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TYPE	RGZESD
H.P.	30.0
AMPS.	35.0
R.P.M	1765
DUTY	CONT 40°C AM
CLASS INSUL	F
NEMA DESIGN	B
SH END BRG	50RU03K30

FRAME	286T
SERVICE FACTOR	1.15
VOLTS	460
HERTZ	60
DATE CODE	
KVA CODE	G
NEMA NOM. EFF	93.0
OPP END BRG	50BC03JPP3

Molded Case Circuit Breakers

Troubleshooting Nuisance Tripping

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Introduction

The Energy Independence and Security Act of 2007 (EISA) passed by Congress and signed into law December 19, 2007 mandates efficiency standards for general-purpose, three-phase alternating current industrial motors from 1 to 500 HP NEMA Design A & B that are manufactured for sale in the United States after December 19, 2010. Premium efficiency motors consume less power by lowering the full load amperes (FLA) of the motor and are typically 2% - 8% more efficient than standard motors. A side effect of the premium efficiency design is to increase the motor inrush or locked rotor amperes (LRA) from the normal 6 times FLA to 9-14 times FLA. This shift in the motor market may impact the selection and the performance of industrial motor control and protection equipment. The purpose of this paper is to expand on the effects of increased inrush which may result in nuisance tripping of molded case circuit breakers.

What's the Code?

NEC 430-52 (C) (1) specifies the maximum values of fuses or circuit breakers which can be used to protect motor branch circuits. An inverse-time breaker (thermal-magnetic breaker UL489 MCCB) can be selected at a maximum of 250% of full load current. The values do not change for Design B "energy efficient" motors as compared to the classic Design B motor.

The same section of code allows for selection of an instantaneous trip breaker (magnetic only or MCP) with the maximum values of 800% (8 x FLA) Design B and the maximum increases to 1100% (11 x FLA) for Design B energy efficient motors. So, a thermal-magnetic or a magnetic-only molded case circuit breaker can be selected per the NEC to provide short-circuit protection for a motor.

Determining possible causes

The selection of the instantaneous trip breaker (magnetic only or MCP) may be increased because of increased inrush. It should be noted that thermal-magnetic circuit breakers are UL listed while magnetic-only breakers are only UR approved. Instantaneous (magnetic-only) trip breakers must be tested by UL with the specific contactor and overload relay to be used in order to comply with NEC and UL. UL testing is also required to apply high fault current ratings (KAIC) to the assembled starter. This is why Sprecher + Schuh utilizes thermal-magnetic breakers as a standard in our classic Combination Circuit Breaker starters.

When a thermal-magnetic breaker trips during start-up and the overload does not trip, the first task is to determine if there has been a short-circuit condition in the motor or in the feeder circuit. Thermal-magnetic molded case circuit breakers have two separate tripping mechanisms.

- The thermal tripping mechanism consists of a set of bimetallic elements which are heated as current passes through. Current greater than 120% but less than 10 times FLA.
- The magnetic tripping mechanism is a solenoid that will only respond to higher short-circuit currents which are on the order of 10 x FLA.

If nuisance tripping is suspect, the first question that the Sprecher + Schuh Tech Support Team is likely to ask is "How many seconds between pressing the start button and the breaker tripping?". If the answer was minutes after starting, then we have to ask; "Why didn't the

overload relay trip since it should take care of any overcurrent condition up to and including locked rotor current (LRA - which is assumed to be 6 x FLA)?". The breaker should only trip in case of a short-circuit. It's all about response time per the published time-current curve for the molded case circuit breaker. A trip within 1-2 seconds of pressing the start button suggests that the breaker experienced currents large enough to cause the magnetic trip mechanism to trigger. If we find no damage resulting from short-circuit then nuisance tripping becomes a possibility to consider.

The next step is to determine the magnetic response setting of the breaker. Most thermal-magnetic circuit breakers 200 amps and larger have three potentiometers at the bottom of the breaker which are adjustable from 5-10 times the thermal trip value. If nuisance tripping is suspected; set the magnetic trip value to 10x and try it again. This means that it takes a 2000 amp surge of current to operate the breaker instantaneously. If the breaker trips again instantaneously or in 1-2 seconds then the next step is to look at the motor nameplate and determine two things: the motor design type and Inrush.

Is the motor the problem?

The motor design type, which is normally Design B (but could be Design B Energy Efficient). Energy efficient motors have a lower FLA than classic design of motors and a larger inrush (> 6 x FLA) is to be expected. More specific information concerning inrush can be determined from the 'Start KVA/HP Code'. This code is an alphabetic letter and usually labeled simply "Code" on the motor nameplate.

Let's take for example Code "F" then we reach for our handy "Electrical Engineering Pocket Handbook" as distributed by EASA shops and from the applicable chart we find that the code represents the value 5.0-5.6.

NEMA CODE LETTER	LOCKED ROTOR KVA PER HP*	NEMA CODE LETTER	LOCKED ROTOR KVA PER HP*
A	0-3.15	L	9.0-10.0
B	3.15-3.55	M	10.0-11.2
C	3.55-4.00	N	11.2-12.5
D	4.00-4.50	P	12.5-14.0
E	4.50-5.00	R	14.0-16.0
F	5.00-5.60	S	16.0-18.0
G	5.60-6.30	T	18.0-20.0
H	6.30-7.10	U	20.0-22.4
J	7.10-8.00	V	22.74 and up
K	8.00-9.00		

NEMA Standard MG 1-10.37.2
* Locked KVA per horsepower range includes the lower figure up to, but not including, the higher figure. Fore example, 3.14 is designated by letter A and 3.15 by letter B.

Determining Maximum FLA

The same page in our reference should have the following formula:

$$\text{Start. Kva per HP} = \frac{\text{Volts x Locked-rotor Amp}}{\text{1000 x HP}} \times \begin{cases} \text{1 for 1-phase} \\ \text{2 for 2-phase} \\ \text{1.732 for 3-phase} \end{cases}$$

Or we might shorten to the following formula

$$\text{Code (value)} = \frac{\text{Volts x LRA}}{\text{577 x HP}}$$

Then we can turn the above formula into the following formula:

$$\text{LRA} = \frac{\text{Code (value) x HP x 577}}{\text{Volts}}$$

Let's make an example to work through the math as follows:

- 100 HP motor @ 460 VAC
- FLA from motor nameplate 114 Amps
- Design B
- Code F (which we determined has a max. of 6.3)

So, plugging in known values we get

$$\text{LRA} = \frac{\text{5.6 x 100 x 577}}{\text{460}} = \text{702 Amps}$$

Comparing 702 LRA to the 114 FLA we find the inrush to be 6.2 X FLA which is more than the standard motor data (as represented in UL and NEC) which is assumed to be 6 x FLA.

It is important to note that the FLA chart found in the contactor introduction pages of our North American Industrial Controls catalog was extracted from NEC 430-148 & 150 and it indicates a 100 HP @ 460 VAC should have an FLA of 124 Amps. NEC and similar charts in UL standards assume that motors are Design B with 6 x FLA. These charts have not changed at all since EISA was passed by Congress and in fact the FLA of this motor is indicated to be 114 amps. The HP to FLA charts from NEC and UL are in effect yesterday's news and out-of-date compared to motors being shipped today. Normally, a small decrease in FLA will not change the choice of overload relay and similarly not affect the choice of the magnetic setting of the molded case circuit breaker.

Most motor control personnel have historically agreed that the optimal choice for sizing a thermal-magnetic breaker is 150% of the FLA. The 150% choice is well below the maximum 250% set by NEC430-52.C.1 and the time current curve should easily allow for starting and running of the motor under normal conditions. Some molded case circuit breaker

people might suggest that a magnetic-only circuit breaker would be better suited for a motor application. The fact is that UL requires that a UR approved magnetic-only circuit breaker must be tested with the contactor and overload to be labeled as UL508A Industrial Equipment Approved. On the other hand UL Listed molded case circuit breakers do not have to be tested with the respective contactor and overload relay to be approved under UL508A or to receive a Short Circuit Current Rating (SCCR). So either magnetic-only breaker or molded thermal magnetic breaker may be used for short-circuit protection if selected properly.

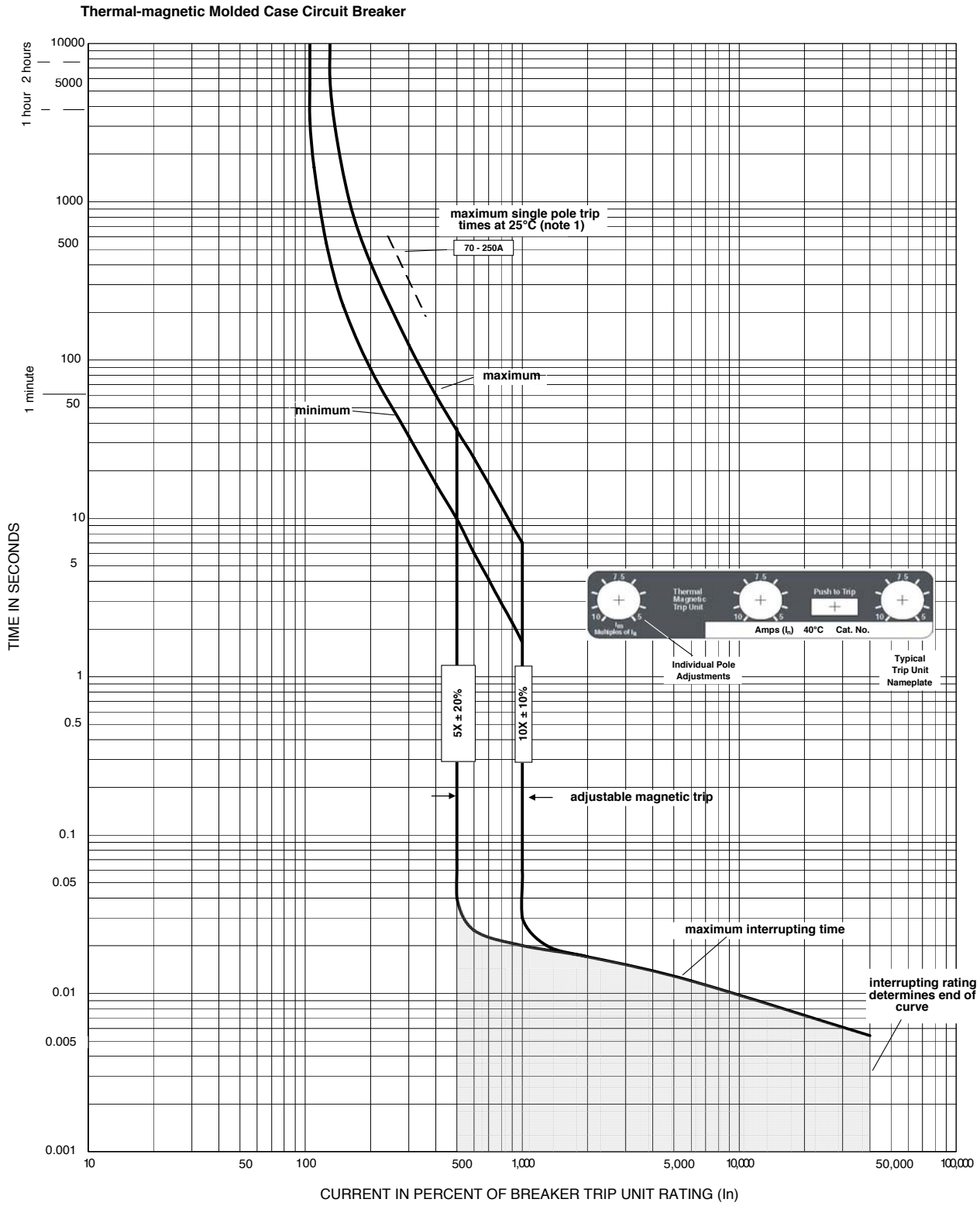
The problem in our example is that our customer reported that the 200Amp (175% x FLA) breaker in the example continues to trip immediately on start-up. So, Tech Support called the pump & motor manufacture's representative and ask for the locked-rotor inrush current of this motor. After consulting with the manufacturer in India the representative came back with value of 1107 amps. 1107 LRA compared to 114 FLA results in a 9.7 X FLA inrush. This is hardly representative of Code 'F' as marked on the motor nameplate but rather should be marked with Code 'K'. The incorrect code on the motor nameplate didn't help our effort to determine the reason for the breaker tripping but now we have a confirmed LRA value and we should be able to solve this problem. By now the 200 Amp breaker magnetic dial is set for 10 or 2000 amps. Tech Support acquired the time current curve for the breaker from the manufacturer (Figure 1).

Most breakers have the X-axis as "current in percent of breaker trip unit rating" so in our example 1107/200 = 554%. A look at the time-current curve indicates that the 200 amp breaker should hold 1107 amps for 25 seconds before tripping. The 200 amp breaker should not be tripping immediately in this application but it does trip intermitently (about 30% of the time). So, we replaced the breaker with a 225 amp breaker and set the magnetic trip at 10 times 225 amp or 2250, which allows for a slightly greater inrush than the 200 amp breaker set at 2000 amps. The tripping problem was solved.

Conclusion

Some few motors are not labeled properly and have high RMS inrush but depending on factors which are not clearly identified can cause nuisance tripping probably caused by peak inrush values for the first few cycles at start. We expect to see more issues involving high inrush motors.

Figure 1: Typical Motor Time Current Curve



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