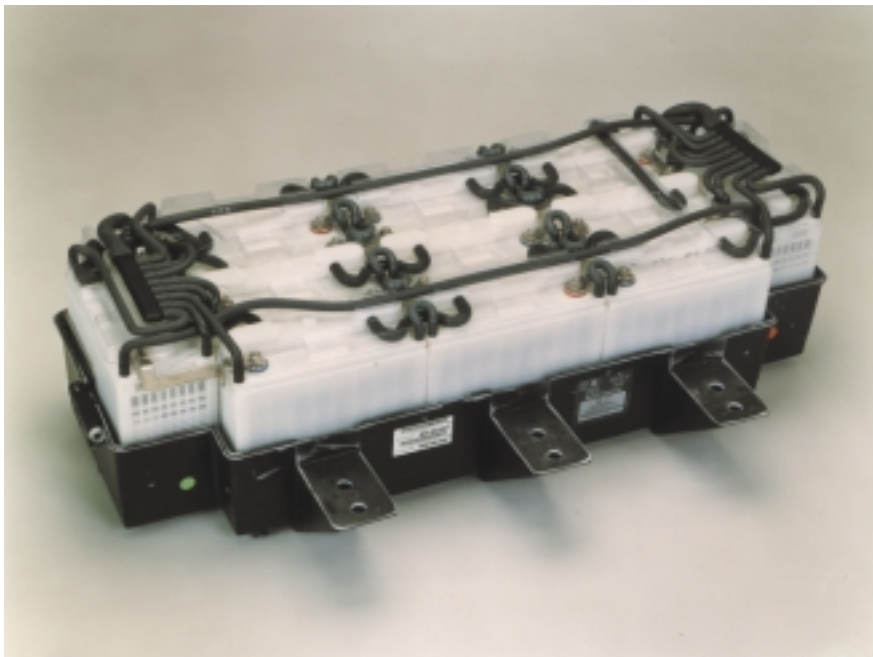


**Technical manual
installation, operation and maintenance
for Ni-Cd STM MR-MRE monoblocks type**



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Introduction

This manual is intended for users, technical and maintenance personnel.

It contains the main characteristics of the low maintenance Saft Ni-Cd STM MR-MRE monoblocks.

It provides guidelines for use and maintenance to obtain the best performance and a long useful life.

The instructions are of general validity for batteries in Electric Vehicles.

Nevertheless, every vehicle will have a specific battery that has been adapted to its own mechanical, electrical, thermal, and other characteristics.

Depending on the referenced model, specific instructions might be added to this document.

For uses other than the ones described in this manual, contact Saft.

Important recommendations

- Install the battery such as to ensure good ventilation.
- Never allow a flame or fire to come near the battery.
- The electrolyte is harmful to the skin and particularly to the eyes. In the event of contact with eyes, wash immediately with running water and/or with a 10 % solution of boric acid.
- Wear base-resistant gloves and goggles to manipulate the electrolyte.
- Never use sulfuric acid or acidified water to top-up electrolyte, as acid, even in traces, destroys the battery.
- Use tools with insulated handles.
- When batteries or vehicles equipped with STM MR-MRE batteries are operated in closed premises, natural or forced ventilation is necessary. Always respect the applicable safety codes and regulations of the country of operation.

1. Characteristics of STM MR-MRE monoblocks

1.1. General description

1.1.1. Operation principle of vented Ni-Cd cells

The electrochemistry concept of the batteries is to supply energy to electrical and electronic products. Chemical energy stored in a battery is converted into electric current when the battery is discharged. This electric current is produced directly by chemical reactions that occur within the battery.

The nickel-cadmium cell is an electrochemical system in which the electrodes containing the active materials undergo changes in oxido-reduction state without any change in physical state. The active materials are submerged in alkaline electrolyte. They remain in solid state and do not dissolve during the oxido-reduction process. As a result, the electrodes are long-lived, since no chemical mechanism exists that might cause the loss of active materials.

When a battery is charged or discharged, the hydroxide ions (OH) are transferred from one electrode to the other via the electrolyte. The alkaline electrolyte, a liquid solution of potassium hydroxide (KOH) and additives, provides the means of transport for the ions.

It does not participate in the electrochemical reaction. Its role in the operation being passive, the electrolyte is only remotely affected by the state of charge of the nickel-cadmium battery.

During overcharge, the water contained in the electrolyte is decomposed into oxygen and hydrogen.

In a low maintenance battery, a significant amount of these gases recombines in the battery, thus reducing water consumption. The remaining amount leaves the cells through the hydraulic system. Consequently, the electrolyte level is reduced after a certain number of charging cycles and periodic topping-up of the battery with water becomes necessary (chapter 6.2.).

1.1.2. Description of STM MR-MRE nickel-cadmium monoblocks

The low maintenance STM monoblock consists of 5 nickel-cadmium cells of 1.2 V nominal voltage each.

These 5 cells are assembled into a polypropylene monoblock container to obtain a nominal voltage of 6 V.

The suffix MR indicates low maintenance and air cooling.

The suffix MRE indicates low maintenance and water cooling.

When the monoblocks are delivered in single monoblock units (not pre-assembled by Saft into crates or boxes), the monoblock STM 5-140 MR is supplied with belt plates. In order to decrease the weight of each battery unit during use, the belt plates of STM 5-140 monoblocks can be removed if the battery structure (crates or boxes, etc.) provides sufficient mechanical protection against deformation of the small sides of the monoblocks (refer to chapter 3.).

The monoblock STM 5-100 MR and MRE's do not have independent support plates. The support structure is integrated in the monoblock container.

The blocks will be assembled into a battery by serial interconnection, in order to achieve the desired operational voltage. When the forced air cooling monoblocks are mounted into a vehicle, sufficient space along the large sides must be provided for correct cooling.

■ Electrodes

The STM monoblocks are constituted of sintered positive electrodes and plastic bonded negative electrodes.

The positive electrode is created by chemical impregnation of nickel hydroxide and additives into a sintered nickel structure, placed onto a perforated nickel-plated steel strip.

The negative electrode is obtained by pasting cadmium oxide and a plastic bonding additive onto a perforated nickel-plated steel strip.

Subsequently, a multi-layer separator is placed between the positive and the negative electrodes to form the plate-group.

■ Electrolyte

The alkaline electrolyte in a nickel-cadmium battery is a liquid solution of potassium hydroxide (KOH), lithium hydroxide (LiOH), or sodium hydroxide (NaOH) into distilled or demineralized water. During the electrochemical reactions, the physical density of the electrolyte remains practically constant. Under no circumstances can it be used as an indicator of state of charge.

Only overcharging will cause a normal water consumption and a slow concentration in the physical density of the electrolyte.

The difference in density between a charged and a discharged battery can be considered to be negligible.

After topping-up of the battery, the density of the electrolyte is at

its lowest. After consumption of the electrolyte reserve, the density of the electrolyte is at its highest.

The construction of a monoblock does not permit electrolyte sampling of an STM battery with integrated ramp without mechanical destruction of the monoblock. Measuring the density of the electrolyte is therefore impossible.

■ Separator

The separator of the STM monoblocks is multilayer, non-woven and made of polypropylene. It was selected to satisfy the three principal objectives: to be a good insulator between the electrodes, to have the right porosity for excellent electric performance during charge and discharge, and ensure the passage of oxygen ions during charge to facilitate the recombination.

■ Container

The monoblock container and the fluid chambers containing the cooling liquid, if present, are made of polypropylene, as are the cover and the filling ramp that are welded to the container after the insertion and connection of the battery plate-group and the electrolyte.

1.2. Mechanical characteristics

	STM 5-100		STM 5-140 MR	
	MR	MRE	with plates	without plates
Weight (kg)	12.9	13.2	18.4	17.0
Dimensions (mm)				
. length	248	246	282	244
. width	120	123	153	153
. height	260	260	260	260
Electrolyte reserve (cm ³)	175	175	160	160
Terminal	M 8 x 1.25		M 8 x 1.25	
Refer to attached diagram	① / ②		③ / ④	

1.3. Electrical characteristics

	STM 5-100 MR and MRE	STM 5-140 MR
Rated capacity IEC C/3	100 Ah	136 Ah
Nominal voltage U _n	6 V	6 V
Apparent internal resistance (completely charged) at + 20°C	4 mΩ	4 mΩ

1.4. Description of the centralized filling system

1.4.1. General description

This chapter describes the working principle of the single point water filling system used on STM monoblocks.

■ Assembly instructions

see chapter 3.3.

■ Operating instructions (topping-up)

see chapter 6.2.

The water filling system connects a number of monoblocks in hydraulic series.

During normal operation of the battery, a significant amount of the gases produced during overcharge recombines in the batteries. The remaining gas is exhausted through the hydraulic system.

When topping-up of the battery is necessary, water filling is done from a reservoir that feeds the battery with a low-pressure pump or through gravity. The topping-up is being effected cell by cell to a predetermined level. The filling of an hydraulic system is completed when all batteries are filled and water appears at the end of its hydraulic system. The filling of a battery is completed when all cells of the battery are filled.

The main component of the system is the water filling ramp that guarantees the evacuation of the gases, as well as the

automatic regulation of the electrolyte level in each cell during topping-up.

For a battery with several hydraulic circuits, the topping-up will be done separately for each hydraulic circuit.

1.4.2. Working principle of a centralized filling ramp

The concept is to fill a cell with water up to a specified level (N) allowing gas which is in the cell to escape. When the maximum level is reached, the electrolyte closes the gas exhaust tube and the consequent excess pressure stops the water flow into the cell.

The water will then flow to the next cell and so on, to the last cell of the hydraulic circuit.

The centralized filling ramp is a soldered assembly of the monoblock cover (1) and a ramp (2) equipped on the upper part with a tubular water inlet (3) and a tubular water outlet (4), and an exhaust tube (5) on the lower part (see fig.1 below).

The water flows across the ramp through a plunging siphon (6) and into the cell through the exhaust hole (7), while the air escapes through the exhaust tube (5).

The lower edge of the gas exhaust tube (5) settles the expected electrolyte level of the cell.

When the electrolyte reaches this level, the remaining air in the cell can no longer escape through the gas exhaust tube (5) and the water reserve generated by the plunging siphon (6) ensures a safe obstruction of the gas inside the cell. When the filling of the cell is finished, the water flows to the next cell or the next monoblock.

The centralized filling ramp has no moving parts and offers full operational security. Further, this system prevents the cell electrolyte from any contact with the next cell, thus avoiding any risk of current leakage between several cells in a battery.

□ Filling through gravity

The flow rate of the water must be between 0.7 and 1 liter/minute and the relative pressure under 0.15 bar.

□ Low pressure filling

The flow rate of the water must be lower than 0.7 liter/minute and the relative pressure below 0.3 bar.

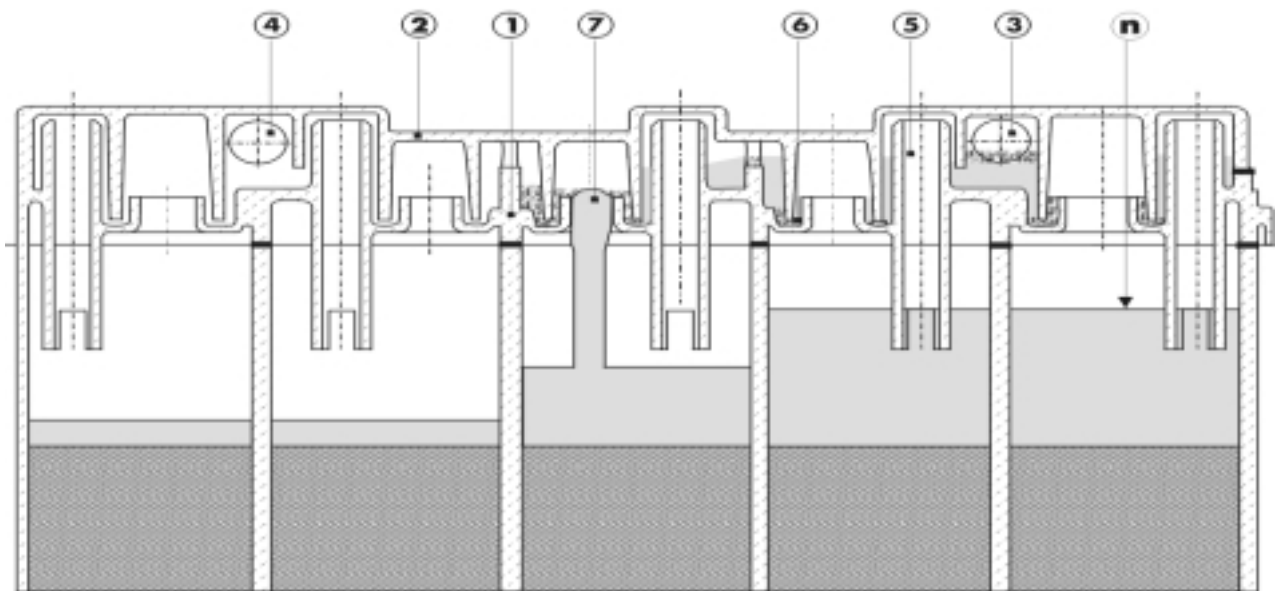


Figure n° 1

2. Precautions and practices

2.1. Transport, storage

Low maintenance STM batteries are delivered filled with electrolyte and electrically discharged. It is normal that the electrolyte level is not visible after a long storage and transport period, even in the monoblocks STM 5-100 MR and 5-140 MR. It will become visible during charge (refer to chapter 4).

Depending on customer specifications, low maintenance STM monoblocks can be delivered completely assembled into batteries, partly assembled, or as a kit of monoblocks and accessories.

In the latter two cases, to avoid any spilling of electrolyte during transport, the monoblocks are fitted with transport plugs.

Never drain the electrolyte in the monoblocks

The battery units can be stored in whatever their state of charge. After a storage period of more than one year, it is necessary to carry out a commissioning charge before use (see chapter 4.2.)

2.2. Water and electrolyte

The water and electrolyte used in Saft Ni-Cd batteries must be chemically pure.

Under normal operating conditions, it is neither necessary nor possible to change or add electrolyte (KOH).

It is only a matter of readjusting water that was consumed during overcharges, in adjusting the levels regularly (see chapter 6.2.).

If monoblocks have lost their electrolyte by accident (drop, spills, mishandling, etc...) it may be necessary to replenish the electrolyte. This can only be done in a Saft factory by Saft specialists. Please contact us without fail.

Measuring the electrolyte specific density

The low maintenance STM monoblocks that are equipped with a centralized filling ramp should be considered sealed. Measuring or reconcentrating the electrolyte density is impossible.

2.2.1. Water quality

It is absolutely necessary that chemically pure water, distilled or demineralized, is used for topping-up (see appendix 9). Prevent the use of tap water as it contains impurities, that will adversely effect the electrolyte, operation quality, and the useful life of the monoblocks. Store water in hermetically sealed plastic containers.

2.2.2. Harm caused in using sulfuric acid or acidious water

Sulfuric acid (as it is used in lead- acid batteries) seriously damages alkaline batteries. Never put sulfuric acid in nickel-cadmium batteries.

Also prevent the use of topping-up water recommended for lead-acid batteries since it may contain sulfuric acid.

When in doubt about water purity, effect a litmus test (or equivalent).

Never check or top up the batteries with instruments used for lead-acid batteries

2.3. Electrical shocks and burns

Batteries assembled from a large number of monoblocks can attain high voltages. Therefore great care caution must be taken during the installation and maintenance of a battery system to avoid serious burns or electrical shocks.

- ❑ **Cut off the AC and DC circuits before working on batteries.**

Make sure that people understand the risk of high voltage batteries and that all manipulation is carried out with insulated tools and other adequate protection equipment.

2.4. Possible dangers through hydrogen

Low maintenance STM monoblocks are connected in hydraulic series. The hydraulic circuit exhausts oxygen and hydrogen gases that are produced during overcharge.

- ❑ **The hydraulic system can contain highly explosive gases at any moment.**

All interventions on the battery require particular attention to prevent of any kind of leakage. If a leak is detected, it must be repaired immediately. Furthermore, general safety rules must be strictly observed: dispersion of gases as they leave the hydraulic system to avoid the forming of dangerously concentrated hydrogen gas pockets; and good ventilation. Keep the battery away from any heat or ignition source.

3. Installation

An installation according to the following, and perhaps more specific, instructions is imperative to ensure the longevity and performance of the battery as well as its operational safety. Specifically, the installation and assembly of the monoblocks into batteries, their hydraulic connection, and the installation of the ventilation and cooling systems must be done with great care.

For the final installation that will be specific to every vehicle, this manual only provides general guidelines.

All battery installations must be approved by Saft.

3.1. Assembly into batteries

The electrical connection in series of monoblocks will be made according to the space available and to minimize the length of the cables or rigid connections.

The connection of the hydraulic system to each of the monoblocks will follow a path parallel to the electrical circuit so that there is no potential difference between the two ends of a connecting pipe. The direction of the water or gas flow is not important.

The maximum number of monoblocks connected in hydraulic series is limited to 10 on a single circuit, which is equivalent to 50 cells. For larger battery units, several totally independent circuits must be provided (for details see chapter 3.3.).

During the installation into batteries, the monoblocks must not be able to move in any three directions depending on the mechanical constraints.

The monoblock STM 5-140 MR's are being shipped with belt plates. The monoblock STM 5-100 MR and STM 5-100 MRE's have built-in belt plates to prevent a swelling.

The plates of the monoblock STM 5-140 MR's can be removed, under condition that the battery structure provides sufficient protection against deformation of their small sides.

Only the small sides of the blocks must be braced in case of connection of rows of several monoblocks.

In practice, the monoblock STM 5-140 MR's will be set up in rows on the axis of the small sides, without any gap but with a shim plate between the monoblocks. The consolidated bracing system must withstand an expansion force of 150 daN per row.

Liquid-cooled STM 5-100 MRE monoblocks do not require free vertical space on any side.

By contrast, it is important to leave space between the large sides of the STM 5-100 MR and STM 5-140 MR monoblocks in order to ensure the collective cooling through air circulation. The ventilation space between rows must be between 10 and 20 mm (refer chapter 3.2.).

3.2. Ventilation and cooling

During operation (charge or discharge), STM batteries generate heat, like all electrochemical systems. In daily use, a steady heat accumulation must be avoided.

As a result, the battery needs a good cooling system in order to disperse the dissipated heat efficiently.

The free space of 10 mm to 20 mm between rows of STM 5-100 MR and STM 5-140 MR monoblocks on their large sides serves as a cooling corridor.

In addition, heat dissipation can be improved by providing ventilation space above and/or underneath the STM 5-100 MR and STM 5-140 MR monoblocks.

In the case of forced air cooling, the ventilators will blow cold air vertically and horizontally across the batteries. All cooling systems will be dimensioned to ensure the most homogenous temperature of the monoblocks in one battery.

Furthermore, it is recommended to control the battery temperature by sensors or thermostats, which can be supplied by Saft on request.

The optimized solutions for a cooling system must be designed for every battery, depending on the type of car, its use, the type of battery etc.

❑ Special case of STM 5-100 MRE liquid cooled monoblocks

Cooling of these monoblocks is effected by circulation of liquid in fluid chambers on the large sides.

The basic design rules for a liquid cooling system are as follows:

- the maximum number of fluid chambers in a hydraulic series is limited to 3 with a pressure loss of < 80 mbar.
- in the best interest of thermal balance, two fluid chambers that belong to one monoblock will be connected through two independent cooling circuits.
- water flow of 40 l/h/series of 3 fluid chambers with a maximum pressure of 0.3 bar in the hydraulic circuits must be homogenous. It must be assured that no preferential waterflow exists that would cause uneven cooling of the monoblocks. When replenishing the cooling liquid, care should be taken that no air bubbles form that would cause partial or no cooling at all, thus accelerating the aging process or the destruction of the monoblocks or the battery.
- the thermal exchange system of the cooling liquid/air is not included in the supplies from Saft, except under special contract. This includes: distribution hoses, draining accessories, pump, radiator.
- during the mounting of the battery and specifically during the installation of the electric and hydraulic circuits (filling and cooling), particular care must be taken that none of these three circuits is interconnected.
- for details about the material and dimension of the hoses of the cooling system see appendix 7.

3.3. Assembly of centralized water filling system

3.3.1. Precautions and recommendations

The centralized water filling system links a number of monoblocks in hydraulic series.

The installation of such a system must therefore be effected with a maximum caution to avoid any risk of gas or electrolyte leakage to ensure good operation compliant with required safety regulations.

Important:

- To ensure that the hydraulic system is sealed, (no gas and/or water leakages), the connection of the ramp with hoses must be done carefully. **Whenever a leakage occurs** (possible after some period of operation), it **must be repaired immediately**.
- To minimize the risk of current leaking into the hydraulic system (which is carrying gases and water) verify the following:
 - the hydraulic connection must always follow the electrical one, in order not to create a potential difference higher than that between two cells at opposing ends of the hose connection.
 - the number of monoblocks that are connected in hydraulic series is limited to 10 (50 cells maximum), which in turn limits the nominal voltage of one ramp to 60 V.

All Saft monoblocks to be equipped with a centralized water filling system, are equipped with the water filling ramp.

All necessary accessories, such as hoses, pipes, elbows, can be supplied with each battery. List of part numbers, see app. 5.

3.3.2. General instructions for assembly

■ Levels

The whole system should always be installed at the same level. However, if different levels exist, start the hydraulic circuit at the highest point, such that the water can always flow downward and without causing more pressure than that due to the loss of content in the ramps of the monoblock.

Install the water filling and gas outlets in a well ventilated place, where the oxygen and hydrogen gases can easily disperse and evacuate. All risks of sparks and ignition sources must be avoided. It is imperative to protect the outlets against rain, dust, mud, etc.

During the study of the pipe layout, attention should be given that no syphon containing water or condensation can block the outlets in case of freezing.

■ Pipes and hoses

For the hydraulic connection between two monoblocks, use a hose as specified in appendix 6.

For distances greater than 200 mm (between the battery and the water tank for example), or to form a loop, use flexible reinforced PVC pipe with a diameter of 10 x 16 mm, part number 208 859.

For very tight loops it is preferable to use a 90° polypropylene elbow, part number 444 103.

Avoid any nipping or squeezing of the flexible pipes or hoses during the assembly of the system.

Avoid forming vertical loops in which water would remain after the filling operation.

■ Inlets and outlets

During normal operation (not topping-up), the hydraulic circuit must be closed on one side (inlet), such that any gas can escape through the outlet on the other side.

■ Water inlet

Use self closing connecting plugs, part number 280 604 (female connector) and part number 280 605 (male connector). When disconnecting these plugs, both parts will automatically be closed, i.e.

- the inlet to the hydraulic circuit on the battery side is closed,
- the pipe to the water reservoir is closed, and stops the water flow.

■ Water and gas outlet

Do not use self-closing plugs. Use free-pass plugs, part number 280 602 (female connector) or directly the soft pipe in reinforced PVC 10 x 6, part number 208 859.

4. Placing into service

Low maintenance STM monoblocks are delivered filled and electrically discharged. On receipt and/or after a storage period, a commissioning cycle is required.

Do not top-up with water prior to the first charge, even if the electrolyte level is underneath the minimum level or does not show at all.

After long storage periods, the electrolyte can be totally absorbed by the electrodes

Individually shipped monoblocks or batteries are equipped with transport plugs on the ramps or filling circuits to avoid the loss of electrolyte

4.1. Procedure before use

- a) Upon receipt, remove transport plugs from monoblocks, if any.
- b) Ensure correct and seal hydraulic interconnections.
- c) Verify that electrical inter-connection of the blocks and the connection of the battery to the vehicle are correct.
- d) Check tightness of terminal connecting nuts.

• **Torque applied should be as follows:**

12 ± 2 N.m

4.2. Commissioning cycle and topping-up with water

- a) Commissioning at constant current charge (see table below).
- b) Top-up with water, using the centralized water filling system 30 minutes after the end of the charge.

	STM 5-100 MR	STM 5-100 MRE	STM 5-140 MR
Current (I)	7 A	10 A	9 A
Time (t)	21 h	15 h	22 h
Voltage (V)	no limit *		

* Voltage can reach 9 V per monoblock.

Maximum temperature at the beginning of the charge: + 35°C

Maximum temperature during the charge: + 50°C

Commissioning cycle of STM monoblocks

5. Operation

5.1. Operating temperature

Due to the electrochemical reaction, all Ni-Cd batteries generate heat during charge and discharge. As STM monoblock batteries are batteries of high energy density, and they are used in regular cycling, particular attention must be paid to the temperature of the battery. Daily use in electric vehicles requires the control of the temperature and the installation of a cooling system to prevent the authorized maximum operational temperature from being exceeded.

The temperature measured inside a central cell must always be below + 60°C.

■ Temperature during charging

For optimum battery performance and life, it is preferable to begin charging at an internal battery temperature of below + 35°C.

This means, in practice, after a discharge, it is necessary to take enough time to let the battery cool down to below + 35°C before starting the charging operation. Charges at higher temperature are always possible, but the battery capacity and its useful life will progressively be reduced. Nevertheless, full capacity will be restored after some full charges at temperatures below + 35°C.

5.2. Two-level charge

5.2.1. Normal charge

In cycling applications, STM batteries are preferably charged at constant current between 0.15 and 0.2 C₅A.

5.2.2. Fast charge

It is possible to recharge up to 80% with a current between 1 and 1.5 C₅A.

The fast charge current is applied as follows:

- STM 5-100 MR-MRE: 150 A
- STM 5-140 MR: 210 A

5.2.3. Maintenance charge

This is a normal charge with a higher overcharge coefficient that will permit increased capacity. At its term, the battery is topped-up with water.

5.2.4. Recommended charging method

For ambient temperature between 0°C and +35°C.

❑ The charging method described below is generally applicable for STM MR-MRE batteries installed in electric vehicles. However, individual charging methods might be required for specific customer needs, depending on the application, climatic conditions, etc. For exceptional cases, consult Saft.

The recommended charging method for Saft STM MR-MRE batteries is two-level constant current charge IOla, as shown in the diagram below.

■ Principle

The battery is charged at constant current. Its voltage increases. As soon as the predetermined charging voltage has been reached, the charge current is reduced in order to limit useless heat dissipation during

overcharge while assuring the necessary overcharge. The change-point threshold, is indicated in the diagram by a small circle.

First level: constant current at 0.2 C₅A up to predetermined threshold voltage.

Second level: constant current reduced to 0.05 C₅A without voltage limitation.

The charge coefficient is 1.15.

The maximum charging time of a fully discharged battery is approximately 8 hours.

■ Temperature compensation

It is essential that the battery reach the threshold voltage before it is fully charged. As the voltage characteristics of Ni-Cd batteries vary with their temperature (higher voltage when cold and lower voltage when hot), it is imperative to correct the voltage threshold according to the battery temperature.

The relation between threshold voltage and temperature can be viewed as linear.

The voltage threshold for STM batteries is indicated at a temperature of +10°C and is adjusted according to the battery temperature with a negative coefficient in millivolts per °C.

● Voltage threshold

The voltage threshold that ends the first level is set at 1.63 V/cell, i.e. 8.15 V per monoblock.

● Temperature coefficient:

For T>10°C

-0.003 V/°C/cell,

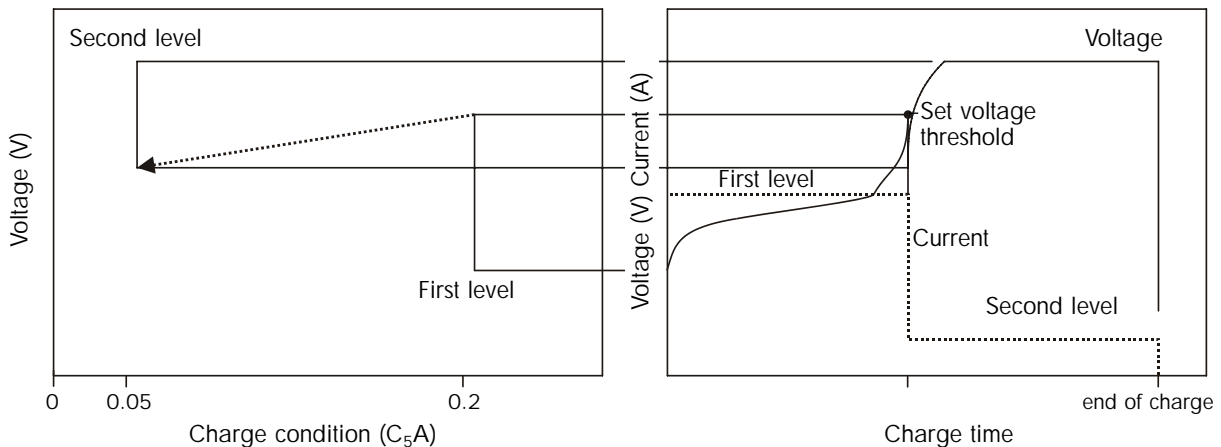
i.e. -0.015 V/°C/monoblock.

For T<10°C

-0.006 V/°C/cell,

i.e. -0.03 V/°C/monoblock.

Cut-off can be manual, controlled by a time switch, or electronically.



	STM 5-100 MR and MRE	STM 5-140 MR
First level		
Constant current	20 A	28 A
0.2 C₅A		
Voltage threshold	8.15 V/monoblock	8.15 V/monoblock
Time t1	until the voltage threshold is reached	
Second level		
Constant current	5 A	7 A
0.05 C₅A		
Voltage threshold	open	open
Temperature coefficient	-0.015 V/°C/monoblock T>10°C -0.03 V/°C/monoblock T>10°C	
Overcharge coefficient	1.15	

Recommended charge method for STM monoblocks

Examples of charge voltage at different temperatures:

■ Charge of an STM monoblock at +35°C:

Voltage threshold at +10°C8.15 V
 Charge temperature+35°C
 Temperature difference starting at +10°C+25°C
 Correcting factor of the:
 Voltage threshold +25°C x (-0.015) V/°C =..... -0.375 V
 Voltage threshold for charge at +35°C 8.15 V -0.375 V = .. 7.78 V

■ Charge of a STM monoblock at 0°C:

Voltage threshold at +10°C8.15 V
 Charge temperature0°C
 Temperature difference starting at +10°C-10°C
 Correcting factor of the:
 Voltage threshold -10°C x (-0.03)V/°C = +0.3 V
 Voltage threshold for charge at 0°C8.15 V +0.3 V = 8.45 V

A special document concerning the charging methods recommended by Saft is available on request from the application service.

5.3. Discharge

5.3.1. Discharge current

The maximum current in continuous discharge is $2 C_5A$. If necessary, the monoblocks must be cooled to limit heating (electrolyte temperature $< +60^\circ C$).

Peak discharges of short duration, less than or equal to 10 sec, up to a current of $5 C_5A$ are permitted according to the state of charge and the minimum acceptable voltage of the monoblocks.

5.3.2. Voltage in discharge

The voltage level during discharge depends on the current drawn on the battery, and the temperature.

The rated capacity of STM monoblocks is set at $+20^\circ C$ for an end voltage of 5 V.

In practice, STM monoblocks can be very deeply discharged. Occasional polarity inversion will not harm the monoblocks.

However, this polarity inversion must remain exceptional to avoid water consumption not taken into account by topping-up.

The table on the right shows general rules and voltages:

	STM 5-100 MR and MRE	STM 5-140 MR
Constant	200 A	270 A
Peak (10 s)	500 A	680 A

Maximum discharge currents

Current	Capacity measured at	End voltage in operation
0.2 C_5A	5.0 V/monoblock	4.9 V/monoblock
1 C_5A	4.5 V/monoblock	4.4 V/monoblock
2 C_5A	4.2 V/monoblock	4.0 V/monoblock

End voltages in discharge

6. Maintenance

6.1. Periodic maintenance

Under normal operating conditions, when charging recommendations are respected, and correcting factors are applied, low maintenance STM batteries require no regular maintenance apart from topping-up (see chapter 6.2.).

A brief overall inspection of the battery system during a general revision of the vehicle should be carried out. The following points are to be verified:

- the state of the fans, if present,
- the tightness of the connections,
- the seal of the hydraulic circuit (filling, cooling),
- cleaning the batteries with soapy water (detergents must be avoided).

The verification of the electrolyte density is both unnecessary and impossible.

6.2. Topping-up operation

■ Measuring the electrolyte level

Topping-up with distilled or demineralized water (for water quality refer to chapter 2.2.) is necessary, because Ni-Cd batteries consume water through electrolysis during overcharge.

The electrolyte level is visible through the plastic container of the STM 5-100 MR monoblocks during charge. The electrolyte level is not visible in the STM 5-100 MRE monoblocks due to the double walls of the fluid chambers, and barely visible in the STM 5-140 MR monoblocks. The only reliable time to measure the electrolyte level is at the end of charge or a few minutes after the end of charge (when the electrolyte is at its highest level).

In practice, topping-up is done according to overcharged amperehours.

■ Frequency of topping-up

After a number of cumulated overcharged amperehours according to model:

- STM 5-100 MR et MRE: 1 000 Ah overcharged
- STM 5-140 MR: 800 Ah overcharged

■ Topping-up operation

- Topping-up must not be carried out during the first 30 minutes after the end of an overcharge (1), but it can be carried out during a peak charge period and after its controlled term (2).

Water is filled into the hydraulic system from a reservoir by gravity or by vacuum, according to the principles described in chapter 1.4.

When topping-up is effected using gravity, the flow rate at the inlet must be between 0.7 and 1 liter/minute and the relative pressure at the inlet of the first cell of the first monoblock must be less than 0.15 bar relative.

Stop filling a few seconds after water spills over at the vent pipe(s). The inlet pipe will close and the flow of water will stop automatically when the inlet connector(s) are being removed.

When topping-up is effected using gravity, the flow rate at the inlet must be between 0.7 and 1 liter/minute and the relative depression in the monoblock must be less than or equal to 0.3 bar.

(1) During the first 30 minutes following the end of the overcharge, the residual gases from the overcharge process can disturb the filling operation and, most importantly, decrease the water quantity filled into the cells.

(2) After the 30 minutes period following a controlled term of the peak charge, the electrolyte level is too low, such that the monoblocks will be overfilled, thus seriously risking an overspill of electrolyte during the following charge and consequently a dilution of the electrolyte during the next topping-up.

7. Equipment repair and overhaul of batteries

7.1. Electrolyte specific density

Low maintenance STM monoblocks equipped with a centralized filling ramp welded to the cover can be considered as being closed. Measuring or reconcentrating the electrolyte density is impossible.

However, if a concentration of the electrolyte is deemed necessary, this can only be done by specialists from Saft.

7.2. Reconditioning

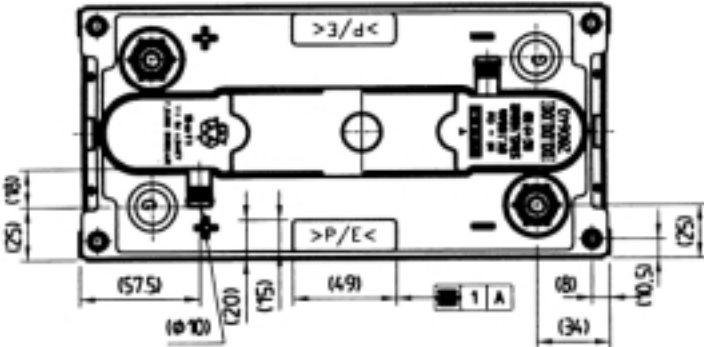
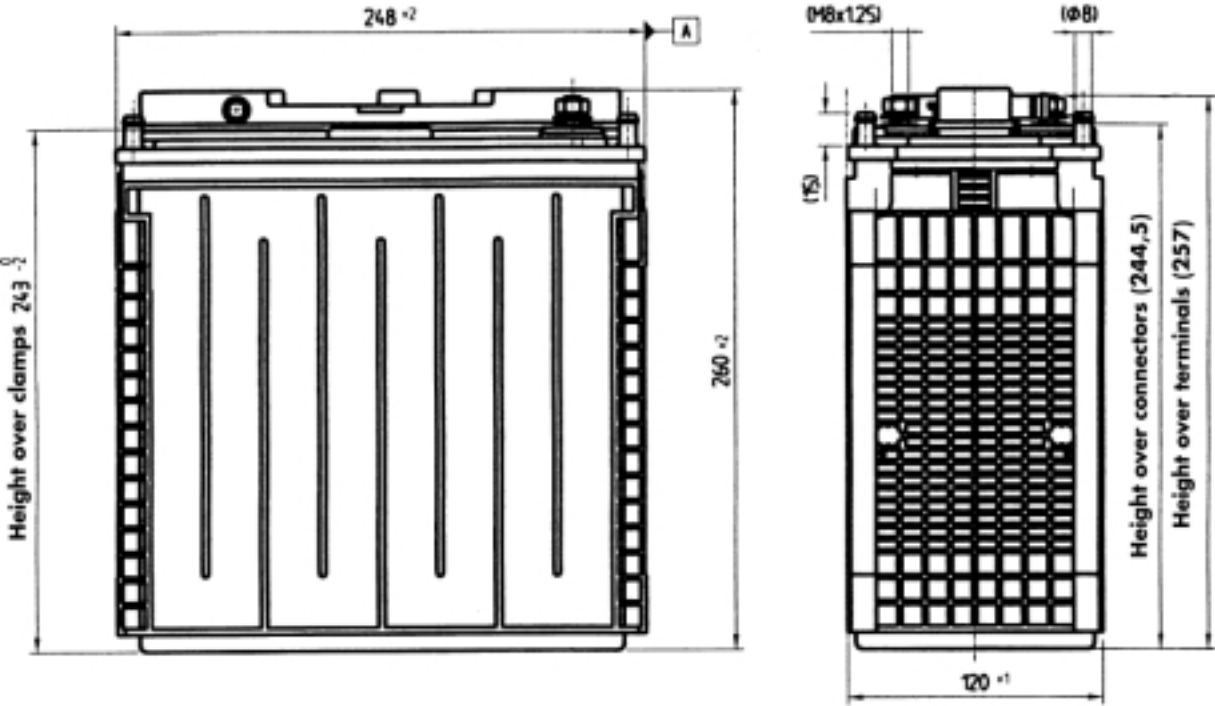
Reconditioning becomes necessary when the battery capacity is judged as being too low, when the battery or the electronics of an electric vehicle have been repaired, or when it has lost the battery management information.

Procedure:

Commissioning charge at constant current as described in chapter 4.2:

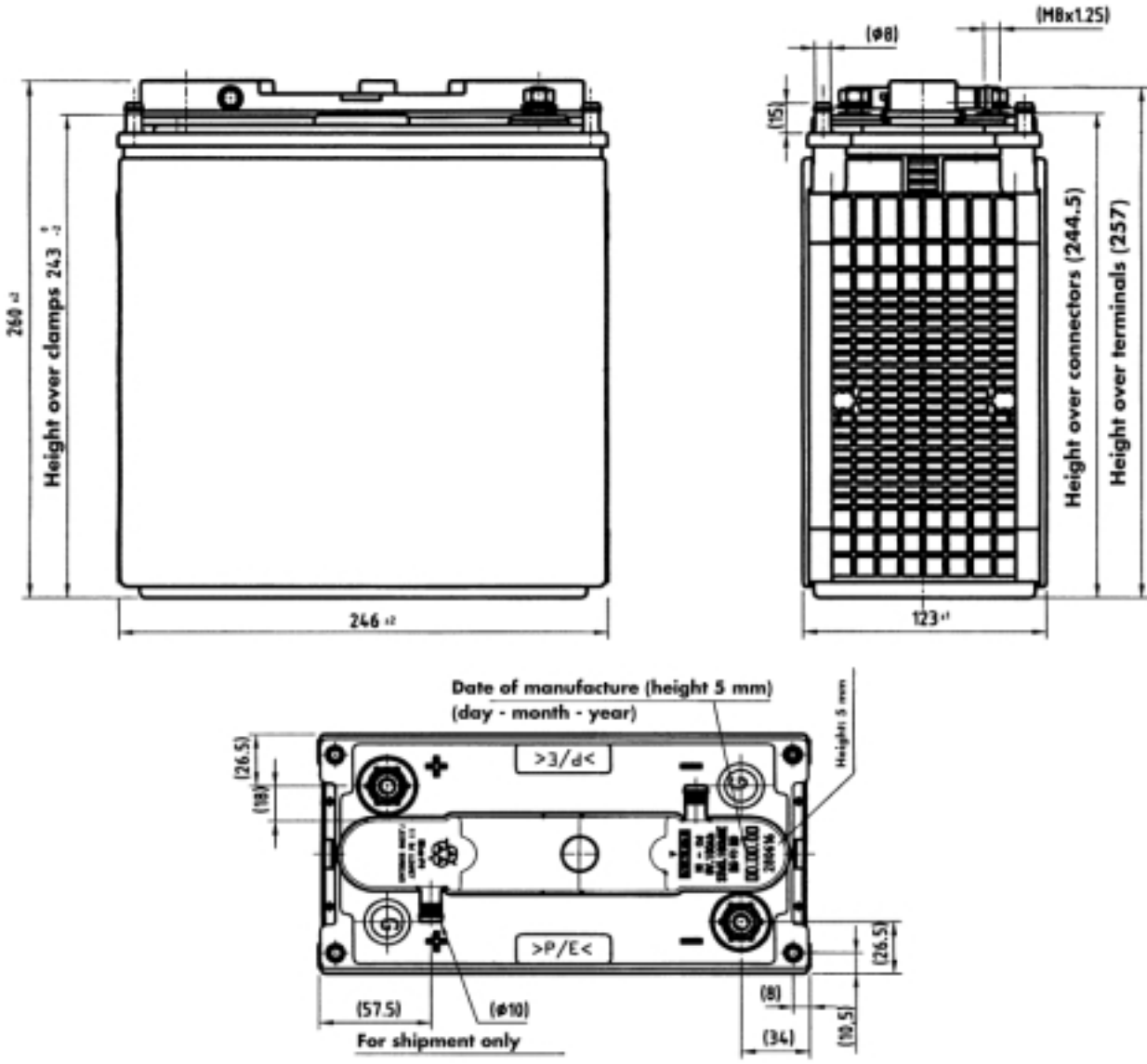
- STM 5-100 MR:
7 A during 21 hours
- STM 5-100 MRE:
10 A during 15 hours
- STM 5-140 MR:
9 A during 22 hours

Appendix 1



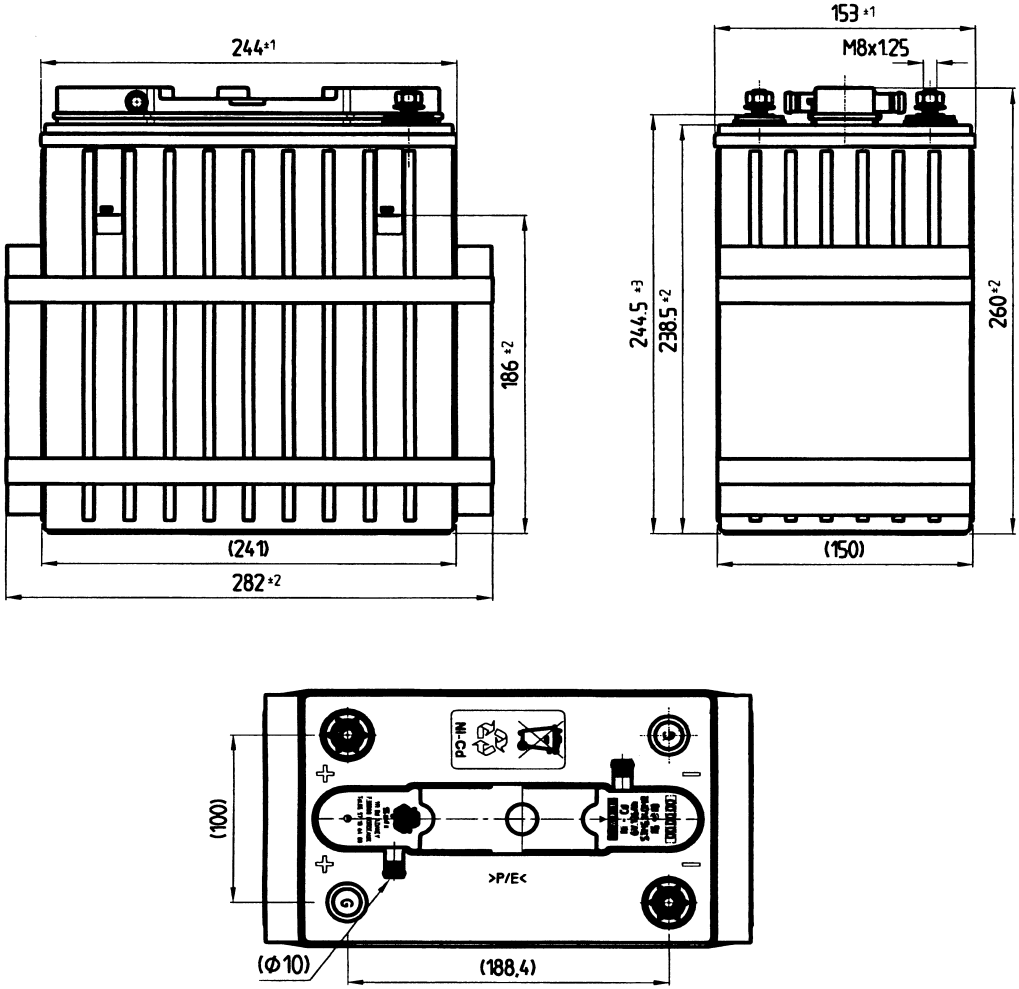
Monoblock STM 5-100 MR + G RD equipped
Positive left – Filling right

Appendix 2



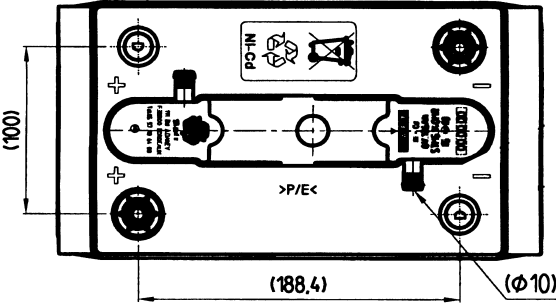
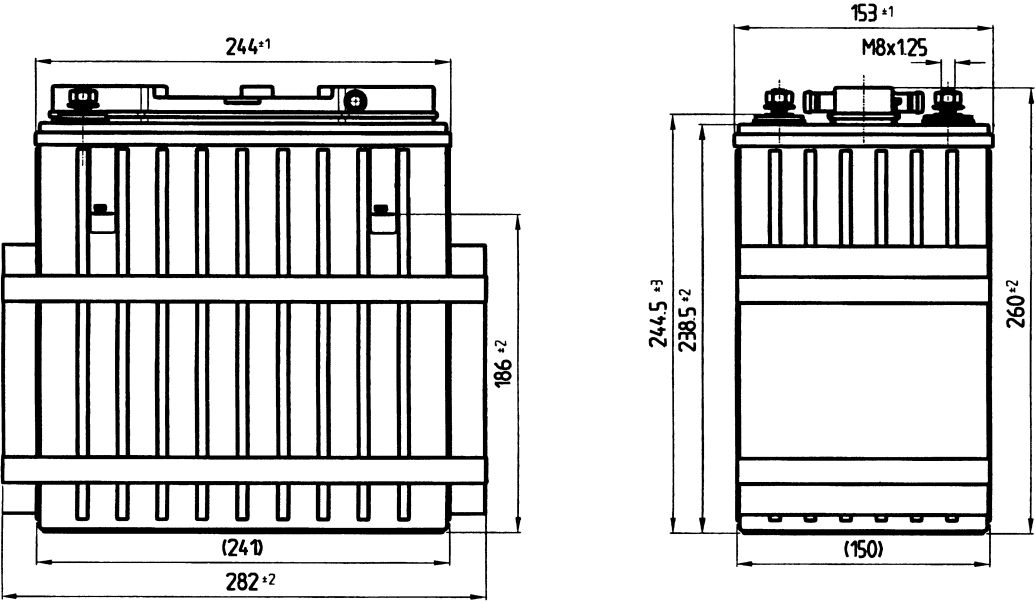
Monoblock STM 5-100 MRE + G RD equipped
Positive left – Filling right

Appendix 3



Monoblock STM 5-140 MR + G RD equipped
Positive left – Filling right

Appendix 4



Monoblock STM 5-140 MR + D RG equipped
Positive right – Filling left

Appendix 5

Accessories for the centralized filling system

Reinforced soft PVC hose10 x 16	208 859	for connections > 200 mm
Polypropylene elbow	444 103	hose-to-hose connection
Female connector	280 604	plug, normally closed
Male connector	280 605	plug, normally closed
Female connector	280 602	free
Male connector	280 603	free
Male connector (wall penetration)	280 804	free
Male connector (wall penetration)	280 805	self-closing

Appendix 6

Basic specification for filling circuit hoses

Operating temperature: -30°C to $+70^{\circ}\text{C}$

Maximum relative operating pressure: 300 mbar

Resistant to the following liquids:

- Electrolyte KOH (solution at 400 g/l) and NaOH (solution at 100 g/l)
- Oil 75 W 80
- Brake fluid
- Lead-free gasoline
- Cooling liquid
- Vaseline

Base material: Elastomer EPDM ("all rubber", without internal reinforcement)

Resistivity: $10^6 \Omega\cdot\text{cm}$, as per ASTM D257

Recommended dimensions for sleeveless connection to monoblock nozzle:

- \varnothing inside 9.4 ± 0.3
- \varnothing outside 14.1 ± 0.3

Visual: No color requirements specified

The inside of the hoses must be perfectly smooth to avoid leaks when fitting the hose on the connecting nozzles.

Appendix 7

Basic specification for the cooling system hoses

Operating temperature: -30°C to $+70^{\circ}\text{C}$

Maximum relative operating pressure: 500 mbar

Resistant to the following liquids:

- Electrolyte KOH (solution at 400 g/l)
- Oil 75 W 80
- Brake fluid
- Lead-free gasoline
- Cooling liquid
- Vaseline

Elasticity test: 4 000 cycles at $+20^{\circ}\text{C}$, relative pressure: 0 – 500 mbar

After pressure cycle, verification of tightness at relative pressure of 300 mbar between -30°C and $+70^{\circ}\text{C}$

Base material: Elastomer EPDM ("all rubber", without internal reinforcement)

Resistivity: $10^6 \Omega\cdot\text{cm}$, as per ASTM D257

Recommended dimensions for sleeveless connection to monoblock nozzle:

- \varnothing inside $7^{+0.2}_{-0.3}$
- \varnothing outside 11.6 ± 0.5

Visual: No color requirements specified

The inside of the hoses must be perfectly smooth to avoid leaks when fitting the hose on the connecting nozzles.

Appendix 8

Basic specification for rigid connections

Base material: baseline inspected annealed copper, as per chapter 4.2.1 of regulation NF A 51.119

Protection: nickel-plated, adhesion as per chapter 4.2 of regulation NF A 91.101

Recommended cross chapter: 40 mm² 16 x 2.5

Boring: $\varnothing 8.25 \pm 0.2$

Appendix 9

Basic specification for distilled or demineralized water

Physical characteristics

Limpid, colorless, odorless when boiling

Resistivity at + 20°C > 30 000 Ω.cm

Chemical Characteristics

- $5 \leq \text{pH} \leq 7$
- Absence of organic matter and reducing substances:
COD (chemical oxygen demand) < 30 mg/l (permanganate test)
- Total ions $\text{SO}_4^{2-} + \text{Cl}^- < 10 \text{ mg/l}$ and $\text{Cl}^- < 2 \text{ mg/l}$

Dry residue $\leq 15 \text{ mg/l}$

Silicium as $\text{SiO}_2 < 20 \text{ mg/l}$



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