

# Liquid resistance starters

Wound rotor motor control for demanding industrial applications from 185 kW to 6.2 MW



**MOTOR CONTROL AND DRIVES**

*In applications where the driven machine presents a high starting load and/or there is a need to start with absolute minimal current draw, a wound rotor (or slip ring) motor can provide unparalleled starting performance.*

*NHP offers a range of Australian made and industry proven fixed and moving electrode liquid resistance starters for use with low and medium voltage wound rotor motors from 185 kW to 6.2 MW.*



## The issues

The torque and current versus speed characteristics of a wound rotor motor can be altered and controlled through the addition of resistances to the rotor circuit. While one of the more common methods for starting wound rotor motors is the multi-stage secondary resistance starter, this may provide inconsistent starting performance and require frequent and costly maintenance.

Close control of starting torque and current also requires more resistance stages adding complexity and cost to the motor control system.

## The solution

With many systems comprising little more than a tank which holds an electrolytic solution, thermostats and floats to monitor electrolyte temperature and level - along with an enclosure which houses a shorting contactor and timer - the simplicity of liquid resistance starters makes them the ideal proposition for any down time critical plant and/or for remote installations where the availability of specialist electrical personnel may be limited.

For these reasons, electrical engineers and equipment specifiers have turned their attention to liquid resistance starting of wound rotor motors.

## Applications

Suitable for use with heavy industrial machines such as ball and SAG mills, crushers, conveyors, compressors, chippers, fans, pumps, mixers and saws.



## Key benefits

- Simple and easy to understand technology
- Optimum control over starting current, torque and motor/load acceleration
- High reliability
- No need for specialist electrical personnel or equipment
- Low maintenance
- Long service life
- Minimises downtime in critical plants

# NHP liquid resistance starters

## Designed and manufactured in Australia

NHP's range of liquid resistance starters and the individual components used within them comply to all applicable codes and directives, as well as Australian and New Zealand standards, offering a number of significant advantages.

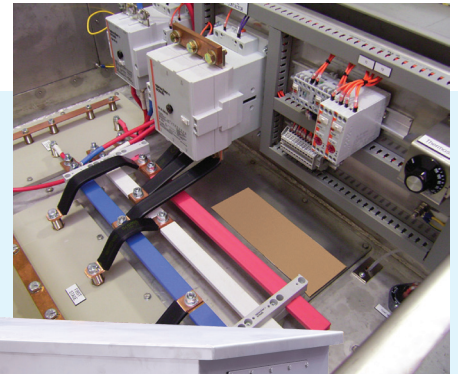
NHP's direct involvement in all elements of production from conception through to design and manufacture ensures commercial benefits, a superior level of quality control and consistency of product that promises performance and results you can trust.

While our starters are generally manufactured to NHP's standard format, they can also be customised to meet customer specification and/or any specific site conditions.

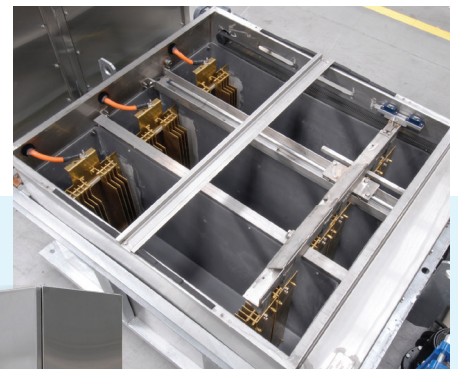
Our range of HLR moving electrode starters offers a turn down ratio in excess of 200:1, the highest in the industry. This is achieved via a unique horizontal moving electrode system and delivers the softest possible starts and smoothest transition to run, which, in turn, greatly extends the mechanical life of the motor and driven machine.

In line with NHP's 'end to end' solutions promise, we offer a comprehensive range of value add services including around the clock support from a dedicated and highly qualified team.

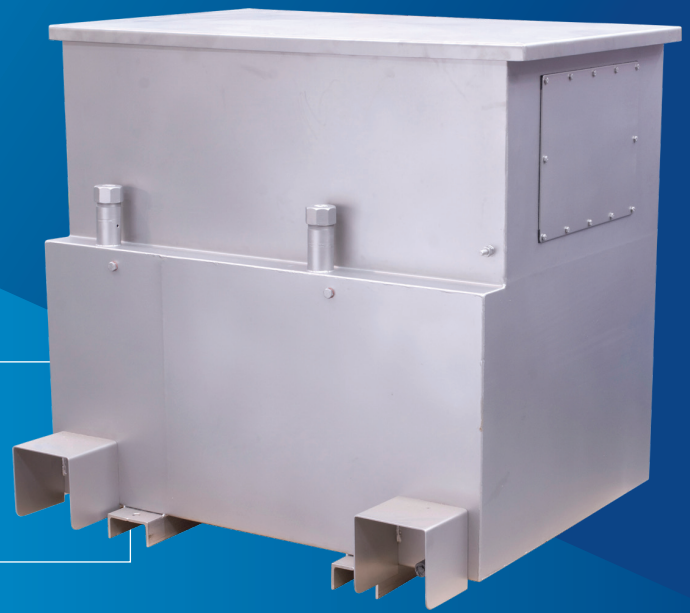
**M350 fixed electrode starters are manufactured in Australia and are intended for wound rotor motor applications from 185 kW to 750 kW**



**HLR moving electrode starters are designed and manufactured in Australia and are intended for wound rotor motors from 500 kW to 6.2 MW**



# Fixed electrode liquid resistance starters



## M350 Starter

For use with low and medium voltage wound rotor motors from 185 kW to 750 kW, maximum rotor volts = 1500 V

## Overview

The M350 is a two stage liquid resistance starter, each stage replacing the equivalent of approximately five stages of fixed resistance.

The resistance units comprise electrodes (either two or three) immersed in electrolyte, contained within a 350 litre stainless steel tank. The number of electrodes used is determined by the kW rating of the motor, the number of starts per hour and the run-up time.

The principle of operation is based on the difference in resistivity between the liquid electrolyte and its vapour contained in an electrode chamber. The passage of the initial rotor current causes immediate partial vaporisation of the electrolyte and instantaneously adjusts resistance and starting torque to optimum value.

During run-up, the thermal interchange which occurs decreases the resistance and a timed contactor then short circuits the low residual resistance.

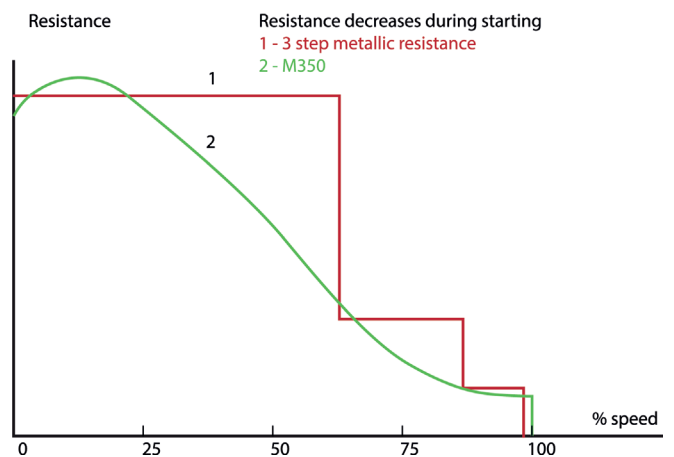
The progressive decrease in resistance provides smooth and continuous acceleration, hence the motor reaches full speed in the shortest possible time with the absence of mechanical stress.

As the resistance decreases in direct relation to the motor speed, the possibility of operator misuse is minimised and motor burn-out problems are resolved.

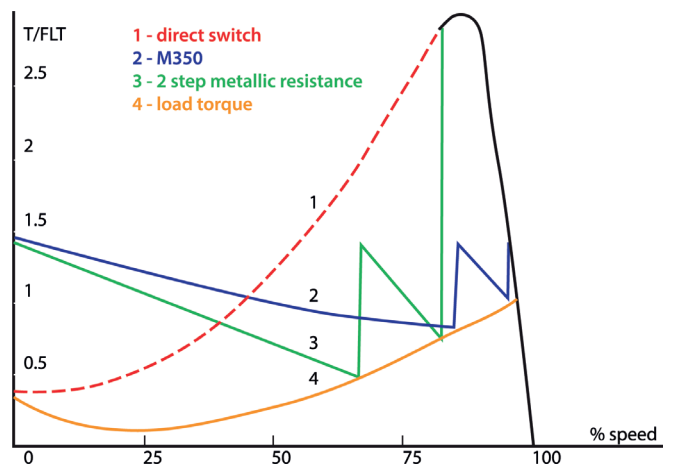
## Flexibility

M350 starters are easily adjustable on-site to meet changes in torque or load. This is achieved by altering the electrolyte strength.

## Resistance comparison during starting



## Torque comparison during starting



## Environmental stability

A layer of oil is floated on top of the electrolyte to form a seal which not only minimises evaporation, but eliminates contamination from the atmosphere.

## Climatic conditions

Whether in the snow fields, or the desert regions of the outback, M350 starters are operating almost maintenance free. Their only requirement is the need to occasionally top them up with drinking water (pH = 7 to 9) every 12 months or so.

## M350 ratings

M350 starters are designed to meet the starting torque requirements of the application and the starting duty (starting time and starts per hour) specified by the user. The ratings given to M350 starters are therefore variable and application dependant.

Starter model	Nominal motor kW rating at average starting torque of			
	0.7 x FLT	1.0 x FLT	1.4 x FLT	2.0 x FLT
Single motor drives				
M350/2	500	355	250	185
M350/3	750	650	450	315

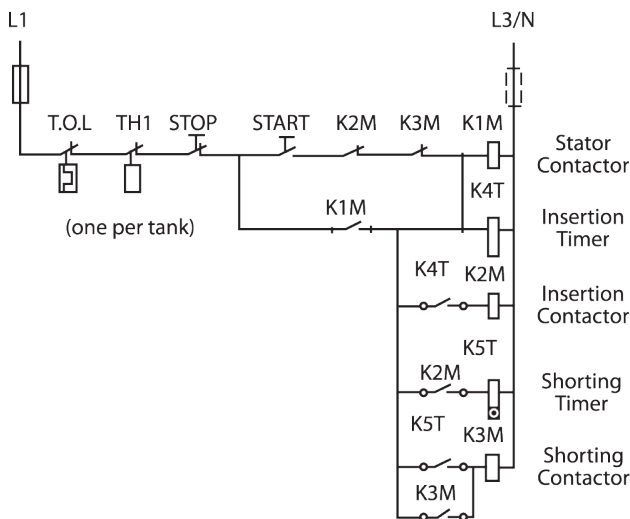
### Notes:

- Nominal ratings only, based on four consecutive starts followed by two starts per hour from hot.
- Actual ratings will depend on start torque and run up time required.
- FLT = Full Load Torque (otherwise referred to as Motor Rated Torque).

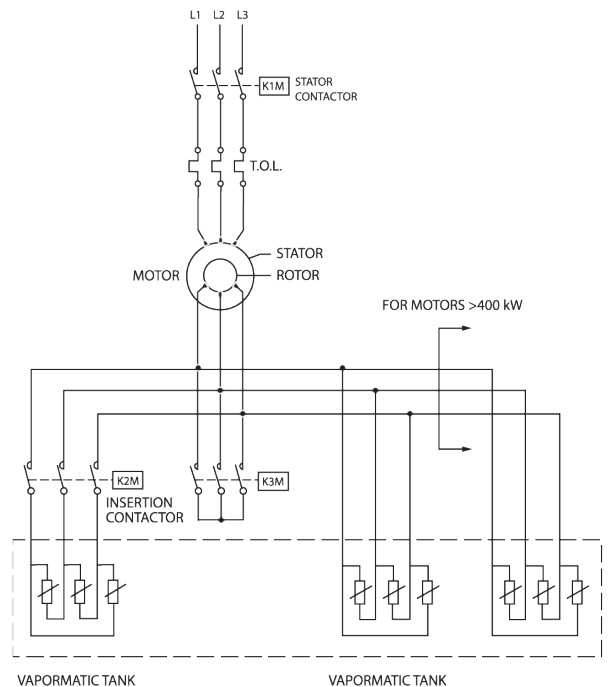


M350 electrode assembly. One of two or three used in an M350 starter.

## M350 control circuit



## M350 power circuit



# Moving electrode liquid resistance starters

## HLR Starter

For use with low and medium voltage wound rotor motors from 500 kW to 6.2 MW, maximum rotor volts = 3500 V

Designed and manufactured in Australia by NHP



## Overview

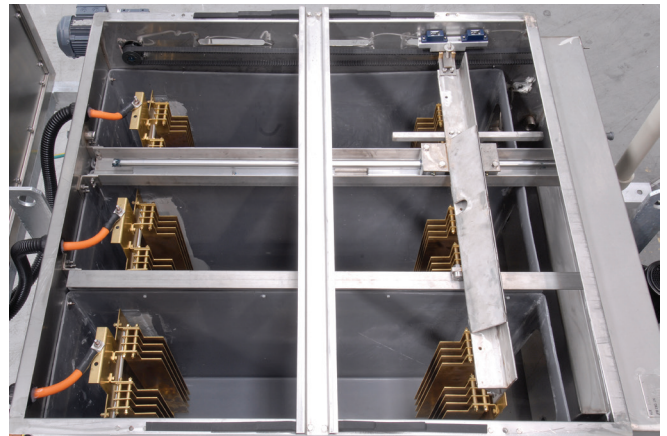
The HLR starter consists of a stainless steel tank containing the electrolyte and electrode assemblies, control cubicles which house the shorting contactor and ancillary control equipment, mounted on and within a galvanized steel frame (no frame for HLR700 and HLR1100 models).

Electrode movement is provided by a gear motor and belt drive. A clutch arrangement is used to connect the moving electrode carriage to the belt drive. This prevents damage should the carriage be driven into the end stops and also eliminates the need for over travel limit switches.

Through the geared motor and belt drive assembly, the variable speed drive controls the rate at which the electrodes move, and in turn, the starting time of the motor. The electrodes move through a horizontal plane to provide a near linear resistance/travel characteristic. The turn down ratio (ratio of initial to final resistance) is typically 200:1, thereby providing smooth starting and an extremely low torque surge on energisation of the rotor shorting contactor. The horizontal movement of the electrodes also acts to agitate the electrolyte, thereby eliminating the need for a circulation pump for most 'standard' duty applications.

Electrolyte level is monitored by a float switch and starting is prevented if the level is low. A thermostat is also provided to prevent starting if the electrolyte temperature is too high and a thermometer allows actual electrolyte temperature to be monitored.

In some cases a circulation pump is combined with a water to water heat exchanger to remove heat from the



electrolyte. Additions of this nature are required when the starting duty produces more heat than can be dissipated by the tank and in applications that can benefit from limited speed control, for example belt inspection on a conveyor or similar operations on other machines.

The electrolyte tank is readily accessible for inspection and maintenance via viewing windows and hinged lids.

Sodium carbonate is mixed with potable water for the electrolyte and oil is floated on the surface to inhibit evaporation and minimise the effects of contamination in the atmosphere.

Maintenance primarily consists of topping up the electrolyte with potable water, greasing the electrode carriage guide rail bearings and ensuring all connections are tight, annually or as otherwise required.

# Controls and instrumentation

## Inputs

Start input	1x N/O, close to start input
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## Outputs

Ready to Start / Run	1x N/O relay output
Shorting Contactor Closed	1x N/O relay output
Electrolyte Temperature Alarm	1x N/O relay output
Electrolyte Temperature Trip	1x N/O relay output
Electrolyte Level Alarm	1x N/O relay output
Electrolyte Level Trip	1x N/O relay output
General Starter Fault	1x N/O relay output
Cubicle Door Open	1x N/O relay output

## Indicators

Ready to Start / Run	1x Green indicator
Shorting Contactor Closed	1x Amber indicator
Electrolyte Temperature Alarm	1x Amber indicator
Electrolyte Temperature Trip	1x Red indicator
Electrolyte Level Alarm	1x Amber indicator
Electrolyte Level Trip	1x Red indicator
General Starter Fault	1x Red indicator
Cubicle Door Open	1x Red indicator
Initial Rotor Current	1x Analogue meter
Electrolyte Temperature	1x Tank mounted meter

Additional relays and indicators available on request

## HLR Ratings

HLR starters are designed to meet the starting torque requirements of the application and the starting duty (starting time and starts per hour) specified by the user. The ratings given to HLR starters are therefore variable and application dependant.

Starter model	Nominal motor kW rating at average starting torque of			
	0.7 x FLT	1.0 x FLT	1.4 x FLT	2.0 x FLT
Single motor drives				
HLR 700	1,400	1,000	700	500
HLR 1100	1,600	1,000	790	550
HLR 2300	4,200	3,000	2,100	1,500
HLR 4000	6,200	4,500	3,100	2,200

## Multiple motors - individually coupled

Some machines, such as the head end drive of a conveyor system, may comprise multiple motors that are not directly coupled. For advice, please contact your local NHP Account Representative.



## Liquid to liquid heat exchangers

For high start duty applications, it is often necessary to add a liquid to liquid type heat exchanger and circulation pump to an HLR starter. These require a cool water supply to also be available on-site and can be of the shell and tube or plate type, depending upon site conditions and space limitations. Shell and tube type heat exchangers are easier to clean and maintain, but are larger than the plate type heat exchanger.

### Notes:

- Nominal ratings only, based on four consecutive starts followed by two starts per hour from hot. One start per hour from hot for HLR4000 models.
- Actual ratings will depend on start torque and run-up time required.
- For higher starts per hour or for extended run-up times, a heat exchanger may be added.
- Electrode movement and run-up time controlled by inbuilt variable speed drive.
- FLT = Full Load Torque (otherwise referred to as Motor Rated Torque).
- Control of larger motors is possible. Please contact your local NHP Account Representative for selection assistance and advice.

# Frequently asked questions

## 1) What type of information is required to facilitate design and selection of an NHP liquid resistance starter?

Please complete all the information in the LRS design and selection guide on page 10 of this brochure and email to:

[sales@nhp.com.au](mailto:sales@nhp.com.au)

## 2) Is the electrolyte prepared on-site or is it supplied premixed in drums?

The electrolyte is prepared on-site. The liquid resistance starter is first filled to capacity with potable water. A suitable container (~10 litres) is filled with water electrolyte via the LRS drain valve and approximately 1/2 kilogram of the supplied sodium carbonate is mixed into the container contents until completely dissolved. The contents of the container are then returned to the LRS tank via the open lid, evenly distributed with care to ensure that the carriage linear bearings are not splashed. This process is repeated until the entire dose of sodium carbonate delivered with the starter has been added. During the first few actual start cycles, most of the dissolved oxygen will be driven out of the electrolyte. At this stage, a thin layer of oil (also supplied with the starter) is then floated on the electrolyte surface to minimise evaporation.

## 3) If the electrolyte is prepared on-site, are there any specific requirements for chemical characteristic and purity of potable water?

Either plain potable (drinking) water or, if not available, demineralised water are suitable. Bore water should not be used.

## 4) How often should the electrolyte be changed? Also, are there any special instructions for handling and disposal?

For normal starting duty, the electrolyte should be completely drained, the tank cleaned and fresh electrolyte added once every five years. As the amount of dry electrolyte is minimal by weight of solution, it may be disposed of via an industrial sewer subject to local authority approval. A document that outlines handling and disposal of the sodium carbonate electrolyte is provided with each starter.

## 5) What type of maintenance activity is required to keep the liquid resistance starter in top working order?

General maintenance primarily consists of topping up the electrolyte with potable water, greasing the electrode guide rail bearings on moving electrode liquid resistance starters and making sure all mechanical and electrical connections are tight. This type of work is normally conducted annually or as required.

## 6) Is the performance of the liquid resistance starter affected by significant changes in ambient temperature?

Due to its large mass (700 to 4000 litres subject to tank capacity) the liquid electrolyte acts as a storage unit for temperature. For example, if the ambient temperature varies between 10 °C overnight and 40 °C during the day, the temperature of the liquid electrolyte would approximate the average daily ambient temperature.

## 7) Are all NHP liquid resistance starters fitted with a heat exchanger?

Heat exchangers are only needed in applications that require frequent starting, have extended run up times or in applications where slip control may be needed for machine setup purposes, .e.,g belt alignment on a conveyor system.

## 8) Does NHP produce liquid resistance starters to customer specifications?

Yes. While standard tank assemblies and drive mechanisms are used in all of its starters, approximately 75% of all liquid starters manufactured by NHP provide control and interface to customer specifications.

## 9) Is slip energy recovery possible with NHP liquid resistance starters?

While liquid resistance starters on their own do not provide a means of slip energy recovery, the NHP range of liquid starters can be made to interface directly with dedicated slip energy recovery systems.

# LRS design and selection guide



Please complete all the relevant information below and email to [sales@nhp.com.au](mailto:sales@nhp.com.au)

Company name\* \_\_\_\_\_

Contact name\* \_\_\_\_\_

Contact phone\* \_\_\_\_\_ email\* \_\_\_\_\_

Project name and reference number\* \_\_\_\_\_

Application (driven machine)\* \_\_\_\_\_

\_\_\_\_\_

Motor kW rating\* \_\_\_\_\_ Stator volts\* \_\_\_\_\_ Stator amps \_\_\_\_\_

Rotor volts\* \_\_\_\_\_ Rotor amps\* \_\_\_\_\_

Number of poles \_\_\_\_\_ Drive (machine) speed \_\_\_\_\_

Number of consecutive starts per hour from cold\* \_\_\_\_\_

Number of starts per hour from hot\* \_\_\_\_\_ Starting torque required\* \_\_\_\_\_

Start-up time\* \_\_\_\_\_ Ambient temperature\* \_\_\_\_\_ Temperature range\* \_\_\_\_\_

Type of control (open or closed loop) \_\_\_\_\_

Control supply (if other than 24 V DC) \_\_\_\_\_

Availability of cool water supply (for units that may require the addition of a heat exchanger?  
(Allows selection of most appropriate heat exchanger type ie liquid to liquid or liquid to air)\* Yes  No

List of special control and interface requirements: \_\_\_\_\_

\_\_\_\_\_

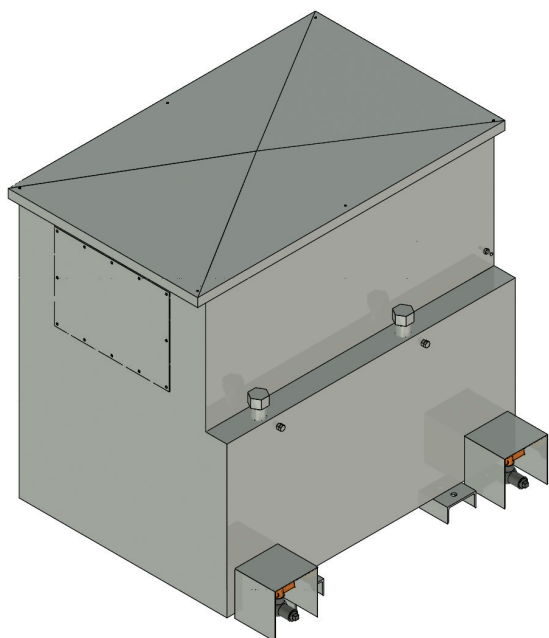
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\* Denotes minimum information required for selection and budgeting purposes.

# Dimensions and weights

## M350 Fixed electrode starters



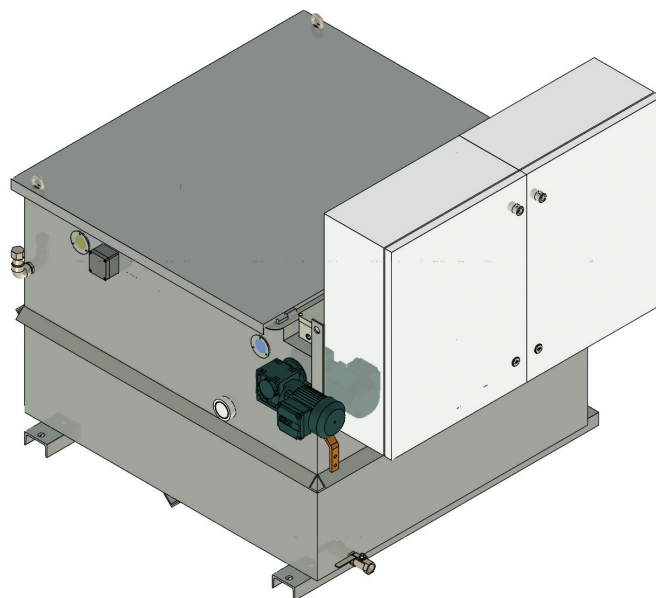
### Dimensions and weight

Model	Height (mm)	Width (mm)	Length (mm)	Dry weight (kg)	Operating weight (kg)
M350/2	915	1010	1060	350	710
M350/3	915	1010	1050	355	715

#### Notes:

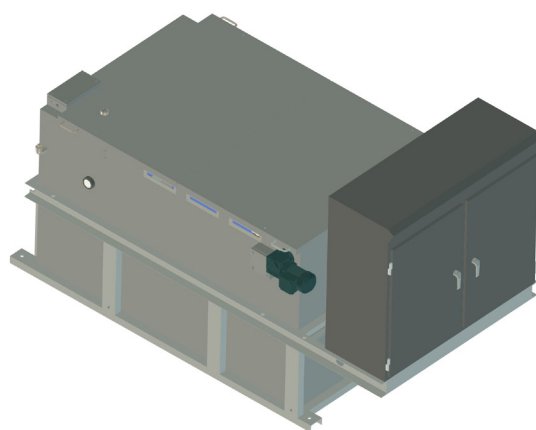
- Dimensions exclude optional heat exchangers and subject to change without notice. Not to be used for construction purposes.

## HLR moving electrode starters



### Dimensions and weight

Model	Height (mm)	Width (mm)	Length (mm)	Dry weight (kg)	Operating weight (kg)
HLR700	1480	1460	1700	430	1350
HLR1100	1640	1460	1700	440	1565



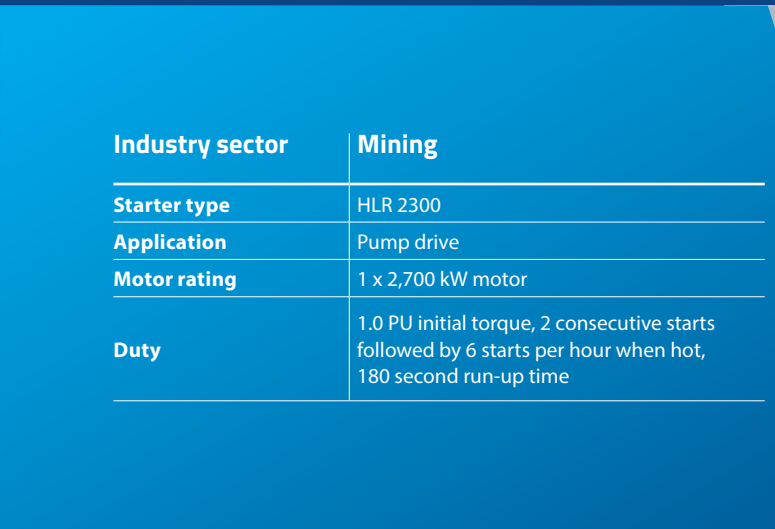
### Dimensions and weight

Model	Height (mm)	Width (mm)	Length (mm)	Dry weight (kg)	Operating weight (kg)
HLR2300	1730	1500	2800	1010	3365
HLR4000	1880	2140	3700	1520	5620

# Typical liquid resistance starters installations



<b>Industry sector</b>	<b>Mining</b>
<b>Starter type</b>	HLR 2300
<b>Application</b>	SAG mill drive
<b>Motor rating</b>	1 x 3,250 kW motor
<b>Duty</b>	1.5 PU initial torque, 6 consecutive starts followed by 2 starts per hour when hot, 20 second run-up time



<b>Industry sector</b>	<b>Mining</b>
<b>Starter type</b>	HLR 2300
<b>Application</b>	Pump drive
<b>Motor rating</b>	1 x 2,700 kW motor
<b>Duty</b>	1.0 PU initial torque, 2 consecutive starts followed by 6 starts per hour when hot, 180 second run-up time



<b>Industry sector</b>	<b>Mining</b>
<b>Starter type</b>	HLR 2300
<b>Application</b>	Ball mill drive
<b>Motor rating</b>	1 x 3,800 kW motor
<b>Duty</b>	1.5 PU Initial torque, 4 consecutive starts followed by 3 starts per hour when hot, 20 second run-up time



The NHP logo consists of the letters 'NHP' in a bold, white, sans-serif font, centered within a dark blue square background.

**NHP**

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NHP28BCH 05/22