

USE OF SOFT STARTERS FOR THREE-PHASE SCROLL COMPRESSORS

1 Introduction

The design of the Copeland Scroll ensures that the internal compression components start unloaded, even if system pressures are not balanced. Since the compressor's internal pressures are balanced at start-up, low voltage starting characteristics are excellent. The 3-phase peak amplitude typically occurs over a period of less than 50ms (Fig 1). Nevertheless, the starting current of compressors may cause undesirable voltage fluctuations. The alternative to a full voltage start is some sort of acceleration control called "soft starting". Local regulations may require that all new motor installations above a certain size incorporate a means of soft starting the motor. There are several different approaches to soft starting. Today electronic soft starts are widely used, whereas previously intermediate resistors were the standard method. Information is provided on both types.

Electronic soft starts and intermediate resistors are not provided by Copeland.

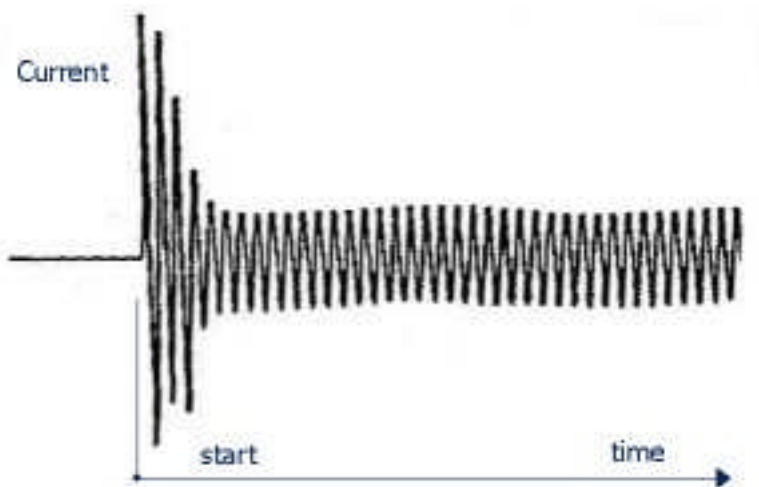


Fig 1. Typical starting characteristic for 3-phase scroll compressor

2 Three-Phase Soft Starting

Smaller Copeland scroll compressors will start with 20% of the nominal torque available from the motor. Models in this category include:

- Air Conditioning Scroll ZR22 – ZR81
- Air Conditioning Scroll ZP23 – ZP83
- Refrigeration Scroll ZF06 – ZF18
- Refrigeration Scroll ZS15 – ZS45
- Refrigeration Scroll ZB15 – ZB45
- Heat Pump Scroll ZH15 – ZH45

Torque is proportional to (voltage)². Hence the voltage can be reduced according to the following equation:

$$V_S^2 / V_N^2 = 0.2$$

where V_N is the nominal voltage (e.g. 400V) and V_S is required minimum voltage to start the compressor. From this, the minimum voltage V_S is derived as 179V for a nominal 400V. In order to allow safety margin a minimum voltage of 200V is recommended. The voltage can safely be reduced to 200V during the start cycle. With voltage reduced from 400 to 200V the locked rotor current will be reduced by a factor of 2. This value, in amps, is termed the minimum starting current, I_S .

For larger scroll models, the voltage and hence the starting current may be reduced by a factor of 1.8. The minimum recommended starting voltage for a 400V nominal compressor is 220V.

Models in this category include:

- Air Conditioning Scroll ZR90 – ZR380
- Air Conditioning Scroll ZP90 – ZP385
- Refrigeration Scroll ZF24 – ZF48
- Refrigeration Scroll ZS56 – ZS11M
- Refrigeration Scroll ZB56 – ZB220
- Heat Pump Scroll ZH56 – ZH11M

2.1 Electronic Soft Starts

These may be used. The above minimum voltage and current values should be used for their selection. The ramp up period should be less than 1 second (typically 0.8 secs), after which the device should be effectively out of circuit. The customer should check that the compressor starts under normal system conditions with the device in circuit.

Ramp down should not be necessary. If used the ramp down should also be less than one second.

2.2 Resistor Soft Starts

The first method to be developed utilises intermediate resistors which are in circuit during the starting cycle. The voltage at the motor terminals and the starting current are both reduced. The motor torque is also reduced. After the motor has started the resistors are by-passed.

The value of the resistors can be calculated and the value of the power factor at locked rotor (P_f) is required. The value of the required intermediate resistor, per phase, is calculated from the following equation:

$$R = \left[\left[\frac{V}{I_S} \right]^2 - \left[\frac{V \sqrt{1 - P_f^2}}{I_L} \right]^2 \right]^{1/2} - \frac{V \cdot P_f}{I_L}$$

Where:

R = Intermediate resistor per phase, ohms

V = voltage per phase, V (e.g. 230V per phase for nominal 400V 3-ph supply)

I_L = Locked Rotor Current, amps

I_S = Minimum starting current, as defined above, amps

P_f = Power factor at locked rotor conditions