



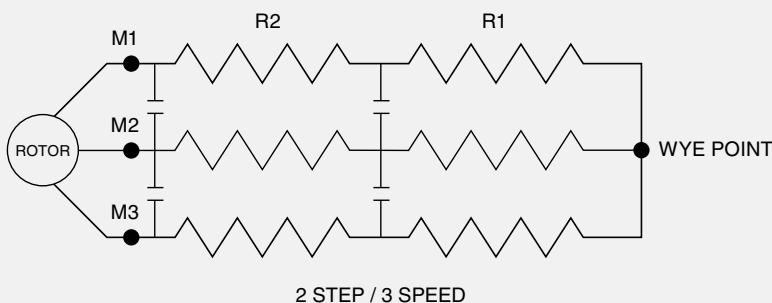
Wound rotor motors, as opposed to AC induction motors, generate the same torque in both forward and reverse. They are commonly used on fans, pumps, conveyors and crane systems.

The motors are rated according to their primary and secondary windings. The primary ratings are given in volts and power (kilowatts), while the secondary ratings are specified in terms of voltage and current (the secondary current is defined by the locked rotor output, verified during testing of the motor).

Resistance Calculation

To calculate the total resistance per phase, the following information is required:

1. Secondary voltage
2. Secondary current
3. The number of speeds/steps required for the application. The number of steps is the actual number of resistor stages to be switched through, whereas the number of speeds is the number of steps plus one (the "extra" speed being no resistors at all in the circuit.)
4. Duty class, according to NEMA
5. Starting torque, (which can also be specified as the last digit of the classification number.)



Formula for Total Resistance

$$R_{tot} = \text{Secondary Voltage} / (\text{Secondary Current} \times 1.713 \times \text{Percentage Starting Torque})$$

The total resistance is then divided into the requisite number of steps. The size is not uniform to allow for smooth transitions of motor speed as the load's inertia changes. The most common breakdowns are given below, with the first step being that closest to the secondary AC power source and then moving progressively toward the motor.

The amperage associated with each step is determined by the amount of current seen by the individual steps, as dictated by how long they are left in the circuit and by the duty class of the motor. These values listed below are percentages of the rated secondary current. As a general rule, pumps, fans and conveyor systems are Class 130, while crane systems can be Class 160, 170 or 190.

One note concerning the secondary current: if the starting torque is greater than 100%, remember to also use this factor in sizing the individual resistor steps. For example, if the starting torque is 150% of nominal, the amperage used for designing the resistor sizes will be 1.5 times the rated secondary current of the motor.

NEMA Classification of Resistors

The following table is for selecting the NEMA Class for an application in relation to starting torque and duty cycle.

Approximate Percent of Full-Load Current on First Point Starting @ Rest	Class Numbers Applying to Duty Cycles							
	30 sec. on Out of each 15 min.	5 sec. on Out of each 80 sec.	10 sec. on Out of each 80 sec.	15 sec. on Out of each 90 sec.	15 sec. on Out of each 60 sec.	15 sec. on Out of each 45 sec.	15 sec. on Out of each 30 sec.	Continuous Duty
25	101	111	131	141	151	161	171	91
50	102	112	132	142	152	162	172	92
70	103	113	133	143	153	163	173	93
100	104	114	134	144	154	164	174	94
150	105	115	135	145	155	165	175	95
200 or over	106	116	136	146	156	166	176	96

NEMA Resistor Application Standards

APPLICATION	NEMA CLASS	APPLICATION	NEMA CLASS	APPLICATION	NEMA CLASS
Blowers		Food Plants		Rubber Mills	
Centrifugal 133-93		Butter Churns, Dough Mixer 135		Banbury, Crackers..... 135	
Constant Pressure 135-95		Hoists		Calenders 155	
Brick Plants		Winch 153		Mixing Mills, Washers 135	
Augers, Conveyors, 135		Mine Slope 172		Steel Mills	
Dry Plans, Pug Mills		Mine Vertical 162		Accumulators..... 153	
By-product Coke Plants		Contractor's Hoists 152		Casting Machines-Pig, 153	
Door Machine, Leveler Ram, 153		Larry Cars 153		Charging Machines	
Pusher Bar, Valve Reversing Machines		Lift Bridges 152		Bridge..... 153 or 163	
Cement Mills		Machine Tools		Peel 153 or 163	
Conveyors 135		Bending Rolls 163 or 164		Trolley 153 or 163	
Crushers 145		Boring Mills 135		Coiling Machines 135	
Elevators 135		Bulldozers 135		Converters-Metal 154	
Rotary Dryers 145-95		Drills, Gear Cutters 115		Conveyors..... 135-155	
Grinders and Pulverizers 135		Grinders 135		Crushers 145	
Kilns 135-95		Hobbing Machines, Lathes 115		Furnace Door, Gas Valves, 155	
Coal and Ore Bridges		Milling Machines		Gas Washers	
Bridge 153		Presses, Punches..... 135		Hot Metal Mixers..... 163	
Closing, Holding 162		Saws, Shapers 115		Ingot Buggy, Kickoff, 153	
Trolley 162 or 163		Metal Mining		Levelers	
Coal Mines		Ball, Rod and Tube Mills..... 135		Manipulator Fingers..... 153 or 163	
Car Hauls 162		Car Dumpers-Rotary 153		Pickling Machine, 153	
Conveyors 135 or 155		Converters-Copper 154		Pilars-Slab, Racks	
Cutters 135		Crushers 145		Reelers 135	
Crushers 145		Conveyors..... 135		Saws-Hot or Cold 155	
Fans 134 or 95		Tilting Furnace 153		Screw Downs..... 153 or 163	
Hoists		Paper Mills		Shears, Shuffle Bars..... 155	
Slope 172		Beaters..... 135		Side Guards..... 153 or 163	
Vertical 162		Calenders..... 154-92		Sizing Rolls, Slab Buggy, 155	
Jigs, Picking Tables 135		Chippers..... 145		Soaking Pit Covers	
Rotary Car Dumpers 153		Pipeworking		Straighteners 153	
Shaker Screens 135		Cutting and Threading 135		Tables	
Compressors		Expanding and Flanging 135-95		Approach..... 153	
Constant Speed 135		Power Plants		Lift 153 or 163	
Varying Speed		Clinker Grinders 135		Main Roll 153 or 163	
Centrifugal 93		Coal Crushers 135		Roll 153	
Plunger Type 95		Conveyors		Shear Approach..... 153 or 163	
Concrete Mixers 135		Belt, Screw..... 135		Transfer..... 153	
Cranes-General Purpose		Pulverized Fuel Feeders..... 135		Tilting Furnace..... 153	
Hoist 153-163		Pulverizers		Wire Stranding Machine 153	
Bridge or Trolley with		Ball Type 135		Woodworking Plants	
Sleeve Bearings 153-163		Centrifugal 134		Boring Machines, Lathe, 115	
Roller Bearings 152-162		Stokers..... 135-93		Mortiser, Moulder, Planers,	
Flour Mills		Pumps		Power Trimmer and Mitre,	
Line Shafting 135		Centrifugal 134-93		Sanders, Saws, Shapers,	
		Plunger 135-95		Shingle Machine	

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