

## Norsk Hydro - competence based on international experience

The Norsk Hydro Magnesiumgesellschaft mbH is a subsidiary of Norsk Hydro ASA, Oslo, the largest industrial enterprise in Norway with a workforce numbering more than 39,000 worldwide. The activities of the Norsk Hydro concern are focused on the oil and energy sector with concern-owned production facilities for mineral oil and natural gas, on agriculture as the world's largest producer of artificial fertilizers, and on light metals with the production of aluminium and magnesium.

As the world's largest producer of magnesium with production facilities in Europe and in North America, Norsk Hydro is backed by sound expertise acquired over a period of decades in the production, processing and recycling of magnesium. This experience and our know-how relating to the overall life cycle of magnesium is exploited to the benefit of our customers.

Norsk Hydro's own research and development departments make for sophisticated production technology, as do measures aimed at environmental protection. A motivated workforce, an effective production system, efficient power utilization and attention to minimum environmental impact and maximum on-the-job safety are major objectives underlying our activities.

Recognition of our quality assurance system to DIN EN ISO 9001 specifications is just one outcome of our endeavours.

## Our experience: your security



Magnesium anodes and CORREX™ impressed current anodes designed to prevent corrosion in hot-water storage tanks



Magnesium ground anodes for the cathodic protection of buried pipelines and storage tanks.



Compact magnesium anodes for the cathodic protection of cooling systems and heat exchangers in industrial applications

### Cathodic protection in water and soil

Within the Norsk Hydro group, the Norsk Hydro Magnesiumgesellschaft has been specializing for more than forty years in the field of cathodic protection.

As a leading supplier in Europe, we offer a wide selection of products ranging from the standard magnesium anode or the customized anode to the CORREX™ impressed current anode. Our products for series installation in hot-water storage tanks and for the solving of corrosion-related problems in the industrial and plant construction sector are developed and manufactured in accordance with DIN, EN and ASTM standard specifications.

Our full range of accessories for all fields of application and the opportunity for account to be taken of customers' specific requirements in design or technical aspects make our production as individualized as your demands on a technically perfected, economically efficient solution.

Electro-chemical series of metals in tap water (E<sub>n</sub>)

Material	Volts
Magnesium	- 1.40
Zinc	- 0.82
Galvanized steel	- 0.79
Cadmium	- 0.57
Steel C 85	- 0.41
Lead	- 0.28
Tin	- 0.18
Aluminium	- 0.17
Copper	+0.14
Stainless steel 18/8 pass.	+0.16
Nickel	+0.18
Titanium	+0.18
Silver	+0.19
Mercury	+0.19
Gold	+0.31
Platinum	+0.55

### The principle underlying cathodic protection

All metals have a certain tendency to disintegrate. The strength of this tendency depends on the metal and the electrolyte. The more negative the potential of a metal (see table), the more base the metal is and the greater is its inclination to disintegrate.

If two metals with differing potentials are interconnected with electronic conductivity in the presence of an electrolyte, the outcome is a galvanic element: The baser metal (anode) starts to disintegrate, while the more noble metal (cathode) is protected by a cathodic shift in potential.

### Magnesium anodes

Magnesium, the basest metal in the electro-chemical series, is physiologically safe and thus ideal as a so-called "sacrificial anode".

The difference in potential between magnesium and steel is about 1 V; as driving voltage, this causes a protective current to be discharged.

In enamelled steel tanks the current flows from the magnesium anode to the defects (cathode) in the enamelling. Whereas the magnesium is gradually disintegrated through the current discharge and through intrinsic corrosion (sacrificial anode principle), the defects are subject to a reduced potential which can be referred to as cathodic polarization and which prevents the steel from corroding.

### Impressed current anodes

In contrast to the sacrificial anode principle, the mode of functioning of CORREX™ impressed current anodes is based on the external, potentiostatically controlled current infeed via an electronic control unit\*. The anode consists of a titanium wire coated with a noble-metal mixed oxide. Titanium as an inert material is not consumed in the current discharge and is thus maintenance-free.

The second element of the CORREX™ impressed current system is the CORREX™ interrupter potentiostat\*, which cuts out the incoming current periodically for a short time. In these cut-out times (µs) the titanium anode acts as a reference electrode which measures the actual potential in the tank. The electronic system of the potentiostat compares this measured potential with the setpoint potential and automatically adapts the incoming current to the intensity required for protection.

The precise dosage of the current intensity of the potentiostatically controlled impressed current anode prevents with absolute certainty both underprotection, i.e. insufficient corrosion protection, and overprotection associated with the risk of uncontrolled hydrogen development\*.

\*CORREX™ MP, CORREX™ IMP, CORREX™ UP

Our products meet the requirements of a wide range of applications and design specifications. The sound, competent consultancy essential to all application-oriented issues is based on our extensive know-how, our innovative potential and our practice-oriented operations. These factors enable us to adapt all our products to meet customers' specific requirements.  
The following sectors are covered:

#### Cathodic protection sector

CORREX™ impressed current anodes

Magnesium cast-rod anodes and accessories

Compact magnesium anodes

Magnesium ground anodes

Technical services

#### Mg metals sector

Magnesium alloys

Magnesium recycling

Other magnesium products

## Products, solutions and services: a survey

### CORREX™ impressed current anodes

CORREX™ impressed current anodes for hot-water storage tanks offer optimal long-term cathodic protection and are distinguished by the following features:

- for installation in enamelled hot-water storage tanks
- for installation in stainless steel tanks
- long-term maintenance-free protection
- potential-controlled protective current infeed\*
- reliable electronic system
- no risk of under- or over-protection\*
- optimal automatic adaptation to individual operating conditions\*
- dependable corrosion protection even for complex tank designs
- integrated function and fault display
- wear-free titanium electrodes
- compatible insulated-hole or sleeve mounting
- physiologically safe
- low power consumption

### CORREX™ products

#### ■ CORREX™ UP

Our high-tech product for enamelled water tanks in all sizes

#### ■ CORREX™ MP

The right product for enamelled water tanks up to 300 l capacity

#### ■ CORREX™ IMP

The integrated, customized solution

#### ■ CORREX™ stainless steel

for the protection of stainless steel tanks

#### ■ CORREX™ GP

Power potentiostats for engineering projects



### Magnesium cast-rod anodes

The Norsk Hydro magnesium cast-rod anode has a long and successful track record of economically efficient application in the internal cathodic protection of hot-water storage tanks:

- for series installation in enamelled hot-water storage tanks
- optimal anode dimensioning
- the enamel + anode protective system has stood the test in millions of applications
- chain anodes for retrofitting under confined installation conditions
- simple functioning and consumption control through current measuring in case of insulated installation
- physiologically safe
- wide range of installation systems for insulated-hole or sleeve mounting
- high quality standard through 100% production control (emission spectrometry, material consumption rate measurement)
- qualified services (electrochemical measurements on prototypes in the laboratory and in the field)

### Products and accessories:

- Cast-rod anodes
- Extruded-rod anodes
- Chain anodes
- Anode testers
- Anode checkers
- Accessories for insulated installation
- Screw plugs with PTFE sealing ring



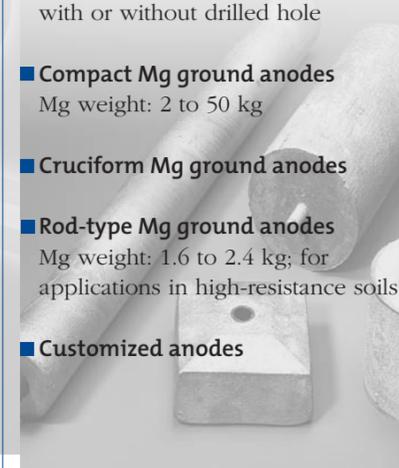
### Compact magnesium anodes Magnesium ground anodes

Compact magnesium anodes are used primarily for the internal protection of condensers, oil coolers and cooling-water systems in power stations and industrial plants. They are available in round or rectangular section, in a wide range of dimensions and weights, and with or without a cast-in component.

Magnesium ground anodes are used for the external protection of buried storage tanks, liquid-gas tanks or pipelines. They are supplied ready for installation with a special backfill in a textile sack and with connecting cable or ready for assembly by the customer with cast-in steel core in various dimensions and with magnesium weights ranging from 1.6 to 50 kg.

### Products:

- Cylindrical compact Mg anodes with or without steel core with or without drilled hole
- Rectangular compact Mg anodes with or without steel core with or without drilled hole
- Compact Mg ground anodes  
Mg weight: 2 to 50 kg
- Cruciform Mg ground anodes
- Rod-type Mg ground anodes  
Mg weight: 1.6 to 2.4 kg; for applications in high-resistance soils
- Customized anodes



### Further magnesium products

The Norsk Hydro Magnesiumgesellschaft offers a wide range of Mg products for various applications.

### Products:

- Magnesium alloys\*\* in various chemical compositions
- Pure magnesium chips are used, for example, in the chemical industry for the production of organic compounds by the Grignard process.
- Magnesium in small bits is used in the aluminium industry as an alloying element. We can offer bits in various weights for add by alloying
- Standard samples for magnesium analysis are produced by the parent concern for pure magnesium and all standard magnesium alloys. Take advantage of our 50 years' experience in magnesium production.

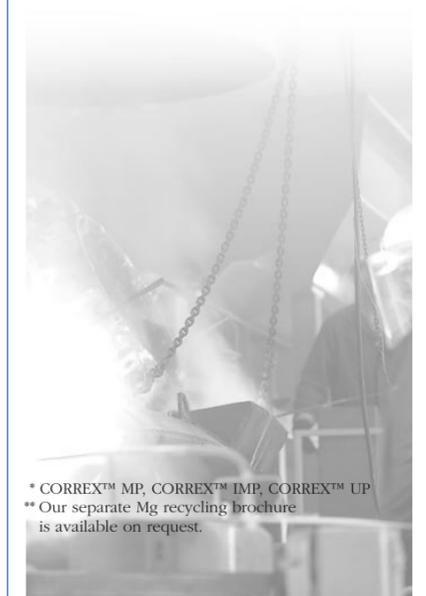


### Magnesium recycling\*\*

Today, recycling is everyone's concern. Society wants a safe, clean environment; final consumers want low-priced products with a reasonable service life and a recycling potential (life cycle economics). Using state-of-the-art technologies, we recycle at our Bottrop plant, for example, magnesium casting scrap from the die casting process and salt-free magnesium scrapings, etc. with the aim of closing the material cycle to the greatest possible degree and of protecting valuable resources. The alloys produced are reused directly for industrial products.

### Products:

- HP magnesium alloys\*\*
- Reprocessing of Mg casting scrap\*\*



\* CORREX™ MP, CORREX™ IMP, CORREX™ UP  
\*\* Our separate Mg recycling brochure is available on request.

# CORREX™: systemized impressed current anodes

# CORREX™



## CORREX™ impressed current anodes

CORREX™ impressed current anodes\* are the only impressed current system available for internal tank protection operating on a microelectronically controlled and regulated interrupter measuring principle – with a long, successful track record. The potential-controlled protective current discharge is adapted automatically to the respective tank and operating conditions, preventing the tank from being under- or over-protected. These intelligent measuring and regulating characteristics thus provide a reliable tank protection system whose efficiency is outclassed by no other technical system.

In contrast to conventional sacrificial anodes, which are depleted as the utilization period increases, the CORREX™ impressed current anode is enduringly wear- and maintenance-free. It moreover prevents hazardous pitting in stainless steel tanks. The fact that the CORREX™ impressed current anode has been deployed hundreds of thousands of times in practical applications in both enamelled steel and stainless steel tanks is impressive proof of the success of Norsk Hydro's CORREX™ impressed current anode.



## CORREX™ potentiostats

These interrupter potentiostats are the electronic "brains" of CORREX™ impressed current anodes\*. They transform the mains current, feed the rectified protective current via the titanium anodes into the tanks, and regulate the current intensity completely independently by comparing the setpoint potential with the actual, measured potential. For this purpose the current infeed is interrupted periodically (µs range) for the purpose of measuring the actual potential in the tank in that extremely short cutout phase by means of the titanium anode, which then performs its second function as a reference electrode.

In this way the CORREX™ impressed current anode responds directly to changes in operating conditions and adapts the protective current automatically to the instantaneous, actual requirement. The outcome: optimal protection of the hot-water storage tank.



## CORREX™ titanium electrodes

Titanium is an inert material which, unlike magnesium, does not disintegrate on current discharge. In addition to its function as an infeed electrode, the mixed-oxide-coated titanium rod also serves as a reference electrode for periodic measurement of the actual potential in the tank\*.



## CORREX™ MP – the solution for enamelled tanks up to 3000 l capacity

The mini plug-in potentiostat and the short titanium electrode are adapted to the requirements of smaller tanks with a complex internal design and with a capacity of up to 300 l. For visual control, the green LED lights up when the system is correctly functioning, and the red LED in the event of a fault. The wear-free titanium anodes are available in all standard versions.

Technical data	
Mains voltage	230 V +/- 10%
Frequency	50/60 Hz
Current rating	50 mA
Power input	< 3 VA
Admissible ambient temp.	0° - 40° C
Safety class	II, for operation on enclosed, dry premises
Housing	Plug-in potentiostat
Titanium electrode / length	232 mm

### Insulated-hole mounting

including accessories for pressure-tight installation in a bushing bore

### Sleeve mounting

including insulated screw plug with PTFE sealing ring



## CORREX™ IMP – the customized integrated impressed current anode

Besides offering corrosion protection, the CORREX™ IMP allows additional functions to be integrated to meet the customer's specific requirements. This means, for example, that additional display elements can be dispensed with or existing applications supplemented.



## CORREX™ UP – the universal high-tech product for enamelled tanks up to 2000 l capacity

Designed specifically to meet the performance requirements of large tanks with a capacity of up to 2000 l, the dual function of the indicator LED prevents installation faults in this case. When protective current is flowing, the green LED lights up to signal the correct functioning of the anode. If the current infeed is defective (e.g. due to the connecting lines having faulty contacts when the system is started up), the red LED flashes. In addition, the electronic system detects any installation faults (e.g. hazardous direct contact between the titanium anode and other components or the steel tank) and indicates these faults with the flashing red LED while cutting out the current infeed. (Tanks with > 2000 l capacity can be efficiently protected by installing more than one unit)

Technical data	
Mains voltage	230 V +/- 10%
Frequency	50/60 Hz
Current rating	100 mA
Power input	< 4 VA
Admissible ambient temp.	0° - 40° C
Safety class	II, for operation on enclosed, dry premises
Housing/installation variants	Plug-in potentiostat Built-in potentiostat Switchpanel potentiostat** p.c. board**
Titanium electrode /lengths	400 mm, 800 mm

### Insulated-hole mounting

including accessories for pressure-tight installation in a bushing bore

### Sleeve mounting

including insulated screw plug with PTFE sealing ring

\*CORREX™ MP, CORREX™ IMP, CORREX™ UP  
\*\*prepared for safety class II



**CORREX™ stainless steel for the cathodic protection of stainless steel tanks**

The resistance of “stainless” steels to pitting and crevice corrosion decreases with an increasing chloride content in the water and in the extra susceptible areas of the tank welds. With CORREX™ stainless steel, a purpose-developed solution has been provided to counter this risk efficiently even with stainless steel surfaces. Unlike the other CORREX™ products, the CORREX™ stainless steel potentiostat has a reference potential adapted specifically to stainless steel. The housings are equipped with venting slots to control heat build-up resulting from a high continuous load.

Norsk Hydro offers CORREX™ stainless steel in two product variants. The MP 1.9 plug-in potentiostat is designed to protect areas of up to 2 m<sup>2</sup>, and the UP 24 plug-in potentiostat areas of up to 3 m<sup>2</sup>. For larger tank areas (inclusive of heating coils) the number of potentiostats and titanium electrodes can be adapted accordingly.

Technical data	CORREX MP™ 1.9	CORREX UP™ 24
Mains voltage	230 V	230 V
Frequency	50/60 Hz	50/60 Hz
Current rating	100 mA	150 mA
Power input	< 4 VA	< 6 VA
Admissible ambient temp.	0° - 40° C	0° - 40° C
Safety class	II, for operation on enclosed, dry premises	II, for operation on enclosed, dry premises
Housing	Plug-in potentiostat	Plug-in potentiostat
Titanium electrode/length	400 mm, 800 mm	400 mm, 800 mm

**Insulated-hole mounting**

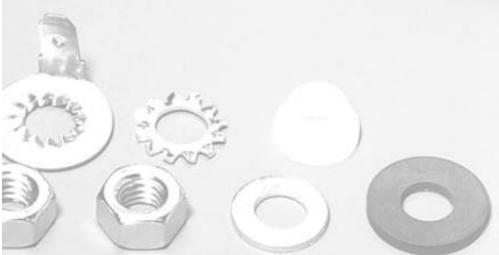
including accessories for pressure-tight installation in a bushing bore



**CORREX™ GP – power potentiostats for engineering projects**

For installation in uncoated large-scale tanks and for steel reinforcements in concrete, we offer 12 V power potentiostats with 2 A and 10 A current capacity. Technical layout and installation of the electrodes are subject to engineering services by local consultant engineers.

Technical data	Model 12V/2 A	Model 12V/10 A
Mains voltage	230 V +/- 10%	230 V +/- 10%
Frequency	50/60 Hz	50/60 Hz
Current rating	0 - 2 A, with potentiostatic control	0 - 10 A, with potentiostatic control
Driving voltage	1.5 - 12 V, with potentiostatic control	1.5 - 12 V, with potentiostatic control
Reference potential, adjustable	1.5 - 3.5 V	1.5 - 3.5 V
Admissible ambient temp.	0° - 40° C; adequate heat discharge must be ensured / rel. humidity 0-85%	0° - 40° C; adequate heat discharge must be ensured / rel. humidity 0-85%
Dimensions	H 215 mm, W 111 mm, D 75 mm	H 335 mm, W 183 mm, D 80 mm

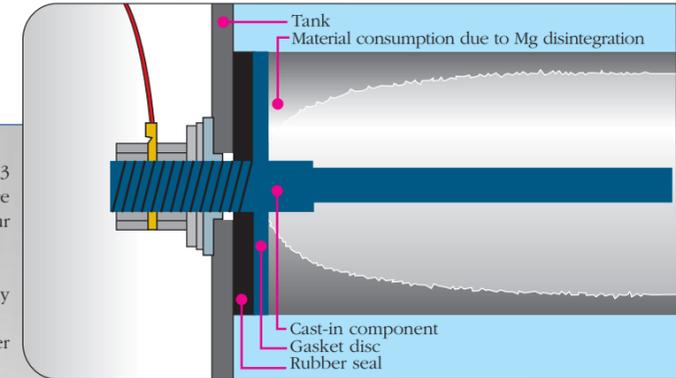


Magnesium anodes

**Magnesium anodes**

Our magnesium cast-rod anodes are manufactured in the tried-and-tested MgAl6Zn3 alloy. The production is subject to a continuous quality control. Special significance is due to the material consumption rate as a basis for service-life predictions. Our product quality is a factor on which you can depend.

We ensure permanently leakproof installation by offering our Mg anodes optionally with a cast-in component with an integrated gasket disc. This guarantees the necessary contact pressure for faultless functioning of the seal below, even after the inevitable loss of magnesium during operation.



**Mg cast-rod anodes and accessories**

Our Mg anode products are designed with a view to widely varying applications and installation systems. The insulated anode installation allows, for example, simple performance and consumption controls through current metering while the tank is in operation (see Anode Testers and Anode Checkers).

The screw plugs with PTFE sealing rings are designed for direct sealing in the threaded sleeve with no additional sealing agent. They can be screwed in and unscrewed under low torque. Depending on the installation variant selected, we offer the Mg anode with cast-in wire or thread, with or without gasket. The cast-in component is designed to take account of the various installation systems:

- Wire 4 mm diameter for welding with screw plug G 3/4, 1, 1 1/4 or NPT 3/4
- Threaded bolt with gasket disc for insulated-hole mounting or for sleeve mounting with insulated screw plug
- Threaded bolt without gasket disc for direct internal installation

**Dimensions available (MgAl6Zn3 alloy)**

Parameter	22 mm	26 mm	33 mm
Diameter	22 mm	26 mm	33 mm
Max. length	1000 mm	1500 mm	1500 mm
Approx. weight	0.7 kg/m	1.0 kg/m	1.6 kg/m

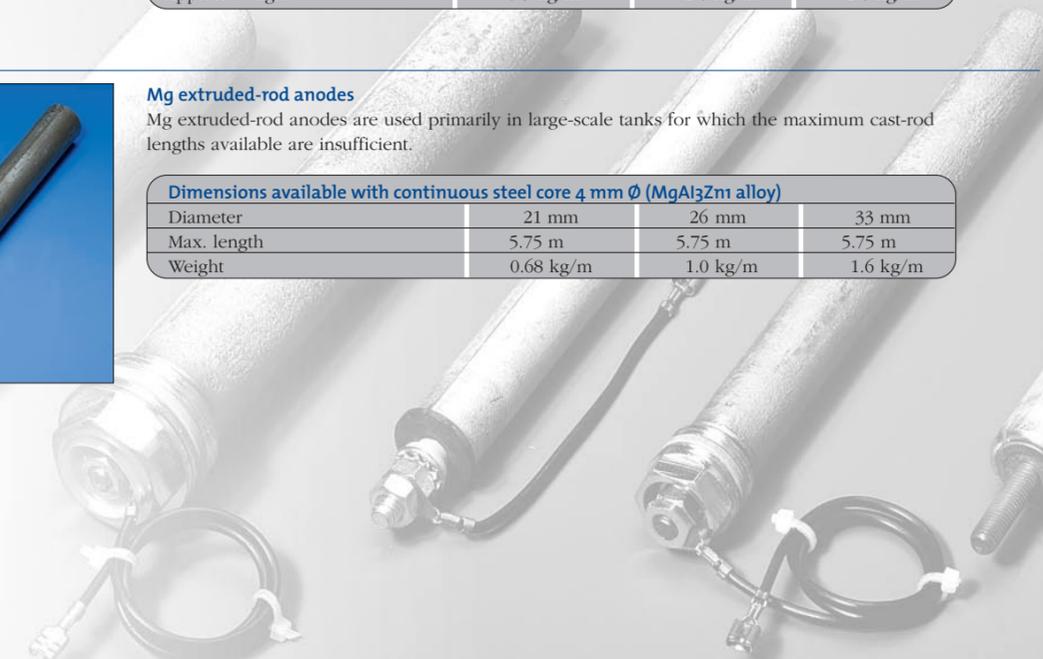


**Mg extruded-rod anodes**

Mg extruded-rod anodes are used primarily in large-scale tanks for which the maximum cast-rod lengths available are insufficient.

**Dimensions available with continuous steel core 4 mm Ø (MgAl3Zn1 alloy)**

Parameter	21 mm	26 mm	33 mm
Diameter	21 mm	26 mm	33 mm
Max. length	5.75 m	5.75 m	5.75 m
Weight	0.68 kg/m	1.0 kg/m	1.6 kg/m



# Magnesium anodes



## Magnesium chain anodes

Ideal for the retrofitting of upright water heaters with a low overall height. The 133 mm long chain links are cast on a flexible steel wire with a diameter of 3 mm and a link spacing of 32 mm. The number of chain links is optional and can be adapted to the respective tank height.

Types available		
Diameter	22 mm	33 mm
Insulated-hole mounting	M 8 x 30 with gasket disc	M 8 x 30 with gasket disc
Sleeve mounting ...		
... with welded screw	G 3/4, 3/4 NPT	G 1 1/4
... with insulated screw	G 3/4	G 1 1/4

The screw plugs can be obtained with a PTFE sealing ring.



## Compact magnesium anodes

Compact magnesium anodes are used primarily for the internal protection of condensers, coolers and cooling-water systems. They are available in round or rectangular form, with or without cast-in component. On request, machining can be adapted to the customer's specific requirements.

### Examples of dimensions and weights available in our standard range:

ø 66 mm	1.2 – 7 kg	120 x 120 x 50 mm	1.2 kg
ø 115 mm	0.5 – 7 kg	300 x 200 x 50 mm	5.0 kg
ø 150 mm	5.0 – 10 kg	300 x 200 x 100 mm	10.0 kg
ø 200 mm	15 – 25 kg	360 x 180 x 30 mm	3.1 kg

Further dimensions, designs and weights on request.



## Magnesium ground anodes

Buried steel storage tanks and pipelines are coated for passive protection against corrosion. Like the defects in enamelled tanks, however, the exterior coatings are not pore-free either. This means that, depending on the nature of the soil, these objects are not immune to electrochemical corrosion. The use of magnesium ground anodes is an effective means of preventing damage by external corrosion. The round, cruciform or rod-shaped Mg ground anodes, which have a unit weight of 1.6 – 50 kg, are normally packed in backfill in a textile sack, placed in the soil close to the object to be protected, moistened, and measurably short-circuited by means of a cable. The weight of the anode is determined from the calculated or measured protective current requirement and the required service life. The current capacity of 1 kg magnesium ground anode is ca. 125 mA/year.

We supply fully packed Mg ground anodes with connecting cable as well as rough magnesium castings for your own anode assembly.



## Customized anodes

If you have not yet found the right Mg anode types to meet your requirements, just contact us with a view to customized anodes. By agreement we can also cast in customer-provided moulds and/or with customer-provided cast-in components.

# Magnesium anodes Testing equipment and installation accessories



## Anode tester

The anode tester is designed for standard installation in hot-water storage tanks for the simple, time-saving control of magnesium anodes. This measuring instrument is series-connected between the insulated Mg anode and the tank material. On actuation of the control button, the protective current flowing between anode and tank is used to indicate the measured value.

With a current flow of > 0.3 mA, the indicator on the scale moves in the green area. If it remains in the red area when the button is pressed, the anode is not discharging sufficient current and needs to be replaced.

The advantages at a glance:

- The anode performance can be checked without tank operation being interrupted
- The performance can be controlled by the tank owner himself
- Red/green display makes it simple to read off the results
- No external power source required
- Prevention of corrosion through timely anode replacement
- Simplicity of installation and operation



## Anode checker

The anode checker is a battery-operated ammeter for flexible, on-the-spot controls. It is used by the plumber or service engineer for the reliable testing of insulated Mg anodes in hot-water storage tanks.

For measuring purposes, the unit is connected to the terminals of the two measuring cables between anode and tank. If a protective current of > 0.3, > 10 or > 50 mA is flowing, the corresponding green LED lights up to indicate that the anode is adequately functioning. If the red LED lights up, the current flowing is less than 0.3 mA, so that the Mg anode needs replacing.

The anode checker is the ideal servicing instrument. It dispenses with the need to open the tank or to interrupt its operation, and thus eliminates the associated costs.



## Accessories for insulated Mg anode installation

To enable you to exploit the advantages of insulated-hole or sleeve mounting, we supply for our anodes matching gaskets, insulating sleeves, and toothed lock washers with or without flat connectors. We also offer plain washers, nuts and/or pre-insulated screw plugs as well as connection cables for dependable contact between anode and tank.