LIQUID RESISTANCE STARTERS

Wound rotor motor control for demanding industrial applications from 200 kW to 12.4 MW

MOTOR CONTROL & DRIVES

AUSTRALIAN MADE

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 200 kW to 12.4 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. Whilst one of the more common methods for starting wound rotor motors is the multi-stage secondary resistance starter, it is understood the resistors can generate substantial amounts of heat during starting, 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, and an enclosure which houses a shorting contactor and timer, the simplicity of liquid resistance 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, 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
- Ideal for down time critical plant

NHP liquid resistance starters

AUSTRALIAN DESIGN AND MANUFACTURE

Designed by NHP and manufactured at our national manufacturing and distribution centre at Laverton North, Victoria, the NHP range of liquid resistance starters offer a number of significant advantages.

Our starters and the individual components used within them, comply to all applicable codes, directives and Australian standards.

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 promise performance and results you can trust.

Whilst our starters are generally manufactured to NHP 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 extend the mechanical life of the motor and driven machine.

In line with NHP's 'end to end' solutions promise, is a comprehensive range of value add services that offer round the clock support from a dedicated and proficiently qualified team.

M350 fixed electrode starters are manufactured in Australia and are intended for wound rotor motors applications from 200 kW to 750 kW

HLR moving electrode starters are designed and manufactured in Australia and are intended for wound rotor motors from 200 kW to 12.4 MW

AUSTRALIAN MADE

Images provided for representative purposes only

Fixed electrode liquid resistance starters

M350 STARTER

For use with low and medium voltage wound rotor motors from 200 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.

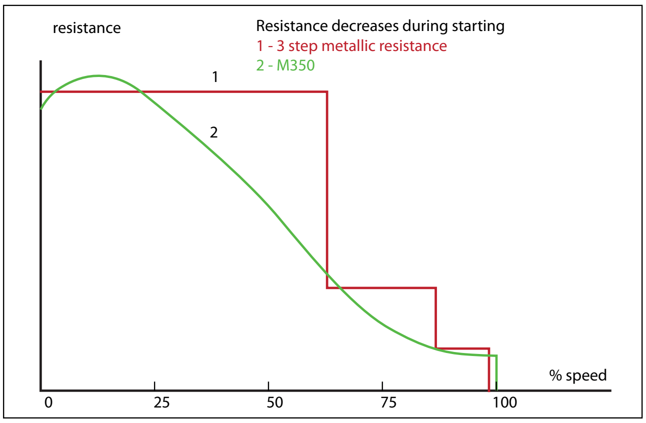
During run-up, the thermal interchange which occurs decreases the resistance and a timed contactor then short circuits the low residual resistance.

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.

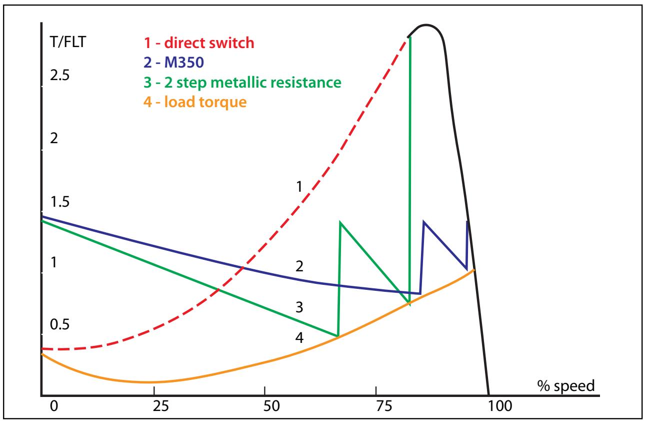
As the resistance decreases in direct relation to the motor speed, the possibility of operator misuse is minimised and motor burn-out problems are resolved.

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.

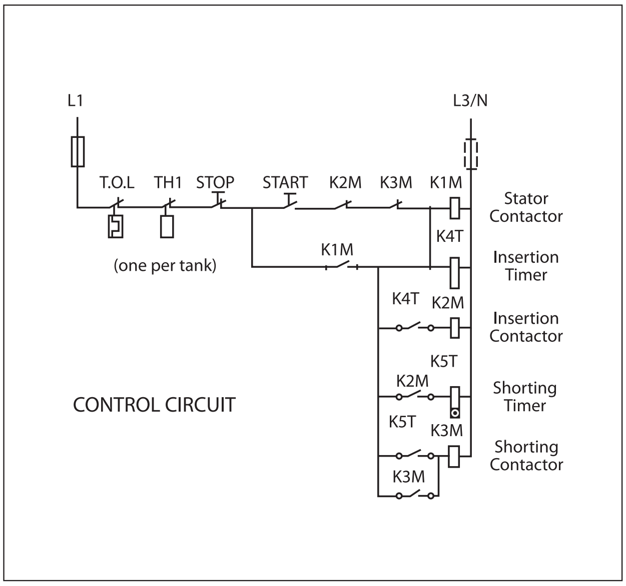
CLIMATIC CONDITIONS

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.

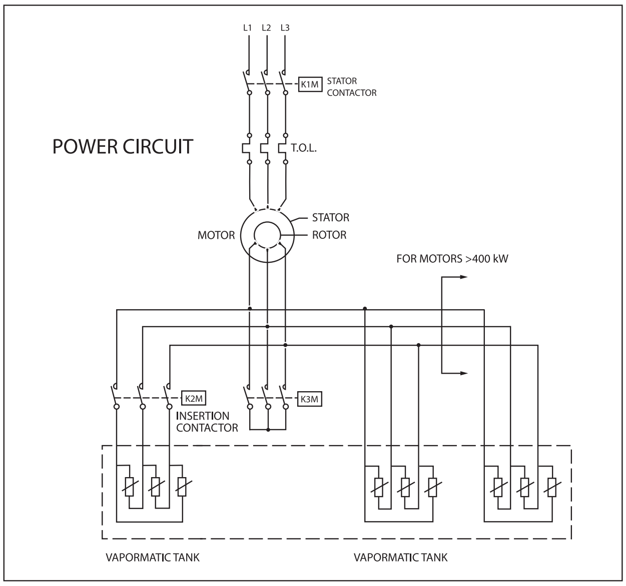
AVAILABILITY

For ratings up to 750 kW very quick deliveries can be achieved as all components required for construction are available ex-stock.

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



M350 control circuit



M350 power circuit

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 starting torque of;**			
Single motor drives	**0.7 x FLT**	**1.0 x FLT**	**1.4 x FLT**	**2.0 x FLT**
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.*

Moving electrode liquid resistance starters

HLR STARTER

For use with low and medium voltage wound rotor motors from 200 kW to 12,400 kW, 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, it also eliminates the need for over travel limit switches.

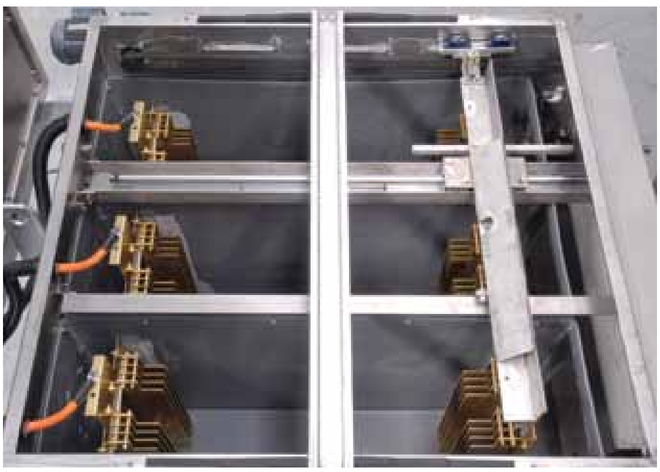
Through the geared motor and belt drive assembly, the variable speed drive controls the rate at which the electrodes move, and in turn, the starting time of the motor. The electrodes move through a horizontal plane to provide a near linear resistance/travel characteristic. The turn down ratio (ratio 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 or a water to air 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.



Dual and triple units can be provided for applications with multiple motors driving the same load. Load sharing, or trimming resistors as they are otherwise known, can be added to match the speed and current drawn by motors that are individually controlled but driving the same load, for example head end drives on a conveyor system.

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.

STANDARD I/O AND SIGNALLING

Input signals	Dry contact input
Start/Run	1 x normally open input (close to start/run, open to stop)

Output signals	Voltage free contact
Ready to start	1 x normally open
Shorting (Run) contactor closed	1 x normally open
Electrolyte level (Low)	1 x normally open
Electrolyte temperature (High)	1 x normally open
Starter fault	1 x normally open

Indication

Start
Run
Fault
Electrolyte level low
Electrolyte temp high

Metering

Rotor current	1 x analogue meter (displays initial start current)
Electrolyte temperature	1 x tank mounted analogue meter

HLR RATINGS

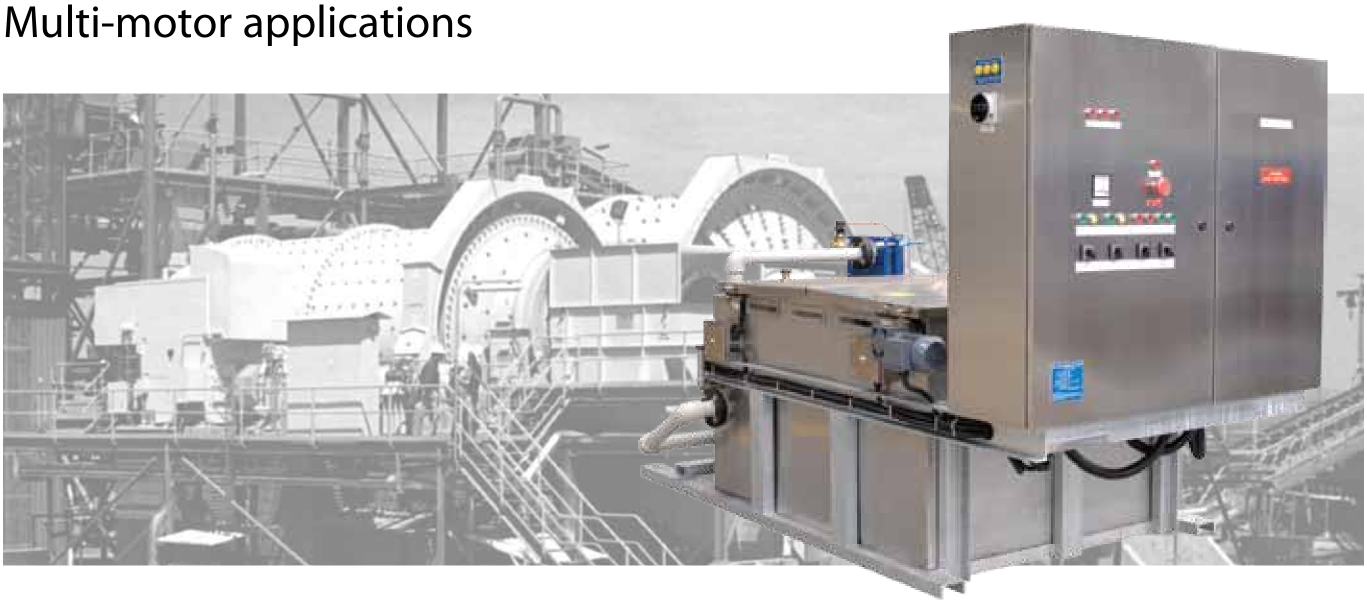
HLR starters are designed to meet the starting torque requirements of the application and the starting duty (starting time and starts per hour) specified by the user. The ratings given to HLR starters are therefore variable and application dependant.

Starter model	**Nominal motor kW rating at starting torque of;**			
Single motor drives	**0.7 x FLT**	**1.0 x FLT**	**1.4 x FLT**	**2.0 x FLT**
HLR700	1,400	1,000	700	500
HLR1100	1,600	1,100	790	550
HLR1400	2,600	1,800	1,300	900
HLR2300	4,200	3,000	2,100	1,500
HLR4000	6,200	4,500	3,100	2,200
HLR4000/2	12,400	9,000	6,200	4,400
Dual and triple motor drives				
HLR700 Dual Compact	2 x 1000	2 x 700	2 x 500	2 x 360
HLR2000 Dual Compact	2 x 4,200	2 x 3,000	2 x 2,100	2 x 1,500
HLR4000 Dual	2 x 6,200	2 x 4,500	2 x 3,100	2 x 2,200
HLR4000/2 Dual	2 x 12,400	2 x 9,000	2 x 6,200	2 x 4,400
HLR1300 Triple Compact	3 x 2,000	3 x 1,500	3 x 1,000	3 x 700

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. Contact NHP for selection assistance and advice.*

Multi-motor applications



MULTIPLE MOTORS DRIVING A COMMON LOAD

In many larger installations it is not uncommon to find multiple motors driving common load. The HLR range of liquid resistance starters are suitable for such installations and offer several unique characteristics that provide a significant technical and commercial advantage.

Compact dual and triple HLR starters comprise a single liquid electrolyte tank which contains multiple sets of electrodes (liquid resistance banks) to drive multiple motors. This ensures electrolyte level, temperature, and strength/resistance is the same for each driven motor thereby ensuring their acceleration rates are identical.

For larger dual motor drives in which the motors may be controlled via a common controller and multiple tanks, innovative electrical and mechanical design ensures motor acceleration rates are closely monitored and controlled.

MULTIPLE MOTORS - DIRECTLY COUPLED

As mentioned, innovative electrical and mechanical design ensures the acceleration rate of each motor is closely monitor and controlled. This process ensure motors accelerate in a near identical fashion thereby minimising the possibility of one motor working harder than the other as the driven machine is accelerated to operating speed. Once at operating speed, the motors share the load equally and no external control or intervention is required.

MULTIPLE MOTORS - INDIVIDUALLY COUPLED

Some machines, for example the head end drive of a conveyor system, may comprise multiple motors that are not directly coupled. Compact dual and triple starters provide the required acceleration control during the start up cycle.

Because the drive mechanisms in such applications experience different wear rates, it is often necessary to load match motors operating at full speed. This functionality is achieved through the introduction of trimming or load sharing resistors.

TRIMMING (LOAD SHARING) RESISTORS

Available in open frame or fully enclosed arrangements, trimming resistors are used in installations where there is a need to speed match multiple motors driving a common load. Whilst these are designed to meet application specific requirements, a typical specification for a trimming resistor unit may be that it provides 1% additional slip, adjustable in 0.1% increments.

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 a 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.

AIR TO LIQUID HEAT EXCHANGERS

For medium start duty applications or in installations where there is an absence of a cool water supply, a liquid to air type heat exchanger may present as a better solution. These operate by moving cool air through a radiator style core assembly. The electrolyte is pumped through the radiator and cooled accordingly.

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 the page opposite and email to:

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 maximum 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 needed.

6. Is the performance of the Liquid Resistance Starter affected by significant changes in ambient temperature?

Due to its large mass (700 to 8000 litres subject to tank capacity) the liquid electrolyte acts as a storage unit for temperature. If for example 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 speed control may be needed for machine set up purposes, eg. belt alignment on a conveyor system.

In such applications a joint decision is made on the most appropriate type of heat exchanger, be it liquid to liquid or liquid to air, for the installation.

8. What are the key advantages of 'Compact Dual and Triple' Liquid Resistance Starters?

Compact dual and triple starters are available for multi-motor installations such as those experienced on larger conveyors, mills and crushers. These starters make it possible to start multiple motors in tandem via a single tank assembly and present several technical and commercial advantages.

Acceleration rates for each motor are very closely matched. This is made possible by the fact that the electrolyte temperature and strength and hence the rotor resistance, is exactly the same for each driven motor.

9. Does NHP produce Liquid Resistance Starters to customer specifications?

Yes, whilst 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.

10. Is slip energy recovery possible with NHP Liquid Resistance Starters?

Whilst 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 fax or email to: 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 exchanges?
(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: ______

______

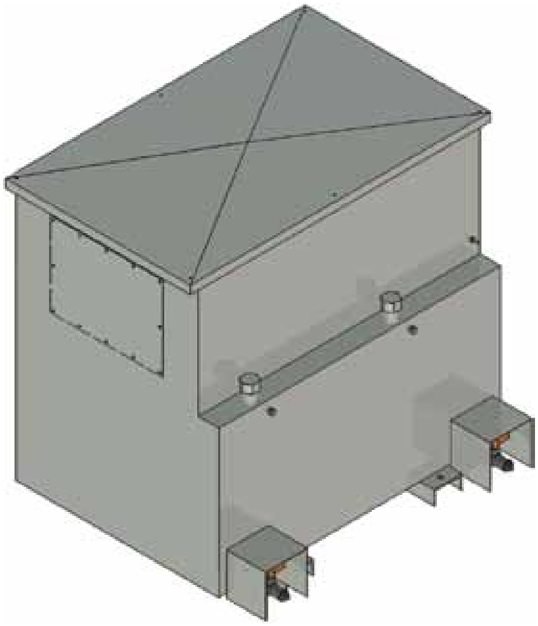
______

______

* Denotes minimum information required for selection and budgeting purposes.

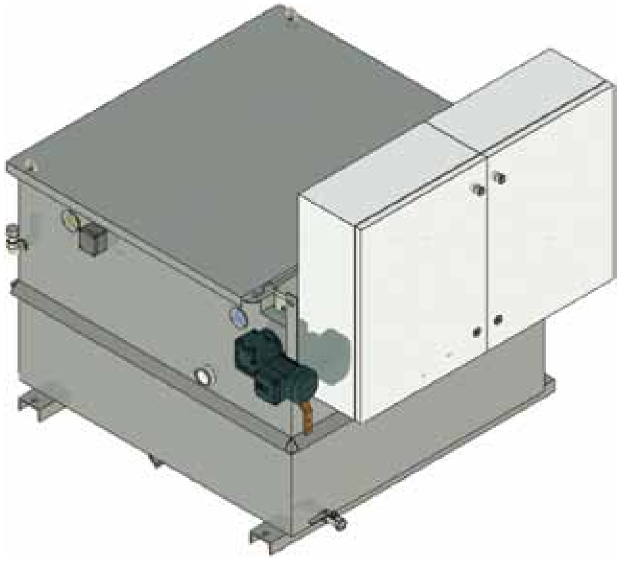
Dimensions and weights

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

HLR MOVING ELECTRODE STARTERS



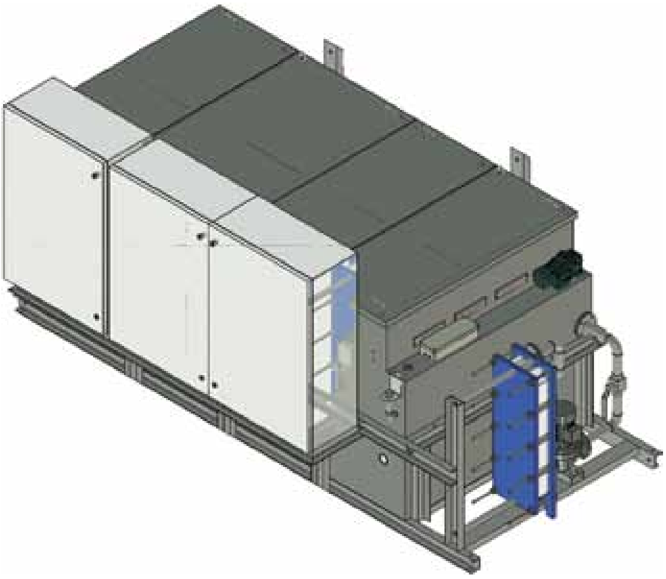
SINGLE MOTOR: HLR700, HLR1100, HLR1400, HLR2300
DUAL MOTOR: HLR700DUAL

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
HLR1400	2040	1920	1700	800	2235
HLR2300	1730	1500	2800	1010	3365
HLR700DUAL	2040	1920	1700	800	2235

Note:

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

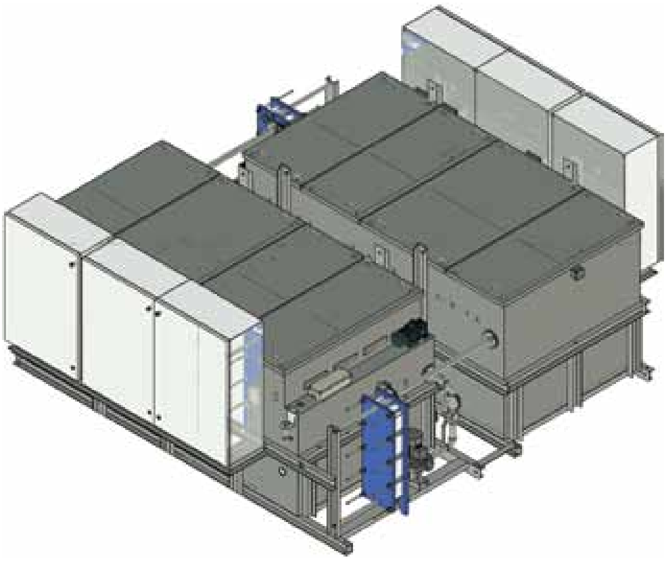
HLR MOVING ELECTRODE STARTERS



SINGLE MOTOR: HLR4000, HLR4000/2, HLR4000/3
DUAL MOTOR: HLR2000DUAL
TRIPLE MOTOR: HLR1300TRIPLE

DIMENSIONS AND WEIGHT					
Model	Height (mm)	Width (mm)	Length (mm)	Dry Weight (kg)	Operating Weight (kg)
HLR2000DUAL				1700	5800
HLR4000				1520	5620
HLR4000/2	1880	2140	3700	1700	5800
HLR4000/3				1890	5990
HLR1300/3				1890	5990

HLR MOVING ELECTRODE STARTERS



DUAL MOTOR: HLR4000DUAL, HLR4000/2DUAL

DIMENSIONS AND WEIGHT					
Model	Height (mm)	Width (mm)	Length (mm)	Dry Weight (kg)	Operating Weight (kg)
HLR4000DUAL	1880	4320	3700	3200	11400
HLR4000/2DUAL	1880	4320	3700	3200	11400

Note:

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

Typical Liquid Resistance Starters installations

Industry Sector:	**Mining**
Starter Type	HLR 2300
Application:	SAG mill drive
Motor Rating:	1 x 3,250 kW motor
Duty:	1.5 PU Initial torque, 6 consecutive starts followed by 2 starts per hour when hot, 20 second run-up time

Industry Sector:	**Mining**
Starter Type	HLR 2300
Application:	Pump drive
Motor Rating:	1 x 2,700 kW motor
Duty:	1.0 PU Initial torque, 2 consecutive starts followed by 6 starts per hour when hot, 180 second run-up time

Industry Sector:	**Mining**
Starter Type	HLR 1000 triple
Application:	Head end conveyor drive
Motor Rating:	3 x 630 kW motors
Duty:	0.3 PU Initial torque, 6 consecutive starts followed by 6 starts per hour when hot, 60 second run-up time

Industry Sector:	**Mining**
Starter Type	HLR 2300
Application:	Ball mill drive
Motor Rating:	1 x 3,800 kW motor
Duty:	1.5 PU Initial torque, 4 consecutive starts followed by 3 starts per hour when hot, 20 second run-up time

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