GDAŃSK UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTROCHEMISTRY, CORROSION & MATERIALS ENGINEERING

REPORT

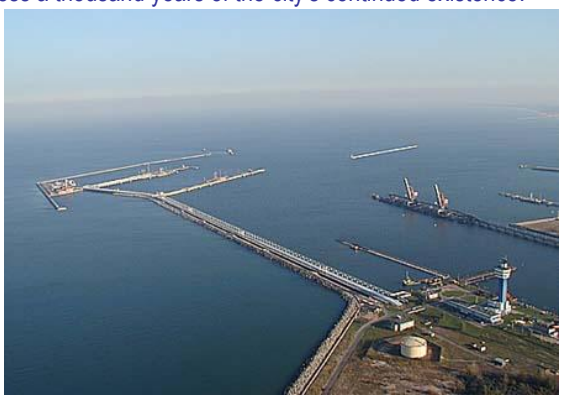
(2000-2003)

Gdańsk 2004

GDAŃSK

Gdańsk is the Polish maritime capital with a population nearing half a million. It is a large centre of economic life, science, culture, and a popular tourist destination. Lying on the Bay of Gdańsk and the southern coast of the Baltic Sea the city is a thousand years old. With its Hanseatic tradition, it has, for ages, played a major role in the commercial relationships between Northern and Western Europe on the one hand, and the countries of Central and Eastern Europe on the other hand. Today, Gdańsk is the capital of the Pomeranian province and is an important administration centre.

In its "golden age" the city enjoyed the specific status of a municipal republic. It was also a melting pot of cultures and ethnic groups. The air of tolerance and the wealth built on trade made culture, science, and art flourish. Today, works by outstanding Gdańsk masters can be admired in museums, churches, and galleries. These collections, as well as historic sites of enchanting beauty witness a thousand years of the city's continued existence.



The recent ten years or so have brought a huge transformation to the economy of Gdańsk. The city's industrial map continues to include some of the traditional branches, e.g. the shipping, petrochemical, chemical, and food industries. However, the share of know-how-based lines such as: electronics; telecommunications; IT technology; cosmetics and pharmaceuticals are on the rise. The specific trade of amber processing is also far from minor in importance. Gdańsk cultivates its centuries-long tradition in the field, and its nickname of the world capital of amber is well earned. Just like in the olden days the city owes much to its sea port. The harbour, the largest along the Polish coast and on the entire Southern Baltic basin, continues to develop.

Gdańsk is strategically located at the crossing of major transit routes and plays the function of a large transport and cargo-handling centre. It offers a well-developed business infrastructure, rich research, technical and advisory backup and highly-educated human resources. All these factors put Gdańsk among the top-ranking Polish cities in terms of investment attractiveness. The city owns extensive land available for investments and sites designated for development, including buildings of historic status. The envisaged future of Gdańsk is directed to such ventures as, for instance, the bold project of creating a multi-functional downtown area to span 3 Maja Street and bind a separated city into a single organism, reconstructing the 17th century Elizabethan theatre and revitalising the 19th century Lower City residential district. Ultimately, the city cherishes a vision of a huge investment undertaking: the project of erecting the New City on the post-industrial estate reclaimed from the Gdańsk Shipyard.

Gdańsk has a modern international airport and two ferry terminals servicing regular lines between Gdańsk and Copenhagen via Trelleborg (Denmark), and Gdańsk and Nynashamn (Sweden).

Our living standard is determined by the quality of the surrounding natural environment. In Gdańsk the issue of environmental protection is given an exceptionally high priority, as is evidenced by its numerous environmental investments. Nature has been very generous here. Sprawling on the southern Baltic coast, Gdańsk has gained a lot thanks to its background of the picturesque Tri-City Landscape Park and the hills and lakes of the Swiss-like Kashubian district.

The attractions on offer to those who seek leisure by the sea comprises twenty-three kilometres of clean beaches, three organised bathing-areas, and a 130-metre long pier. These are complimented by such other outdoor attractions as the Gdańsk cycling tracks, zoological gardens, the famous Oliwa Park with its ancient trees, the "Gdańsk Fortress" Culture Park of City Fortifications with unique authentic military architecture, numerous parks and city squares and the nature reserves of the Sobieszewo Island. The list is far from complete. The heart of the Old City features a yacht marina. Amateurs of water sports can indulge in their pastime out in the Bay of Gdańsk or along the Motława Arm, an exquisite watercourse for canoeing activities.

GDAŃSK UNIVERSITY OF TECHNOLOGY

Gdansk University of Technology (GUT) is the oldest and the largest scientific and technological academic institution in the Pomeranian region, employing 2,500 staff including 1200 academics. The number of students approximates 20,000, most of them studying full-time. Their career choices vary from architecture to business and management, from mathematics and computer science to biotechnology and environmental engineering, from applied chemistry to geodesy and transport, from ocean engineering to mechanical engineering and ship technology, from civil engineering to telecommunication, electrical and control engineering; but their life goals are common: to meet the challenge of the changing world.

There are 10 faculties covering almost all fields of science and technology. All of them are situated in the campus. Gdansk University of Technology provides broad-based education and research within engineering science, natural science and architecture. Education and co-operation with industry are an increasingly important part of our existence and have now become a life-long process.

GUT's aim is to play a key role throughout the whole of this chain. At our University we focus principally on the Eng., MSc Eng., M. Arch and Ph.D. programmes. Our role in this life-long learning process will increase in the future. All teaching at Gdansk University of Technology is based on a solid, scientific foundation and a great deal of the research conducted at our University is well to the fore in the international arena.

Our faculties cover a much wider range of education than other Polish technical universities do, and the scientific research comprises the areas which include the domains of technology of the 21st century. This refers to all the faculties constituting the basic core of the school but is also appropriate for numerous non-faculty units. The most remarkable example of adapting the University to the challenges of the 21st century is embodied by the unique scientific and research equipment, exemplified by NMR 500 MHz apparatus, powerful supercomputers ranked as belonging to an exclusive group of a few hundred fastest mathematical machines in the world (see list TOP 500!), which can be found in the Academic Computer Centre TASK. This equipment, combined with the very high and noteworthy qualifications of our computer scientists makes our school one of the best schools in Poland and one of better recognised schools in Europe, educating unique specialists in programming technology and computer methods of solving the most complicated scientific, engineering, organisational and economic problems.

Apart from education and research, Gdansk University of Technology has a very old tradition and rich, yet classic, student life, with student union activities and cultural and sport events of a wide and varied nature.

CHEMICAL FACULTY

Staff: Professors – 43, academic teachers with Ph.D. degrees – 54, other academic teachers 24, total staff - 236

The Chemical Faculty is divided into 15 departments. The faculty's main research topics include: physical chemistry - applied electrochemistry, solution structure and thermodynamics; inorganic chemistry, chemistry and stereochemistry of organosilicon compounds, solid state chemistry; organic chemistry - new synthetic methods, mechanisms of reactions, supramolecular chemistry, stereochemistry; biotechnology - rational design of chemotherapeutic agents, production and application of recombinant proteins; chemical engineering mass transfer in bubble column reactors, heat transfer; environmental and analytical chemistry - analytical methods of detection and determination of pollutants, separation methods in environment protection; chemical technology - chemistry and technology of elastomers and biocompatible polymers; chemistry and technology of (lipids and detergents; food chemistry and technology - seafood proteins, food preservation, analysis and quality assessment; corrosion science - mechanism and kinetics of corrosion processes, electrochemical anticorrosion protection technologies, electrochemical investigation techniques, passivity and passivation, surface treatment, analysis of non-stationary electrochemical processes, joint time-frequency methods and higher order spectral analyses of electrode processes.

Several scientific and technological achievements of the Chemical Faculty's staff members are worth mentioning. Scientists working at the Chemical Faculty before World War II made a substantial contribution to chemical sciences. One of them is Professor Adolph Butenandt who, in 1939, was awarded the Nobel Prize for his achievements in research on the chemistry of steroids. This high level of scientific research has been sustained in the post-war years. Selected achievements of this period include: the discovery and development of novel chemotheraputic agents, including edeine, tetaine, amphotericin B derivatives of low toxicity, acridine derivatives (Ledacrin, C-1311); substantial contributions to peptide chemistry ("Gdańsk peptide school"); disclosing of several factors affecting the functional properties of proteins in heated and in frozen stored muscle foods; development of technology of novel silicon adhesives (SIKOP); elaboration of a new type of analytic device for determination of organic chlorine compounds in industrial petroleum refinery systems; development of a new method of corrosion protection of huge steel containers and pipelines, (for which the faculty was awarded a Bronze Medal at the World Exhibition of Invention, Research and Industrial Innovation EUREKA'1995, Brussels); development of new catalysts for industrial hydrogenation of fats; new technology of processing microcellular polyurethane elastomers applicable in the leather industry. The courses offered in the Chemical Faculty lead to engineer (equivalent to BSc) or magister (equivalent to MSc) titles in: Biotechnology, Chemical Technology, Environmental Protection and Materials Engineering. Postgraduate studies leading to a PhD diploma are offered to Polish as well as non-Polish residents holding a magister title (or equivalent) in chemistry, chemical technology, materials engineering or biotechnology. In 2002 there were 130 PhD students.

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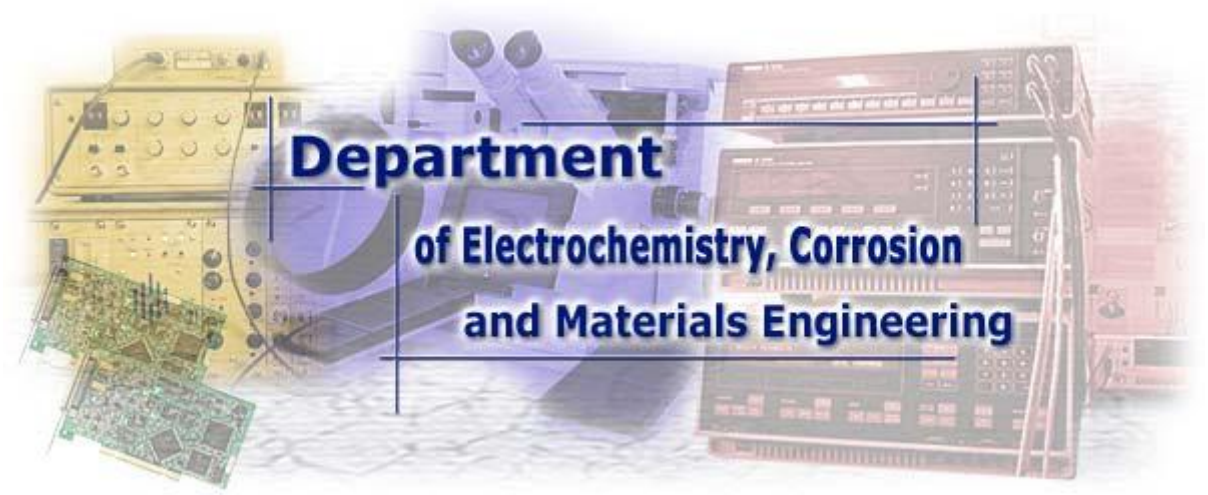


1. THE HISTORY OF THE DEPARTMENT

The Marine Corrosion Chair existing within The Department of Physical Chemistry was created in 1956. The chair of Anticorrosion Technology was formed in 1968/69 within the institute for Chemical Engineering and Measurement Techniques, after structural changes from the Department into Institutes. The Chairs were located in Chemistry Building A. after financing new construction the Chair moved to new laboratories and work shops in the Chemistry Building C, 3rd floor in 1989/90.

The Department of Anticorrosion Technology was created in 1991 after the Chemical Faculty returned to the Department structure.

Because of the Departmental development and new scientific interests, on 1st of September 2003 the name was changed to: the Department of Electrochemistry, Corrosion and Materials Engineering.

2. STAFF

The staff of the Department consists of six senior lecturers (with Ph.D. academic titles), one principal lecturer, two specialists, two senior technicians, and five PhD students. The Head of Department is Full Professor Kazimierz Darowicki.

Table 1 gives names, telephone numbers and e-mail addresses of the department's staff.

Tab. 1. Department's staff

Position	Academic Title	Name	Tel. +4858	E-mail
Head of Department Full professor	Titular Professor DSc.	Kazimierz Darowicki	347-24-83	zak@chem.pg.gda.pl
Principal lecturer	Dr	Zbigniew Klenowicz	347-19-77	klenowic@chem.pg.gda.pl
Senior lecturer	Dr	Stefan Krakowak	347-12-17	stefank@chem.pg.gda.pl
Senior lecturer	Dr	Juliusz Orlikowski	347-22-83	juliuszo@pg.gda.pl
Senior lecturer	Dr	Paweł Ślepski	347-14-40	pawelkor@chem.pg.gda.pl
Senior lecturer	Dr	Andrzej Miszczyk	347-19-15	misa@chem.pg.gda.pl
Senior lecturer	Dr	Artur Zieliński	347-14-40	ziela@chem.pg.gda.pl
Senior lecturer	Dr	Krzysztof Żakowski	347-16-97	zaczek@chem.pg.gda.pl
PhD student	MSc	Jarosław Kawula	347-21-66	jkawula@chem.pg.gda.pl
PhD student	MSc	Waldemar Felisiak	347-21-66	felix@chem.pg.gda.pl
PhD student	MSc	Arkadiusz Mirakowski	347-12-17	arekmir@yahoo.com
PhD student	MSc	Michał Szociński	347-19-15	micszoci@chem.pg.gda.pl
PhD student	MSc	Anna Arutunow	347-22-83	anka@chem.pg.gda.pl
Specialist	MSc	Elżbieta Stankiewicz	347-10-92	ela@chem.pg.gda.pl
Specialist	Ing.	Bronisław Kempa	347-29-06	kempa@chem.pg.gda.pl
Senior technician		Andrzej Dul	347-29-06	dul@chem.pg.gda.pl
Senior technician		Tadeusz Sonneck	347-28-51	sonneck@chem.pg.gda.pl

3. TEACHING

The Department of Electrochemistry, Corrosion and Materials Engineering is the only didactic unit in Poland, which realises didactic programmes and research in the field of corrosion science and anticorrosion protection. Nowadays, the department specializes in two areas: Corrosion Engineering and Antiprotection Technology. Corrosion Engineering is a specialty involved with Materials Engineering studies, whereas Antiprotection Technology is a part of Chemical Technology studies. Offered didactic programmes were discussed and appraised by the Working Party "EDUCATION" EUROPEAN FEDERATION OF CORROSION (EFC) and got very good notices. Besides MSc. Studies, Anticorrosion Protection postgraduate studies and professional courses are also organised in the department.

3.1. Corrosion Engineering speciality

Material degradation is a very common phenomenon; hence the knowledge of corrosion processes and methods of its prevention and protection is one of the most important features of Materials Engineering.

On the basis of the department's apparatus, laboratory, and teaching experience the Corrosion Engineering specialty has been formed within the Materials Engineering interfaculty studies.

The didactic aim of this specialty is preparation to professional work in the field of anticorrosion protection. Creation of this specialty was based on accepted and new didactic programme, which was developed in the Corrosion Protection Centre of University of Manchester Institute of Science and Technology (UMIST). Materials Engineering didactic programme is very wide and consists of studies of mechanisms and types of corrosion processes; synthesis, research and uses of organic coatings and linings in anticorrosion protection; application of electrochemical protection techniques; passivity studies and stainless steel, nickel, aluminium and titanium utilization; inhibitors activity and their use in water and refinery systems; characteristics of corrosion processes at high temperatures; impact of the biological agents on the corrosion processes run; thin layer formation on metal surfaces by means of plasma methods, chemical and physical deposition; application of non-destructive techniques in failure diagnostics and corrosion monitoring. One of the major elements of the department's didactic programme is coating systems designed for corrosion protection; design of the inhibitor protection, cathodic and

anodic protection installations. In many practical cases it is necessary to employ various materials and protection methods; hence students discuss corrosion protection systems, their design fundamentals and function in details. An important issue is normalisation and management in corrosion science and anticorrosion protection.

Tab. 2. Corrosion Engineering specialty subjects

General subjects	
1	Mathematics
2	Physics
3	Chemistry
4	Electrochemistry
5	Informatics
6	Digital measurements
7	Electrotechniques and Electronics
8	Mechanics
9	Thermodynamics
10	Engineering Graphics
11	Solid State Physics
12	Crystallography
13	Solid State Chemistry
14	Background of materials engineering
15	Materials and technical development
16	Metals and Alloys
17	Polymer Engineering
18	Engineering materials
19	New-developed materials
20	Engineering ceramics
21	Computer modelling of materials
22	Experimental methods of examination
23	Strength of materials
24	Electron and optical microscopy
25	Corrosion measurements
26	Metallurgy
27	Powder metallurgy
28	Heat treatment
29	Material bonding
30	Production and processing of materials
31	Quality control
32	Nanotechnology
33	Physical education
34	Foreign language
35	Intellectual protection rights
36	Environmental protection
37	Marketing and finance
38	Management
39	Economics
Speciality subjects*	
1	Corrosion processes
2	Organic coatings
3	Electrochemical protection
4	Electrochemical measurements techniques
5	Passivity and passivation
6	Corrosion inhibitors

7	High temperature corrosion
8	Corrosion normalization and management
9	Biocorrosion
10	Diagnostic and monitoring
11	Anticorrosion systems
12	Surface engineering
13	Anticorrosion systems design

*A detailed description of particular subjects including the topics discussed, the number of classes per semester and schedule of laboratory exercises can be found on the web side of the department http://www.korozja.pl

3.2. Anticorrosion protection specialty

As opposed to Corrosion Engineering studies, Anticorrosion Protection studies are realised as a part of Chemical Technology studies. So, this didactic proposition is aimed at students who have a very good chemical background and its main purpose is the preparation of engineers for anticorrosion protection on the basis of chemical engineering knowledge, solid state chemistry, organic chemistry and physical chemistry.

Tab. 3. Corrosion Engineering specialty subjects

General subjects	
1	Mathematics
2	Informatics background
3	Statistics and data preparation
4	Physics
5	Chemical basis
6	Inorganic chemistry
7	Physical chemistry
8	Organic chemistry
9	Analytical chemistry
10	Structural research methods
11	Chemical and technical thermodynamics
12	Theory of machines
13	Chemical apparatus
14	Chemical Engineering
15	Techniques of mixture separation
16	Chemical reactors
17	Technological processes modelling
18	Automatics and measurements in chemical technology
19	Electrotechniques and electronics
20	Chemical technology background
21	Inorganic technology
22	Organic technology
23	Technological project
24	Materials engineering
25	Materials of high purity and special uses
26	Surface phenomenon and industrial catalysis
27	Environmental hazards and safety precautions
28	Ecological and ethical problems of chemical production
29	Physical education
30	Philosophy
31	Economics and management in company

32	Transition laboratory studies
33	Foreign language
34	English technical terminology
35	Corrosion and materials science
36	Backgrounds of biotechnology
40	Diploma
Speciality subjects*	
1	Corrosion metallography
2	Background of metal corrosion
3	Electrode processes
4	Chemistry of polymers
5	Anticorrosion protection
6	Corrosion research methods
7	Corrosion monitoring
8	Electroanalysis
9	Methods of polymer materials examination
10	Electrochemical methods in environmental protection
11	Polymer production and processing
12	Structure of polymers
13	Electrochemical protection
14	Non-metallic coatings
15	Corrosion inhibitors
16	Nanotechnology

* A detailed description of particular subjects including the topics discussed, the number of classes per semester and schedule of laboratory exercises can be found on the web side of the department http://www.korozja.pl

3.3. Postgraduate studies – Anticorrosion protection

The main aim of this study is the introduction to theoretical backgrounds, practical aspects and new trends in anticorrosion protection, with special interest in organic coatings. The programme is composed of 250 didactic hours in 2-semesters (meetings twice a month). Postgraduate studies include:

- Corrosion background
- Corrosion metallography
- Corrosion engineering
- Corrosion diagnostics
- Organic coatings protection
- Electrochemical protection
- Ecological issues
- Thesis

Participants of the postgraduate studies receive certificates licensed by Gdańsk University of Technology.

3.4. PhD studies

The Chemical Faculty also gives the possibility of four-year PhD studies which are comprised of Electrochemistry and Corrosion.

PhD studies recruitment is based on the MSc certificate competition. PhD studies participants are obliged to attend their lectures, deliver a fixed number of teaching classes and pass exams on the subjects proposed by the Faculty Council. The final PhD exam is preceded by opening of PhD trial and examinations on a speciality subject, a modern language and an additional, non-speciality discipline.

4. CERTIFICATION OF PERSONNEL

Personnel certification unit No. AC 084z approved on 17 October 2001 is authorised to issue the certificate for supervision over the anticorrosion protection measures accomplished with organic and inorganic coatings.
The certification unit operates in accordance with the PN-EN 45013 standard following the European Union directives in this matter. The certificate can be issued to anyone who fulfils the requirements No. **WCH-0001/2000** defined by the Faculty of Chemistry, Gdańsk University of Technology and passes the exams.

4.1. Procedural rules of the certification process of personnel

People applying for the certificate must fill in the application for Staff Certification Collective that is obliged to define competence stage:

- **stage 1**: assistant inspector
- **stage 2**: inspector
- **stage 3**: senior inspector

The applicant should fulfil the following requirements:

Stage 1

- medium or high education,
- provide documents referring to finished technical courses accepted by the Staff Certification Collective (40-80 hours)

Stage 2

- medium or high education,
- have practical experience concerning anticorrosion protection using organic coatings (at least 1- 3 years)
- provide documents referring to finished technical courses accepted by the Staff Certification Collective (40-80 hours)

Stage 3

- medium or high education,
- provide second stage competence certificate and documents referring to finished technical courses accepted by the Staff Certification Collective (40 hours)
- provide documents referring to finished technical courses involved with organic coatings (at least 1- 3 years) accepted by the Staff Certification Collective and wide professional achievements

4.2. Administration and registration of competence certification application

Documents that must be enclosed with the application form:

a) documents allowing precise determination of applicant qualifications
b) fee contribution copy

Verified application forms are accepted and applicants receive confirmation that enables exam accession. The application form becomes included in the book of registers. The Staff Certification Collective prepares the project of contact of certificate issue.

4.3. Final exam and candidates' assessment

The exam is composed of a general exam, a speciality exam and a practical exam. In the case of a certificate's renewal the exam is composed of general and speciality exam that includes knowledge of security directives, national standards and legislation.

Both general and speciality exams are in written form. The number of questions is defined by the examiner. All the problems that could be addressed at the exam can be found in the handbook available from the Staff Certification Collective.

The scope and complexity of problems faced as well as the duration time of the exam are sufficient to verify whether the applicants are competent to obey technological, technical, safety and environmental protection requirements in practice.

4.4. Administration and issuing of certificates

The decision over issuing of certificates is taken by the Head of Staff Certification Collective. The Collective prepares and delivers to the applicant:

- information about certificate administration
- agreement about the certificate supervision

The applicant must sign the contract in order to obtain the certificate. The certificate is valid for 3 years from the date of its issue.

4.5. Renewal of certificate validity and issue of duplicate certificates

As the validity of the certificate ceases there is a possibility of its renewal for the following 3 years provided that the applicant passes general and specialty exams that include knowledge about latest technical and material innovations in the field, security directives, national standards and legislation.

The Staff Certification Collective can issue a duplicate certificate if requested by the certificate holder. The appropriate form and fee should be delivered to the Staff Certification Collective.

4.6. Supervision of the correct use of certificates

The Certification Unit supervises the correct use of certificates according to respective regulations.

4.7. Revocations / appeals

In the case of any controversies and disputes, the applicant can appeal to the Head of Staff Certification Collective or to the Dean of Chemical Faculty as a last resort.

4.8. Fees

Applicants must contribute:

- fee for certification procedure and exam
- fee for supervision of the correct use of certificates

Handbooks and the specimens of all forms can by purchased from the Staff Certification Collective, Faculty of Chemistry, or Gdańsk University of Technology.

5. APPARATUS

The Department of Electrochemistry, Corrosion and Materials Engineering is equipped with some of the best experimental and technical apparatus in Poland, and even in Europe. Such equipment can be used for electrochemical and corrosion research. Recently, special apparatus for coatings and linings inspections and diagnostics of metal constructions with non-destructive techniques has been developed.

FREQUENCY RESPONSE ANALYZER SOLARTRON 1250 + ELECTROCHEMICAL INTERFACE 1228

The pictured system consists of frequency response analyzer SI 1250 and electrochemical interface 1228. It can be used in DC electrochemical experiments with application of SI 1250 as potentiostat or galvanostat. Module SI 1250 allows impedance and harmonic analysis. Due to the installation of GPIB connector experiment PC computer can easily handle parameters and the data obtained. Operational parameters of the system are as follows:

- DC polarisation voltage ±12-V
- maximal resolution 100-μV
- current -±2-A
- impedance input 1 MΩ
- frequency range 10 μHz – 65536 Hz
- interface RS-423 and GPIB IEEE 488

FREQUENCY RESPONSE ANALYZER SOLARTRON 1280B

The described set-up is combined of transmittance analyzer and electrochemical interface. It can be used in the field and in laboratory research due to floating outputs. SOLARTRON 1280B enables pursuance of DC polarisation, harmonic analysis, electrochemical noises, and electrochemical impedance spectroscopy measurements. Operational parameters of the system are as follows:

- resolution: 1pA/ 1μV
- polarisation: +/- 2A, +/- 14.5
- measurement frequency range: 1mHz – 20 kHz

FREQUENCY RESPONSE ANALYSER SI 1255 + IMPEDANCE INTERFACE ATLAS 91815

This system is a combination of transmittance analyzer 1255 iand high-impedance buffer Atlas 91815. It works in two-electrodes set and is applied to coating and linings barrier systems evaluation and dielectric researches. Due to the installation of GPIB interface experiment PC computer can easily handle parameters and the data obtained. Operational parameters of the system are as follows:

- capacity: 1 pF -1 mF
- resistance: 1Ω - 1 TΩ
- perturbation signal amplitude: 5 mV – 1 V
- measurement frequency range: 1 MHz - 1mHz

SYCOPEL-SPECTROSTAT

This portable, battery charged system for impedance measurements, which was adopted for two-electrodes investigations and is used for protective coatings and linings quality evaluation. Operational parameters of the system are as follows:

- input impedance R~10^{11}
- frequency range 1 mHz-100 kHz
- amplitude 5mV-1V
- power supply 220V/50Hz or batteries
- control Notebook, or PC computer
- measurement accuracy 0.1% - 5%

DIGITAL SYSTEM „GAMMRY"

Gammry is a digital system designed for corrosion and electrochemical measurements. There are three such sets that co-operate with personal computers. The Gammry system is composed of number measurement techniques. The most important are as follows:

- electrochemical noise
- electrochemical impedance spectroscopy
- potentiodynamic polarisation
- cyclic voltamperometry
- cyclic thermometry

Portable computer equipped with digital measurement system is employed for field investigations.

AUTOLAB PGSTAT 30

PGSTAT30 is a modular potentiostat/galvanostat for high-current applications (I_{max} 1 A). It allows voltage accomplishment between working electrode and counter electrode up to 30V and is equipped with IR drop compensation. It enables employment of a wide range of electrochemical techniques. Moreover, it is equipped with an additional FRA2 module. The combination of PGSTAT30+FRA2 enables impedance mensuration of 1 mΩ to 100 GΩ and capacitance mensuration of 0.1 pF to 5000 F that give the application potential in corrosion researches, bio-electrochemistry, investigations of cells, batteries, super-capacitors in many other branches. PGSTAT30 can work in three-electrode or four-electrode system (i.e. investigation of liquid interfaces).

QUARTZ ELECTROCHEMICAL NANOBALANCE

EQCN-700 is a measurement technique for *in situ* monitoring of small weightloss of metal working electrodes. The working electrode is in the form of a thin layer on one of the thin quartz plates that is glued to the electrochemical cell. Crystal quartz AT-cut oscillates with nominal frequency of 10 MHz. Even the smallest weightloss of the working electrodes implies alteration of quartz crystal oscillations. Such frequency is equal with oscillations frequency of the reference crystal and is measured by detailed measurement set-up. Measured alteration of quartz crystal oscillations can be counted to adequate weightloss of the working electrode according to the Sauerbrey equation. Nanobalance EQCN-700 is equipped with digital voltage output that enables digital signal obtainment. Nanobalance digital resolution is of 0.1 Hz, which refers to 0.1 ng of effective electrode weightloss. The system is also equipped with Faraday's cage that allows avoidance of disadvantageous environment impact. Input terminals inside the cage enable measurements using a standard three-electrode arrangement.

Monochromatic ELIPSOMETER EL X-02C by Dre-Dr. Reiss Elipsometerbau GmbH.

The extended version of the elipsometer EL X-02C allows accomplishment of optical characterization of surface layers. In corrosion measurements it enables detailed analysis of optical properties of oxide films that occur on the metal surface. Such a system gives the possibility to determine and compare the state of the passive layers, to identify the influence of various corrosion inhibitors, to evaluate the properties of protective coatings in atomic scale. The elipsometer constitutes a complementary tool in electrochemical measurements enabling recognition of the relation between metals and alloys corrosion resistance and the properties of oxide layers.

ACOUSTIC EMISSION SYSTEM

Vallen 8AMSY4 is a two-channel acoustic emission system for registration and analysis of acoustic signals generated by distortions within solid, liquid and gaseous media. Piezoelectric sensors, pre-amplifiers, high-pass and low-pass filters are used to register the acoustic activity. The signals captured by the sensor are amplified (pre-amplifiers – 34dB-46dB), filtered and converted into digital form. Depending on the type of filter-bank employed the system is able to register acoustic activity in a given frequency band for instance 25kHz-800kHz, 95kHz-800kHz, 25kHz-300kHz etc. Digital conversion involves the following parameters – sampling frequency 0,625MHz-10MHz, maximum length of a single signal registered 524 288 samples, discrimination level: 9,9dB-99, 9dB, amplitude –100mV-100mV. Due to signal digitalisation it is possible to analyse the parameters of substantial importance such as: signal amplitude, energy, duration time, the number acoustic events etc. The system is equipped with the localization module and can be employed for detection of cracks, leaks, material discontinuities, structural integrity evaluation, weld quality assessment and much more.

ELECTROCHEMICAL NOISE MEASUREMENT SYSTEM

A specialized system designed for electrochemical noise measurements based on the National Instruments ™ SCXI technology. The system is consists of the chassis extendable with additional modules that allow the performing of a wide range of measurements including thermocouples, bridge type sensors and high voltage applications (input signals to 250 V). In the primary EN applications of the pictured device the voltage measurements on the level of microvolts and current measurements of the level of pico amperes are possible, due to the application of an amplifier module. Four isolated analogue inputs allow simultaneous preconditioning of current and potential noise with independent amplification and lowpass filtering (4 Hz or 10 kHz). SCXI system can interact with A/D converter of sampling rate up to 333 kHz and provides software controlled antialiasing elliptic filter of the eighth order.

RADIODETECTION

Radiodetection system RD4000 FF MAX by Radiodetection Ltd., Great Britain. The system is an indispensable tool for corrosion measurements performed in field. It enables:

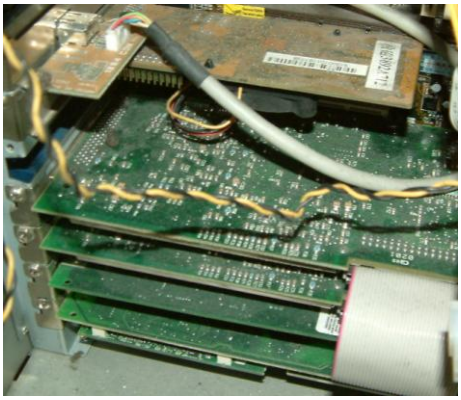
- precise identification of the pipeline path and depth (useful for potential measurements along pipeline path),
- precise allocation of pipeline external insulation failure spotting,
- detection of the changes of pipeline's technical parameters (i.e. electrical connections with other underground constructions, regions with impaired insulation etc.).

METALLOGRAPHIC MICROSCOPE

Zeiss Neophot 32 – is an inverted metallographic microscope utilized in the field of materials engineering research field. It boasts in following:

- observation methods in bright, dark and polarized light,
- integrated system of image capturing including small-picture reflex, large-format 4"x5" camera and automated exposure interface,
- CCD camera output for capturing and analysis of digital images (MultiScan® image analysis system),
- magnification range 10x – 2000x,
- eyepieces of 10x magnification providing wide observation range,
- objectives: 1,25x; 2,5x; 3,2x; 6,3x; 12,5x; 25x; 50x; 100x,
- internal magnification converter: 0,8x; 1x; 1,25x; 1,6x; 2x.

DIGITAL MEASUREMENT CARDS



The systems designated to impedance measurements in dynamic conditions are based on digital measurement cards by National Instruments. Perturbation signal is generated with the PCI-6111 card equipped with fast 16-bit digital-analogue converter. Acquisition of voltage and current signal is accomplished with 2 conjugated PCI6052E cards. The applications created with LabView 5.1 software are used to drive the cards and to analyze the results obtained.

6. RESEARCH ACTIVITIES

Research and didactic activities are closely interrelated. Conducted investigations modify and improve the didactic process. On the other hand the scientists document their scientific progress by performing the research and publishing its results. Such an approach makes continuous progress in scientific research a priority of the Department.

An important achievement of the Department is the authorship of a chapter included in one of the fundamental books in corrosion field MATERIALS SCIENCE & TECHNOLOGY SERIES issued by VCH-Wiley.

Juchniewicz R., Jankowski J., Darowicki K.: Cathodic and anodic protection, in (Ed) Schutze M., Corrosion and Degradation Vol. 1, VCH-Wiley, New York 2000, Series Materials Science and Technology (Ed) Cahn R.W., Haasen P., Kramer E.J.

6.1. List of the publications in periodicals included in the Philadelphia List since 2000

Measurable effects of scientific activities are the papers which are published in the periodicals included the designated Philadelphia List. These periodicals merit in publications possessing the character of innovation and acceptance of the paper is preceded by very rigorous and conscientious refereeing process. The staff of the Department belongs to the group of the most active employees of the Faculty of Chemistry and boasts significant productions listed below.

56. Darowicki K., Orlikowski J., Arutunow A.: *New possibility of the passive layer cracking dynamics detection using a new Dynamic Electrochemical Impedance Spectroscopy,* CORROS. ENG. SCI. TECH., (in press) 2004

55. Darowicki K., Krakowiak S., Ślepski P.: *Evaluation of pitting corrosion by means of potentiodynamic electrochemical impedance spectroscopy*, ELECTROCHIM. ACTA, (in press) 2004

54. Jankowski J.: Harmonic Synthesis: A Novel Electrochemical Method for Corrosion Rate Monitoring. J. ELECTROCHEM. SOC., 150 (4): 181-191 2003

53. Darowicki K., Krakowiak A., Zieliński A.: *Analysis of spontaneous electrochemical oscillations by wavelet transformation method,* RUSS. J. ELECTROCHEM, 39 (9), 935-940 2003

52. Darowicki K., Felisiak W., Zieliński A.: *Frequency distribution of chemical oscillation in the closed Belousov-Zhabotinsky reaction,* POLISH J. CHEM., (in press) 2004

51. Darowicki K., Felisiak W.: *Application of Cohen's class time-frequency distribution in the Belousov-Zhabotinsky reaction analysis,* INT. J. BIFURCAT. CHAOS, 14 (10): OCT 2004

50. Darowicki K., Zakowski K.: *A new time-frequency detection method of stray current field interface on metal structure,* CORROS. SCI., 46, 1061-1070 2004

49. Darowicki K., Orlikowski J., Arutunow A.: *Dynamic EIS measurements of the passive layer cracking under static tensile stress,* J. SOLID STATE ELECTROCHEM., (in press) 2004

48. Darowicki K., Szociński M.: *Evaluating the performance of organic coatings under mechanical stress using electrochemical impedance, spectroscopy,* J. SOLID STATE ELECTROCHEM.,(in press) 2004

47. ORLIKOWSKI J., Cebulski S., Darowicki K.: *Electrochemical investigations of conductive coatings applied as anodes in cathodic protection of reinforced concrete,.* CEME. CONCR. COMPOS., (in press) 2004

46. Darowicki K., Zielinski A., Krakowiak A.: *Harmonic analysis of corrosion processes,* RUSS. J. ELECTROCHEM., 39 (2): 119-213, 2003

45. Darowicki K., Krakowiak A.: *The Application of Gabor transformation in the harmonic analysis of corrosion processes,* ANTI-CORROS. METHOD. M., 50 (3): 193-200, 2003

44. Klenowicz Z., Darowicki K., Krakowiak S.: *Corrosion-erosion damage of heat exchanger tubes by desalted crude oil flowing at shell side,* MATER. CORROS., 54 (3): 181-187, 2003

43. Darowicki K., Felisiak W., Zieliński A.: *A novel method of spectral analysis of oscillator Belousov-Zhabotinky reaction,* J. MATCH. CHEM., 33 (3-4): 245-254 MAY 2003

42. Darowicki K., Orlikowski J., Arutunow A.: *Investigations of stress corrosion cracking by means of dynamic electrochemical impedance spectroscopy,* ELECTROCHIM. ACTA, 48 (28): 4189-4196 NOV. 2003

41. Darowicki K., Slepski P.: *Instantaneous electrochemical impedance spectroscopy of electrode reaction,* ELECTROCHIM. ACTA., 49 (5): 763-772 , 2004

40. Darowicki K, Bordzilowski J., Krakowiak S., Królikowska A.: *Impedance measurements of coating properties on bridge structures,* PROG. ORG. COAT., 46 (3): 56-59, 2003

39. Darowicki K., Orlikowski J., Krakowiak S.: *Conducting coatings as anodes in cathodic protection,* PROG. ORG. COAT., 46 (3): 31-36, 2003

38. Darowicki K., Krakowiak S.: *Inspection of rubber lining operating in flue gas desulphurisation units,* PROG. ORG. COAT., 46 (3): 51-55, 2003

37. Darowicki K., Slepski P.: *Dynamic electrochemical impedance spectroscopy of the first order electrode reaction,* J. ELECTROANAL. CHEM., 547 (1): 1-8, 2003

36. Darowicki K., Zielinski A.: *Analysis of spontaneous electrochemical oscillations by energy distribution technique,* ELECTROCHIM. ACTA, 48 (11): 1559-1566, 2003

35. Darowicki K., Mirakowski A., Krakowiak S.: *Investigation of pitting corrosion of stainless steel by means of acoustic emission and potentiodynamic methods,* CORROS. SCI., 45 (8): 1747-1756, 2003

34. Smulko J., Darowicki K.: *Non-linearity of electrochemical noise caused by pitting corrosion,* J. ELECTROANAL. CHEM., 545 (1-2): 59-63 MARCH 27, 2003

33. Darowicki K., Krakowiak A.: *Digital harmonic analysis of cadmium ion reduction on a dropping mercury electrode,* RUSS. J. ELECTROCHEM., 39 (2): 134-140, 2003

32. Darowicki K., Zielinski A., Slepski P.: *Continuous frequency method of measurement of electrode impedance,* INSTRUM. SCI. TECHNOL., 2 (12): 53-63, 2003

31. Zakowski K., Darowicki K.: *Potential changes in an electric field and electrolytic corrosion,* ANTI-CORROS. METHOD. M., 50 (1): 25-33, 2003

30. Miszczyk A., Darowicki K.: *Effect of environmental temperature variations on protective properties of organic coatings,* PROG. ORG. COAT., 46 (1): 49-54 JAN 2003

29. Jankowski J.: *Electrochemical methods for corrosion rate determination under cathodic polarisation conditions – a review. Part I – DC Method,* Corros. Rev., 20(3): 159-177 2002

28. Jankowski J.: *Electrochemical methods for corrosion rate determination under cathodic polarisation conditions – a review. Part II – AC Methods,* Corros. Rev., 20(3): 179-200 2002

27. Darowicki K., Slepski P.: *Influence of the analyzing window on electrode impedance measurement by the continuous frequency scanning method,* J. ELECTROANAL. CHEM., 533 (1-2): 25-31 SEP 2002

26. Darowicki K., Orlikowski J.: *Conducting composites as cable anodes in cathodic protection: a literature summary,* ANTI-CORROS. METHOD. M., 49 (5): 330-334 2002

25. Darowicki K., Krakowiak A.: *Harmonic analysis of the current of an electric system simulating the electrode process in conditions of linearly changing potential,* INSTRUM. SCI. TECHNOL., 30 (3): 341-352 2002

24. Zakowski K., Darowicki K.: *Diagnosis of reference electrodes in cathodic protection systems by electrochemical impedance spectroscopy,* CORROS. REV., 20 (4-5): 391-401 2002

23. Darowicki K., Orlikowski J.: *Conducting composites as cable anodes in cathodic protection,* SCI. ENG. COMPOS. MATER., 10 (1): 65-70 2002

22. Darowicki K., Krakowiak A, Zielinski A.: *The comparative study of different methods of spectral analysis of electrochemical oscillations,* ELECTROCHEM. COMMUN., 4 (2): 158-162 FEB 2002

21. Smulko J., Darowicki K., Zielinski A.: *Pitting corrosion in steel and electrochemical noise intensity,* ELECTROCHEM. COMMUN., 4 (5): 388-391 MAY 2002

20. Krakowiak S., Darowicki K.: *The effect of the temperature change rate on determination of the critical pitting temperature of stainless steels,* ANTI-CORROS. METHOD. M., 49 (2): 105-110 2002.

19. Miszczyk A., Darowicki K.: *Reliability of flue gas desulphurisation installations - the essential condition of efficient air pollution control,* POL. J. ENVIRONS. STUD., 11 (3): 205-209 2002.

18. Zielinski A., Smulko J., Krakowiak S., Darowicki K.: *The stationarity characteristics of electrochemical current noise,* ANTI-CORROS. METHOD. M., 49 (1): 27-32 2002

17. Smulko J., Darowicki K., Zielinski A.: *Detection of random transients caused by pitting corrosion,* ELECTROCHIM. ACTA, 47 (8): 1297-1303 FEB 1 2002.

16. Klenowicz Z., Darowicki K.: *Waste incinerators: Corrosion problems and construction materials - A review.,* CORROS. REV., 19 (5-6): 467-491 2001

15. Krakowiak S., Darowicki K., Bordziłowski J.: *The impedance method of monitoring the degradation of rubber linings in applications where progressive deterioration is the predominant failure mechanism, ANTI-*CORROS. METHOD. M., 48 (6): 358-363 2001

14. Darowicki K., Bohdanowicz W., Walaszkowski J.: *Pro-ecological aspects of application of cathodic protection,* POL. J. ENVIRONS. STUD., 10 (5): 325-330 2001

13. Darowicki K., Zielinski A.: *Joint time-frequency analysis of electrochemical noise,* J. ELECTROANAL. CHEM., 504 (2): 201-207 MAY 18 2001

12. Miszczyk A., Darowicki K.: *Accelerated aging of organic coating systems by thermal treatment,* CORROS. SCI., 43 (7): 1337-1343 JUL 2001

11. Darowicki K., Krakowiak A., Zielinski A.: *New methods of spectral analysis of current oscillations of electrochemical processes,* J. ELECTROCHEM. SOC., 148 (5): E233-E236 MAY 2001

10. Darowicki K., Janicki S.: *Impedance evaluation of the effect of $Ru_{0.3}Ti_{0.7}O_2$ on electrochemical properties of polymeric conducting electrodes used in cathodic protection,* J. ELECTROCHEM. SOC., 148 (3): B116-B120 MAR 2001

9. Darowicki K., Krakowiak A., Zielinski A.: *The Wigner-Ville distribution in the analysis of deterministic components of spontaneous oscillations,* POL. J. CHEM., 75 (3): 443-452 MAR 2001

8. Żakowski K., Darowicki K.: *Some aspects of potential measurements in a stray current field,* CORROS. REV., 19 (1): 55-67 2001

7. Darowicki K., Janicki S.: *Electrochemical investigations of modified polymeric composites,* MATER. CORROS., 51 (12): 835-840 DEC 2000

6. Darowicki K.: *Theoretical description of the measuring method of instantaneous impedance spectra,* J. ELECTROANAL. CHEM., 486 (2): 101-105 MAY 29 2000

5. Darowicki K., Orlikowski J., Lentka G.: *Instantaneous impedance spectra of a non-stationary model electrical system,* J. ELECTROANAL. CHEM., 486 (2): 106-110 MAY 29 2000

4. Zakowski K., Darowicki K.: *Methods of evaluation of the corrosion hazard caused by stray currents to metal structures containing aggressive media,* POL. J. ENVIRONS. STUD., 9 (4): 237-241 2000.

3. Darowicki K., Orlikowski J., Walaszkowski J.: *Potentiodynamic investigations of anodic composite materials,* B. ELECTROCHEM., 16 (2): 85-88 FEB 2000

2. Darowicki K., Janicki S., Orlikowski J.: *Electrochemical properties of composite anodes for cathodic protection,* J. APPL. ELECTROCHEM., 30 (3): 333-337 MAR 2000

1. Darowicki K., Krakowiak S.: *The temperature dependencies of susceptibility of 654SMO and 316L stainless steels to pitting,* ANTI-CORROS. METHOD. M., 47 (1): 15-19 2000.

6.2. List of publications since 2000

Apart from the publications in the periodicals included on the Philadelphia List the members of the Department publish their papers in other refereed periodicals. A list of these is given below.

46. Darowicki K., Zielinski A.: *Application of non-stationary techniques in the analysis of electrochemical noise,* FLUCT. NOISE LETT, 3 (4): MARCH 2004

45. Darowicki S., Krakowiak S., Szczęsny R.: *Nieniszcząca i szybka metoda oceny stanu wykładzin gumowych w instalacjach oczyszczania spalin,* ENERGETYKA, 7: 487-491 2003

44. Krakowiak A.: *Corrosion monitoring by frequency intermodulation technique employing Gabor transformation*. Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 305-309

43. Zieliński A.: *Application of the wavelet transformation to estimation of intensity of pitting corrosion.* Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 310-313

42. Ślepski P.: *Application of the short time Fourier transformation to the continuous frequency method of measurement of electrode impedance,* Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 314-319

41. Kawula J.: *Application of the electrochemical quartz crystal microbalance in corrosion studies*, Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 320-324

40. Mirakowski A.: *Application of acoustic emission in evaluation of pitting corrosion in steel*, Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 341-345

39. Felisiak W.: *A review of application of ellipsometry in corrosion research,* Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 325-329

39. Krakowiak S., Ślepski P., Krakowiak A.: *Application of harmonic techniques to evaluation of pitting corrosion,* Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 299-304

38. Szociński M., Miszczyk A.: *Evaluating and predicting the performance of organic coating using impedance spectroscopy*, Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 336-340

37. Jankowski J.: *Corrosion monitoring of selected metals in artificial sea water by harmonic synthesis method*, Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 330-335

36. Żakowski K.: *EIS in diagnostic of cathodic protection systems,* Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 403-408

35. Orlikowski J.: *Application of percolation theory for description of electrical properties of conducting coatings*, Physico-Chem. Mech. Mater. 2002 Spec. iss. Nr 3 Problems of Corrosion and Corrosion Protection of Materials. Vol. 1 p. 346-350

34. Darowicki K., Krakowiak A.: *Zastosowanie transformacji STFT w monitorowaniu korozji techniką intermodulacji częstotliwościowej,* OCHRONA p. KOROZ., 45 (Wyd. Spec.): 172-176 2002

33. Darowicki K., Ślepski P.: *Zastosowanie transformacji STFT z oknem analizującym o zmiennej długości w pomiarze impedancji elektrodowej metodą ciągłego skanowania częstotliwościowego,* OCHRONA p. KOROZ.*, 45 (*Wyd. Spec.): 153-157 2002

32. Darowicki K., Mirakowski A.: *Zastosowanie techniki emisji akustycznej w badaniach korozji wżerowej stali austenitycznej,* OCHRONA p. KOROZ.*,* 45 (Wyd. Spec.): 158-162 2002

31. Darowicki K., Krakowiak S., Ślepski P., Krakowiak A.: *Zastosowanie technik harmonicznych w ocenie korozji wżerowej,* OCHRONA p. KOROZ 45 (Wyd. Spec.): 167-171 2002

30. Kawula J., Darowicki K.: *Zastosowania elektrochemicznej mikrowagi kwarcowej w badaniach korozyjnych,* OCHRONA p. KOROZ., 45 (Wyd. Spec.): 177-180 2002

25. Felisiak W., Darowicki K.: *Zastosowania pomiarów elipsometrycznych w badaniach korozyjnych,* OCHRONA p. KOROZ., 45 (Wyd. Spec.): 181-185 2002

24. Darowicki K., Ślepski P.: *Teoretyczny opis metody pomiaru chwilowego widma impedancyjnego,* OCHRONA p. KOROZ.*,* 45 (Wyd. Spec.): 61-64 2002

23. Darowicki K.: *Katedra Technologii Zabezpieczeń Przeciwkorozyjnych, działalność dydaktyczna,* OCHRONA p. KOROZ., 45(7): 188-189 2002

22. Darowicki K.: *Katedra Technologii Zabezpieczeń Przeciwkorozyjnych, działalność technologiczna.* OCHRONA p. KOROZ 45 (9): 240-244 2002

21. Darowicki K.: *Katedra Technologii Zabezpieczeń Przeciwkorozyjnych, działalność badawcza,* OCHRONA p. KOROZ., *45(8):* 211-216 2002

20. Darowicki K., Krakowiak S., Ślepski P.: *Impedancyjne badanie korozji wżerowej,* OCHRONA p. KOROZ., 45 (Wyd. Spec.): *56-60 2002*

19. Darowicki K, Szczęsny R., Krakowiak S., Orlikowski J., *Doświadczenia w badaniach terenowych powłok i wykładzin organicznych,* OCHRONA p. KOROZ., 45 (Wyd. Spec.): 260-263 2002

18. Żakowski K., Darowicki K.: *Diagnozowanie systemów ochrony katodowej techniką spektroskopii impedancyjnej.* OCHRONA p. KOROZ., 45 (Wyd. Spec.): 186-189 2002

17. Darowicki K., Miszczyk A., Szociński M.: *Degradacja powłokowych systemów ochronnych w zmiennych temperaturach.* OCHRONA p. KOROZ., 45 (Wyd. Spec.): 372-376 2002

16. Orlikowski J. Cebulski S., Krakowiak S., Darowicki K.: *Badania elektrochemiczne wpływu powłok zawierających grafit na korozję stali konstrukcyjnej.* OCHRONA p. KOROZ., 45 (Wyd. Spec.): 367-371 2002

15. Orlikowski J., Krakowiak S., Darowicki K.: *Badania eksploatacyjne żelbetonu podczas realizacji ochrony katodowej,* OCHRONA p. KOROZ.,.45 (Wyd. Spec.) 254-259 2002

14. Darowicki K., Zieliński A.: *Analiza szumu elektrochemicznego z wykorzystaniem transformacji falkowej,* OCHRONA p. KOROZ., 45 (Wyd. Spec.) 163-166 2002

13. Darowicki K.: *Polskie Stowarzyszenie Korozyjne,* KONSTRUKCJE STALOWE 45(1) 2001

12. Darowicki K., Krakowiak A.: *Zastosowanie zjawisk intermodulacji do wyznaczania parametrów charakteryzujących proces korozji,* OCHRONA p. KOROZ., 44: 33-36 2002

11. Żakowski K., Darowicki K.: *Pomiary potencjałowe w polu elektrycznym,* OCHRONA p. KOROZ., 44: 14-20 2000

10. Bordzilowski J., Darowicki K., Krakowiak S., Królikowska A.: *Terenowe pomiary impedancyjne,* OCHRONA p. KOROZ., 44: 317-321 2000

9. Darowicki K., Zieliński A.: *Transformacja falkowa w analizie sygnałów nieustalonych, odpowiadających korozji lokalne,* OCHRONA p. KOROZ., 44: 21-26 2000

8. Miszczyk A., Darowicki K.: *Wykorzystanie szoków termicznych do symulacji starzenia powłok na metalach.* OCHRONA p. KOROZ., 44: 110-115 2000

7. Klenowicz Z., Darowicki K.: *Zagadnienie korozji w spalarniach odpadów,* OCHRONA p. KOROZ., 44: 328-331 2000

6. Krakowiak S., Bordziłowski J., Darowicki K.: *Zastosowanie metody EIS do oceny stanu wykładzin gumowych w warunkach przemysłowych,* OCHRONA p. KOROZ., 44: 348-353 2000

5. Orlikowski J., Cebulski S., Krakowiak S., Darowicki K.: *Badania impedancyjne powłok elektroprzewodzących,* OCHRONA p. KOROZ., 44: 86-91 2000

4. Darowicki K., Krakowiak S.: *Zwiększenie niezawodności instalacji przemysłowych przez zastosowanie nowoczesnych stopów,* EKOTECHNOLOGIA, 4: 5 2000

3. Miszczyk A., Darowicki K.: Korozja i zabezpieczenia przeciwkorozyjne w instalacjach odsiarczania spalin metodą mokrą, EKOTECHNOLOGIA, 4: 1 2000

2. Bordziłowski J., Darowicki K.: *Problemy korozyjne i postępy w zabezpieczaniu przeciwkorozyjnym duktów spalin i kominów przemysłowych*, EKOTECHNOLOGIA, 4: 13 2000

1. Darowicki K., Krakowiak S., Orlikowski J.: *Electrical equivalent circuits and electrochemical impedance spectroscopy,* ANNALES UNIVERSITATIS MARIEA CURIE-SKŁODOWSKA, 34/35: 302 1999/2000

6.3. List of conference lectures delivered between 2000 and 2003

Participation in international conferences constitutes an important element of life of every scientist. The staff of the Department takes active part in such events in the field of electrochemistry and corrosion.

51. Klenowicz Z., Darowicki K., Krakowiak S., Krakowiak A.: *Reason of tube outer damage by crude within heat exchangers* W: CD-ROM Proceedings. EUROCORR 2003 The European Corrosion Congress, Budapest Hungary 28.08-2.10 2003 p.10.

50. Darowicki K., Felisiak W., Zielinski A.: *Analysis of Belousov-Zhabotinsky oscillatory reaction using the short time Fourier transformation.* W Proc. 3rd Baltic Conference on Electrochemistry Corrosion and Materials. Gdańsk-Sobieszewo 23-26 April 2003 p. 21

49. Darowicki K., Zieliński A.: *Applications of parametric techniques in electrochemical noise analysis* Proc. 3rd Baltic Conference on Electrochemistry Corrosion and Materials. Gdańsk-Sobieszewo 23-26 April 2003 p. .25

48. Klenowicz Z., Darowicki K., Krakowiak S., Krakowiak A.: *Cavitation-erosion damage of outer tube walls by crude within heat exchanger with baffles.* Proc. 3rd Baltic Conference on Electrochemistry Corrosion and Materials. Gdańsk-Sobieszewo 23-26 April 2003 p. 30

47. Darowicki K., Ślepski P.: *Determination of instantaneous electrode impedance*. Proc. 3rd Baltic Conference on Electrochemistry Corrosion and Materials. Gdańsk-Sobieszewo 23-26 April 2003, p. 46

46. Orlikowski J., Darowicki K., Arutunow A.: *Dynamic EIS measurements of passive layer cracking under tensile stresses* Proc. 3rd Baltic Conference on Electrochemistry Corrosion and Materials. Gdańsk-Sobieszewo 23-26 April 2003, p. 50

45. Darowicki K., Szociński M.: *Evaluating the performance of organic coatings under cyclic mechanical stress using impedance spectroscopy*. Proc. 3rd Baltic Conference on Electrochemistry Corrosion and Materials. Gdańsk-Sobieszewo 23-26 April 2003, p. 89

44. Krakowiak S., Darowicki K., Ślepski P.: *Impedance measurements of stainless steels under conditions pitting corrosion.* Proc. 3rd Baltic Conference on Electrochemistry Corrosion and Materials. Gdańsk-Sobieszewo 23-26 April 2003, p. 99

43. Zakowski K., Darowicki K.: *Method of detection of stray currents interference using STFT*. Proc. 3rd Baltic Conference on Electrochemistry Corrosion and Materials. Gdańsk-Sobieszewo 23-26 April 2003, p.116

42. Darowicki K., Kawula J.: *The EIS-EQCM investigation of the process of aniline electropolymerization* Proc. 3rd Baltic Conference on Electrochemistry Corrosion and Materials. Gdańsk-Sobieszewo 23-26 April 2003, p. 151

41. Darowicki K., Zielinski A.: *Higher order spectra in the electrochemical noise analysis*. W: Abstracts. EMCR 2003. 8th International Symposium Electrochemical Methods in Corrosion Research. Nieuwpoort-Bielgium 4-9 May 2003 Brussels, O-16

40. Darowicki K., Slepski P.: *Determination of electrode impedance using perturbation signal of chirp type.* W: Abstracts. EMCR 2003. 8th International Symposium Electrochemical Methods in Corrosion Research. Nieuwpoort-Bielgium 4-9 May 2003 Brussels, P-8

39. Krakowiak S., Darowicki K., Slepski P.: *Evaluation of pitting corrosion by means of potentiodynamic electrochemical impedance spectroscopy.* W: Abstracts. EMCR 2003. 8th International Symposium Electrochemical Methods in Corrosion Research. Nieuwpoort-Bielgium 4-9 May 2003 Brussels, P-13

38. Orlikowski J.: Darowicki K., Arutunow A.: *Investigation of stress corrosion cracking by means of dynamic electrochemical impedance spectroscopy.* W: Abstracts. EMCR 2003. 8th International Symposium Electrochemical Methods in Corrosion Research. Nieuwpoort-Bielgium 4-9 May 2003, Brussels, P-19.

36. Darowicki K., Kawula J.: *The mixed EIS-EQCM method for investigation of electrodeposition and electrodissolution of copper in acidic solution.* W: Proceedings. MSCHS 2003. Michal Smialowski International Symposium on Corrosion and Hydrogen Degradation. Advances in Corrosion Science and Application. Zakopane, Poland 9-13 September 2003, p. 144-149

35. Darowicki K., Felisiak J.: *Application of Cohen's class time-frequency distributions in the Belousov-Zhabotinsky reaction analysis.* W: Proceedings. MSCHS 2003. Michal Smialowski International Symposium on Corrosion and Hydrogen Degradation. Advances in Corrosion Science and Application. Zakopane, Poland 9-13 September 2003, s. 138-143

34. Darowicki K., Orlikowski J., Arutunow A.: *The application of dynamic electrochemical impedance spectroscopy for stress corrosion cracking studies*. W: Proceedings. MSCHS 2003. Michal Smialowski International Symposium on Corrosion and Hydrogen Degradation. Advances in Corrosion Science and Application. Zakopane, Poland 9-13 September 2003, s. 144-149

33. Darowicki K., Szociński M.: *Cyclic mechanical stress impact on protective properties of organic coatings*. W: Proceedings. MSCHS 2003. Michal Smialowski International Symposium on Corrosion and Hydrogen Degradation. Advances in Corrosion Science and Application. Zakopane, Poland 9-13 September 2003, p. 309-313.

32. Darowicki K., Mirakowski A., Zielinski A.: *Experimental study of corrosion in reinforced concrete by acoustic emission and electrochemical noise techniques.* W: Proceedings. MSCHS 2003. Michal Smialowski International Symposium on Corrosion and Hydrogen Degradation. Advances in Corrosion Science and Application. Zakopane, Poland 9-13 September 2003, s. 338-344.

31. Darowicki K., Żakowski K.: *Nowa czasowo-częstotliwościowa metoda detekcji interferencji pola prądów błądzących na konstrukcje metalowe. New time – frequency method of detection of stray currents interference on metal structures*. W: Proc. Of International Workshop „Cathodic protection – theory and practice" CP 2002 Sopot 9-10 May 2002, s. 1-10

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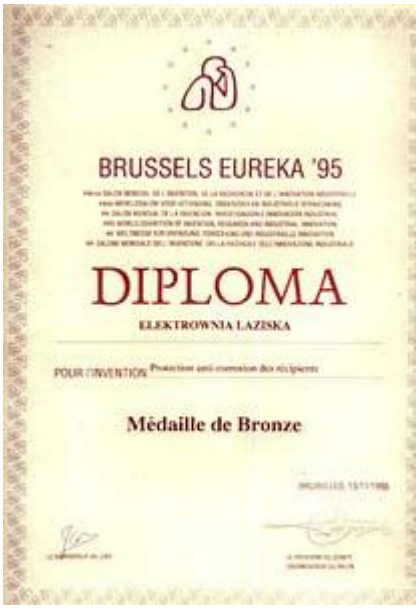
6.4. Main research fields

The Department focuses on several main research fields. The results of the investigations always bear a practical, application-oriented aspect.

1. Impedance measurements in dynamic conditions
2. Electrochemical noise, analysis and interpretation
3. Mechanical stress impact on durability of organic coatings
4. Pitting corrosion of austenitic steels
5. Stress corrosion cracking
6. Investigation of oscillatory reactions using joint time-frequency methods
7. Conducting polymers

7. TECHNOLOGICAL ACTIVITY

A vital field of the Department's activity is co-operating with various branches of industry. The range of orders from industry includes: elaboration of anticorrosion protection technologies, selection of construction materials, corrosion risk assessment and corrosion monitoring. A number of expert diagnoses and evidence is given by the Department. This field of activity has an influence on directions of fundamental research. It also modifies and improves didactic programs realized in the Department adjusting them to job market requirements.



Employees of the Department are the authors of many patents. The technology of anticorrosion protection of large-diameter tanks and pipelines has been awarded a bronze medal at the international exhibition EUREKA in Brussels.

7.2. List of co-operants

For many years the Department has been co-operating with a number of clients representing various branches of industry. Such co-operation is facilitated by the fact that corrosion engineers employed in the co-operating units are postgraduates of the Department. They maintain vital contact with us by participation in postgraduate studies, courses and seminars organized by the Department. The list of our co-operants includes:

1. LOTOS Group S.A. Polish Oil Corporation, Gdańsk
2. ORLEN Polish Oil Corporation, Płock
3. International Paper Kwidzyn S.A., Kwidzyn
4. Chemical Plant PULAWY, Puławy
5. Chemical Plant ANWIL, Włocławek
6. POLPHARMA Pharmaceuticals S.A, Starograd Gdański
7. Bełchatów Power Station S.A., Bełchatów
8. Kozienice Power Station S.A., Kozienice
9. Łaziska Power Plant S.A., Łaziska
10. Brewing Company, Poznań
11. Brown Coal Mine, Bełchatów
12. Gdansk City Council
13. Gdansk Repair Shipyard, Gdańsk
14. SAUR NEPTUN Gdańsk, Gdańsk
15. Building Society CHEŁM, Gdańsk
16. Building Society JASIEŃ, Gdańsk
17. Building Society MORENA, Gdańsk
18. Building Society ZAKONICZYN, Gdańsk
19. KORCHEM, Bełchatów
20. UNITEX, Gdańsk

21. K&W, Nothkirshe Kapele, Germany
22. ALCAN Ltd., Canada
23. Municipal Roads Administration, Gdańsk
24. Gdynia Shipyard S.A., Gdynia
25. SAFE Ltd., Gdynia
26. Institute for Building, Mechanisation and Electrification of Agriculture, Branch Gdańsk
27. Heat Energy Company, Łomża
28. Municipal Water and Sewerage Company, Elbląg
29. Gdynia City Council
30. MARCOR Company, Gdynia
31. COREKO, Gdańsk

7.3. List of scientific projects realized since 2000

There are several scientific projects financed by the MINISTRY OF SCIENTIFIC RESEARCH AND INFORMATION TECHNOLOGY POLISH GOVERNMENT as well as contracts ordered by industry entities that are realised in the Department.

7.3.1. Scientific projects financed by the Ministry of Scientific Research and Information Technology

1. Investigation of the correlation relationship of stray currents in conurbation

2. Application of harmonic analysis technique in corrosion risk assessment under polarization conditions

3. Microscopic examination of modified surfaces of composite materials used for cathodic protection

4. Application of protective coatings based on hybrid inorganic-organic binder as anodes in cathodic protection system

5. Time-frequency analysis of potential changes of steel constructions maintained in stray currents field

6. Activated polymeric anodes for cathodic protection systems

7. Monitoring of corrosion rate using harmonic synthesis method

8. Influence of temperature the susceptibility of stainless steel to pitting corrosion

9. Selection and inspection of coating systems for protection of steel bridge structures

10. Time-frequency analysis of electrochemical noise

11. Investigation of the possibilities of new electrochemical techniques application to corrosion monitoring of reinforced concrete bridge constructions

12. Electrochemical investigation of coatings and corrosion phenomena

13. Corrosion rate monitoring with harmonic synthesis method

14. Influence of temperature on the susceptibility of stainless steel to pitting corrosion

7.2.2. Contracts ordered by various entities

Municipal Roads Administration, Gdańsk

- Inspection of electrochemical protection of Siennicki Bridge against stray currents

International Paper Kwidzyn S.A., Kwidzyn

- Identification of the reasons of accelerated corrosion and selection of appropriate construction materials for installations and tanks with the following technological numbers: 32-001, 32-008 and 32-715
- Corrosion risk assessment connected with aggressive environment present in technological lines of the IP Kwidzyn
- Corrosion risk assessment of the filters operating in cellulose bleachery

Gdynia Shipyard S.A., Gdynia

- Evaluation of corrosive impact of sea water on 316L steel welds prior to passivation, performed on the vessel number 8189
- Assessment of Avesta 302 pickling/ passivating agent impact on coating systems applied in holds

SAFE Ltd., Gdynia

- Investigation of two types of cast steel abrasive

Institute for Building, Mechanisation and Electrification of Agriculture, Branch Gdańsk

- Investigation of stock fodder influence on durability of organic coatings – impedance investigations in simulated conditions
- Impedance assessment of protective properties of organic coatings (chlorinated rubber and epoxy ones) applied in stock buildings

Heat Energy Company, Łomża

- Corrosion risk assessment of a reducer from the stack made of reinforced concrete in the Thermal-electric Power Station in Łomża

Elbrewery Company Ltd., Elbląg

- Assessment of the state of the mash tub and proposal of the anticorrosion protection system
- Assessment of the state of diatomaceous earth frame filter

Energy Company S.A., Zielona Góra

- Anticorrosion protection of Międzyrzecka – Zbąszynek 110 kV overhead transmission line by the inhibitor method

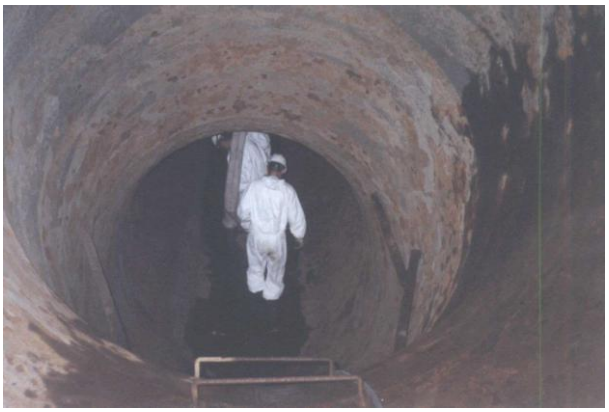
Shipyard CENAL Ltd., Gdańsk

- Elaboration of the anticorrosion protection system for the docks ALDOK I and ALDOK II

EuRoPol GAZ S.A., Warsaw

- Assessment of stray currents impact on the Jamał – Western Europe gas pipeline - Zambrów-Kondratki section

Bełchatów Power Station, Bełchatów



- Evaluation of guaranteed parameters of rubber linings of R1/6 absorber and gas outlet ducts.
- Evaluation of guaranteed parameters of rubber linings of 4 absorbers on the following FGD units – R1/8, R1/10, R1/11, R1/12
- Start-up measurements on Wikaline SL lining protecting R1/10 and R1/11 absorbers bottoms aimed at creation of a databse and linings lifetime prediction
- Comparison analysis of paint systems for units 7 and 9 of the FGD system
- Technical assessment of cooling water pipelines between cooling tower no. 1 and turbine condenser on the blocks 1 and 2

Research Institute of Plastics and Paints, Gliwice

- Investigation of lacquer coatings using electrochemical impedance spectroscopy

Municipal Water and Sewerage Company, Elbląg

- Identification of the reasons of an increase in iron content in water transmitted via Szopy – Elbląg pipeline and preparation of preventative measures

POLPHARMA Pharmaceuticals S.A., Starogard Gdański

- Selection of organic acid-resistant steels

ALCAN INTERNATIONAL Ltd., Canada

- Laboratory selection of corrosion inhibitors for aluminium alloys

OLIVA Ltd., Gdynia

- Durability evaluation of paint systems used in power industry
- Impedance examinations of Epinox 77 coating (summer version) at elevated temperatures
- Determination of coatings resistance to cathodic protection impact and investigation of coatings durability upon exposure to aggressive media
- Evaluation of Epinox 77 coating durability while cathodic polarization of the substrate

Paint and Lacquer Factory MALCHEM, Sułkowice

- Investigation of polyvinyl coating system for protection of bridge constructions

Gdańsk Repair Shipyard, Gdańsk

- ISO/DIS 8501-3 standard
- Investigation of sand abrasives
- Analysis of copper slag abrasive according to the ISO 11126-3 standard
- Identification of coating binders
- Metallographic examination of a fragment of pump valve casing from cooling system on „Bona Spring" vessel

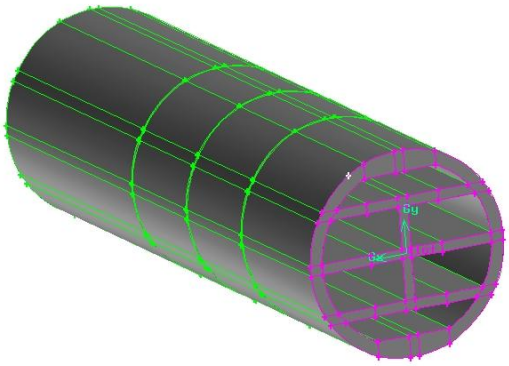
KORCHEM K&W Ltd., Biłgoraj near Bełchatów

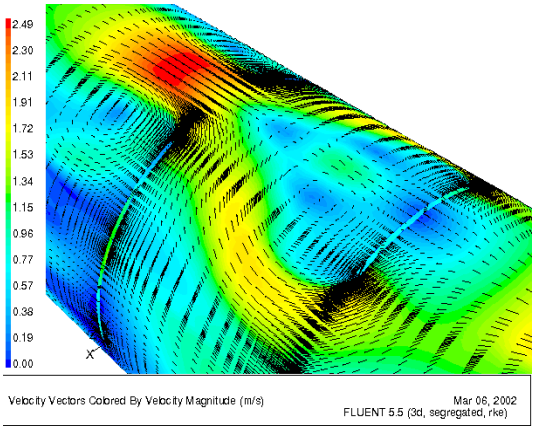
- Investigation of WIKALINE SL lining from the absorber no. 12 bottom in Bełchatów Power Station
- Investigation of WIKABUTYL NO 16 lining from the absorbers no. 9 and 7 ISO and control samples in Bełchatów Power Station

Gdynia City Council

- Determination of the quality of road paint in Gdynia and decomposed paint analysis according to respective standards

LOTOS Group S.A. Polish Oil Corporation, Gdańsk





- Identification of the reasons for water-side corrosion of the heat exchanger 100E 14
- Diagnostics and corrosion damage identification of the heat exchangers 100E 54 and 100E 55
- Corrosion risk assessment of underground petroleum pipelines and storage tanks bottoms
- Local inspection of refinery installations during technical shut down periods including corrosion risk assessment and elaboration of anticorrosion protection technology for release pipelines
- Anticorrosion protection of gas outlet ducts and stacks
- Elaboration of new technology of anticorrosion protection for oil dewaxing installation
- Inspection of cathodic protection system on liquid gas tanks no. 2070 S4G, S50
- The reasons for corrosion identification of the heat exchanger 650E01 – amine washing installation 650/RGSA
- Comparative study on various corrosion inhibitors

Service and Commerce Company BUTRA, Sopot

- Corrosion investigations of the flame breaker and exhaust valve

MARCOR Company, Gdynia

- Electrochemical investigations of Radiner Fs and Radiner Fi formulations

Building Association ZAKONICZYN, Gdańsk

- Examination of zinc coating and internal sediments from selected sections of galvanized steel pipes

Building Association POŁUDNIE, Gdańsk

- Quality assessment of galvanized steel pipes from the installations in buildings 23E, 24E, 25E, 32D and 35 D of Building Association POŁUDNIE in Gdańsk
- Corrosion risk assessment and preliminary anticorrosion protection system concept for hot water installation in the buildings of Building Association POŁUDNIE in Gdańsk

Northern Shipyard, Gdańsk

- Identification of the reasons for corrosion of fresh water tank and suggestion of protective measures

SAUR Neptun Gdańsk

- Identification of the reasons for accelerated damage of mechanical filter

Investor Service Office ABOL, Bytów

- Elaboration of cathodic protection system documentation for planned Redzikowo – Słupsk gas pipeline

Chemical Plant PUŁAWY S.A., Puławy

- Analysis of corrosion and potential protective measures for urea installation, especially while integrated with melamine installation

Chemical Plant ANWIL S.A., Włocławek

- Corrosion resistance assessment of SAF 2304 steel with respect to cooling water and nitric acid

Brewing Company S.A., Poznań

- Elaboration of tank passivation technology and passivation effectiveness control

Polish Oil Corporation ORLEN, Płock

- Cathodic protection of fuel tanks at the filling station in Czarnków
- Cathodic protection of fuel tanks at the filling station in Pradów
- Cathodic protection of fuel tanks at the filling station in Władysławowo

8. PROPOSAL

We are ready to serve with our experience in the field of corrosion prevention. Our proposal includes the following issues:

- Diagnostics of the anticorrosion protection systems designated for environmental protection installations such as flue gas desulphurization installations, electrofilters, waste incinerators, sewage purification plants etc.
- Selection of construction materials for chemical industry installations
- Monitoring of corrosion aggressiveness of water
- Anticorrosion protection of industry and potable water installations
- Design of cathodic protection installation
- Detection and corrosion analysis of electromagnetic fields
- Anticorrosion protection technologies using organic coatings
- Corrosion diagnostics of steel constructions
- Detection of defects and leaks using acoustic emission technique
- Wall and insulation layer thickness measurements using ultrasound method
- Thermovisual analysis of state of objects
- Design and assembling of corrosion monitoring digital systems
- Inspection of protective coatings

The Department conducts educational courses covering the topics of corrosion and anticorrosion protection.

9. IMPORTANT ADRESSES AND TELEPHONE NUMBERS

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10. CAMPUS MAP

Department of Electrochemistry, Corrosion and Materials Engineering

1. Main Building and Auditorium Maximum
2. Main Building – Extension B
3. Chemical Faculty and Auditorium of Chemistry
4. University Health Centre
5. Lodge
6. Post Office
7. Printing Office
8. Faculty of Hydro and Environmental Engineering
9, 10, 11. Faculty of Electrical and Control Engineering
12. Auditorium Novum
13, 14. Faculty of Civil Engineering
15. Students' Centre
16. Faculty of Management and Economics
17. Faculty of Electronics, Telecommunications and Informatics
18, 19. Faculty of Mechanical Engineering
20. Faculty of Ocean Engineering and Ship Technology
21. Polish Academy of Science, Institute of Rotating Machinery