challenges, research, and material and product development.
- Exchange of experience in this area.
- Develop contacts with other stakeholders incl. Authorities.
- Possibility to present your own innovations and research.

BUILDING AND INFRASTRUCTURE

Project Title: Impact of heat tinted oxides from welding operation on the localized corrosion susceptibility of stainless-steel alloys		Acronym: Ssweld
Research area: Building and infrastructure, Water distribution	Project period: 01/03/2022 – 01/12/2025	
Research leader: Charles Leballeur charles.leballeur@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Stainless steel, welding, localized corrosion, chloride.	

Stainless steel alloys are widely used in different sector of activity involving all kind of water transportation, from drinking water application to seawater desalination. For all these applications, welding of stainless-steel products is very common. If the good practices for welding of stainless steel are widely known, the operating conditions can sometimes make them difficult to apply. End-user feedback has shown that numerous cases of pitting corrosion at welded areas are due to improper welding operation. Indeed, operating conditions can lead to difficulty to apply a perfect inerting which lead to the formation of heat tinted oxides. These oxides are known to potentially reduce the corrosion resistance of stainless steel. Pickling & repassivation of inner welding surfaces can be a solution to recover stainless steel corrosion properties. However pickling operations are sometimes not possible due to field constraints. Some authors have considered the existence of a chromium depleted zone beneath the oxide as the main cause of an observed decrease in corrosion resistance. However, other authors disagree and suggested other mechanisms explaining the presence or lack of a chromium-depleted zone. One practical factor often correlated to the corrosion resistance is the color of the tint. According to von Moltke et al, the color of the oxide is only an indication of the thickness of the oxide, not the composition or the corrosion resistance. In contrast, Kearns connected the corrosion resistance to the color of the heat tint, finding that a rose-colored tint had lower corrosion resistance than the straw colored. Enrichment of iron in the outermost oxide as well as in oxides above a certain thickness has been shown to decrease the corrosion resistance of stainless steels with heat tints in chloride environments. Standard AWS D18.2 classified different levels of tinted oxides as a function of the residual oxygen level from purging gas operation during welding. However, no relevant information can be found in the literature regarding the magnitude of tinted oxides on the corrosion resistance of stainless steel (i. e. lack of quantified engineering diagrams based on corrosion testing). Therefore, there is an interest to quantify the corrosion resistance decrease of stainless-steel welds as a function of the residual tinted oxides (i. e. as function of inerting quality).

For this study the corrosion susceptibility of selected stainless-steel grades will be investigated as a function of the heat tint levels achieved from controlled welding operation at different oxygen levels. Testing will be conducted with different chloride concentrations adapted to tested grades, with the aim to provide guidelines for the use of welded stainless steel with residual oxides in service conditions. The global aim is to provide engineering data and scientific knowledge to decide acceptable welding results when not achieved in perfect inerting conditions.

Project aims:

- Assess the corrosion resistance of different stainless-steel grades in chloride containing solution as a function of the controlled heat tinted levels.
- Determine criteria of acceptance for weld discoloration in term of corrosion resistance.

BUILDING AND INFRASTRUCTURE

Project Title: Data base building for the use of stainless steels and Ni-base alloys in brines and Industrial water		Acronym: B&W
Research area: Building and infrastructure, Water distribution	Project period: 01/01/2025 – 31/12/2027	
Research leader: Charles Leballeur charles.leballeur@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Brines and Waters	
	Keywords: Stainless steel, nickel base alloy, industrial water, water distribution, brines, localized corrosion	

Considering corrosion, the selection of stainless-steel grades and nickel base alloys for water immersion applications can be made as a function of the chloride content, temperature and pH. Engineering diagrams indicating the limit of use of the different grades are most of the time built from short term standard testing which are not always fully representative of long-term exposure and are most of the time conservative. Furthermore, it seems that there is a lack of data for crevice corrosion, especially for environments with high chloride content.

Therefore, there are some interests to challenge these engineering diagrams but also to refine them for specific environments (waters with very high chloride content for instance) or configurations (crevice corrosion) with the aim to provide reliable data base for material selection.

Project aims:

The main aim of this project is to provide useful and reliable data for the material selection of passive alloys in water-based electrolyte.

- The first task will consist of gathering data from literature and field experiences available (open literature and/data shared by partners).
- Then corrosion testing will be carried out to complete and/or refine the already database collected through the first task.
- Corrosion testing will mainly consist in mid- or long-term immersion tests. However, the reliability of short-term testing method will also be assessed by comparison with long-term testing.

BUILDING AND INFRASTRUCTURE

Project Title: Brass Replacement Alloys Validation Operations		Acronym: BRAVO
Research area: Building and infrastructure, Water distribution	Project period: 01/10/2024 – 30/06/2025	
Research leader: Charlotta Obitz charlotta.obitz@ri.se +46 73 088 7675	Source of funding: Public funding	
	Keywords: Brass, industry transition, drinking water	

The Swedish brass industry employs over 2000 people with a turnover exceeding 8 billion SEK. It is essential for the survival and development of this industry to succeed in the industrial transition towards a circular system for lead-free brass. In previous projects, lead-free alloys have been tried, partly developed and assessed. Removing of lead from leaded brass has been tested at laboratory scale. Main remaining challenges are related to industrial implementation of a viable method for removing lead from brass produced from scarp as well as producing on an industrial scale lead free brass products with an alloy complying to the latest requirements and ensuring long terms properties of the produced pieces. A systemic perspective considering all aspects such as environmental and health impacts, products reliability or raw material supply is essential to avoid suboptimization. The long-term goal after a full-scale project is the implementation of a circular industrial system for lead-free brass in Sweden. To achieve this goal, a feasibility study is first needed to assess the remaining challenges and determine the most viable path for further implementation. The feasibility study will result in consortium grouping all needed technical competences and industrial partners, a roadmap describing all necessary actions for full industrial implementation of a circular system for lead-free brass in Sweden and based on the results above an application for a full-scale project.

Project aims:

- The long-term goal after a full-scale project is the implementation of a circular system for lead-free alloys in Sweden.

The feasibility study is the first step aiming at :

- Identifying remaining challenges and hinders for an industrial implementation of the production of lead-free alloys in Sweden and propose clear and concrete strategies to overcome those challenges, taking into consideration avoiding suboptimization at a system level.
- Put together a consortium grouping all needed technical competences and industrial partners Present a road-map describing all necessary actions for full industrial implementation of a circular system for lead-free brass alloys in Sweden.
- Write an application for a full-scale project.

MARINE MATERIALS

Project Title: Full-Scale Experiments to Determine the Long-term Effect of Cathodic Protection on Disbondment of 3LPP-coated tubes at bare zones (Bare Field Joint applications)		Acronym: BFJ
Research area: Marine materials, Cathodic protection	Project period: 01/02/2022 – 01/09/2026	
Research leader: Nicolas Larché nicolas.larche@institut-corrosion.fr +33 298 05 15 52	Source of funding: Industrial funding	
	Keywords: Cathodic disbondment, bare field joints, cathodic protection, seawater, seabed, heat flux	

To reduce drastically the cost of field operations, it may be considered to eliminate field joint coating completely on pipelines coated with an anti-corrosion coating such as three-layer polyethylene or polypropylene, regarding that bare areas are protected with cathodic protection (CP). This raises the question whether CP will lead to significant disbondment and at which rate.

Institut de la Corrosion developed a test methodology to evaluate CP-induced cathodic disbondment of full scale tubes in natural seawater and in natural seabed, with temperature control inside tubes.

In this new project the cathodic disbondment rate of bare zone of 3LPP-coated tubes will be investigated in natural seawater and in seabed, at different internal temperatures from 25°C to 90°C.

Full-scale tube lengths of diameter 8" are tested. The disbondment rates and associated mechanisms will be studied for exposure durations from 6 to 24 months. The results from full-scale bare zones will be compared to commonly used artificial defects used in standards.

Project aims:

The main aim of the project is to quantify the actual disbondment rates of full-scale tube bare field zones under CP, exposed under different conditions in seawater and in seabed.

MARINE MATERIALS

Project Title: Industrial upscale of surface protection system & fibre optic-based condition monitoring for the Seasnake MVC		Acronym: SEASNAKE+
Research area: Marine materials, Coatings	Project period: 15/12/2023 – 15/12/2026	
Research leader: Katarina Bokström katarina.bokstrom@ri.se +46 10 228 4960	Source of funding: Public funding (Swedish Energy Agency)	
	Keywords: Antifouling, shape sensing, connecting devices, energy transport, Marine technology sensors and instrumentation, Cables and pipelines	

The main objective of SEASNAKE+ is to scale-up and demonstrate (TRL6-7) the dynamic medium voltage cable (dMVC) with improved lifetime by easy clean paint; in-line in-situ paint application chamber; in-situ cleaning robot; giving to the cable new and scalable protection system and monitoring system. The SEASNAKE+ dMVC will be validated first at small scale in nearshore condition in two different sites (Swedish west coast and Mediterranean Sea) and once the full-scale prototypes will be ready, in a real ocean environment in the Mediterranean Sea. SEASNAKE+ objectives and activities are based upon the learnings and proof-of-concept (TRL4) of a new lightweight (no armoring) and flexible cable carried out within the previous SEASNAKE.

SEASNAKE+ expands those efforts on European level as key gaps and opportunities has been identified during the projects for scaling up the production and integrate the protection system application into the production, along with new sophisticated and innovative ways to measure cables movement (shape sense) and failure modes in an integrated fiber optic solution.

Project aims:

- Increase economic viability by reducing the Levelized Cost of Energy (LCoE).
- Scale up of surface treatment solutions in the production.
- Implement predictive conditioning solutions in the cable design.
- Minimised Environmental Impact & Increased Availability (reliability, maintainability and survivability).
- Demonstration of dynamic cable solutions.

MARINE MATERIALS

Project Title: Improved, environmentally friendly and plastic free coating systems for offshore corrosion mitigation		Acronym: Green CX Coatings
Research area: Marine materials, Coatings	Project period: 01/01/2023 – 31/12/2025	
Research leader: Krystel Pélissier krystel.pelissier@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Paint and Lining for Steel	
	Keywords: ISO 12944-6, Low VOC, polysiloxane, zinc ethyl silicate	

The application of coatings is an inescapable measure in the constant struggle against material ageing and corrosion. Several measures can be applied to delay corrosion phenomena, but the application of anticorrosive coatings remains one of the best options. The protective coating industry is in constant evolution mostly due to two major driving forces, i) the constant need of improvement of anticorrosive solution for long term performance (and ultimately less maintenance) and ii) the constant evolution of the market regulation (environmental, health) due to a general awareness of the impact of this industry sector. This constant evolution leads to the development of new anticorrosive technologies through the use of novel approach such as reduced content of Volatile Organic Compounds (VOCs) in the formulation. However, no tangible feedback still exists for this type of new technologies despite their increased incorporation in anticorrosive coating architectures (primer, intermediate, topcoat). Even though their low VOCs characteristics make them attractive in terms of environmental concerns, end users are still cautious when considering their uses, regardless of their potential good performance. Indeed, for example, high solid polysiloxane technology is considered as an interesting alternative to traditional polyurethane topcoat when the stability to weathering is considered. However, few studies exist on the performance (corrosion in addition to weathering) of this kind of topcoats tested in field exposure. Another example of low VOCs coating which can be quoted is the use of waterborne zinc silicates. Studies conducted within RISE in the MRC Corrosion Protection have demonstrated the good performance of this type of primer when they were designed as a single coat system. This good behavior was observed both in accelerated testing and in field exposure. One of the drawbacks of this kind of system is the difficulty to design a multi-coat system where the waterborne zinc silicate primer is topcoated. Indeed, their good anticorrosive performance can be lost due to an incompatibility with the topcoat. In light of these findings and observations, a project on topcoats for waterborne zinc silicate will be launched within MRC Corrosion Protection in 2023. A unique opportunity to collaborate between the MRC Paint and the MRC Corrosion Protection is arising when both problematics can be studied together.

Project aims:

- To test different plastic free topcoats for zinc silicate technologies and to assess their performance for C5 and CX atmospheres.
- To assess polysiloxane performance and compare it with traditional polyurethane technology for C5 and CX atmospheres.

MARINE MATERIALS

Project Title: Evaluation of Terahertz spectroscopy possibility on non-destructive evaluation of painted steel as a function of surface preparation		Acronym: Optikan
Research area: Marine materials, Coatings	Project period: 01/06/2024 – 31/06/2025	
Research leader: Krystel Pélissier krystel.pelissier@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Paint and Lining for Steel	
	Keywords: Surface preparation, NDT, field exposure	

Surface protection against corrosion continues to attract research interest since all materials are subjected to degradation in the form of costly corrosion. Application of organic coatings remains a favored choice. However, to obtain good long-term performance, good and adequate surface preparation is required. It is a pre-requisite for good adhesion between the metal surface and the coating to avoid premature failure. It is thus vital to correctly prepare the surface before coating application as presence of contaminants on the surface (dust, grease, oils, salts) will act as a weak boundary layer leading to coating failure or development of blistering. The impact of the quality of the surface preparation on the performance of organic coatings was largely studied and dry abrasive blasting remains the most used method. However, this conventional way of preparing steel surface requires a lot of work and can be sometimes not usual on site such as in the case of maintenance work and new methods for surface preparation are needed. It is difficult to correctly study the effect of surface preparation as accelerated testing cannot reproduce defects such as blistering or rusting and are based on the degradation from the scribe. On another way, field testing is time consuming and costly even though it gives a better overview of organic coating performance. In a recent project, the impact of surface preparation on performance of anticorrosive coatings for marine applications and in the case of maintenance work, it was shown that using the scribe creep as only indicator no real differences were seen between the reference and the least stringent surface preparation (laboratory tested). Thus, new methods to evaluate coating performance are needed. In a recent collaboration within Optikan, the use of Terahertz spectroscopy was found sensible and adapted to evaluate painted materials. This technique is sensitive to red rust present at the coating-steel interface and could be used to discriminate against the different surface preparation.

Project aims:

- To further assess the possibility of Terahertz spectroscopy.
- To try to better highlight the impact of the surface preparation.

MARINE MATERIALS

Project Title: Biofilm-Induced corrosion of metal structures for Aquaculture Application and development of Adapted Corrosion Sensors for Optimized Maintenance		Acronym: SeaCHEM-DC2
Research area: Marine materials, Monitoring & sensors	Project period: 01/06/2023 – 01/06/2026	
Research leader: Mohammad Hassanzadeh mohammad.hassanzadeh@institut-corrosion.fr +33 298 05 15 52	Source of funding: Public Funding (HORIZON)	
	Keywords: Seawater corrosion, biofilm, fatigue-corrosion, stainless steels, sensors, offshore seaweed aquaculture	

The European Seachem DN project involves a total of 10 doctoral candidates (DC1-10) working on a same global challenge about offshore cultivation and valorization of seaweed. This international training program, encompassing 7 intersectoral partners (5 academic, 1 non-academic) in 4 countries, focuses on innovative technological developments across a range of interdisciplinary fields such as construction engineering, materials science, (micro-)biology, (bio-)chemical engineering, environmental biotechnology and machine learning. The main scientific goal of SeaChem project is to uplift the underdeveloped EU seaweed aquaculture by developing and implementing the next generation of offshore cultivation technologies and advanced extraction processes, thus maximizing the value chain of offshore grown seaweed.

The doctoral candidate DC2 at Institut de la Corrosion will study biofilm-induced corrosion of metal structures for offshore seaweed aquaculture application, and development of adapted corrosion sensors for optimized maintenance. It includes the study of fatigue under crevice corrosion. Results will be combined and linked to DC3 (Mapping of corrosion around marine structures). The overall objective is to gain increased knowledge on biofilm-induced corrosion of stainless steels for seaweed aquaculture application and development of adapted corrosion sensors.

Project aims:

The main objective is to identify and analyse main corrosion risks that can be encountered in the concerned metal structures and to define, use and develop monitoring technologies for optimized maintenance regarding corrosion aspects.

MARINE MATERIALS

Project Title: Environmental Impact of Material corrosion and Anti-corrosion Systems in Offshore Seaweed Aquaculture		Acronym: SeaCHEM-DC4
Research area: Marine materials, Monitoring & sensors	Project period: 01/02/2023 – 01/02/2026	
Research leader: Caya de Leeuw Van Weenen caya.de.leeuw.van.weenen@institut-corrosion.fr +33 298 05 15 52	Source of funding: Public Funding (HORIZON)	
	Keywords: Environmental impact, Offshore seaweed aquaculture, monitoring, corrosion and anti-corrosion systems, pollution, e-DNA	

The European Seachem DN project involves a total of 10 doctoral candidates (DC1-10) working on a same global challenge about offshore cultivation and valorization of seaweed. This international training program, encompassing 7 intersectoral partners (5 academic, 1 non-academic) in 4 countries, focuses on innovative technological developments across a range of interdisciplinary fields such as construction engineering, materials science, (micro-)biology, (bio-)chemical engineering, environmental biotechnology and machine learning. The main scientific goal of SeaChem project is to uplift the underdeveloped EU seaweed aquaculture by developing and implementing the next generation of offshore cultivation technologies and advanced extraction processes, thus maximizing the value chain of offshore grown seaweed.

The topic for the doctoral candidate DC4 at Institut de la Corrosion is about the environmental impact of material corrosion and anti-corrosion systems involved in offshore seaweed aquaculture, both in terms of seawater pollution and seaweed quality. The main objective is to define, use and develop monitoring technologies for material and pre-existing structures as well as seaweed cultivation/harvesting structures. The monitoring science development will focus on increasing capabilities to both follow and predict materials corrosion and environment specific characteristics. Among others, the monitoring techniques to be explored and developed will be based on image analysis, environmental sensors and also on biomarkers such as e-DNA analysis. The obtained information can then be used in the probabilistic analysis for go/no-go decisions on O&M activities and to define optimal conditions for seaweed cultivation. The deterioration of materials and fouling/algae formation are related to the environment (pH, salinity, temperature etc) which means that DC4 will also gather data on environmental indicators including eDNA, to understand the environment that nurture the seaweed production that will contribute to the European and International Ocean Governance (IOG) ambitions for our oceans to be clean and healthy, resilient, productive and understood. The DC will share data with the other DC candidates of the seaCHEM project. The eDNA analysis could be combined with image of algae cultivation/growth rate/ to predict optimal environmental envelope for seaweed cultivation (using one or several biomarkers).

Project aims:

Define and use novel monitoring technologies and/or developed methodology to quantify the environmental impact of corrosion and anti-corrosion systems in seaweed aquaculture and to predict the optimal environmental envelope for seaweed cultivation.

MARINE MATERIALS

Project Title: Impact of seawater treatment on corrosion resistance of stainless steel and nickel base alloys		Acronym: TreatedSW
Research area: Marine materials, Offshore	Project period: 01/01/2024 - 31/12/2025	
Research leader: Charles Leballeur charles.leballeur@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Marine Corrosion	
	Keywords: Stainless steel, Marine, offshore, crevice corrosion, dissolved oxygen, chlorination	

Low grade stainless steels and nickel base alloys with PREN < 40 are not recommended for seawater applications. They are known to be susceptible to localized corrosion in chloride-containing electrolytes. However, the use of these alloys can be considered under specific condition. For instance, in seawater injection well, low or very low dissolved oxygen content is reached. Under this specific condition, some low grades alloys have shown to be corrosion free at dissolved oxygen level below 20 ppb. For some applications, varying dissolved oxygen level can be encountered. Therefore, there is an interest to assess the behavior of different materials in natural seawater with reduced dissolved oxygen level. The corrosion susceptibility of several stainless steels and nickel base alloys as a function of the dissolved oxygen level have been investigated in a previous program and allowed to get relevant results. For additional treatment such as biocide treatment. Chlorination which is the most used biocide treatment is well known to increase the oxidant power of water and thus to increase the risk of corrosion initiation of stainless steel. Therefore, interaction between deaeration (fully or partially) and chlorination can significantly impact the localized corrosion resistance of stainless-steels and nickel base alloys. The impact of such treatment will be investigated for several alloys from low grade to highly corrosion resistant alloys.

Project aims:

- Assess the crevice corrosion susceptibility of different stainless-steel grades in aerated and deaerated seawater with and without biocide treatment.
- Complete existing guidelines (collected from previous studies) for material selection in treated seawater involving deaeration and chlorination.

MARINE MATERIALS

Project Title: Definition and optimization of a short-term testing adapted to crevice corrosion of passive alloys II		Acronym: ShortCrev II
Research area: Marine materials, Offshore	Project period: 01/01/2024 - 31/12/2025	
Research leader: Charles Leballeur charles.leballeur@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Marine Corrosion	
	Keywords: Stainless steel, Marine, offshore, crevice corrosion, test method	

Commonly used quality control test such as standardized short term electrochemical test G61, G48 or G150 are not fully adapted to predict crevice corrosion results for stainless steel in seawater, particularly of corrosion resistant alloys (CRAs). From the experience of the French Corrosion Institute, immersion tests in simulated environments and involving crevice formers (ISO18070) are more suitable. The drawback of such testing performed at OCP is the time of test which is rather long (3 to 6 months).

Therefore, there is an interest to develop a new test method allowing to characterize the actual crevice corrosion resistance of stainless steels alloys in seawater within short or mid duration. A first program has allowed to define a test method consisting of successive steps at polarization of the material combined with the use crevice former as defined in ISO18070. The first results obtained with this method on duplex and superduplex have shown satisfying results with a good correlation to results obtained from long-term testing.

As a continuation of this program, further qualifications of the test method will be performed. The aim of this project will be to validate the relevancy of the results obtained with this method on additional alloys. The possibility to use this test method in synthetic seawater instead of natural seawater will also be investigated.

Project aims:

- Confirm the relevancy of the test method by testing different alloys.
- Assess the possibility to use synthetic seawater with the test method proposed.

MARINE MATERIALS

Project Title: Assessment of low grade alloys in natural seawater		Acronym: LowPREN SW
Research area: Marine materials, Offshore	Project period: 01/01/2024 - 31/12/2025	
Research leader: Charles Leballeur charles.leballeur@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Marine Corrosion	
	Keywords: Stainless steel, Nickel base alloys Marine, offshore, crevice corrosion, pitting corrosion, seawater, biofilm	

It is widely admitted that stainless steels and nickel base alloys with PREN lower than 40 are not suitable for seawater applications. Nevertheless, for specific applications, a moderate or at least a lower risk of localized corrosion can be expected. For instance, during pre-commissioning operations, the material can be exposed to seawater for short periods in stagnant or with very low renewal rate. The seawater renewal rate is expected to impact the development of biofilm and thus the so-called ennoblement, knowing for its detrimental effect on the corrosion resistance of passive alloys. The impact of temperature is also known to affect the risk of localized corrosion initiation, as well as the geometrical condition. Crevice corrosion is the first root cause of corrosion failure for passive alloys. However, some applications can be exempt of geometry leading to crevice corrosion. Under this condition, the main risk is pitting corrosion which imply a lower risk of corrosion initiation. Therefore, the use of some of these "low grades" can be reconsidered depending on the actual environmental condition.

The content of this project will be to assess the pitting and crevice corrosion risk of selected alloys (stainless steels and nickel base) in natural seawater at different temperature ranging from 11 to 25°C. The impact of the renewal condition compared to stagnant or confined condition could also be investigated. New alloys, candidate for seawater applications will also be assessed.

Project aims:

- Assess the pitting and crevice corrosion risk of several candidate alloys in natural renewed seawater for temperatures ranging from 11 to 25°C.
- Assess the impact of stagnant and/or various seawater renewal rate on the ennoblement induced by biofilm settlement and thus on the localized corrosion risk.

MARINE MATERIALS

Project Title: Next generation Marine Materials for Resilient Offshore Renewable Energy Devices		Acronym: MORE
Research area: Marine materials, Offshore	Project period: 01/12/2023 - 01/12/2026	
Research leader: Johan B Lindén johan.b.linden@ri.se +46 10 516 6066	Source of funding: Public funding (Swedish Energy Agency)	
	Keywords: Marine Materials, Offshore Renewable Energy, Tribocorrosion, Multi-degradation	

MORE (Next Generation Marine Materials for Resilient Offshore Renewable Energy Devices) proposes the creation of a new robust methodology with improved tools for material selection and validation to harmonize testing procedures able to generate the next generation of materials for Offshore Renewable Energy (ORE) devices to overcome the present energy and environmental challenges.

The MORE project will focus on harmonizing small- and large-scale multi-degradation rigs, to create a fast track for validation of materials, starting from, but not limited to, metallic materials and metal coatings typically suffering tribocorrosion and multi-degradation (passive metals), to enable the industrial uptake of these methods. MORE will demonstrate a multi-degradation validation pathway for materials and subcomponents to be used as a case study in the offshore renewable energy sector. While innovative marine renewable energy device technologies are gaining popularity, the technicalities of operating them in hostile environment remain complex and challenging jeopardizing the deployment of these very important technologies for the future generations.

MORE aims at enhancing zero emission power technologies (CETP Challenge 2): wave energy has demonstrated a more efficient use of the surface area compared to wind turbines. By improving the material use in the systems and by developing better material qualifying protocol the MORE project aims at lowering technology production costs.

Project aims:

- Knowledge transfer from offshore O&G currently used solutions, material selection and testing protocols to offshore Renewable Energy power technologies.
- To develop a new testing methodology based on realistic and accelerated testing techniques simulating many years of actual operation that support and enforce go/no-go decisions on components and subsystems designed at early TRLs.
- Scale up and demonstrate the reliability of the new proposed testing methodology leading to a better material selection, resulting in a lower LCOE (5-10%) via substantial reduction of maintenance costs.
- To produce a first-of-a-kind practical implementation of the novel testing methodology for material selection and validation for critical subsystems common to offshore renewable energy devices.
- To establish new testing recommendations, guidelines and recommended practices for standardisation thus providing an important toolbox for enhanced material technology developments, qualification testing and system design.
- The case studies will evaluate the practical applicability and impact of the new material selection methodology both for cross-cutting environmental challenges and for critical components in wave energy technologies in both user cases.

MARINE MATERIALS

Project Title: Sustainable production, processing and modelling of durable additive manufactured materials for enhanced performance and long-term service in complex environments.		Acronym: DurAMat
Research area: Marine materials, Stainless steel	Project period: 01/09/2023 – 28/02/2028	
Research leader: Dominique Thierry dominique.thierry@ri.se +33 676806676	Source of funding: Public funding (Horizon)	
	Keywords: AM, Stainless steel, marine corrosion, atmospheric corrosion	

Additive Manufacturing (AM) presents an opportunity for developing economic eco-friendly metal products with enhanced long-lasting performance. Metal AM covers a wide range of technologies where a three-dimensional metallic component is manufactured by adding layer-upon-layer of material, also better-known as 3D printing. AM technology builds on the rational use of raw materials (through optimized product design and re-use of feedstock, reduced use of chemicals and lowered waste of resources), increased energy efficiency (by decreasing post-processing and assembly efforts), economic savings (reduced labour, storage and logistics, and little need for multi-assemblies), and faster processing times.

The work performed at RISE is part of a Doctoral network (MSCA Horizon) coordinated by VUB (Belgium). The work at RISE will be focused on atmospheric and fatigue corrosion, including hydrogen embrittlement (HE), of duplex steel alloys for marine applications.

Project aims:

- To study AM duplex stainless steel with different heat treatments for different final applications including atmospheric (infrastructure) and marine conditions (energy sector).
- To evaluate the risk of corrosion fatigue and hydrogen embrittlement on AM duplex stainless steel using different heat treatments.

The consortium is formed by the following partners: Vrije Universiteit Brussel (VUB, coordinator), RISE, University of Göteborg, Guarantee, HelmholtzZentrum Hereon, Warwick University, Universidade NOVA de Lisboa, TU Dresden, Endures, Small Materials and Technologies, Lda, Christian Albrechts University of Kiel, OnderzoeksCentrum voor de Aanwending van Staal. OCAS NV.

ENERGY

Project Title: Next Generation Advanced Flexible Biomass Power Plants		Acronym: FlexGEN
Research area: Energy, Biorefinery and biomass	Project period: 01/02/2023 – 01/02/2027	
Research leader: Rikard Norling rikard.norling@ri.se +46 10 228 48 89	Source of funding: Public funding (Swedish Energy Agency)	
	Keywords: Corrosion, Combined Heat and Power, Renewable Energy	

The future renewable energy system will call for a flexible system with a plethora of different production means and energy storage to meet the demand for the security of supply and affordability. A large part will be non-dispatchable, such as wind and solar energy, and therefore require replacement capacity. Today's heat and power plants in Sweden cannot decouple the electricity and heat production. Hence there is a flexibility limitation coupled with the heat demand. This needs now to be decoupled. The first step in decoupling can be to introduce a condensing tail with a suitable set of valves and a heat sink. Further, the flexibility and efficiency can be increased with improved starting- and stopping capability, maximized load flexibility, and new advanced plant configurations.

Corrosion is one of the critical limiting factors to achieve this, in particular while maintaining an acceptable plant efficiency. It is well known that boilers using biomass or waste as fuel are challenged by high temperature corrosion. Biomass contains high amounts of corrosive species, primarily alkali metals and chlorine. These corrosive species initiate corrosion which can cause wall thinning and pitting, resulting in catastrophic failure of components, especially the boiler water walls and superheater tubes. Future power plants will require higher steam temperatures to increase energy efficiency in steam turbines. This change will impose new challenges on the materials along the whole system.

Project aims:

- To evaluate possible material options at hand. Reaching the targets may require coatings on high-strength materials or composite tubes, which will be evaluated.
- To find smart plant configurations that decouple positions with high corrosivity from high material temperatures and to identify next generation boiler material concepts suitable for these configurations.
- New plant configurations which include hydrogen firing in addition to biomass will be evaluated and the related new difficult material challenges caused by the changed gas composition and firing conditions will be investigated.

ENERGY

Project Title: Cathodic Protection influence & modelling		Acronym: CPInfMod
Research area: Energy, Cathodic protection in soil	Project period: 01/01/2023 – 31/12/2025	
Research leader: Erwan Diler erwan.diler@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Soil	
	Keywords: Keywords: Fusion Bonded Epoxy, Three-layer Polyethylene, Soils, cathodic protection, cathodic disbondment	

In soils, protection against corrosion of buried metal structures is generally achieved using a combination of an organic coating and cathodic protection (CP). CP consists of lowering the corrosion potential of the structure to be protected using an external current (polarization). This polarization, when it reaches sufficiently electronegative potentials, reduces the residual corrosion rate to negligible values on the scale of the operating life of the structure (<10µm/year).

For buried structures, cathodic protection is usually operated most efficiently using impressed current. In a complex CP environment, several structures under cathodic protection may be present, in a relatively restricted area. When the CP of a structure is switch-off or when it is insufficiently polarized, influence phenomena can appear, with the appearance of stray currents through the (foreign) structure under influence.

The stray currents, generated by an external CP device, on a non-polarized foreign metallic structure depends on numerous parameters such as: the nature of the ground (water content, resistivity, texture), the type of coating and the types of defects, the location of the structures, the applied potential, and the current demand. The stray current amplitude is ruled by the ohm law and function of electric field in soil, the media resistivity and resistance at interface. In addition to the soil, surface state and CP conditions, the localization of the elements under CP (anode, cathode) and foreign structure is crucial. Indeed, depending on the relative position of each element, the influence can be i) anodic, ii) cathodic, iii) combined and iv) induced.

Project aims:

- Perform a critical literature review on the CP influence phenomena and modelling in soil.
- Study representative cases by finite element modelling.

ENERGY

Project Title: Investigation of coating disbondment rate in soils		Acronym: CD Rate
Research area: Energy, Cathodic protection in soil	Project period: 01/01/2023 – 31/12/2025	
Research leader: Erwan Diler erwan.diler@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Soil	
	Keywords: Fusion Bonded Epoxy, Three-layer Polyethylene, Soils, cathodic protection, cathodic disbondment	

To ensure the integrity of offshore and onshore structures against corrosion, a complementary approach combining cathodic protection (CP) and organic coatings is usually used. The efficiency of the CP is ensured by maintaining the potential of the structures in a protective range, following the standard recommendations, such as ISO 15589-1.

The influence of cathodic protection on the coating is rather complex since it depends on many factors such as the nature of the coating, the soil (type, pH buffer capacity, moisture level...), the temperature, the electrochemical processes and the kinetic involved. In the literature, many standard tests are proposed to assess the cathodic disbondment. However, the objective of these short-term methods is more to rank the different coatings than to determine a representative disbondment kinetic. These tests are usually limited to chloride containing electrolyte and thus possibly not representative of the underground environment.

A recent study, performed at IC, highlighted that higher cathodic disbondment was observed in seawater in contrast to soils. This can be explained by the high content of Na⁺ in seawater, known to sustain a high alkalinity below the disbonded coating, and promote the interface and/or coating degradation. In soils, under unsaturated conditions (40-65% water saturation), the cathodic disbondment of the tested FBE and 3LPEs remain limited for current density lower than 2 A/m².

Project aims:

Determine the coating disbondment rate for a commercial Fusion Bonded Epoxy (FBE) and a Liquid Epoxy (LE) at the vicinity of 2 A/m² to be compared with previous data.

ENERGY

Project Title: Polarization database of cathodic protection in soils		Acronym: CPSoilDatabase
Research area: Energy, Cathodic protection in soil	Project period: 01/01/2023 – 31/12/2025	
Research leader: Erwan Diler erwan.diler@institut-corrosion.fr +33 298 05 15 52	Source of funding: MRC Soil	Keywords: Polarization, cathodic protection, soil, moisture level, texture, carbon steel

Soil can be defined as a mixture of rock particles, organic matter, air and water. The main physical properties of soils are texture, structure, porosity, and resistivity. Soil texture is determined by the relative proportion of the three kinds of soil mineral particles, called soil separates: sand, silt and clay.

Water that enters a field is removed from a field by runoff, drainage, evaporation or transpiration. Water in soils mainly affect the gaseous and species diffusion and the soil resistivity. The oxygen effective diffusivity strongly depends on the moisture level. This can be explained by the tortuosity, the air and water ratio, i.e. the oxygen diffusivity in air being much more higher than in water. The moisture level also affects the active surface, i.e. the polarizable surface of the metal. The active surface increases with the moisture content. In terms of oxygen reduction, the competition between the active surface and the oxygen diffusivity is expected to lead to high CP current demand at moisture level in the range of about 60% wat. sat. In contrast, at 100% wat. sat. the current demand is expected to be very low (low oxygen diffusivity). The moisture level also affects the soil resistivity, i.e. the lower the water content, the higher the resistivity, as well as the Open Circuit Potential. Under resistive media, ohmic drop (IR) in soil can affect the current distribution, affecting thus de current demand and polarization curves. The coupons (defect) geometry can also have an influence. Thus, the current demand in soil is difficult to predict.

Polarization curves for different soil textures and moisture levels are crucial for modelling of cathodic protection. It allows better understand the seasonal fluctuation in terms of current demand and distribution along a structure to be protected. It allows also to model complex structures and interference phenomena.

Project aims:

Develop and define a method to obtain reproducible, comparable, and stabilized polarization curves in different soils at various moisture level.

ENERGY

Project Title: Effect of the presence of CO contamination in CO₂ on the risk of SCC in CCUS application		Acronym: COsc
Research area: Energy, CCUS	Project period: 01/01/2022 – 01/12/2026	
Research leader: Christophe Mendibide christophe.mendibide@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: MRC CCUS & H₂S	Keywords: Carbon capture, Stress corrosion cracking, CO ₂ , CO

In Carbon Capture, Utilization and Storage (CCUS) applications, the industrial process is generally divided into 3 different stages:

- Carbon capture generally through a so-called “amine unit”.
- Transporation of the captured CO₂ in pipeline, generally in dense phase or supercritical state.
- Storage or utilization of the gas.

After the capture stage, CO₂ is produced with a non-negligible level of impurities like, NO_x, SO_x, CO, O₂, H₂S...

From the literature and experience, particularly in heat-exchanger applications, it is well-known that the presence of CO in pure CO₂ can generate a pseudo-passive state of the carbon- and low alloy steels generally active in pure CO₂ environments. This pseudo-passivity can therefore promote a stress corrosion cracking phenomena at room temperature (SCC).

The project focuses on the evaluation of the risk of SCC in CO₂ saturated solution when the gas is contaminated with CO. Electrochemical and SCC experiments are conducted in solution saturated with CO₂-CO that mimic the in-service exposure during the transport of CO₂ in pipelines.

Project aims:

- Estimate if the presence of CO contamination in CCUS process can promote SCC.
- Estimate what are the critical level of CO that triggers the SCC cracking.
- Evaluate the effect of other contaminants like O₂.
- Evaluate the behavior of standard pipeline steel in CO₂-CO-O₂ atmospheres.

ENERGY

Project Title: Assessment of the corrosion resistance of CRAs in environments simulating the shutdown at the CCUS injection sites		Acronym: CRAInject
Research area: Energy, CCUS	Project period: 01/01/2022 – 01/12/2026	
Research leader: Christophe Mendibide christophe.mendibide@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: MRC CCUS & H₂S	
	Keywords: Carbon capture, Stress corrosion cracking, localized corrosion, crevice corrosion, corrosion resistant alloys	

In Carbon Capture, Utilization and Storage (CCUS) applications, the industrial process is generally divided into 3 different stages:

- Carbon capture generally through a so-called "amine unit".
- Transportation of the captured CO₂ in pipeline, generally in dense phase or supercritical state.
- Storage or utilization of the gas.

The storage can be made in depleted oilfield that are build with many different carbon steels and corrosion resistant alloys.

In standard operation, a literature review conducted before starting this project highlight that there is no significant risk of corrosion in the injection area. However, during shutdown operations, the formation or aquifer waters can flowback and contact the metallic components used for the injection process. A brine containing a high level of chloride, saturated with CO₂, generally in a supercritical state, can therefore contact the metals, leading to possible corrosion of carbon steels or of the CRA grades used in the infrastructures.

The objective of the project is to estimate if the CRAs typically in place storage site can suffer from corrosion and stress corrosion cracking due to this phenomenon.

Project aims:

- Evaluate the corrosion resistance of CRA in conditions simulating the water flowback at CCUS storage sites.
- Qualify the resistance of a couple of CRA grades regarding the risk of localized & crevice corrosion as well as SCC.

ENERGY

Project Title: Catalytically active and corrosion resistant thin films		Acronym: Fun Mat II
Research area: Energy, Fuel cells and electrolysers	Project period: 01/01/2019 – 31/12/2027	
Research leader: Smita G. Rao smita.gangaprasad.rao@ri.se +46 10 228 47 87	Source of funding: Public funding	
	Keywords: Catalysis, oxygen reduction reaction, corrosion, thin film	

Water recombination-based devices are one of the alternatives for the production of green electricity. These devices however rely heavily on electrocatalysts to increase their efficiency. In today's industrial devices precious and costly metals such as platinum (Pt) are used as catalysts. Other more abundant and cheaper alternatives, for example, cobalt and manganese oxides, are therefore being investigated.

In this project, pure cobalt (Co) thin films were synthesised to investigate if thin films can be used for the catalysis of ORR. This was successfully carried out by electrochemically modifying the magnetron sputtered thin films and growing catalytically active hexagonal cobalt oxide nanoparticles.

Multicomponent system CoCrFeNi is an emerging alloy system with high research interest for its high corrosion resistance suitable for harsh environments in which the applications for water recombination are found. In this project, CoCrFeNi and CoCrFeMoNi were synthesised as thin films. The corrosion resistance of the films was investigated in addition to their catalytic activity. The effect of Fe and Mo content on these properties was also studied. The presence of Fe was crucial for the electrochemical activation of films and catalytic activity towards ORR. The addition of Mo improved the corrosion resistance in simulated PEM fuel cell environment.

In the continuation of the project, the thin film structure will be tailored to further improve the catalytic and corrosion resistance. Mn will be investigated as an alternative to Co. The synthesised materials will also be tested in small-scale alkaline batteries and fuel cells.

This project is a PhD project and a collaboration between RISE and Linköping University. Details of the project results can be found in Clara Linder's Ph.D. thesis (2024).

Project aims:

- Investigate corrosion properties of thin film in alkaline and acidic environments.
- Investigate catalytic activity towards water recombination of corrosion resistant thin films.
- Combine catalytic activity and corrosion resistance in one material system synthesised as a thin film.

ENERGY

Project Title: Thin protective titanium suboxide coatings for next-generation porous transport layers of PEM water electrolyzers		Acronym: Protis
Research area: Energy, Fuel cells and electrolyzers	Project period: 01/03/2023 – 31/08/2026	
Research leader: Michel Prestat michel.prestat@institut-corrosion.fr +33 298 05 15 52	Source of funding: Public funding (ANR)	
	Keywords: Proton exchange membrane water electrolysis, thin films, porous transport layers	

Proton exchange membrane water electrolysis (PEMWE) is one of the low temperature processes for producing hydrogen by electrochemically splitting the water molecule. However, the high capital expenditures (capex) due to the use of expensive corrosion-resistant materials limit the economic competitiveness of this technology compared to the well-established fossil fuel-based hydrogen production, like steam reforming, that generates intensive CO₂ emissions. In particular, on the anode side, the state-of-the-art porous transports layers (PTL), that are metallic elements distributing water, gas and electrons, are made of titanium protected by precious metal coatings (Pt, Au) in order to withstand the acidic conditions and the high electrochemical potential.

Two main corrosion-related strategies can therefore be considered in order to significantly decrease the PEMWE capex: replacing titanium by other alloys, such as stainless steels, and developing novel cost-effective coatings. The PROTIS project combines these two approaches by investigating the protection of 316L stainless steels by thin layers of titanium suboxides.

This project, coordinated by IC, is carried out in collaboration with the LEMTA (Laboratoire d'Energétique et de Mécanique Théorique et Appliquée, Université de Lorraine, France) and the Laboratory of Materials for Energy Conversion of Empa (Swiss Federal Laboratories for Materials Science and Technology, Switzerland).

Project aims:

- Synthesizing thin titanium suboxide films by physical vapor deposition and atomic layer deposition on porous stainless steel PTL.
- Developing accelerated stress tests for evaluating the long-term behavior of the protective coatings.
- Implementing the novel coated PTL in PEMWE cells and assessing their effect on the electrolysis performance and durability.

ENERGY

Project Title: Aluminum in Lightweight PEMFCs with High-temperature		Acronym: ALPH
Research area: Energy, Fuel cells and electrolyzers	Project period: 01/08/2025 – 01/08/2027	
Research leader: Karin Törne karin.torne@ri.se +46 70 750 25 12	Source of funding: Public funding (ANR)	
	Keywords: Aluminum alloys, PVD coating, HT-PEMFC (High Temperature Proton Exchange Membrane Fuel Cell), Bipolar plates	

A significant part of the total CO₂ emissions within the EU are from transport in heavy-duty trucks, and these emissions could be drastically reduced by electrifying the transport. However, heavy-duty trucks have strict demands on both energy and power density; a battery may be insufficient to power an electric driveline for a heavy-duty truck. Here fuel cells are a promising alternative to allow for electrified cargo transportation with drastically reduced CO₂ emissions.

However, conventional low temperature proton exchange membrane fuel cell (LT-PEMFC) systems may provide insufficient power to a heavy-duty truck driveline. By operating at higher temperatures, such as those in a high temperature PEM fuel cell (HT-PEMFC), at e.g. 160 °C, the need for temperature and water management may be simplified, thereby reducing the weight and increasing the power density of the fuel cell.

Further weight decreases may be possible by replacing graphite based bipolar plates with aluminum plates. However, as the environment in an HT-PEMFC is highly corrosive, stable coatings need to be developed to enable the use of aluminum bipolar plates. The ALPH-project will develop coatings for aluminum bipolar plates for use in HT-PEMFC. The project also intends to further develop methodology to characterize these plates ex-situ and perform in situ HT-PEMFC cell tests using the coated plates. Furthermore, aluminum plates will be formed with suitable flow fields and the welding of bipolar plates to form a stack will be investigated. The produced and coated aluminum plates will be evaluated regarding their potential use in a HT-PEMFC powered drivelines for heavy-duty trucks.

Project aims:

- Improving the corrosion properties of coated Al-BPPs for HT-PEMFC and developing ex-situ corrosion characterization methodology for BPPs in HT-PEMFC.
- Demonstrating manufacturing steps of Al-BPP by designing and manufacturing single cell flow fields as well as laser welding aluminum sheets.
- Demonstrating the feasibility of Al-BPP in HT-PEMFC and obtain more than 1000 h runtime with acceptable degradation (5 % decrease in cell voltage / 1000 h).
- Evaluating Al-BPP for HT-PEMFC and comparing the design and potential power density of an air cooled and a liquid cooled HT-PEMFC for heavy duty trucks.

ENERGY

Project Title: Unlocking the Full Potential of Electrolysis with Next-Generation Proton Exchange Membrane Stacks		Acronym: UNICORN
Research area: Energy, Fuel cells and electrolysers	Project period: 01/09/2023 – 31/08/2026	
Research leader: Michel Prestat michel.prestat@institut-corrosion.fr +33 298051552	Source of funding: Public funding (Clean Energy Transition Partnership)	
	Keywords: PEM, coating, corrosion, bipolar plates	

Proton exchange membrane water electrolysis (PEMWE) is currently the most promising route towards green hydrogen production due to the "zero-gap" cell configuration, leading to higher operational current densities, and nearly instantaneous response to fluctuating power output, making it ideal for coupling with renewable energy sources. The major shortcoming of PEMWE, however, is that it requires the use of expensive components, made from critical raw materials, to overcome the harsh acidic operating environment, highly oxidative potentials at the anode, and stringent gas-crossover requirements. Today's commercial PEMWE systems all rely on noble metal catalysts and protective coatings, titanium-based bipolar plates, and perfluorinated sulfonic acid (PFSA)-based membranes. These materials lead to increased capital expenditure (CAPEX) costs and have been identified as either critical raw materials (e.g., platinum group metals and titanium) or materials with sustainability/environmental concerns (e.g., PFSA). Developing low cost, non-toxic, safe-by-design PEMWE stacks is therefore crucial to ensure the future of electrolysis remains affordable, circular, and sustainable.

Project aims:
The main objective of the UNICORN project is to develop and demonstrate a PEM electrolyser stack with increased performance, reduced CAPEX, and increased sustainability. To accomplish this, a 40 kW stack consisting of 10 cells (>500 cm² active area per cell) will be built integrating novel components and will be validated during 2000 hours of operation using a renewable wind energy profile. In-line with the CTEP objective of accelerating technology development for significant CO₂ reduction by 2030, the UNICORN stack will greatly exceed the 2024 key performance indicators (KPIs) set by the Clean Hydrogen Joint Undertaking, approaching, and in some cases meeting, the 2030 KPIs.

ENERGY

Project Title: Influence of mineral deposits and dynamic mechanical stresses on corrosion in geothermal conditions, mineral scaling, and mechanical stresses on geothermal corrosion		Acronym: Geosteel
Research area: Energy, Geothermy	Project period: 01/01/2022 - 31/12/2025	
Research leader: Christophe Mendibide christophe.mendibide@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Public funding (ANR)	
	Keywords: Geothermal Energy, Stress corrosion cracking	

For reduction of greenhouse gas emissions, investment in the infrastructures of green energy sources is necessary. Geothermal energy is one of the promising ways to achieve this objective by delivering both thermal and electrical energy. However, due to the high corrosivity and scaling ability of geothermal fluids, the selection of proper metallic materials is a big challenge for the safe and reliable development of this non-carbon energy source.

Until now, limited efforts have been devoted to understand the stress corrosion mechanisms by taking into account the effect of mineral scaling on the steel surfaces. Even after the injection of anti-scaling additives in the geothermal field, the reliability of their long-time efficiency is not guaranteed. Furthermore, no valuable information on the incidence of typical geothermal scales such as silica, calcium carbonate, magnesium silicate, is available on the corrosion behavior of passive and non-passive steels. More investigations are necessary to understand the interaction effects of mineral scales deposits deposited on both the steel surface reactions (passivity for stainless steels) and on the initiation – propagation of stress corrosion cracks.

In this context, the project GeoSteelCorr aims to build a methodology for better understanding the role of mineral scaling on the risk of surface corrosion and environmentally assisted cracking of these steels. The work will be conducted after the implementation of a SSRT test bench on an autoclave equipped with a feeding loop and a specific device is used to generate artificial mineral scaling (a temperature up to 300 C and a pressure up to 200 bars). Additionally, for a more in-depth knowledge regarding the mechanism of crack initiation and growth, advanced post-mortem local tests (e.g. SEM, TEM and EDX) will be performed in the frame of this project.

This work is a collaborative research between The FCI, IFPEN, Ecoles des Mines de Saint-Etienne and Insa de Lyon.

Project aims:

- Develop a SSRT test bench allowing to perform testing under hydraulic pressure.
- Develop a specific system allowing the reproduction of mineral scaling in the laboratory.
- Evaluate the role of mineral scaling on the cracking susceptibility of CRA in a geothermal environment.

ENERGY

Project Title: Comparison between test methods for toughness evaluation of pipeline steels under hydrogen pressure		Acronym: Tough H₂
Research area: Energy, Hydrogen	Project period: 01/01/2022 - 31/12/2025	
Research leader: Laura Moli Sanchez laura.moli.sanchez@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Industrial funding	Keywords: Hydrogen, Pressure, Crack Propagation, toughness

There is today no unified test method for material qualification in gaseous hydrogen environments. ASME B31.12 and PBVC documents are specifying test conditions for toughness (KIH) and fatigue evaluation ($da/dN=f(DK)$) referring to international standards like ASTM E1681. This test method can however hardly be applied to low strength carbon steels for several reasons:

- It is impossible to be compliant with geometrical validity checks specified in ASTM E1681 due to test pressure vessels and pipeline wall thickness limitations. Therefore, the test results obtained on pipeline steels according to this standard can often not proceed under linear elastic crack propagation.
- The test is performed under constant applied strain leading to very small crack propagation lengths due to relaxation effects after upon propagation. Also, bolt load specimens are used which need to be loaded in oxygen-free atmospheres.
- The standard test duration for low strength steels specified in ASTM E1681 should be 10000 hours which is not acceptable for standard industrial practices.

Another test method is under study at the French Corrosion Institute based on incremental step loading (ISL) in conditions inspired from the standard ASTM F1624. The objective of the project is to compare both test methods and make an environmental screening for KIH.

In a first task, both ASME and ISL test results performed on in the same environment will be compared to validate the methodology. Then, in the next tasks testing of different grades in different environments (different H₂ pressure, effect of contaminants...) will be considered.

Several pipeline grades will be considered (X65, X70, X100).

This work is conducted in collaboration with IFPEN.

Project aims:

- Define a reliable test method for KIH evaluation under hydrogen pressure.
- Perform a screening of the severity of different environments under H₂ pressure.

ENERGY

Project Title: Characterization of the cracking susceptibility of stainless steels and CRA under H₂ pressure at low temperature		Acronym: Cryo H₂
Research area: Energy, Hydrogen	Project period: 01/01/2022 - 31/12/2025	
Research leader: Laura Moli Sanchez laura.moli.sanchez@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: MRC Storage and Transportation of Hydrogen	Keywords: Hydrogen Pressure, Corrosion Resistant alloys, cryogenic SSRT and Fatigue

In the frame of the development of the hydrogen industry, the question of the behavior of stainless steels and other CRAs under H₂ pressure is raised, particularly for automotive and aeronautic applications. From the results already published in the literature, it seems that the critical temperature for the most common stainless steels, in particular the austenitic grades, is around 0°C to -80/-100°C.

To allow the screening of different material in different environments (mainly to allow for screening the effect of the gas composition), a specific test device is proposed. It consists in round tensile specimens (named hollow-specimen) with a cavity machined in the gauge length allowing to pressurize it internally and test on standard cryo-test benches without safety issue. In a second step testing with pressurization of standard specimen at low temperature will be considered.

The work is divided into several tasks :

- Development of the hollow-specimen test method.
- Reproduction of published data with the test method to assess the reliability of the measurement.
- Material and environmental screening.
- In a second step, testing of standard specimen at low temperature.

SSRT is considered in a first approach but fatigue should also be possible.

Project aims:

- Define a reliable test method for cryogenic test under H₂ pressure using hollow specimens.
- Perform a screening of the severity of different materials and environments under H₂ pressure.

ENERGY

Project Title: Hydrogen permeation through metal under H₂ pressure		Acronym: Perm H₂
Research area: Energy, Hydrogen	Project period: 01/01/2022 - 31/12/2025	
Research leader: Christophe Mendibide christophe.mendibide@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: MRC Storage and Transportation of Hydrogen	
	Keywords: Hydrogen Pressure, Permeation, pipeline steels	

One key parameter to assess the severity of an environment regards hydrogen assisted cracking is the hydrogen uptake and fluxes in the material exposed to embrittling media. If permeation test through metals from liquid media is of common practice, also under pressure (ie.g. Devanathan and Stachurski test method), there is no common practices to perform testing in a H₂ gas media under pressure. Mainly, the test procedure is very important and can lead to large discrepancies. The detection method is also often discussed because the sensitivity can be too low in some media.

This project focuses of the development of a test method for permeation test through carbon steel under H₂ gas pressure. The objective is first to propose a standard test procedure allowing to make measurement with an acceptable reproducibility, before to screen different pipeline steels in different environment. Mainly the effect of contaminants would be considered after having established a robust test procedure.

Project aims:

- Development of a reproducible test method for hydrogen permeation under gas pressure.
- Screening of the severity of different atmosphere (variable H₂ pressure, effect of contaminants....).

ENERGY

Project Title: Hydrogen applicability of steels in gas storage facilities		Acronym: Store H₂
Research area: Energy, Hydrogen	Project period: 01/01/2023 - 01/12/2025	
Research leader: Laura Moli Sanchez laura.moli.sanchez@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Industrial funding	
	Keywords: Hydrogen, Fatigue, Toughness	

In order to achieve the climate targets, there is political consensus on the central role of hydrogen use in all sectors. The storage of hydrogen is the basic requirement for sector coupling because centralized energy storage in underground storage facilities (UGS) enables a secure and long-term supply of hydrogen. Due to the highly fluctuating production of hydrogen from various sources and the equally expected highly fluctuating demand, UGS will play a central role in the future energy system. The required conversion of existing underground gas storage facilities to hydrogen or the storage of natural gas-hydrogen mixtures makes special demands on the technical equipment (well completion), several aspects of which have not yet been sufficiently investigated. An essential aspect in this context is the suitability of underground pipe sections (typically API steels) and their corrosion and mechanical properties when exposed to hydrogen. The suitability of the material itself, as well as the suitability of the welded joints (and welding procedures and heat input by welding) must be investigated. The study described here is intended to provide answers to these questions.

The work is divided in 2 main tasks.

1. An exhaustive literature review including analysis of the existing standard for material qualification under H₂ pressure and their limitation.
2. A qualification program on alloys that could find a possible application in underground storage but whose properties under H₂ atmosphere are poorly documented.

This work is a collaboration between the French Corrosion Institute (France), The University of Leoben (Austria) and the Fraunhofer (Germany)

Project aims:

- Literature review and standard analyses to determine the materials that are already used for H₂ service and the gap in data needed to allow the use of candidate materials with limited documentation of their properties in H₂ environment.
- Qualify for service a couple of materials selected from the literature review and not documented in the literature. Different test methods are considered in the program: toughness, fatigue, constant and ripple load, permeation.

ENERGY

Project Title: Hydrogen embrittlement of pipe, casing and tubing materials used in underground storage of gaseous hydrogen		Acronym: HyMF
Research area: Energy, Hydrogen	Project period: 01/01/2024 - 01/09/2026	
Research leader: Christophe Mendibide christophe.mendibide@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Industrial funding	
	Keywords: Hydrogen, storage, H ₂ S	

In the perspective of hydrogen underground storage, the behavior of the metallic materials used in the infrastructures (pipe, casing, tubing) shall be evaluated under hydrogen pressure to ensure the safety of the facilities. In a design perspective, at least two properties need to be investigated: the toughness and the resistance to the crack propagation under fatigue loading.

Moreover, considering the presence of liquid phases and the possible bacterial activities developing underground, the hydrogen possibly stored can be exposed to water vapor and contaminated with H₂S gas. The objective of this project is to evaluate if H₂S and water vapor can modify the behavior of metallic materials under hydrogen pressure.

- Project aims:
- Screen the mechanical behaviour of metallic materials used in underground hydrogen storage assets.
 - Evaluate the possible effect of H₂S contamination and water vapor in hydrogen on steels.

ENERGY

Project Title: Mn austenitic stainless and non-stainless steels for hydrogen applications: production, transport and storage		Acronym: Hystory
Research area: Energy, Hydrogen	Project period: 01/06/2024 - 31/12/2028	
Research leader: Laura Moli Sanchez laura.moli.sanchez@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Public funding (RFCS)	
	Keywords: Hydrogen, pipeline, transportation and storage	

The goal of the HYSTORY project is to develop Mn austenitic stainless and non stainless steels via high throughput metallurgy screening. The project targets the development of innovative grades for hydrogen production (PEM electrolysers), cryo-compressed hydrogen storage and compressed hydrogen transport. Therefore, the susceptibility to hydrogen embrittlement and the interaction between hydrogen and the microstructures will be deeply studied. The positioning of the novel developed grades versus current steel solutions (austenitic stainless 316L and ferritic line pipe grade) will be assessed in terms of hydrogen embrittlement susceptibility and steel manufacturing competitiveness. In addition, key performance indicators defined for each studied property and weight algorithm will assist the optimization of the metallurgies and the alloys comparison.

The project aims at progressing a development between TRL2 to TRL4 over the project duration.

- Project aims:
- Define an optimized composition of Mn austenitic non-stainless steel for hydrogen applications.
 - Produce a selection of experimental heat at an industrial scale.
 - Screen the properties under hydrogen of the novel developed grade (toughness, FCGR, permeation, SSRT).

ENERGY

Project Title: Clad pipes for safe and effective hydrogen storage and transport		Acronym: CladPipe4H₂
Research area: Energy, Hydrogen	Project period: 01/01/2025 – 01/01/2028	
Research leader: Laura Moli Sanchez laura.moli.sanchez@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Public Funding	
	Keywords: Hydrogen, storage, Transport, Cladding	

The overall aim of the project CladPipe4H₂ is the development, manufacturing and testing of new metallic structural material combinations for safe and effective hydrogen storage, transportation and distribution. In the project, material combinations will be developed and manufactured consisting of a base material to meet the strength requirements and a clad material to fulfil the hydrogen barrier and embrittlement resistance requirements. The main goal of the project is to provide durable structural materials and components for stationary (e.g. power production, machinery, residential and industrial use) and mobile (e.g. road, off-road, rail, ship, and aviation) high-pressure gaseous hydrogen applications (≥ 300 bar). Focus use cases are vessels as well as pipelines and piping for gaseous hydrogen storage and transport being exposed to these high pressures and many load cycles. Due to combination of two metallic materials, costs will be saved by reducing wall thickness compared to monolithic metallic components and by substituting expensive fiber-reinforced polymers. The microstructure and their interaction with hydrogen as well as the influence on the mechanical properties will be investigated. Energy- and cost-effective process routes for small batch size and high-volume production will be realized and the manufactured components will be validated with developed testing methods.

Project aims:

- Develop cladded material for hydrogen transport and storage.
- Develop processing routes for cladded material applications for hydrogen.
- Develop test methodologies for testing cladded materials under hydrogen.

ENERGY

Project Title: Corrosion potential monitoring of different material in environment simulating nuclear waste storage		Acronym: PotWastCorr
Research area: Energy, Nuclear waste disposal	Project period: 01/06/2023 – 30/06/2025	
Research leader: Nicolas Bulidon nicolas.bulidon@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Industrial funding	
	Keywords: Nuclear waste, geological repository, hydrogen production, free potential.	

At the Aube storage center, packages of short-lived low and medium activity waste are stored in gravel structures or concrete structures. Inside waste packages, metals potentially highly reactive with hydraulic binders are subject to a specification which imposes the completion of the technical test to determine the acceptable metal surface in the packages regarding the production of hydrogen by corrosion in an alkaline environment.

The study will be limited to the chemical reactivity of metal waste placed in solutions representative of the pore water of a cement matrix. The tests to be carried out on the different materials (brass, lead, zirconium, zinc) are measurements of free potential in a pH range representative of healthy/degraded concrete, in aerated/deaerated conditions. For each environment, this includes measuring the water reduction potential and measuring the metal free potential. The objective is to compare these potentials to the water reduction potential to specify the test conditions (aerated/deaerated) to be adopted for an exhaustive list of reactive metals.

Project aims:

The main objective of this project is to determine the free potential of different metallic materials in the pore water of cement-based matrix.

ENERGY

Project Title: Study of corrosion of metallic materials in organic acids environments		Acronym: Morgacor
Research area: Energy, Nuclear waste disposal	Project period: 01/06/2023 - 30/06/2025	
Research leader: Nicolas Bulidon nicolas.bulidon@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Industrial funding	
	Keywords: Nuclear waste, geological repository, corrosion rate, organic acid.	

In the context of the radioactive waste disposal CIGEO, some nuclear waste packages may contain organic and metallic materials. Organic materials are present in technological waste and in process waste produced during operation, maintenance or dismantling operations carried out in fuel cycle installations. Some mechanisms for the degradation of organic matter can lead to the formation of carboxylic acids.

The objective of this study is to evaluate the effect of formic and oxalic acids on the corrosion of stainless steels (304L and 316L) and carbon steel (X65). The influence of the temperature and the acid concentration will be assessed. The tests will be performed in aerated and deaerated solutions. Weight loss measurements and free potential monitoring will be carried out.

Project aims:

The main objective of this project is to assess the corrosion resistance of the metallic materials in organic acid environments.

ENERGY

Project Title: Study of corrosion on the carbon steel X65 in the disposal of high-level radioactive waste		Acronym: Corracim3
Research area: Energy, Nuclear waste disposal	Project period: 01/06/2023 - 30/06/2025	
Research leader: Nicolas Bulidon nicolas.bulidon@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Industrial funding	
	Keywords: Nuclear waste, geological repository, corrosion rate, corrosion products, cement	

Since 2014 the multi-barriers concept developed for storage of high activity long life nuclear wastes, includes a cement layer. This cement-based grout material will be injected to neutralize the potential acidity resulting from the host rock oxidation induced by the drilling process of the disposal cell.

The project aims in evaluating the corrosion of the casing (API5L X65) in contact with new cement grout material compositions in aerated environment (water). After each exposure time (from one month to 18 months), the following analyses will be performed:

- Mass loss to evaluate the corrosion rate.
- SEM examinations and Raman analyses to determine the nature of the corrosion products.
- Chemical analysis of the water in contact with the cement material.

These results will be compared with those already obtained with the previous tested composition of filling material (cement-bentonite grout). Additional tests will be performed to evaluate the influence of argillite fragments and the effect of cracking in the cement layer.

Project aims:

- To assess the corrosion resistance of the carbon steel in a new cement environment.
- To define the cement grout material which will be the most fitting in the deep geological storage.

ENERGY

Project Title: Potential influence of microorganisms on the corrosion of carbon steel in the French radioactive waste disposal context		Acronym: HAnubiss 3
Research area: Energy, Nuclear waste disposal	Project period: 01/06/2023 – 01/06/2027	
Research leader: Erwan Diler erwan.diler@institut-corrosion.fr +33 298 05 15 52	Source of funding: Public funding	
	Keywords: Corrosion, Microbially Influenced Corrosion, carbon steel, cement grout, pore water, microbiology	

In the context of the high-level radioactive waste disposal CIGEO, the corrosion rate due to microbially influenced corrosion (MIC) has to be evaluated. In France, it is envisaged to dispose of high- and intermediate-level long-lived radioactive waste at a depth of 500 m in a deep geological disposal, drilled in the Callovo-Oxfordian claystone (Cox) formation. To do so, according to the current concept, a carbon steel casing will be inserted inside disposal cells, which are horizontal tunnels drilled in the Cox. A specific cement grout will be injected between the carbon steel casing and the claystone. The main objective of this filling grout is to balance the transitory acidic conditions in the medium induced by the Cox oxidation. In addition, the alkalinity provided by the cement is expected to favor the steel passivity and act as strong environmental constraint for microorganisms. However, throughout its life, the disposal cell will be subject to various hydraulic, thermal, physical-chemical, and mechanical transients. This study is conducted to evaluate the possibility of MIC in such environments for various cement grout formulations and temperatures.

The corrosiveness will be investigated with or without microorganisms enriched from samples of Andra's underground research laboratory and complemented by adapted collection strains. Two cement grout mixtures, three temperatures (30, 50 and 80°C), three dissolved oxygen levels, and three durations (6, 12 and 18 months) are investigated. The monitoring of corrosion during the experiments will be ensured using a gravimetric method and real-time corrosion sensors based on the measurements of the electrical resistance. The corrosion data will be completed with microbiological analyses including cultural and molecular characterizations. This work is performed in collaboration with Corrodys (France).

Project aims:
<ul style="list-style-type: none"> • Assess the potential influence of microorganisms in this specific environment. • Compare the cement-grout formulations in terms of environment constraints and impacts on carbon steel corrosion. • Assess the influence of low oxygen on the corrosion rate and potential MIC.

ENERGY

Project Title: Qualification of newly developed corrosion monitoring systems under ionizing radiation for the radioactive waste French underground laboratory		Acronym: SensIRAD 2
Research area: Energy, Nuclear waste disposal	Project period: 01/03/2025 – 01/09/2026	
Research leader: Johan Becker & Erwan Diler johan.becker@institut-corrosion.fr erwan.diler@institut-corrosion.fr +33 298 05 15 52	Source of funding: Public fundings (ANDRA)	
	Keywords: Corrosion monitoring, electrical resistance sensors, carbon steel, storage and disposal of radioactive waste	

The French deep geological repository solutions for the disposal of high and intermediate-level long-lived radioactive waste is studied since decades at the underground pilot laboratory (URL) managed by the French National Agency for Radioactive Waste Management (Andra). The URL is located in the East of France, 500 meters deep, in a stable Callovo-Oxfordian claystone layer, selected for its containment properties. The concept relies on a multibarrier approach including the use of a carbon steel (CS) casing inserted in microtunnels and in which sealed radioactive waste container will be then introduced. After insertion of the CS casing, a remaining technological gap between the Cox and the extrados of the casing is filled with a specific cement grout. This cement grout aims to buffer the acidic transient resulting from the release of acidity in the pore water due to the oxidation of sulfur-based minerals.

The Andra is therefore conducting studies focusing on the corrosion and mechanical behavior of the CS casing, with particular interest for real-time corrosion monitoring solutions as an alternative to the common gravimetric method using reference coupons. Several techniques are investigated, including the electrical resistance (ER) raising several challenges to satisfy the requirements implied by the specific conditions of the disposal or radioactive waste in deep geological repository.

In this context, a new ER sensor corrosion monitoring solution has been developed and qualified in the framework of previous projects, i.e. SensAndra and SensIrad. This ER sensor design was proved to enable real-time monitoring of the corrosion under strong ionizing conditions. Besides, results from this first irradiation campaign suggest an influence of the γ -rays on the corrosion dynamic of the low carbon steel ER sensors. To better understand this effect, further investigations will be conducted in this project including irradiation of sensors i) under controlled atmospheric conditions and ii) in cement grout that mimics the environment at the extrados of the URL microtunnels casing.

Project aims:
<ul style="list-style-type: none"> • Develop a test cell that enables to control and monitor environmental conditions (relative humidity, temperature ...) under irradiation conditions. • Assess the effect of the irradiation on the corrosion of a low carbon steel under controlled atmospheric conditions and in cement grout.

ENERGY

Project Title: Effect of the acetates content in test solution on the cracking susceptibility of OCTG material during sour qualification test		Acronym: AcetaSSC
Research area: Energy, Oil and gas	Project period: 01/01/2022 - 31/12/2025	
Research leader: Christophe Mendibide christophe.mendibide@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: MRC CCUS and H₂S	
	Keywords: Geothermal Energy, Stress corrosion cracking	

Carbon steel used in the Oil&Gas industry for production applications are exposed to sour media containing H₂S with several risks of environmental assisted cracking:

- Hydrogen induced cracking (HIC) or Stress oriented hydrogen induced cracking (SOHIC)
- Sulfide Stress Corrosion Cracking (SSC)

pH and H₂S partial pressure are considered as the main parameters governing the risk of cracking and ISO 15156 – part 2 defines specific severities regions of productions environments depending on the level of the two parameters.

For lab qualification tests, 2 main standards are commonly used: NACE TM0177 for SSC test and NACE TM 0284 for HIC. According to these standards, a great variety of test solutions may be chosen by the end-users with acetates contents varying between 5 and 930 mM. These species used to buffer the solution are also suspected to affect the cracking susceptibility in sour environment.

To address the effect of acetates, a work has been initiated to implement hydrogen permeation monitoring and electrochemical impedance spectroscopy during standard SSC qualification. One OCTG grade is selected for the work and will be tested in borderline conditions in solution containing different acetates contents to try correlating the nature of the solution, the cracking susceptibility, the hydrogen uptake and the nature of the corrosion scale forming on the specimens.

The preliminary work will serve a basis of a JIP proposal recently submitted by FCI.

Project aims:

- Develop a technique for hydrogen permeation monitoring during standard SSC test.
- Evaluate the effect of the acetates content on SSC test result of one selected material.
- Correlate the test results with permeation, electrochemical and SEM data.

ENERGY

Project Title: Impact of H₂S fugacity on hydrogen charging and SSC of carbon steels		Acronym: Fugacity II
Research area: Energy, Oil and gas	Project period: 01/04/2022 - 01/12/2025	
Research leader: Christophe Mendibide christophe.mendibide@institut-corrosion.fr +33 4 77 40 00 45	Source of funding: Industrial funding	
	Keywords: Stress corrosion cracking, H ₂ S, Permeation	

As the total pressure of oil & gas production environments increases, thermodynamic calculations using perfect fluids simplifications are not valid anymore. For acid gases such as H₂S, this involves the use of fugacity instead of partial pressure. However, most industrial standards related to H₂S cracking are using partial pressure scales. It is also a common practice to perform H₂S qualification tests at low total pressure, at the same H₂S partial pressure as the one of the production environment, disregarding the potential effects of fugacity.

In a first JIP conducted during the period 2019-2021, the potential impact of fugacity on the risks of H₂S cracking was studied. The proof of concept of the fugacity effect was assessed using hydrogen permeation techniques at high pressure (up to 300 bar). We observed 2 different effects depending on the range of pH and pH₂S:

- Either the permeation flux at high pressure is lower than the one obtained at atmospheric pressure under the same pH/pH₂S node.
- Or, due to variation in scale protectiveness, a so-called “inversed fugacity effect” was observed leading to a higher hydrogen charging flux at high pressure rendering the standard qualification test possibly not enough conservative.

This new project aims at complementing the results obtained in the first program, mainly through the use of cracking tests (HIC/4PB and DCB) together with permeation.

Project aims:

- Evaluation of the possibility to qualify material using the fugacity concept through testing at atmospheric pressure.
- Estimate in which pH/pH₂S conditions the inverse fugacity effect can be observed.
- Estimate the possible effect of buffer system on the results.
- Proof of concept of the fugacity effect above the bubble point (work in full liquid systems).

ENERGY

Project Title: Hydrogen embrittlement resistant new steel links solutions for offshore wind turbines		Acronym: Helix
Research area: Energy, Wind energy	Project period: 01/07/2022 - 31/01/2026	
Research leader: Nicolas Larché nicolas.larche@institut-corrosion.fr +33 298 05 15 52	Source of funding: Public Funding (RFCS)	
	Keywords: Hydrogen embrittlement, bolting, wind energy, cathodic protection, coatings	

To increase the use of electricity produced from renewables the full potential of Europe's offshore wind energy has to be developed. To unlock Europe's offshore potential, the number of installed offshore wind turbines is expected to rise in the coming years. Cost reduction and efficiency are still imperative in this technology and the industry is thus designing larger power generators, up to 10 MW. This trend will lead to larger foundations due to higher mechanical demands. Flanged connections are still an integral part of any offshore developments with fasteners being the primary means for assembly.

Fasteners with diameters over M48 are becoming common and bolts already used can be as high as M72. Therefore, a technical and research effort is needed in the fasteners field to support the ever-increasing size of offshore wind turbines. On one hand, HELIX will develop, test and provide fasteners able to withstand high applied stresses under harsh environmental conditions typical of large offshore wind turbines. This will be achieved by developing and optimising a novel high strength steel grade in qualities 10.9 and 12.9 and new protecting zinc-flake based coatings. On the other hand, HELIX will contribute to unravel how atmospheric and immersed conditions, material composition and microstructure, surface treatment and previous corrosion affect hydrogen embrittlement of high strength steels. HELIX will use advanced characterization techniques as well as traditional techniques under both atmospheric and immersion conditions, to advance in the knowledge of hydrogen absorption in high strength steels under cathodic protection and in atmospheric conditions. This knowledge will not only allow tailoring the steel and coating microstructure to achieve both excellent corrosion protection ability and low risk of hydrogen embrittlement but also influence on policy and practice in the offshore wind sector.

Project aims:

- To optimize new lower cost high strength steel composition with improved hardenability, high toughness and high hydrogen embrittlement resistance.
- To identify the mechanisms of hydrogen absorption/desorption of the optimized steels.
- To develop coatings based on zinc flakes and different topcoat materials to protect the steel and to reduce hydrogen production in service. To develop coatings based on zinc flakes and different topcoat materials to protect the steel and to reduce hydrogen production in service.
- To study the interaction of the optimized steel, the novel coatings and the environment on the hydrogen absorption mechanisms.
- To demonstrate the higher performance of the developed fasteners in real environments.

ENERGY

Project Title: Extended life DURation for steel welds and LINKs for off-shore renewable energy generation		Acronym: Duralink
Research area: Energy, Wind energy	Project period: 01/07/2024 - 31/12/2027	
Research leader: Flavien Vucko flavien.vucko@institut-corrosion.fr +33 298 05 15 52	Source of funding: Public Funding (RFCS)	
	Keywords: High strength steel, hydrogen embrittlement, cathodic protection, fatigue	

The growth and stability of the wind industry will depend essentially on continued reductions in wind energy cost, even below that of fossil-fuel based energy sources. Consequently, the offshore wind industry is upscaling Wind Turbines from 8 MW up to more than 12 MW. This level of upscaling puts tough materials challenges because the mass of the turbine increases linearly with the cube of the rotor radius. DURALINK project is thus motivated by the challenges in structural integrity assessment of the large structures and chains that will support offshore wind generation in the future. Therefore, the main objective of DURALINK is to identify optimization design opportunities for offshore structures that lead to a reduction of the CAPEX and OPEX of offshore wind turbines. To attain this objective, DURALINK will identify optimization design opportunities for offshore structures through the evaluation of existing and improved steel grade welds, corrosion-fatigue analysis with cathodic protection at different potentials and developing predictive models of mechanical degradation. Furthermore, high strength steels composition will be optimized to lower Hydrogen Embrittlement susceptibility improving the security of chains for offshore wind turbines. Finally, DURALINK proposes a novel concept for protection of support structures. For this, it will develop novel thermal sprayed coatings for protection of substructure against marine corrosion able to be deposited by High Velocity Wire Arc Spray. The corrosion performance and enhanced behavior of the coated steels under fatigue, corrosion-fatigue and tribocorrosion conditions will be evaluated.

Project aims:

- To identify optimization design opportunities for offshore structures through the evaluation of existing steel-grade welds through corrosion-fatigue analysis with cathodic protection at different potentials and the development of fatigue models.
- To optimize high strength steels composition, used in chains for offshore XL-WT, to lower Hydrogen Embrittlement susceptibility.
- To improve the fatigue behaviour of welds in S420NL and S460NL steel grades thanks to the effect of High Frequency Mechanical Impact post weld treatment for R > 0.5.
- To develop novel Thermal Spray coatings for protection of substructure against marine corrosion able to be deposited by High Velocity Wire Arc Spray.
- To evaluate the corrosion performance and enhanced behaviour of the coated steels under fatigue, corrosion-fatigue and tribocorrosion conditions.

PROCESS INDUSTRY

Project Title: Effect of chloride on corrosion behaviour of different alloys in simulated biorefinery process		Acronym: CorrBioRef
Research area: Process industry, Biorefinery and biomass	Project period: 01/01/2025 - 31/12/2025	
Research leader: Abdelkader Meroufel & Matthieu Regnier abdelkader.meroufel@ri.se matthieu.regnier@institut-corrosion.fr +46 10 228 49 95	Source of funding: MRC Biorefinery	
	Keywords: Corrosion, Biorefinery Process, Corrosion-resistant Alloy	

Biorefinery is an emerging technology and a continuously growing business sector with a continuous development of new advanced processes. Many of these processes are highly demanding regarding the corrosion resistance of the alloys used in biorefinery plants. This makes it challenging to introduce the new advanced processes on a large commercial scale and to benefit from their full potential. This requires significant extent of effort and knowledge not only related to the processes, but also to material selection to avoid corrosion of components used in such challenging environments.

Based on initial results, the project continues exploring Corrosion resistant alloys (CRAs) behaviour under unsaturated conditions at high temperature as well as the performance in hot acids in semi-immersion exposure conditions. The focus is paid to the stress corrosion cracking phenomenon where no data are available for both end-users and material producers. CRAs performance data will be the main deliverable that will help biorefinery sector in materials selection question.

Project aims:

- To determine the performance of different CRAs in terms of SCC resistance under unsaturated conditions and hot acid in semi-immersion.
- To understand the effect of critical parameters that determine materials behaviour.
- To establish data on materials compatibility in simulated biorefinery processes.

PROCESS INDUSTRY

Project Title: Less Corrosive Biofuel Production Process		Acronym: LowCoBio
Research area: Process industry, Biorefinery and biomass	Project period: 14/12/2024 - 14/12/2027	
Research leader: Matthieu Regniere & Rikard Norling matthieu.regniere@institut-corrosion.fr rikard.norling@ri.se +33 477 40 00 45 +46 10 228 48 89	Source of funding: Public funding	
	Keywords: Biofuel, Corrosion	

The overall aim of the LowCoBio project is to accelerate the commercialization of bio-oil based production routes of renewable fuels. This will be achieved by a cross-cutting project approach where the production processes are developed further, at the same time as corrosion issues of the materials and processes are investigated. This is an important research area since corrosion constitutes one of the present barriers to scale-up. The project aims to provide guidance on adjusting the process conditions throughout the whole production process, from pretreatment to liquefaction and upgrading, so that product quality and yield remain high at the same time as the need for very expensive construction materials is avoided. To achieve its ambitious overall aim, the project has defined 4 specific objectives (SO), described below.

Project aims:

- Improve biofuel production process with reduced product corrosivity.
- Scale-up and demonstration at TRL 5.
- Lifecycle, techno-economic and environmental impact analysis.
- Provide materials selection guidelines.

PROCESS INDUSTRY

Project Title: Industrial Online Corrosion Monitoring – Acoustic Emission and Electrochemical Probes		Acronym: CorrMon
Research area: Process industry, Chemistry	Project period: 01/01/2023 – 31/12/2025	
Research leader: Clément Boissy & Clément Lecart clement.boissy@institut-corrosion.fr clement.lecart@institut-corrosion.fr +33 678 21 57 88	Source of funding: Industrial funding	
	Keywords: Chemical Process Industry, Industrial Corrosion Assessment, Online Monitoring, Acoustic Emission, Electrochemical probe	

Corrosion monitoring is a key point for process industry. It aims to be able to follow corrosion propagation or detect corrosivity deviation to anticipate maintenance operation and optimize OEE. Moreover, corrosion monitoring enables evaluation of the corrosion in operative environment as an extension of laboratory work. IC regularly proposes the use of coupons to evaluate corrosion rate, but this technique is very limited. Online corrosion monitoring by acoustic emission is also currently proposed (mature technology still under development) and use of electrochemical probes is under development.

Acoustic Emission (AE) defines the elastic energy which is released in material in the form of transitional ultrasonic elastic waves, resulting of internal micro displacement. Many developments occurred in recent decades alongside advances in electronics and IT, since 1950 with the works of J. KAISER. Applications of AE technique could be gathered in two families: control of structure integrity and online monitoring. It's in this second family that IC offers and develop its skills for industry. It consists in monitoring equipment during process without external intervention. AE enables to assess potential active damage (SCC, intergranular or pitting corrosion, fatigue...) evolution depending of process parameters and process management. AE is a powerful nondestructive and nonintrusive technique allowing online volume monitoring in severe conditions, for example: chloride stress corrosion cracking in DSS decanter, thermal fatigue phenomena in the bottom of polycondensation calves and mechanical fatigue on the supports of crystallizers.

Electrochemical Probe offer on the market tends to shrink with withdrawal of major company in Europe. It has been developed for Oil and Gas industry and have difficulties to be adapted for process industry considering the wide range of process and materials that requires adaptability and electrochemical expertise. Commercial systems are rather inexpensive but without any adaptability. For this reason, IC is collaborating with ORIGALYS to develop a system that could be used as a potentiostat but also as a datalogger for weeks of recordings. Test lab in 2023 and industrial test in O&G industry (2024) permit to validate the performances of the equipment. The first test in process industry plant is planned for 2025 with several months of monitoring. Improvement of the datalogger regarding power supply and data communication is also planned for 2025.

This project is funding by Industrials plants (Acoustic Emission) and internally (Electrochemical Probes).

Project aims:

- To develop online monitoring of active corrosion and damages.
- To replace offline corrosion monitoring with coupons.
- To provide data to industrial customers in order to help them in decision making for process management or maintenance operation scheduling or investment.

PROCESS INDUSTRY

Project Title: Non-destructive testing using microwaves to assess plastic corrosion		Acronym: NDT plastic
Research area: Process industry, Chemistry	Project period: 01/11/2024 - 30/04/2026	
Research leader: Andrew Gordon andrew.gordon@ri.se +46 10 228 48 55	Source of funding: Public funding (Vinnova)	
	Keywords: Fiber reinforced plastic (FRP), Non-destructive testing (NDT), microwave, inspections, digitalization of industry	

The project will develop and deploy devices to measure the thickness of fiber reinforced plastic (FRP) with microwaves at four different sites, a pulp mill, two chlorine mills and a chemical plant. The microwave devices are constructed with a new and cheap type of chip, allowing for a wide use of the future product. This methodology has been proven in previous projects to be very promising for the purpose. Software and hardware will be developed in collaboration between RISE and Percy Roc.

The response of the measuring instrument will be correlated to evaluations of the material in the laboratory. This knowledge will be the basis for safe and secure use of technology. In addition to knowledge of the effects of different materials on microwave propagation, knowledge of how different environments (chemical solution, liquid and gas) affect the signals will also be obtained. Lessons will also be learned on how to make the product practical for use in industry.

Project aims:

- To determine the thickness of FRP-constructions using a portable microwave unit.
- To develop software that can help in interpretation of corrosion defects as measured with the microwave unit.
- To form a microwave module at a TRL-level and user friendly that it can be used within Swedish industry.

PROCESS INDUSTRY

Project Title: Construction materials for Li-battery recycling process, phase II		Acronym: Recycling-battery
Research area: Process industry, Chemistry	Project period: 01/01/2025 - 31/12/2026	
Research leader: Andrew Gordon andrew.gordon@ri.se +46 10 228 48 55	Source of funding: MRC Corrosion Properties of Polymers	
	Keywords: Li-battery, recycling, hydrometallurgy, Critical Raw Materials Act, black mass, plastic construction materials	

Hydrometallurgy is emerging as an important technique to recycle valuable materials used in Li-ion batteries. The process to extract valuable metals, such as cobalt, nickel and manganese, from the black mass can be performed in several ways, the mixture of H₂SO₄ and H₂O₂ being one of the more economical and efficient to extract the desired elements. However, there is little knowledge within industry on how different plastics perform under such conditions. This project is a continuation project from the investigation of five different thermoplastics and five different laminates (fiber reinforced plastics) exposed in 30wt% H₂SO₄ and 5wt.% H₂O₂ at 60 °C up to six months. In phase II other exposure conditions used within the industry are explored.

Project aims:

- To investigate the possibility to use plastic as construction materials for recycling of black mass.
- To learn more about the degradation mechanisms related to oxidative mixture of sulfuric acid and hydrogen peroxide.

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