

# **Metrohm Autolab**

## **Corrosion Application Products**



Compliance and convenience for your corrosion laboratory

## Corrosion Research

- General corrosion mechanism studies and development of new materials
- Corrosion protection research: characterization of protective coatings, paints
- Pitting corrosion, critical pitting temperature (CPT) determination
- Corrosion inhibitors development and performance studies
- Environmental corrosion: marine, atmospheric, microbial, oil etc.
- Industry specific corrosion research: automotive, oil, power plants, fashion, medical implants etc.
- Corrosion studies under static and hydrodynamic (flow) conditions: laminar (RDE) and turbulent (RCE)
- Tribo-corrosion\*
- H-permeation studies\*\*

\* Possible with the use of third-party tribology devices.

\*\* Autolab PGSTAT302F required. Please contact your Metrohm Autolab distributor for further information.

Subject to change.

Images are exemplary and all local lab regulations and experiment conditions should be considered when using Autolab products.

# Metrohm Autolab: All you need for quality corrosion research

## Would you like deeper, faster & more accurate insight from your corrosion research?

3

No doubt you are concerned about data **accuracy** and **reproducibility**. You also want to maximize resources and create efficient, possibly **automated workflows** while **measuring corrosion rates, investigating corrosion mechanisms, analyzing coating properties** or screening for the **best corrosion inhibitors**.

**Metrohm Autolab's reliable, high performing electrochemical instruments** and **accessories** with dedicated measurement techniques brings the entire world of corrosion research in to your laboratory. You can recreate **real world corrosion processes** in the laboratory, **save time** and **expand your research possibilities**, improving the **reproducibility** and **accuracy** of the results.

**Metrohm Autolab** is your **partner for electrochemistry** – we are dedicated to research and understand your requirements whatever you are exploring. From PGSTATs to sample holders and corrosion cells, all of our parts and accessories are compatible and in some cases interchangeable.

### Typical corrosion parameters and techniques

- Measurement of the polarization resistance ( $R_p$ ) by using linear sweep voltammetry (LSV) and electrochemical impedance spectroscopy (EIS)
- Corrosion rate measurements by using linear sweep voltammetry (LSV) and electrochemical frequency modulation (EFM) techniques
- Determination of additional corrosion parameters such as corrosion current ( $i_{corr}$ ) and corrosion potential ( $E_{corr}$ ), Tafel constants ( $b_a$ ,  $b_c$ ) using linear and cyclic polarization
- Determination of the coating parameters by using electrochemical impedance spectroscopy (EIS)
- Determination of the break down and critical pitting potential ( $E_b$  and CPP) and protection potential ( $E_p$ ) by using linear sweep voltammetry (LSV) and integrated temperature control
- Monitoring of the open circuit potential (OCP) by using time domain (chrono) measurements
- Electrochemical Noise (ECN) measurements by using a zero resistance ammeter (ZRA) configuration with measurements in the time domain (chrono) measurements and analysis in the frequency domain.



# Capture, explore and understand your data with NOVA

4

## Powerful Data Acquisition & Analysis Software

### Effortless Intuitive Software

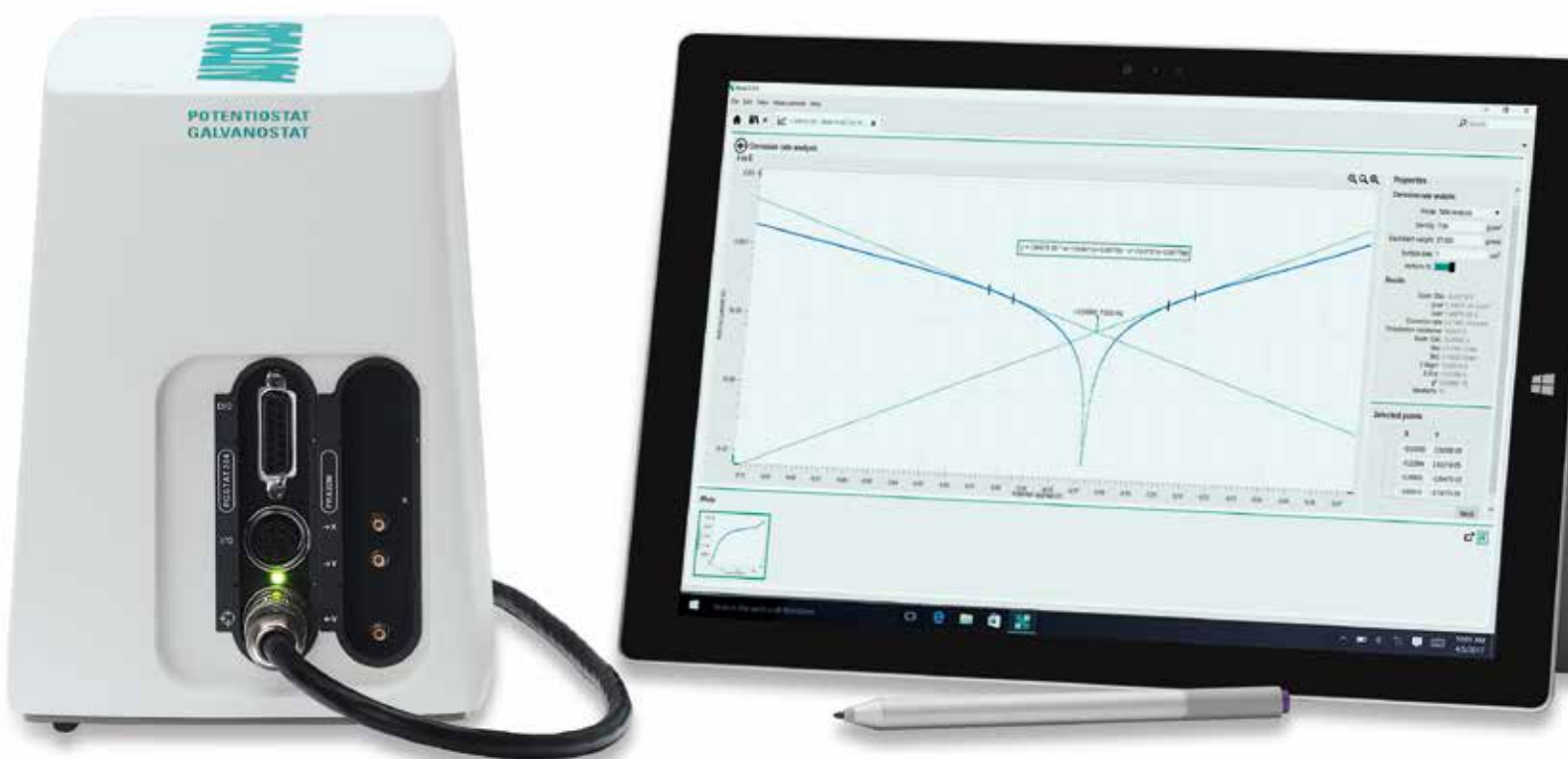
- Users are comfortable with **NOVA's modern user interface** and **straightforward navigation**.
- **NOVA** has approximately **60 essential electrochemistry** procedures available for preliminary exploration including **7 core corrosion techniques**.

### Customized Lab Setup

- With the integrated control of the **Metrohm Liquid Handling** devices you **optimize** your **lab processes** and **avoid costly human error**.

### Efficiently Automated Laboratory

- With the **powerful** and **flexible NOVA 2 software** you can **customize measurement procedures** and **data analysis** to your **exact experimental requirements**.
- **Customize** experiment procedures in real time and save them.
- You can even **automate** your procedures for **maximum convenience!**
- **Improve lab efficiency** by automating your throughput with **Metrohm Liquid Handling** devices, **multiplexers** and the **NOVA 2** software.
- **NOVA Scheduler** helps your planning and allows you to execute a series of procedures on multiple instruments and/or accessories.
- Conveniently **pre-configure** calculations for **other lab users** and the desired result will be **available** at the **end of the measurement**.

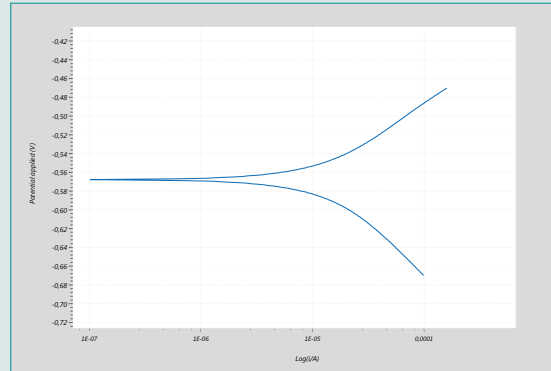


Potentiodynamic polarization with Tafel analysis using the NOVA 2 software.

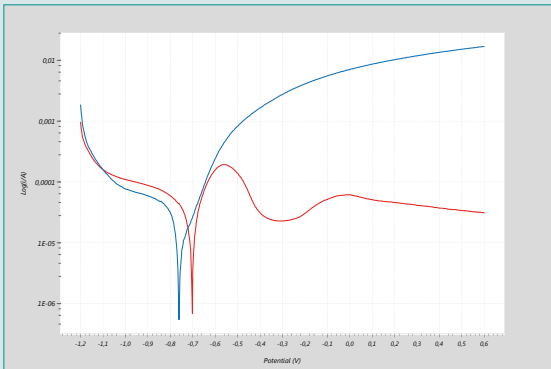
# Core corrosion techniques with NOVA

## Powerful Data Acquisition & Analysis Software

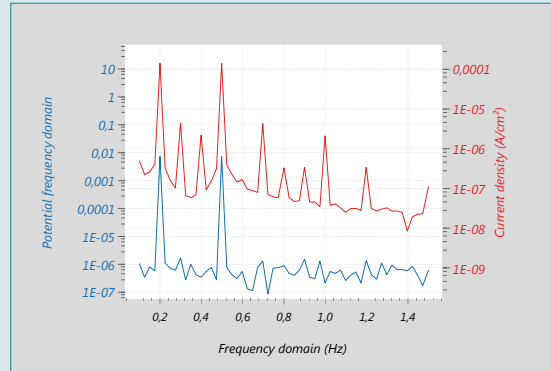
NOVA 2 is the most powerful electrochemistry software on the market with 7 dedicated corrosion techniques that you can use to get your research started immediately. You can also use the power of NOVA to customize and automate your procedures.



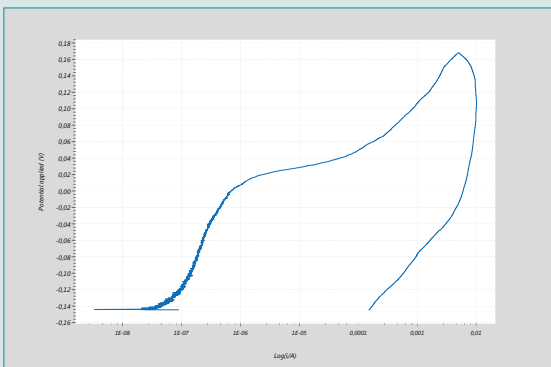
Linear Polarization (LP)



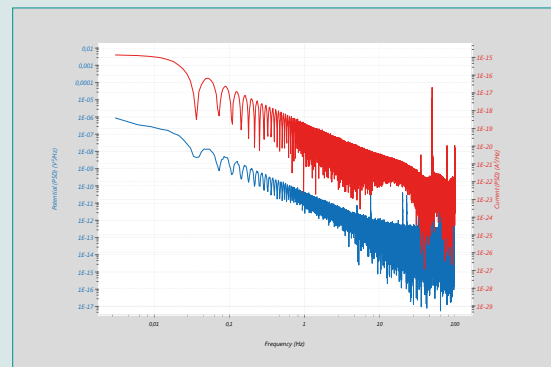
Potentiodynamic polarization (PD) with inhibitors



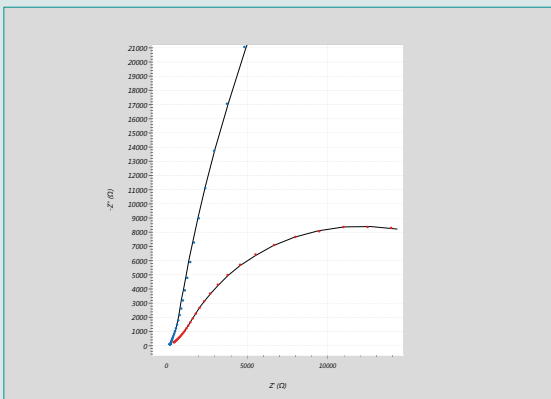
Electrochemical Frequency Modulation (EFM)



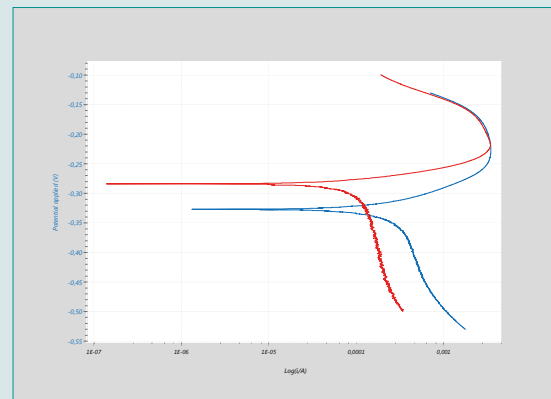
Cyclic Polarization



Electrochemical Noise (ECN)



Electrochemical Impedance (EIS)



Hydrodynamic Measurements (with and without rotation)

## Choose your corrosion workstation

### Corrosion Compact

**Metrohm Autolab** created these workstations to meet the experimental requirements of corrosion professionals across the spectrum of corrosion research with the **flexibility** to **adjust your setup** as **research requirements change**.

- **Immediately** start your research with the prepared high quality 1 L ASTM corrosion cell.
- **Quickly execute core corrosion measurements** with NOVA's standard procedures.

The **Corrosion Compact** package is for you, if you:

- Want to **add electrochemistry** to your existing corrosion workflow
- Have **limited space** and don't want to reconfigure your lab
- Require **ASTM compliance** in your laboratory

#### Corrosion Compact includes:

- Autolab PGSTAT204
- FRA32M module for Electrochemical Impedance Spectroscopy (EIS)
- 1 L ASTM Corrosion Cell (ASTM compliant)
- Powerful NOVA Software

#### 1 L ASTM Corrosion Cell

Two-way gas inlet	<input type="checkbox"/>
Thermostatic jacket	<input type="checkbox"/>
Thermometer 0-150°C	<input type="checkbox"/>
Ag/AgCl reference electrode	<input type="checkbox"/>
Stainless steel counter electrode	<input type="checkbox"/>
Sample holder (1cm <sup>2</sup> )	<input type="checkbox"/>

#### 1 L ASTM Corrosion Cell Specifications

Exposed surface area:	1cm <sup>2</sup>
Sample diameter:	14-16 mm
Sample holder:	PEEK
Seal:	Rubber

The **1 L ASTM Corrosion Cell** is included in both the **Corrosion Compact** and **Corrosion Complete** packages.



# Choose your corrosion workstation

## Corrosion Complete

---

7

The **Corrosion Complete** package is for you, if you:

- Require **efficient execution** of **complex electrochemical experiments** and **data analysis** with **one instrument, one interface**
- **Validate experiments** by acquiring a variety of data using **multiple corrosion techniques**
- Require **ASTM compliance** in your laboratory

### Corrosion Complete includes:

- Autolab PGSTAT302N
- 4 dedicated modules installed
- FRA32M module for Electrochemical Impedance Spectroscopy (EIS)
- Low current amplifier module (ECD) measures ultra-low current measurements (down to 300 aA) and ultra-low signal to noise ratio
- Voltage and pH measurement module (pX1000) provides simultaneous and highly accurate pH, additional voltage and temperature measurements
- Electrochemical Noise module (ECN) is ultra-sensitive and amplifies corrosion noise as a function of time allowing data analysis in the frequency domain
- Pt 1000 temperature sensor for the temperature measurement of the pX1000
- 1 L ASTM Corrosion Cell (ASTM compliant)
- Powerful NOVA Software



PGSTAT302N has a capacity of 8 modules, with the configuration Corrosion Complete there is still the possibility to add up to 4 other modules. Modules can be conveniently added post-installation by one of our service technicians.

# Metrohm Autolab Rotating Cylinder Electrode (RCE)

## Recreate The Outside In Your Lab

**Metrohm Autolab** developed the RCE to be as **versatile** as possible to meet your ever changing **research needs**. The **RCE** is a welcome addition to a portfolio that offers reliable, **high performing electrochemical instruments and accessories** for **corrosion research**.

### RCE Is a Smooth Operator

#### Noise Free Measurements

- **Autolab's Rotating Cylinder Electrode** with a liquid contact provides **superior noise-free corrosion measurements**.
- The RCE's Hg sealed contact produces **smooth and accurate data** that requires **no special handling or tools** for use in your lab.

### No Cumbersome Setup

#### RCE is Compact and Easy to Handle

- The **Autolab RCE** is very compact, **only a tenth** of the **size** of other commercially available RCEs.
- **Small but powerful** the RCE is **easy to handle** and **light** enough to fit into most **experimental setups** without **overcomplicating the configuration**. The **RCE's minimal space** requirement allows you to **setup easily one or more rotating cylinder electrodes** just about **anywhere in your laboratory**.

### Get Hands On

#### No Tools Required

The **functional design** of the **Metrohm Autolab rotating cylinder electrode** allows practical manual assembly and setup.





# Metrohm Autolab Rotating Cylinder Electrode (RCE)

## Recreate The Outside In Your Lab

### Highest Specifications on the Market

Expand Your Research Possibilities

- With the **highest rotation rate** among commercially available systems, **the Autolab Rotating Cylinder Electrode** allows you to simulate the **widest variety of pipe flow conditions** in your lab.
- The RCE can achieve **double the rotation** rate of any other **12 mm rotating cylinder electrode** making **achievable simulated flow rates** that are **50% higher** than any other commercially available.
- Are **standards** a priority for your lab? Relax! The **Autolab Rotating Cylinder Electrode** is fully **ASTM G185-6** compliant.

### Single Size RCE (12 mm)

Efficiency and Compatibility

- You can access the **full rotation rate** of the Autolab RCE (**100-5000 rpm**) with a **12 mm cylinder**.
- The Autolab Rotating Cylinder Electrode is **compatible** with your existing **12 mm cylinders**. No need to create new cylinders or have multiple sizes in your laboratory.\*



\*Commercially manufactured cylinders.

### RDE or RCE?

You Have Options

- Do you already have an **Autolab RDE**? Your **RDE rotator** can also be used with a **cylinder electrode** for **corrosion research**.
- Conveniently **change the electrode** and you are ready to explore other possibilities. You can make this change with **minimal downtime**.

#### Maximum Simulated Turbulent Flow Rates

**1 inch / 2.66 cm** ID pipe with schedule **40: 365 cm/s maximum flow rate**

**24 inch / 57.48 cm** ID pipe with schedule **40: 566 cm/s maximum flow rate**

Achievable **flow rates** are **50% higher** than any other commercially available 12 mm diameter RCE.



# Metrohm Autolab corrosion cells

10

## 0.4 L Corrosion Cell

Exposed surface area:	0.785 cm <sup>2</sup>
Sample diameter:	14 mm
Sample holder material:	POM
Seal:	Viton



## Flat Corrosion Cell

Exposed surface area:	16.9 cm <sup>2</sup>
Sample diameter:	6-8.5 cm
Sample holder material:	PVC
Seal:	Viton O-ring



## 0.250 L Corrosion Cell

Exposed surface area:	1cm <sup>2</sup>
Sample diameter:	14-16 mm
Sample holder material:	PEEK
Seal:	Rubber



# Metrohm Autolab Flat Sample Platform

## For Oversized Corrosion Samples

### Add electrochemistry, subtract research time!

- With the **Autolab Flat Sample Platform** you can conduct electrochemical research with your **existing salt spray chamber samples reducing experiment time** from **weeks to hours** depending on your setup.
- You can **reproduce** your research **easily** and **efficiently** by using your standardized samples used in salt spray chambers in **diverse research environments**.

Metrohm Flat Sample Platform	
Exposed surface area:	16.9 cm <sup>2</sup>
Minimum sample diameter:	5.5 mm
Sample holder material:	PVC
Seal:	Viton O-ring

### Direct connection, clean data

- **The Autolab Flat Sample Platform's** direct connection socket allows you to **connect directly** to the PGSTAT. **Plug right in** and **measure clean, noise-free data**.



# Electrochemical corrosion tests

## ASTM Standards

	Compact	Complete
F746: Standard Test Method for Pitting or Crevice Corrosion of Metallic Surgical Implant Materials	✓*	✓*
F2129: Standard Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements to Determine the Corrosion Susceptibility of Small Implant Devices	✓*	✓*
G5: Standard Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements	✓	✓
G59: Standard Test Method for Conducting Potentiodynamic Polarization Resistance Measurements	✓	✓
G61: Standard Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel -, or Cobalt-Based Alloys	✓	✓
G69: Standard Test Method for Measurement of Corrosion Potentials of Aluminum Alloys	✓*	✓*
G100: Standard Test Method for Conducting Cyclic Galvanostaircase Polarization	✓	✓
G102: Standard Practice for Calculation of Corrosion Rates and Related Information from Electrochemical Measurements	✓	✓
G106: Standard Practice for Verification of Algorithm and Equipment for Electrochemical Impedance Measurements	✓	✓
G148: Standard Practice for Evaluation of Hydrogen Uptake, Permeation, and Transport in Metals by an Electrochemical Technique		✓**
G150: Standard Test Method for Electrochemical Critical Pitting Temperature Testing of Stainless Steels and Related Alloys		✓
G185: Standard Practice for Evaluating and Qualifying Oil Field and Refinery Corrosion Inhibitors Using the Rotating Cylinder Electrode	✓	✓
G199: Standard Guide for Electrochemical Noise Measurement		✓

\*Additional accessories may be required

\*\* PGSTAT302F with with floating mode required

# Electrochemical corrosion tests

## ASTM Standards

Electrochemical Techniques	Parameters of Interest	ASTM Reference Methods
<b>DC Techniques</b> <ul style="list-style-type: none"> <li>• Linear sweep voltammetry</li> <li>• Tafel slope analysis</li> <li>• Potentiodynamic and linear polarization (PD, LP)</li> <li>• Cyclic polarization</li> <li>• Hydrodynamic linear sweep</li> </ul>	<ul style="list-style-type: none"> <li>• Polarization Resistance (<math>R_p</math>)</li> <li>• Corrosion Rate (mm/Year)</li> <li>• Corrosion Current (<math>i_{corr}</math>)</li> <li>• Corrosion Potential (<math>E_{corr}</math>)</li> </ul>	<ul style="list-style-type: none"> <li>• F2129</li> <li>• G5</li> <li>• G59</li> <li>• G61</li> <li>• G100</li> <li>• G102</li> <li>• G185</li> </ul>
<b>AC Techniques</b> <ul style="list-style-type: none"> <li>• Electrochemical impedance spectroscopy (EIS)</li> </ul>	<ul style="list-style-type: none"> <li>• Film Resistance &amp; Conductivity (<math>R_{ct}</math>)</li> <li>• Charge-transfer resistance</li> <li>• Solution Resistance (<math>R_s</math>)</li> <li>• Polarization Resistance (<math>R_p</math>)</li> </ul>	<ul style="list-style-type: none"> <li>• G106</li> </ul>
<b>Chrono &amp; other Techniques</b> <ul style="list-style-type: none"> <li>• Electrochemical noise (ECN)</li> <li>• Critical pitting technique (CPT)</li> <li>• Hydrogen Permeation study</li> </ul>	<ul style="list-style-type: none"> <li>• Redox kinetics</li> <li>• Pit initiation</li> <li>• Crevice progression</li> <li>• Hydrogen resistance</li> <li>• Surface morphology</li> </ul>	<ul style="list-style-type: none"> <li>• F746</li> <li>• G69</li> <li>• G148</li> <li>• G150</li> <li>• G199</li> </ul>



## Dedicated to research

14

Metrohm Autolab sets the standard for electrochemistry instrumentation. Over 30 years ago, we created the first commercially available digital potentiostat/galvanostat that was completely computer controlled. Today our NOVA software is the most powerful electrochemistry software on the market.

Metrohm Autolab creates instruments that are suitable for most application areas including: corrosion, energy, environmental, sensors, and solar. Our customers may not always be electrochemists, but they are engaged in fundamental and applied research harnessing the power of electrochemistry for further understanding. They are driven to understand and improve electrochemical processes with the ambition to deliver new materials with superior properties and future possibilities.

With an Autolab potentiostat/galvanostat and NOVA software there are no limits to where your research can go.

### Reliability

- Metrohm Autolab's **integrated testing process** ensures that each component is **traceable and tested individually** after installation in the instrument.
- Metrohm Autolab instruments undergo up to **405 quality checks** during the manufacturing process.
- Our installed instruments average **99% uptime** in the first **5 years of installation**.\*

### Superior Service

- Metrohm Autolab provides an **industry-leading 3 year warranty** for all its instruments, modules and instrument accessories.
- Our **dedicated distribution and service network** provide a **fast response** for sales and service, usually within **48 hours**.
- Our colleagues are **people you can trust** to understand your requirements and **provide solutions** to **support your research objectives**.

### Versatility

- **Metrohm Autolab** instruments are the **workhorses** of **electrochemical research** delivering the **requirements of most application areas** with our range of **instruments, modules and accessories**.
- **Modular instruments** allow you to **change and expand** the **functionality** of your instrument.
- **Specialist modules can be installed** to provide additional electrochemical measurements and possibilities as your research progresses.

### Powerful software

- NOVA is the **powerful data acquisition and analysis software** that powers your experiment.
- **Essential procedures** and **multiple analysis options** are built-in with the ability to **modify** and **create** your own.
- NOVA helps **maximize your laboratory throughput** with useful features that put the **focus on safety and production**.



\*Based on European markets most widely sold instrumentation.



**Dedicated to research**

[www.metrohm.com/electrochemistry](http://www.metrohm.com/electrochemistry)

