DUAL-ELEMENT TIME-DELAY CLASS J FUSES FOR

PROTECTION OF MOTOR CIRCUITS UTILIZING

IEC CONTROLLERS

by

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I. Introduction

The motor controller plays an extremely important role in the operation and protection of motors and motor circuits. The importance of motors and motor circuits in the everyday operation of commercial and industrial facilities demands the need for proper protection.

Several factors can determine the optimum performance of a manufacturing facility. Included in these factors, but not limited to them, are the ability to meet production schedules, and the ability to reduce operating costs. This paper will analyze one method of protecting IEC (International Electrotechnical Commission) controllers to enhance these two important factors necessary for optimum performance.

Proper protection requirements dictate that controllers, motor circuits, and the motor should be protected from short circuit damage, overload damage, and single phase damage. No design scheme, no matter how expensive or well planned, can prevent short circuits, overloads, or single phasing. However, the designer does have the ability to protect against the damage caused by these overcurrent conditions. This paper will offer the following recommendations to achieve optimum protection.

1) The IEC philosophy of Type 2 coordination requires "no damage", short circuit protection of the IEC controller. The controller must be capable of being placed back into service following short circuit tests per the IEC publication 947-4 [1]. U.L. (Underwriter's Laboratories) Time Delay Class J fuses can provide Type 2 protection. (The other level of protection is Type 1, which will normally allow damage that requires replacement of the controller).

2) The North American philosophy of "back-up" motor overload protection offers the components a second level of protection from overload and single phase damage. The significance of this back-up philosophy becomes apparent should the controller fail to open the circuit. Welded contacts, or miscalibrated relays are two reasons this can happen. Dual-Element, Time-Delay fuses sized slightly larger than the overload relay, will provide this extra level of protection for most commercial and industrial motors.

II Branch Circuit Protection Alternatives

Several protection alternatives are available to the original equipment manufacturer, or system designer. Table I lists the most popular alternatives, and their sizing (rating) philosophies based on motor full load current (FLA).

Table I

Device Type	Rating % of (motor FLA)	Level of Protection	
		IEC Type	Description
Motor Circuit Protector	700%	"1"	Short Circuit only
Fast Acting, Silver Sand* Fuses	300%	"2"	Short Circuit only
Dual-Element, Time-Delay Class J**	125%	"2"	Short Circuit Back up single phase Back up overload

*This refers to the fuse's construction of pure silver links (99.9% pure) and a sand filler material.

** Class J Fuses are currently under consideration for inclusion under IEC publication 269.

The balance of this paper will compare the performance of motor circuit protectors, fast acting fuses, and Dual-Element, Time-Delay fuses, per the guidelines in Table I. This analysis will be based upon how well each of these devices protects the motor controller, the motor circuit components, and the motor. We will refer to Figure 1 to aid in our comparisons. This reflects components used in a typical 10HP, 3Ø, 460 volt, 14 Amp, 1.15 S.F. motor circuit.

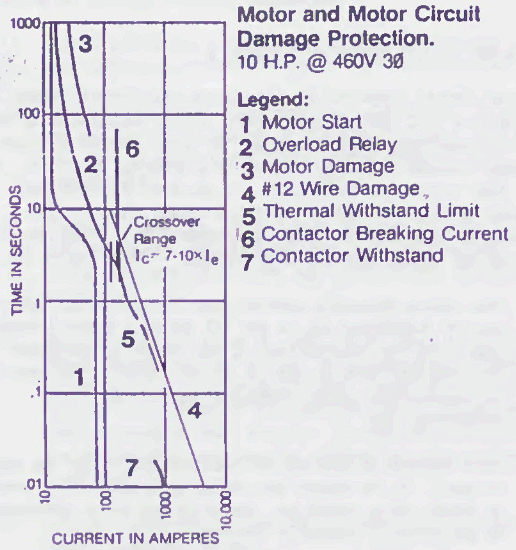

Figure 1.

This figure illustrates several characteristics that should be identified:

Controller - Overload Relay (2)
Contactor Breaking Current (6)
Crossover Range (I_c)
Thermal Withstand Limit (5)
Contactor Withstand (7)

Motor Circuit - #12 Wire Damage (4)

Motor - Motor Start (1)
Motor Damage (3)

Now let's compare the performance of various protective devices.

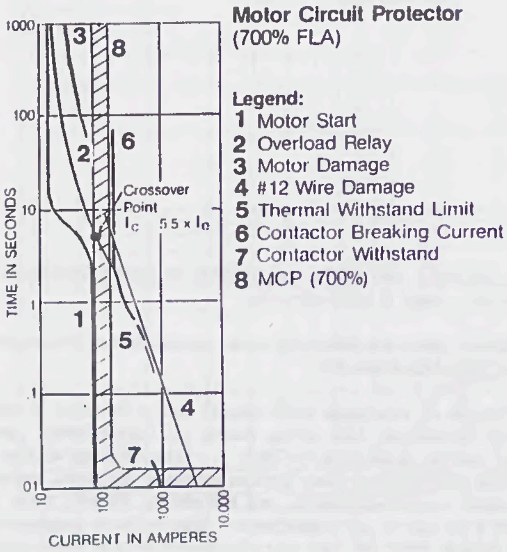

Figure 2.

1. Motor Circuit Protector - Figure 2

A motor circuit protector is a magnectic only (short circuit only) device that will operate under short circuit conditions in excess of its instantaneous trip setting. To allow a motor to start, and prevent nuisance tripping, typical trip settings are 700% - 1300% [2] This device typically takes 1/2 cycle of short circuit current to operate. Unless otherwise noted, these are not considered to be current limiting devices. This brings up two significant points relative to protection - (Note Figure 2)

a. This device typically affords Type "1" protection under short circuit conditions due to the 1/2 cycle or greater opening time (Note the intersection of the contactor withstand curve with the MCP curve at the .01 second level) This type of protection will require complete replacement of the controller, and

b. MCP's provide no back-up overload protection for the motor circuit. If the relays are unable to operate in an overload or single phase condition, the motor and other components can be subjected to excessive heating.

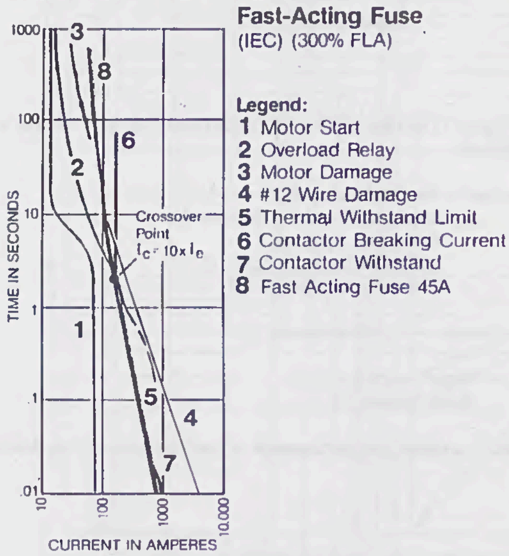

Figure 3.

2. Fast Acting, Silver Sand Fuses. Figure 3

A fast acting fuse is one whose characteristics do not exhibit intentional, built-in time delay during harmless inductive surges (motor starting currents, transformer magnetizing current etc). Because of this lack of time delay, fast acting fuses are typically sized at 300% [2] of motor FLA, to prevent nuisance tripping on motor start-up. However, unlike the MCP, they can exhibit superior short circuit performance due to the silver strips and sand filler material. This is referred to as current limitation. When operating in their current limiting range, these fuses can reduce the damaging energies associated with short circuits. If the characteristics are fast enough, they can protect the motor circuit components, and the motor controller. In many cases, these fuses may provide Type 2 protection for the controller. Two significant points relative to protection can be made here - (Note Figure 3)

a. Let-thru energy for fast acting fuses, although within type 2 limits, will generally be higher than properly sized, lower rated time delay fuses of the same class.

b. Fast acting fuses sized at these values offer no back-up overload protection for the motor circuit. If the relays are unable to operate during an overload or single phase condition, the controller and other components may be subjected to excessive heating, and damage.

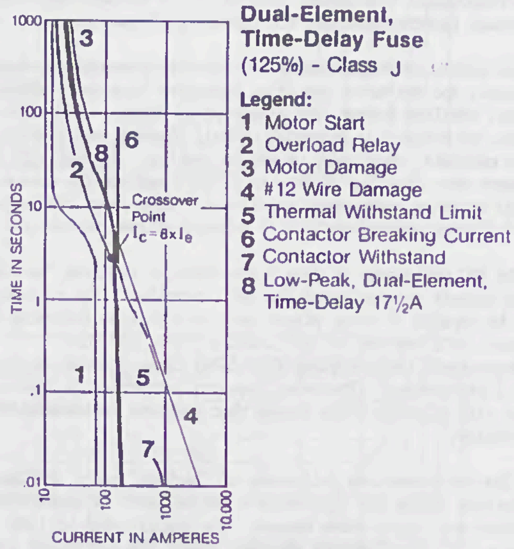

Figure 4.

3. Dual-Element Time Delay Class J Fuses (Figure 4)

A Dual-Element Time-Delay fuse is one whose characteristics have an intentional, built-in delay to withstand harmless inrush currents. This Dual-Element design has two separate elements inside one fuse tube. A spring activated trigger assembly with a heat absorber operates during overloads and single phasing, when sized properly to protect against these conditions. A second element, comprised of a short circuit strip (typically siver) surrounded by sand, operates under a short circuit condition to protect from damaging high fault currents. Short circuits typically occur during the initial start-up of a piece of equipment, or when a maintenance man is working on the quipment.

Sizing Dual-Element Time-Delay Class J fuses at 125% [2] of motor FLA, or the next size larger if 125% does not correspond to a fuse size, affords several distinct protection advantages to the controller, motor circuit, and motor (Note Figure 4)

a. They provide Type 2 protection under short circuit conditions, due to their excellent short circuit let-thru values. This type of protection does, by definition, require that the controller be reusable following fuse replacement. Note that relay calibration shall not be affected.

b. They provide practical, inexpensive back-up overload protection for the motor circuit. If the relays are unable to operate in an overload or single phase condition, properly sized fuses will open before the motor damage curve is reached. This sizing philosophy is based on the fuses and relays being sized upon the actual running current of the motor, if the motor is not fully loaded, or the motor nameplate current.

A further study of Figure 4 shows that several other benefits are established when utilizing 125% sizing:

c. The Dual-Element Time-Delay design allows the motor to start up, even though 125% sizing is used.

d. The motor circuit conductors are protected from short circuit and overload damage.

e. Contactor withstand and contactor heating curves are within the protection capabilities of the fuse (which relates directly to Type 2 protection).

f. The crossover point (Ic) is between the optimum coordination limits of 7-10 times contactor ratings. For overloads up to this value, the relay should operate first. If the relays do not operate, for whatever reason, the backup Dual-Element Time-Delay Class J fuse will open before the motor damage curve is reached. For short circuits above this value, the fuse short circuit element will operate, protecting the motor controller and components from damage.

III. Additional Benefits of Back-up Overload Protection

This paper has dealt with the Class J protection advantages of the motor circuit and its components. There are other economic considerations that make this back-up overload philosophy attractive. These include:

- Reduced downtime
- Reduced installation costs

1. Reduced Downtime

Burned out motors are often the result of improper protection. Overloads and single phasing are major causes of these failures. If overload relays become miscalibrated, the motor loses a major degree of overload protection. If the contacts in the motor controller weld, the relays will offer no protection for the motor. Back-up overload protection with Class J fuses will operate independently of these controller problems, and protect the motor from overload and single phasing damage - protection that is impossible with 300% sizing of fast acting fuses, and 700% sizing of MCP's.

There is less downtime, and lower replacement costs, in changing Dual-Element Time-Delay Class J fuses, as opposed to changing a burned out motor. The type of facility and the processes involved will determine what the downtime can cost.

2. Reduced Installation Costs

Sizing Class J Dual-Element Time-Delay fuses for back-up protection will result in lower fuse ratings than those sized at 300% of motor FLA. This may result in lower fuse costs, lower fuseblocks or disconnect costs, and less space.

To explain let's look at an example:

10HP, 460 Volt, 3 Phase Motor
14 Ampere FLA

Alternative A - Fast Acting Fuses sized at 300%

		Cost * extended
3 - 40A Fuses		$42.09
1 - 3 Pole 60A Block		15.82
	Total Cost	$57.91

Alternative B - Dual-Element Time-Delay Fuses sized at 125%

		Cost * extended
3 - 17-1/2 A Fuses		$22.11
1 - 3 Pole 30A Fuseblock		15.41
	Total Cost	$37.52

* Suggested resale of one manufacturer's product.

The use of Dual-Element Time-Delay fuses has reduced the initial installation cost of these devices by 35%.

IV. Summary

IEC controllers, motor circuit components, and motors can be damaged due to overcurrents. The specification of Class J Dual-Element Time-Delay fuses offer several advantages, if sized for back-up overload protection.

1) Type 2 protection, under short circuit conditions, for the controller.

2) Back up protection under overload conditions. If the relays are miscalibrated or the contacts weld, the fuses can open to protect the motor, motor circuit, and controllers.

3) Back-up protection under single phasing conditions. If the relays are miscalibrated for the contacts weld, the fuses will open to protect the motor, motor circuit, and controller.

4) Reduced downtime after an overload or fault condition. Resetting of overload relays, or replacement of back-up fuses, is more cost effective than replacing motor circuit components, or a burned out motor. This "second line of defense" will decrease the need to replace burned out motors that have seen an overload or single phase condition.

5) Reduced installation cost due to lower fuse ratings and lower fuseblock ratings.

No other overcurrent protective device offers all of these advantages in protecting motor circuits which utilize IEC controllers.

REFERENCES

[1] IEC Publication 947-4: Low Voltage Switchgear and controlgear, Part 4: Contactors and Motor Starters.

[2] National Fire Protection Association' NFPA 70-1990 "National Electrical Code"