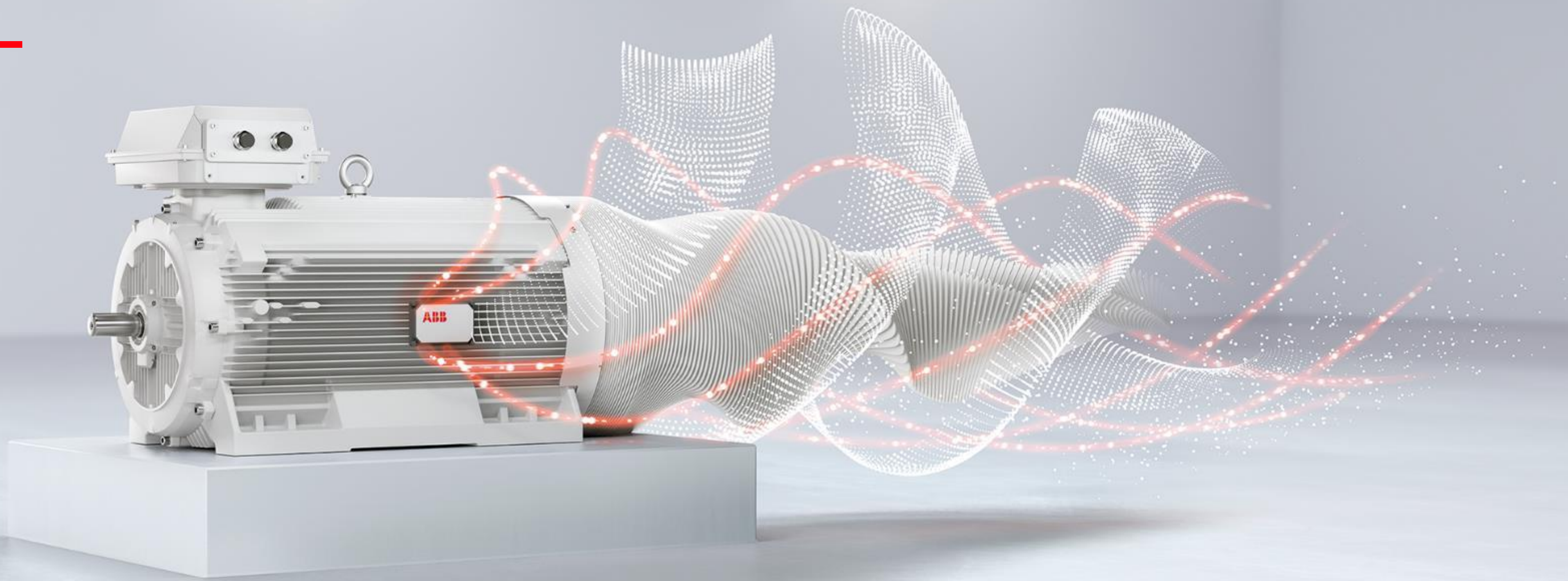


GAS/ELECTRIC PARTNERSHIP, JANUARY 31, 2018

Electric Motor-Driven Compressors

Motor Starting Considerations

Tanner Knecht, ABB Inc.

Agenda

Why EMDs are considered for Compressor applications

Project Example and problems faced

Motor Starting Considerations

Why Go EMD?

External Party Requirements

Noise

- Neighborhoods Nearby Install Location
- Permit Requirements

Emissions

- Environmental Permit
- Nonattainment Area

Project Example – Gulf South Pipeline Company

Things to Consider

- Utility infrastructure – current substation limitations, distance of feeder to station site
- Motor starting – inrush current of MV motor, use of soft starter, number of starts
- Network voltage sag/dip – combined effects above result in use of VFD for starting, across-the-line running
- Size of utility and their procedures/regulations – required permits, easements, T&Cs
- 3rd party coordination – Substation, Utility, Station (ex. Relay Coordination)
- In service considerations – new training, operation procedures, safety procedures

Motor Starting Considerations

Network voltage dips

This is just a rough estimate. It does not consider the motor starting P.F., etc.

Why?

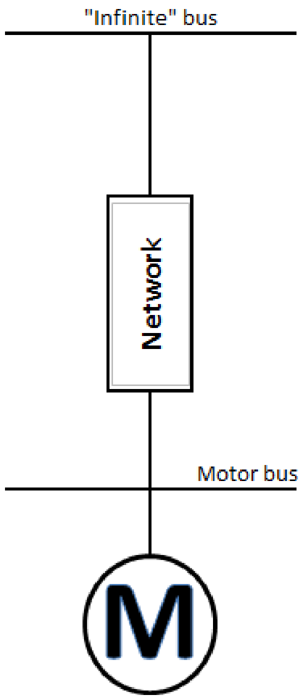
Typical AC motors have an inrush current of 3 to 7 times the nominal current. This phenomena often causes challenges for all involved parties.

What else?

- High transients
- Unplanned shutdowns elsewhere
- Mechanical stress to the motor
- Driven equipment, processes, and the foundations are affected by the starting of an AC electrical motor

CALCULATE VOLTAGE DROP BASED ON GIVEN SCC

Motor output:	10000	kW
Motor FL eff.:	98.2	%
Motor FL PF:	1.0	pu
Motor Is:	4.5	x FLC
Net SCC:	300	MVA
DOL VOLT DROP:	**13.25**	**%**
Motor starting power:	**45.825**	**MVA**



Motor Starting Considerations

Hot/cold starts

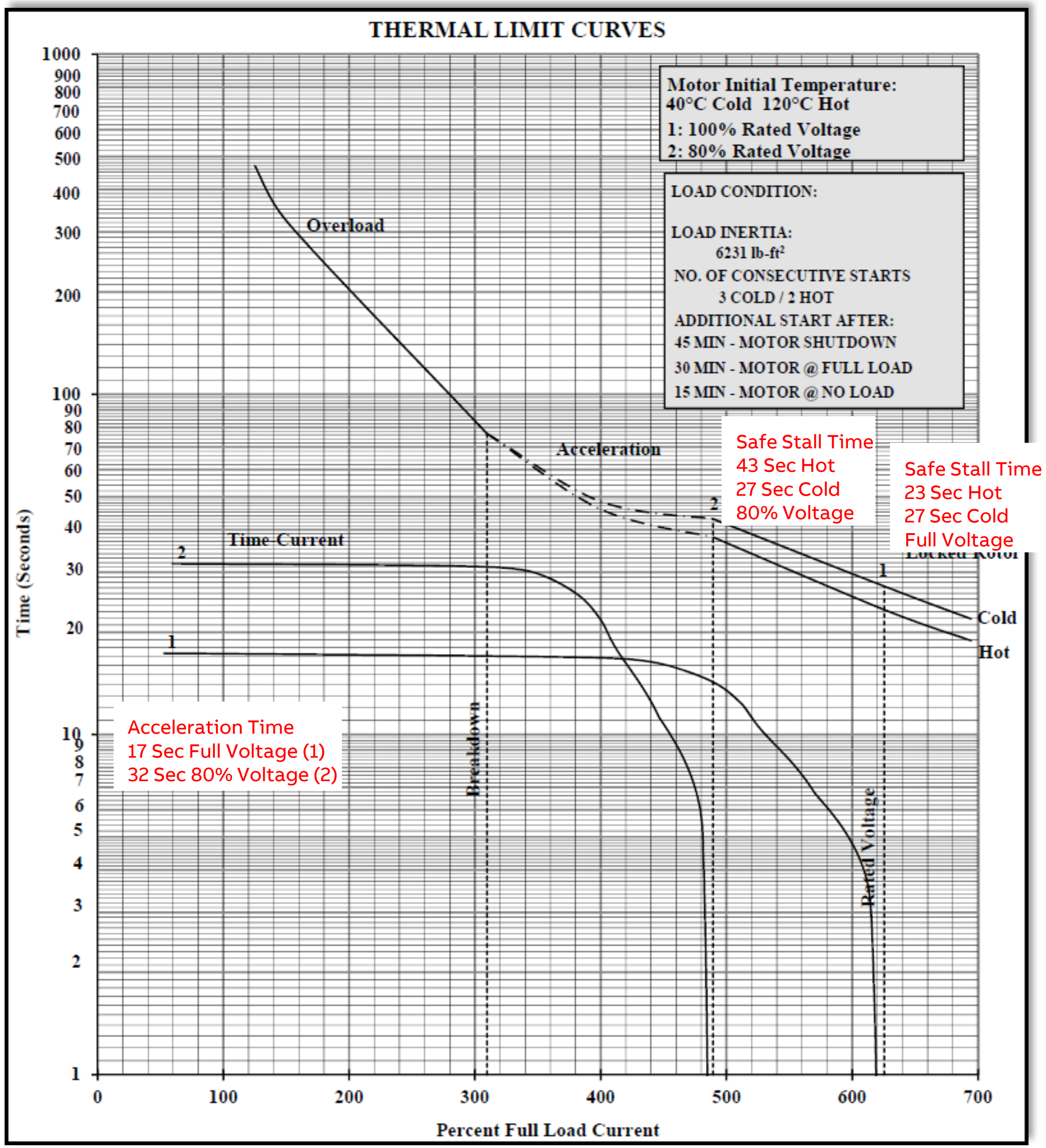
Heating

Every time a motor starts its components are subjected to mechanical and thermal stress.

- Rotors
- Winding insulation

Number of starts per time should not be exceeded.

- 2 (3 for API 541) starts with motor at or below ambient temperature
- 1 (2 for API 541) start with motor at Above ambientand at or below operating temperature
- Followed by required cooling time



Motor Starting Considerations

Speed vs Torque

NEMA MG 1-20.10

20.10.1 Standard Torque

The torques, with rated voltage and frequency applied, shall be not less than the following:

Torques	Percent of Rated Full-Load Torque
Locked-rotor*	60
Pull-up*	60

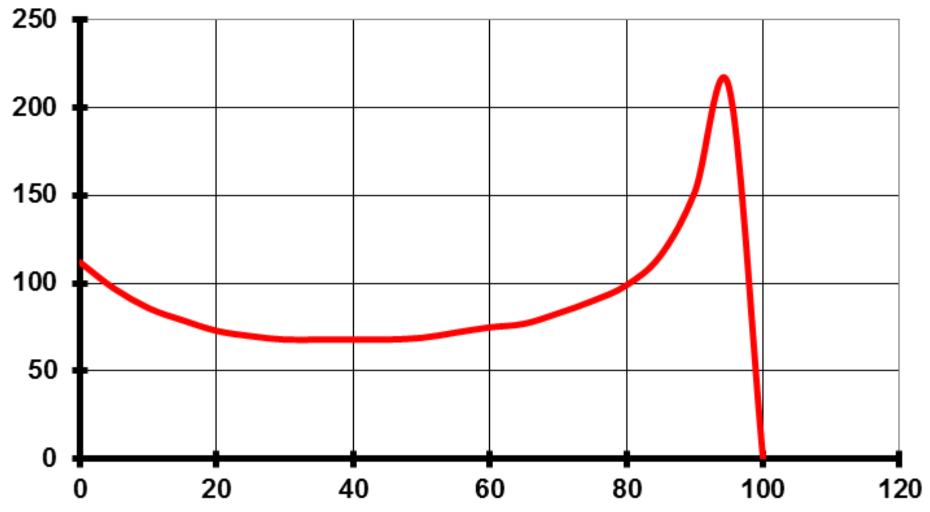
20.10.2 High Torque

When specified, the torques with rated voltage and frequency applied, shall not be less than the following:

Torques	Percent of Rated Full-load Torque
Locked-rotor	200
Pull-up	150
Breakdown	190

20.10.3 Motor Torques When Customer Specifies A Custom Load Curve

When the customer specifies a load curve, the torques may be lower than those specified in 20.10.1 provided the motor developed torque exceeds the load torque by a minimum of 10% of the rated full-load torque at any speed up to that at which breakdown occurs, with starting conditions as specified by the customer (refer to 20.14.2.3).



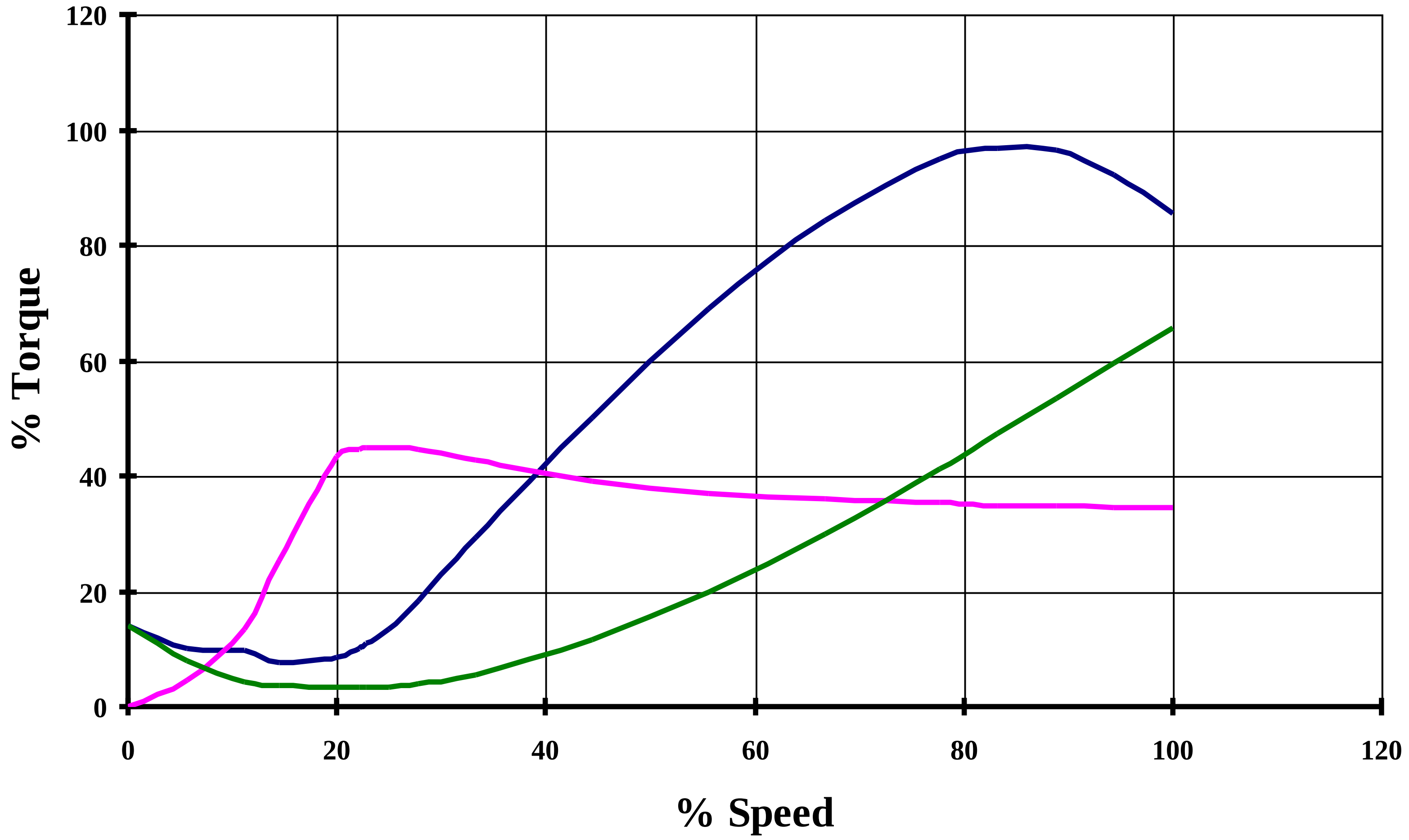
Motor Starting Considerations

Acceleration torque

Compressor Load Curves

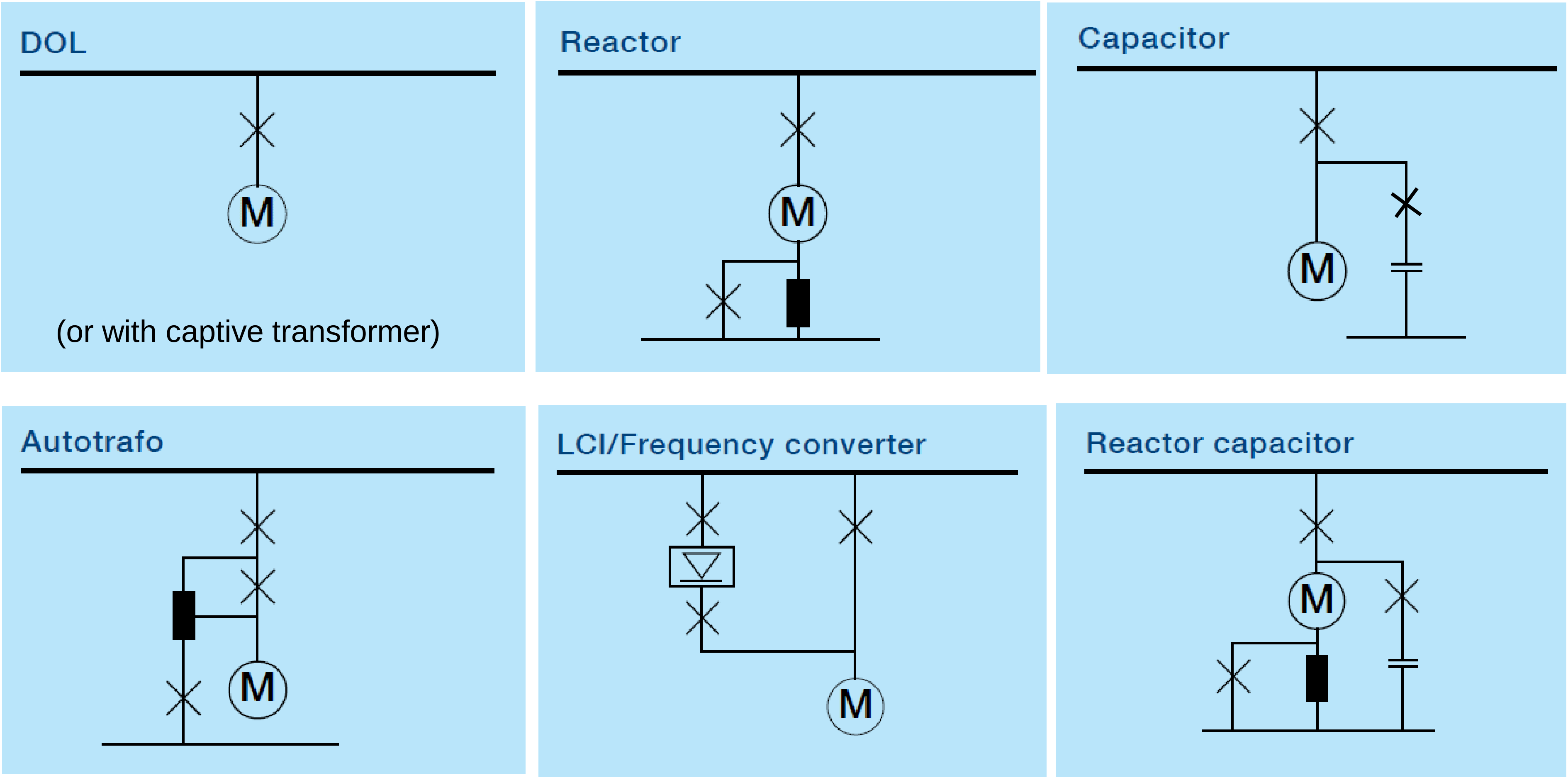
- Unloaded recip compressor (PINK)
- Loaded screw compressor (BLUE)
- Unloaded centrifugal compressor (GREEN)

- Compressor loads vary greatly and there is no way to define a typical compressor load curve.
- Since output torque of a typical motor is lower at lower speeds, it is important to obtain the proper load curve to ensure the motor will be able to produce sufficient torque to accelerate the compressor from zero to full running speed.



Motor Starting Considerations

Various Starting Methods



Motor Starting Considerations

Various Starting Methods

DOL

Direct on line starting does not require any additional external equipments.

This is most economical starting method if there are no specific starting current or voltage drop requirements.

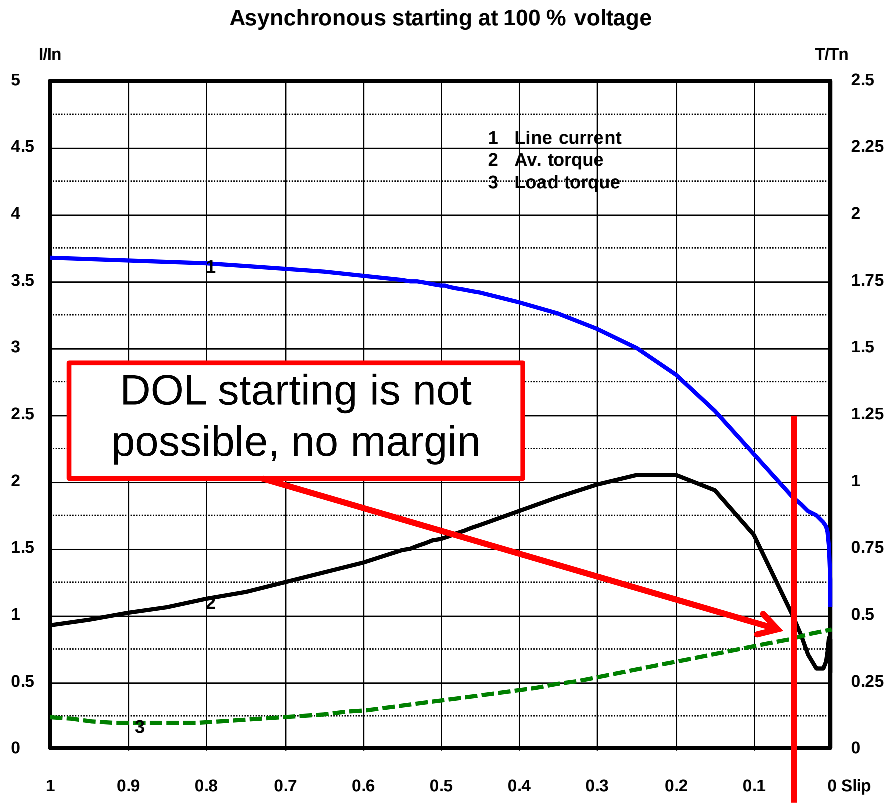
In some cases, motor designers can use a starting resistor in rotor circuit to give additional boost to the motor starting.

Starting resistor is connected in series with rotor field winding and is connected only during starting period and will be automatically disconnected after starting.

Example:

For Synchronous motors starting DOL, 70-80% starting torque curves may not be possible without an oversized motor, starting resistor, or some other alternative starting method.

ABB Oy								Motors and Generators
Handled by: JALI								02.01.2014
Type: AMZ 1600SR20 LTE								
Pn:	9100	kW	cos:	0.98		Tn:	241385	Nm
Un:	13200	V	n:	360	rpm	In:	415.8	A
f:	60	Hz						



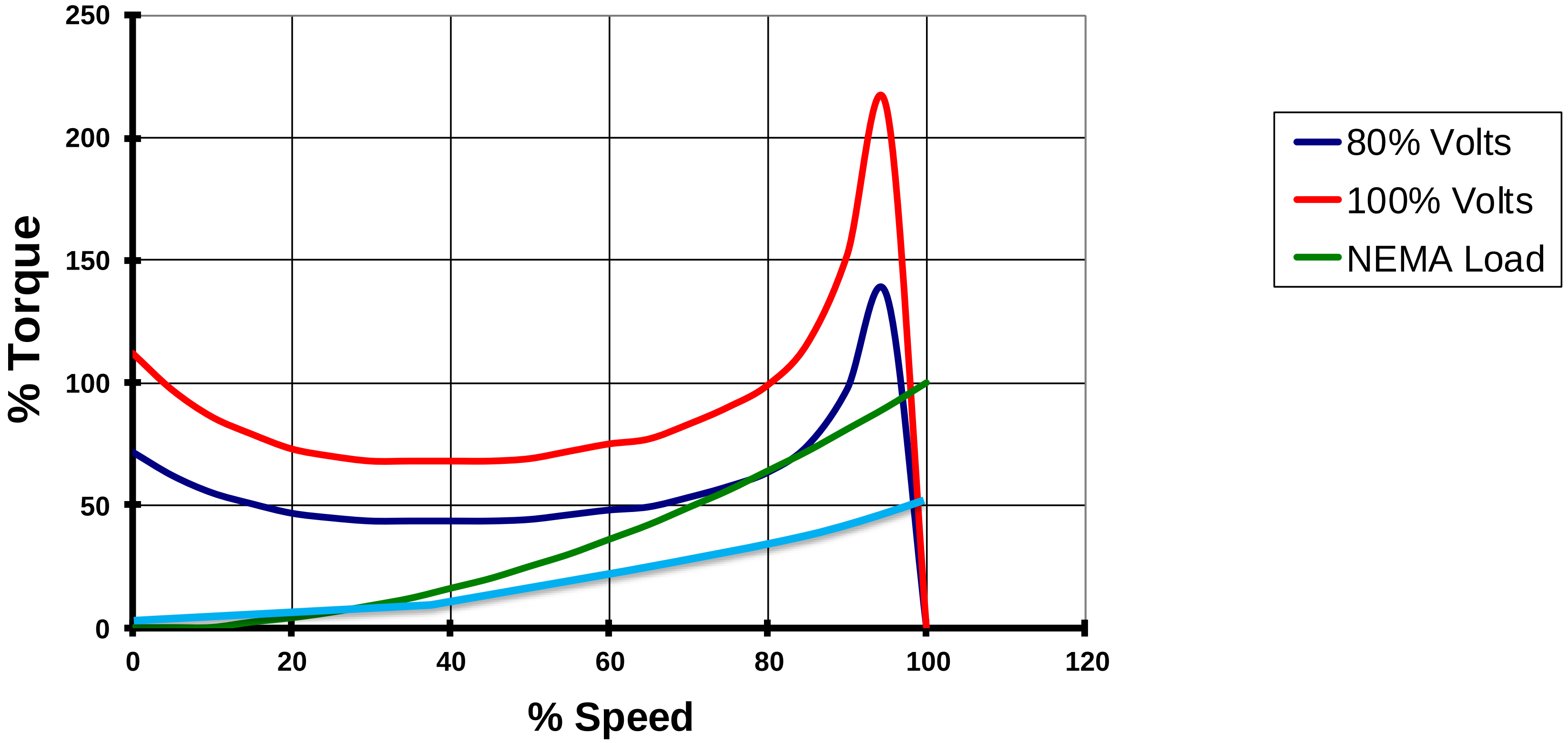
Motor Starting Considerations

Various Starting Methods

Reduced voltage, Full Load

80% voltage start

- Available starting torque is 64% of full voltage start
- Watch out for stall points
- Good practice to have 15-20% margin between motor torque and load torque



Motor Starting Considerations

Various Starting Methods

VFD Starting

Full starting torque.

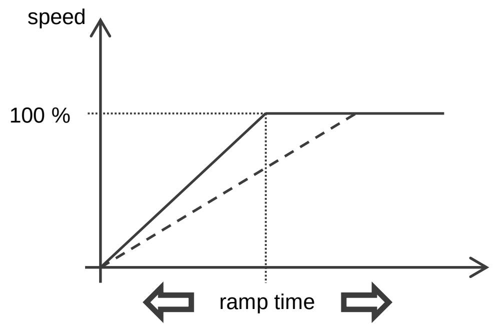
No inrush (100% max)

Unlimited starts

Variable ramp time

Reduced mechanical stress

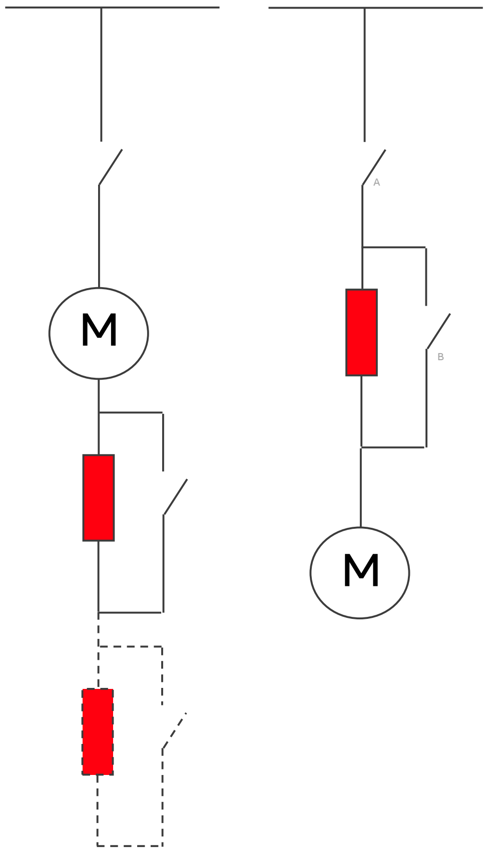
Synchronous machines started synchronously



Motor Starting Considerations

Various Starting Methods

Reactor(s) can be installed either into line or neutral side.



Reactor Starting

Reduction in starting current AND starting torque.

Lower cost than some other methods.

Reactor vs DOL:

1 additional breaker per reactor

1 reactor

+ Reduces/limits starting current taken from the network

+ Lowers voltage drop in the network

+ relatively simple

- Motor torque reduced by the square of the reduction in current, e.g., if the reactor is sized to reduce the current by 50%, the torque will be reduced to 25% of rated

Typical starting reactor for 12,000hp/ 13.8 kV / 60 Hz synchronous motor.

- Three single phase reactors
- Air core, free standing
- Height approx: 6.5 ft.
- Width aprox: 2.5 ft.
- Weight approx. 700 lbs.

Motor Starting Considerations

Various Starting Methods

Capacitor Starting

Reduction in starting current AND starting torque.

Lower cost than some other methods.

Capacitor vs DOL:

1 additional breaker per capacitor

1 capacitor

+ Capacitor supplies reactive power to the network, increases PF during starting

+ Lowers voltage drop in the network.

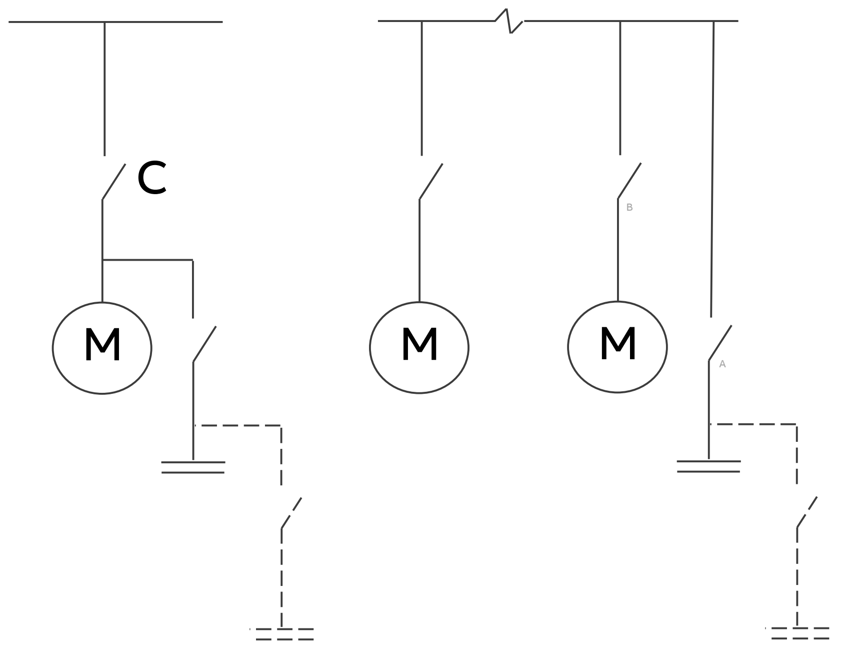
+ Motor may produce nominal starting torque during start-up

- If incorrectly dimensioned Capacitor, motor may get overvoltage into the motor terminals

- Requires relatively large Capacitor-more space (related to the motor power)

- Low risk of resonances between Capacitor and network (always checked during design phase)

Capacitor connected into motor or bus.



Motor Starting Considerations

Various Starting Methods

Autotransformer Starting

Reduction in starting current AND starting torque.

Lower cost than some other methods.

Autotransformer vs DOL:

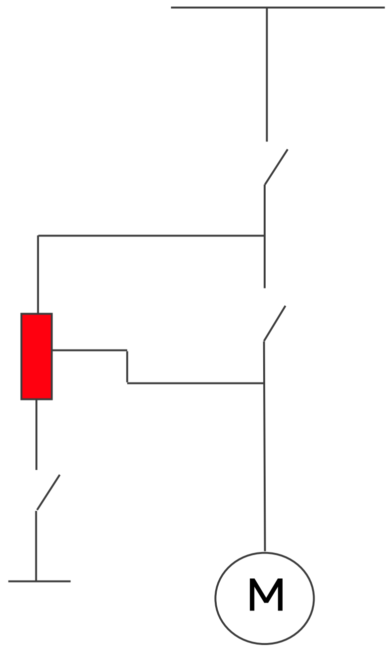
+ Reduces/limits starting current taken from the network

+ Higher torque/current ratio than other RVS methods. Torque is reduced *directly* proportional to current.

+ Lowers voltage drop on the network.

- Motor produces lower starting torque (due to the reduced voltage starting)

- More expensive than reactor starting



ABB