



Starter Types

- Starter Types
- Free Standing
 - Unit Mounted
 - "Single Source"
- Type
- Starter - Constant Speed
 - VFD - Variable Speed

Learning Objectives

1. Review common types of motor starters and their characteristics.
2. Basic electrical definitions.
3. Refrigerant options as defined by ASHRAE 34.

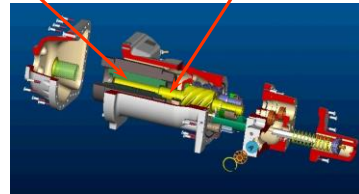
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Motor Components

Motor Components - Typical

Stator (motor windings) Rotor (compressor shaft)



Outline/Agenda

- Starter Types
- Motor Components
- Electrical Definitions
- Starter Types vs. Inrush Current
- Refrigerant Types and ASHRAE 34

Electrical Definitions

Motor Electrics

- Voltage Classes
 - Low Voltage (up to 600v)
 - Medium Voltage (>600v to 6900v)
 - High Voltages (10000 to 13800v)
 - Start-up Methods / Inrush Amps
 - Full amps
 - Reduced amps
- Driven by Motor HP



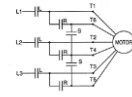
Starter Types

- Across-the-Line
- Part-Winding Start
- Wye-Delta
- Solid State
- Autotransformer
- Primary Reactor
- Variable Frequency Drives

Wye Delta

Wye Start - Delta Run

- Start – Windings connected in wye configuration. Less than line voltage applied to each phase.
- Run – Windings connected in delta configuration. Full line voltage applied to each
- "Wye" is also known as "star" – SDCT

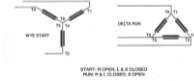


Starting Characteristics:

- Starting current approximately 30% of normal.
- The starting torque approximately 25-30% of normal.

Applications:

- Where load torque during acceleration is low.



START: WYE, L & R CLOSED
RUN: W & R CLOSED, L OPEN

Wye Start, Delta Run

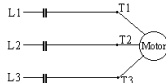
Across-The-Line

Starting Characteristics:

- Motor terminal voltage will be the same as the line voltage.
- The motor current will equal the line current.
- The motor starting torque will be the same as the rated starting torque.

Applications:

- Generally used for smaller, general purpose duty motors i.e. up to 100 HP (74.6 kW) in low voltage applications.
- Electrical systems which can withstand the inrush amps without excessive voltage drop.



Across the Line Starting

Solid State

Solid State

- Uses silicon-controlled rectifiers (SCRs) to vary voltage to motor terminals.
- Can control voltage, ramp time, min/max current
- Ramp-up is smooth, linear and step-less.

Starting Characteristics:

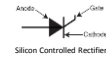
- Motor inrush current approximately 35-50% of LRDA.
- Starting current is 300-500% of RLA.

Applications:

- Where soft start (gradual acceleration) is desired.
- Rate of acceleration needs to be controlled.

Common Misconception:

- Solid state starters have the same starting characteristics as a variable speed drive (VFD).



Silicon Controlled Rectifier

Part Winding

Part Winding

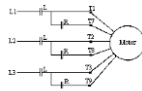
- Motor is incrementally started.
- Usually only 50% or 66% of windings used during start.
- Start winding only engaged for 2-3 seconds.
- On start connection, the motor is not expected to accelerate and may not even turn.

Starting Characteristics:

- Current at start-up usually 60-75%, depending on the specific winding connection.
- Torque at start-up is low and shaft may not turn.
- Heating in the windings is high on the start connection.

Applications:

- Where voltage dips at full inrush are unacceptable.



Start: L Closed, R Open
Run: L & R Closed

Autotransformer

Autotransformer

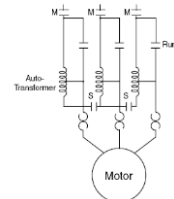
- Autotransformer is placed in series with motor.
- Common transformer start taps: 50%, 65% & 80% of full voltage.
- Open & closed transition types:
 - Open transition physically disconnects power from motor before transitioning to full voltage.
 - Closed transition does not disconnect power from motor when transitioning to full voltage.

Starting Characteristics:

- Terminal voltage less than line voltage (determined by transformer tap).

Applications:

- Common before development of SDCT, VFD and solid state technologies.
- Often seen in replacement applications and large medium-voltage applications.



Primary Reactor

Primary Reactor

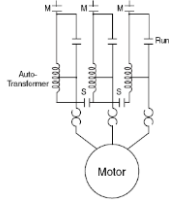
- Mostly used in medium voltage applications.
- Reduces voltage to motor by means of a large resistor.
- Allows changing of incoming line voltage taps to regulate level of inrush current. Usually 50% or 65%.

Starting Characteristics:

- Once connected, motor draws 50%-65% of locked rotor current (depending on voltage tap).
- Once full voltage transition occurs, current quickly reduces to normal.

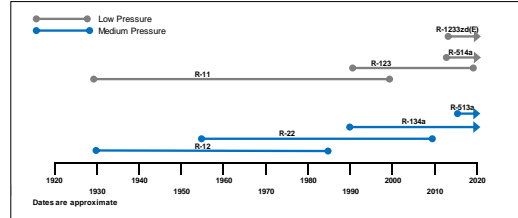
Applications:

- Primarily seen in medium voltage applications.



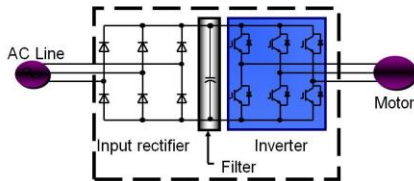
Refrigerants

Manufacturers have mostly standardized between 'Low' and 'Medium' Pressure Chiller designs.



Four (4) Main Refrigerant Options

Variable Speed Drives



- Input rectifier converts AC line voltage to fixed voltage DC.
- DC voltage is filtered to reduce ripple caused by rectification...harmonics
- Inverter changes fixed voltage DC to adjustable AC voltage and frequency which is provided to the motor.

Refrigerants

ASHRAE 34 AND EN 378

ASHRAE 34

A-1: R-134a, R-513A, R123zd(E)

B-1: R-514A

3 of 4 refrigerant options are A1 rated.

	ASHRAE 34 AND EN 378		
Higher Flammability	A3 Propane, Butane	B3	↑ Increase Flammability
Flammability	A2 R-152a	B2 R-40, Methyl Chloride	
Lower Flammability	A2L R-32, R-1234yf, R-1233zd(E)	B2L Ammonia	
No Flame Propagation	A1 R-22, R-410A, R-1233zd(E), R-134a, R-407C, R-513A	B1 R-12, R-514A	
	Lower Toxicity (GTL of less than 400 ppm)	Higher Toxicity (GTL of 400 ppm or greater)	→ Increase Toxicity

Starter Types & Inrush Current

Starting Method	Motor Starting Current as a % of	
	Locked Rotor Current	Full Load Current/Amps or RLA
Across-the-Line	100	600 - 800
Auto Transformer & Primary Reactor	80	480
	65	390
	50	300
Wye-Delta	33	200 - 275
VFD	16.6	100
Solid-State	45	320

Locked Rotor Current - Motor is in stop position ready for start

Full Load Current - Motor full load amps running at design

Conclusion

- Wide variety of motor starter types to suit a given application.
- Inrush current must be mitigated:
 - Mechanical & electrical stress
 - Demand charges
- Variable frequency drives allow for "soft-start" AND speed reduction.
 - Efficiency gains
 - Energy savings
- Regulations driving environmental responsibility in refrigerants.
 - Low ODP & GWP
 - ASHRAE 34 dictates balance between flammability/toxicity

Questions?

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