Curtin University

CURTIN CORROSION CENTRE

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For over 30 years, the Curtin Corrosion Centre (CCC) has been conducting state-of-the-art scholarly and demand-driven research in areas of corrosion related to the petroleum, mining, defence, and chemical processing industries. Likewise, the centre is actively engaged in short-term research and development (R&D) problem-solving projects.

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CRICOS Provider Code 00301J

EXPERTISE

Mechanically assisted corrosion

Mechanically assisted corrosion encompasses the most dangerous forms of corrosion, often leading to catastrophic failures. They occur due to a combination of mechanical factors (e.g. applied and/or residual stresses, cyclic loading, wear) and electrochemical corrosion. The most common types of mechanically assisted corrosion are stress corrosion cracking, erosion- and abrasion-corrosion (tribocorrosion), cavitation corrosion, and corrosion fatigue.

At the Curtin Corrosion Centre, we have experts in the fields of tribocorrosion and environmentally assisted corrosion as well as a wide range of testing methods to evaluate and compare materials under different metallurgical and environmental conditions, allowing us to investigate mechanically assisted corrosion holistically.

Localised corrosion

Our team at the Curtin Corrosion Centre has gained international recognition in the field of localised corrosion of stainless steels, nickel and aluminium alloys. Our research covers both fundamental aspects of localised corrosion phenomena as well as the development of practical engineering guidance for materials selection and corrosion management.

As with mechanically assisted corrosion, we focus on linking the performance of an alloy system with microstructure and manufacturing history. We provide expert knowledge on mitigation strategies and risk identification. The Curtin Corrosion Centre is equipped with state-of-the-art facilities to study localised corrosion phenomena from the nano- to the macro-scale.

Corrosion modelling

The Curtin Corrosion Centre has capabilities for corrosion modelling and simulation allowing to understand corrosion mechanisms, predict corrosion damage and develop custom-designed corrosion mitigation strategies within a wide range of field conditions. The modelling and simulation lab is equipped to compute corrosion rate of galvanic corrosion, potential and current distribution along crevice, potential distribution due to cathodic protection, and assessment of deposited surfaces, among others.

Micro-biologically influenced corrosion

Microbiologically influenced corrosion (MIC) is corrosion initiated, facilitated or accelerated by microorganisms and their metabolic functions. MIC is one of the costliest forms of corrosion and remains highly unpredictable.

The Curtin Corrosion Centre has developed expertise and world-class, state-of-the-art, MIC laboratories and staff to provide high-end technology and methods to study microorganisms (mainly biofilms) and their effects on metallic infrastructure and processes in the resources sector.

Corrosion under insulation

Corrosion under insulation (CUI) is an insidious form of corrosion caused by water entrapped within thermal insulation. The presence of thermal insulation and jacketing slows down water evaporation and prolongs the wetting period. As a result, corrosion proceeds undetected. The hidden nature of the CUI often makes accurate inspection and monitoring difficult. A late detection of CUI can result in disastrous outcomes such as leakages, loss of containment, and even fire and explosion.

Curtin Corrosion Centre actively engages with industry on CUI studies. We investigate both the mechanism and the parameters that influence CUI. Additionally, we explore various promising CUI mitigation strategies, such as the appropriate selection of insulation materials, the use of high-temperature protective coatings, and chemical treatments.

Acid gas corrosion

When dissolved in aqueous solutions, acid gases such as CO_2 or H_2S can be highly corrosive and have led to multiples failures and leakages in the oil and gas industry. These gases are regarded as the primary sources of the internal corrosion of production tubing, transportation pipelines, and sometimes subsequent process equipment.

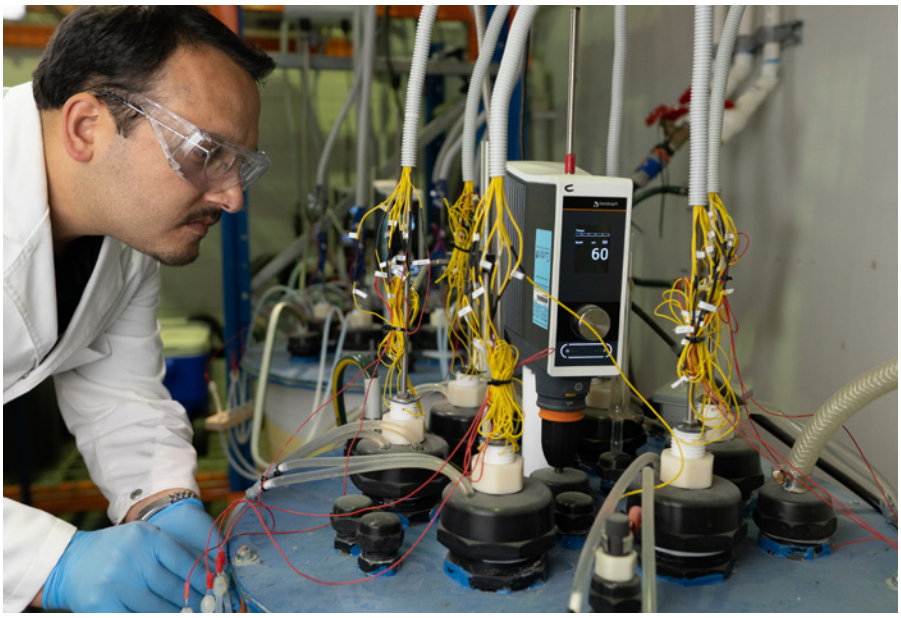
Curtin Corrosion Centre houses state of the art research facilities that can simulate complex operating conditions; e.g., from ambient to high-pressure and high-temperature (HPHT) service, from stagnant to turbulence flow regimes, from single phase to two-phase systems (oil/

water or gas/water), from sweet (CO_2) to highly sour (H_2S) systems, and the effect of mercury. The corrosion behaviour and corrosion prevention of metals exposed to environments containing acid gases are often studied in environments containing CO_2, H_2S—more often gas mixtures—and temperatures mimicking field conditions.

Atmospheric corrosion

Atmospheric corrosion—perhaps the corrosion phenomenon we experience more frequently in our daily lives—refers to the "situation of exposure of a component." Although uniform corrosion (e.g., rust) is the most common form of atmospheric corrosion, atmospheric corrosion does not imply a particular type of corrosion.

At the Curtin Corrosion Centre, we study coatings and materials degradation caused by atmospheric exposure using a combination of fundamental electrochemical methods and simulated exposure cycles in our salt spray and environmental chambers. We can simulate specific outdoor atmospheric conditions, including extreme temperature cycles, UV exposure, marine atmospheres, intermediate immersion, and more. Accelerated tests are used to study the rates of degradation of various coatings in specific environments. Life prediction models based on a combination of electrochemical methods and changes in physical properties after long-term exposures are also being developed at the Curtin Corrosion Centre.



Corrosion protection

Corrosion is a deterioration of metals by reactions with their environments. Except for noble metals such as gold and platinum, corrosion is a natural process for most metals. It has been reported that corrosion costs society between 3 and 5% of the Global Gross Domestic Product. Mitigating corrosion can, therefore, lead to cost savings and increase revenue, improve process safety, and minimise environmental contamination.

Our approach to studying corrosion protection strategies involves a combination of electrochemical and immersion methods, always correlating performance with materials properties and manufacturing routes. We have at our disposal state-of-the-art characterisation techniques that provide further insight into corrosion inhibition and protection mechanisms.

Our researchers are actively engaged in corrosion protection research, including corrosion inhibition, coatings and coating degradation, as well as cathodic protection design. Our environmentally assisted cracking work also involves hydrogen embrittlement associated with cathodic protection of subsea production systems.

Integrity management

An asset's ability to perform its intended function effectively and efficiently while safeguarding the safety and health of personnel and the environment is vital in meeting its business objectives. Structures, machinery, utility and electrical systems and instrumentation are all susceptible to failures due to various forms for corrosion.

Adequate integrity management strategies must be applied systematically to maintain valuable assets in working conditions, so they remain fit-for-purpose. A review of these strategies should be carried out at regular intervals to monitor their effectiveness, adapting rather than reacting to possible changes in service conditions.

At the Curtin Corrosion Centre, we engage with various asset owners and operators to review the effectiveness of integrity management strategies at multiple stages of the life of an asset.

The Curtin Corrosion Centre provides expertise in data-driven decision making. These decisions are aimed for continuous improvement of the corrosion and integrity management strategies.

We are supported by the recognised industry and academic experience of our researchers and engineers, resulting in a broad range of activities tailored to address practical problems and provide relatable data to decision makers.

Large-scale industrial research

Thanks to Curtin University's distinct combination of industry and scholarly expertise, the Curtin Corrosion Centre has partnered with industry to design, build, commission and operate large-scale processing facilities.

In this regard, in collaboration with Chevron, the Curtin Corrosion Centre has engineered and built the only Mono-Ethylene Glycol (MEG) laboratory-scale regeneration and reclamation research facility in Australia. Similarly, the Curtin Corrosion Centre designed a world-first pilot liquified natural gas (LNG) regasification unit in partnership with Woodside. Curtin's LNG process reaches cryogenic temperatures a priori assumed to be impossible to simulate in the laboratory. Our researchers have also developed a noble CO_2 capture by cryogenics process as part of the CO_2 CRC.

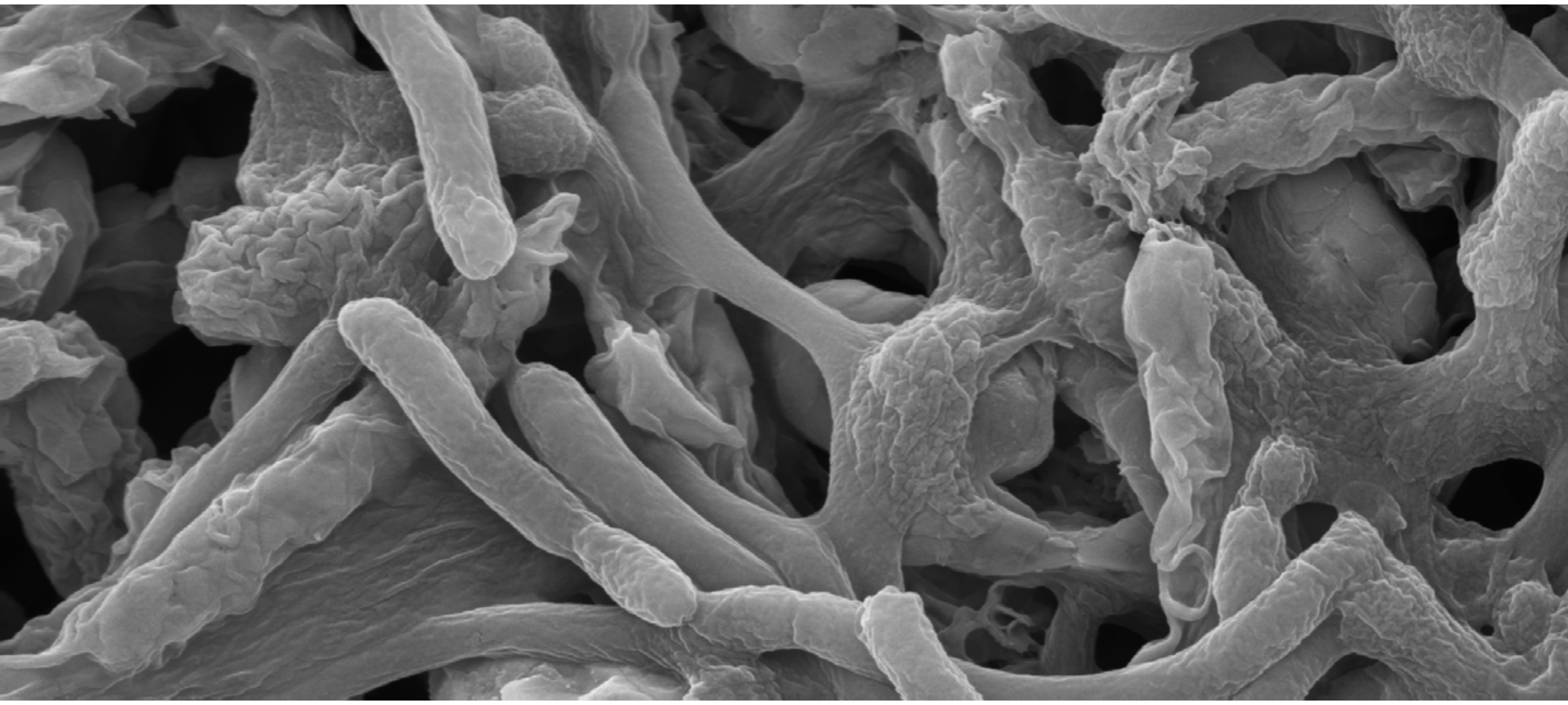
The large-scale units also offer unique learning opportunities to undergraduate and postgraduate students from across the Faculty of Science and Engineering.

EDUCATION (COURSES AND STUDY OPTIONS)

All postgraduate courses for Corrosion Engineering are offered online. Units are taught by leading academics with relevant expertise in the subject matters through both industry experiences and cutting-edge research.

If you have an undergraduate degree in engineering or applied science, then this allows you to break into the market and fast-track your career in a broad spectrum of industries.

A higher degree by research from Curtin will enable you to pursue a specialist area in corrosion and materials science and engineering, build knowledge in your profession and contribute to valuable research.



FACILITIES

EXTREME laboratory

The Curtin Corrosion Centre has developed and commissioned the first laboratory capable of handling high-pressure pure hydrogen sulfide (H_2S) gas as well as any carbon dioxide (CO_2) and H_2S mixture in Australia. Additionally, the new facilities allow us to conduct research using pure hydrogen gas at atmospheric pressure.

Environmentally assisted cracking laboratory

The recently established Environmentally Assisted Cracking Laboratory (EAC-LAB) is equipped with highly specialised testing equipment to evaluate a material's mechanical performance under a wide range of corrosive environments.

Additionally, the equipment and facilities in the EAC-LAB allow us to conduct hydrogen permeation tests using the Devanathan-Stachurski method (ASTM G148), conventional electrochemical experiments, and more.

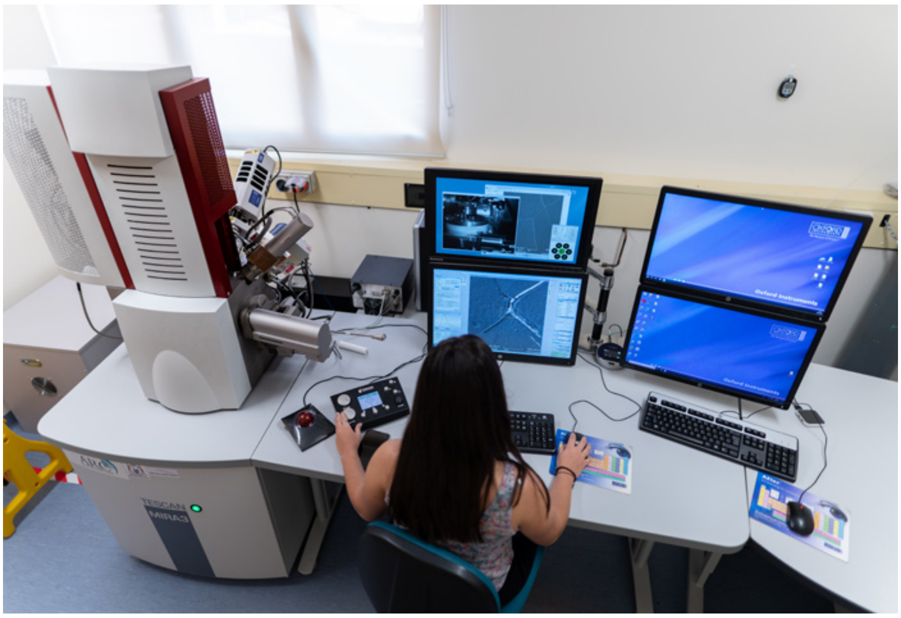
All tests can be done under controlled atmospheres utilising various gases (N_2, CO_2, and air) and under precise temperature control, from 0 to 98°C.

The lab also houses a microhardness apparatus capable of producing Vickers microhardness maps as well as a brand-new light optical microscope with advanced image manipulation capabilities.

Seawater and Atmospheric Corrosion Laboratory

In 2019 the Curtin Corrosion Centre commissioned a new Seawater Laboratory, which is home to our new weathering test equipment and a dedicated section for short- and long-term corrosion, cathodic protection, and electrochemical research in natural seawater.

The state-of-the-art weathering equipment enables coatings and materials degradation studies under complex exposure cycles, which can be tailored to simulate specific field exposure situations. Whereas the seawater testing capabilities allow us to conduct research that is pushing



the boundaries of corrosion resistant alloys, evaluate the mechanisms and kinetics of calcareous film formation, cathodic disbondment performance, and more.

Microbially induced corrosion laboratory

The Curtin Corrosion Centre has developed world-class capabilities for studying microbiologically induced corrosion (MIC) phenomena. By cooperation with several research centres at Curtin and around the world, the Curtin Corrosion Centre has been expanding its research and testing capabilities providing cutting-edge technology and state-of-the-art methods to study microorganisms and their effects on infrastructure and processes in the energy, water, and resources industries.

Our research typically involves transposing a field environment to a laboratory setting. We investigate how microbes respond to the changes in environmental conditions (e.g., aeration, temperature, pressure, shear stress) experienced through different areas in an industrial facility.

Corrosion under insulation facilities

The Curtin Corrosion Centre developed corrosion under insulation (CUI) test facilities capable of evaluating insulation materials, determine the risk of CUI based on different environmental, operating conditions and materials of construction, as well as assessing coating and inhibitor performance under insulation.

The Curtin Corrosion Centre designed and constructed a unique CUI test rig to evaluate CUI severity, CUI mechanisms, in situ monitoring, and the efficacy of chemical treatments and drain holes. The various CUI rigs can simulate hot service up to 150ºC.

The apparatus can be placed in a custom chamber in which the relative humidity and temperature are controlled to mimic atmospheric conditions.

The normal fluctuations in weather conditions experienced in the field such as ambient temperature, %relative humidity can also be simulated and controlled by the environmental chamber. The chamber can be programmed to simulate the fluctuation in temperature and relative humidity during day and night time as well as seasonal profiles.

Advanced electrochemical testing

Researchers at the Curtin Corrosion Centre have a long-standing and internationally recognised experience in utilising conventional and advanced electrochemical methods in several industrial and fundamental research projects. Examples are electrochemical polarisation methods and more advanced techniques such as electrochemical impedance spectroscopy (EIS), zero resistance amperometry (ZRA), and electrochemical noise (EN). EIS, ZRA, and EN are powerful tools developed for continuous monitoring and assessment of corrosion rates and mechanisms, degradation of organic coatings, inhibitor research, etc.

Corrosion inhibition and chemical compatibility

Corrosion inhibitor research and testing facilities at the Curtin Corrosion Centre enable thorough corrosion inhibitor evaluations, ranging from corrosion rate measurements to compatibility testing. The Curtin Corrosion Centre aims to evaluate and improve the mitigation strategies currently used in conventional industry practices.

The world-class facilities at the Curtin Corrosion Centre and other Centers at Curtin University allow advanced investigations of structure-activity relationships of corrosion inhibitors, including sub-micron analysis of surface films formed under extreme corrosive conditions.

Advanced materials characterisation

The John de Laeter Centre

Curtin Corrosion Centre researchers have access to the world-class characterisation facilities at the John de Laeter Centre (JdLC), Curtin's centralised research infrastructure hub.

Curtin Corrosion Centre and JdLC have established collaboration in many areas including research projects, capability developments and analytical skill development. JdLC also provides professional expertise and sample preparation support to researchers. The range of instrumentations can be viewed on the JdLC website.
jdlc.curtin.edu.au

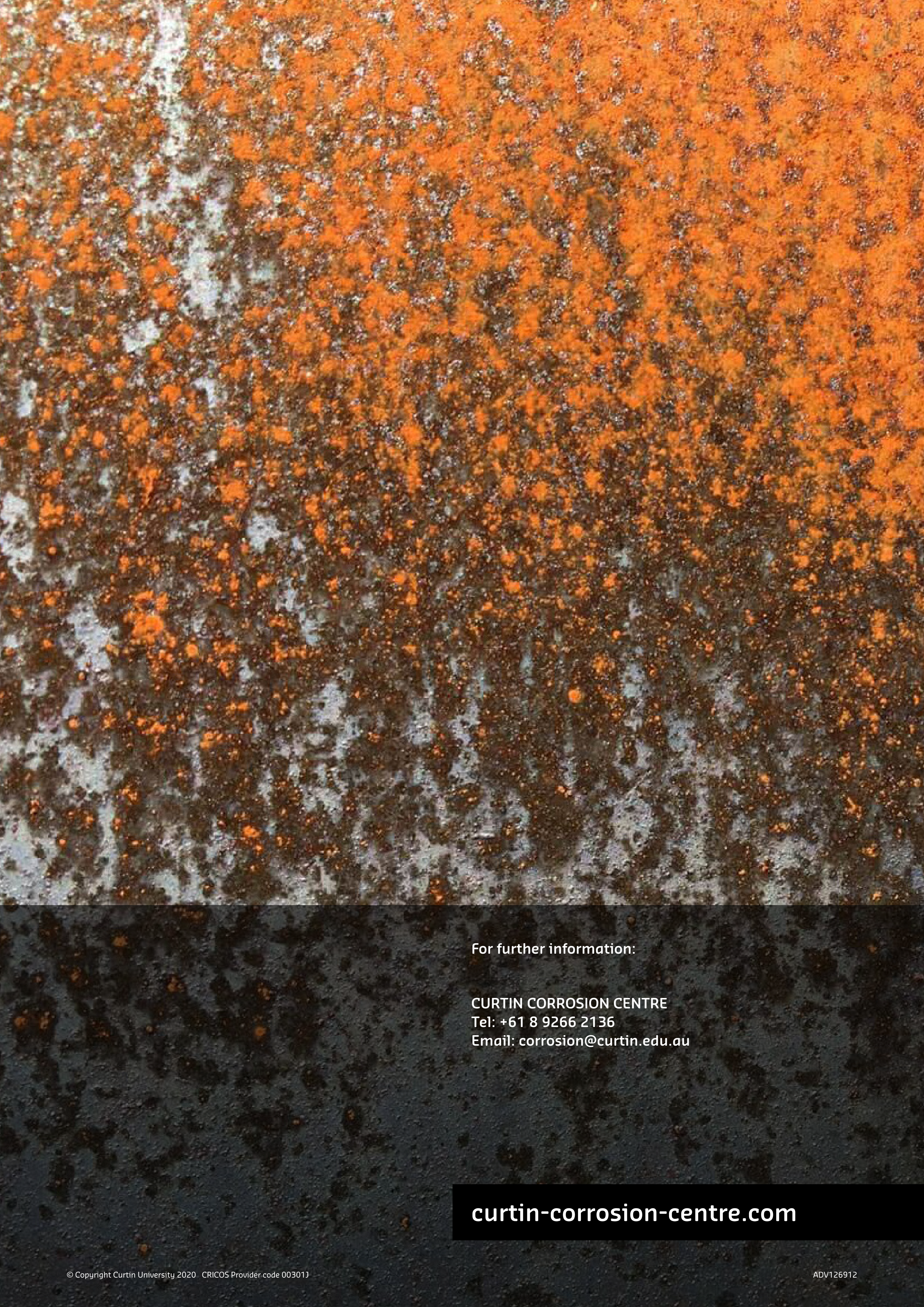
Tribocorrosion

The Tribocorrosion Lab offers a unique three-body abrasion-corrosion setup that was designed to study wear-resistant alloys used in slurry pumps (mining and mineral processing) and sliding bed CO_2 tribocorrosion (oil and gas). In this configuration, the sample is loaded against a rotating rubber counter-face while different abrasive particles (e.g., silica sand) are delivered. Tests can be carried out in the presence of different corrosive conditions and at up to 60°C, under different applied loads.

For general purpose abrasive wear ranking of engineering alloys, an ASTM G65 dry sand rubber wheel (DSRW) is available. Coefficient of friction of surfaces can be measured using pin-on-disc and reciprocating test rigs. At the Department of Mechanical Engineering, roughness measurement can be performed using a standard Talysurf.

Large-scale industrial testing

The Curtin Corrosion Centre owns and operates the only Mono-Ethylene Glycol (MEG) laboratory scale regeneration and reclamation research facility in Australia. The system simulates a full industrial MEG regeneration loop from condensate/MEG separation, divalent cation removal through pre-treatment, regeneration by distillation and either full or slip-stream vacuum reclamation for dissolved salt removal. The system allows the simulation of any potential field fluid composition and operational condition, in order to study and improve industrial plant operation and diagnose operational issues occurring in the field.



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