

## Introduction

A low overload is like a low-grade fever; it doesn't cause immediate death but it indicates that something is wrong, and it can cause damage if allowed to continue. It can cause localized overheating, weaken the spring clips or damage the plating on fuse holders and increase their contact resistance. It can melt the solder on surface-mount fuses. It can melt plastic housings and make fuses impossible to remove.

## The Problem

Currents between 110 and 135 percent of fuse ratings present a severe challenge to the designer because they can subject parts to high heat for extended periods of time, and because fuse behavior at these currents can be difficult to predict.

If the fuse does not blow before damage occurs there can be claims under warranty and additional cost for service to the customer; it might even be cause for a product recall, depending on the damage and characteristics of the incident.

Low overloads can be caused by deterioration in insulation, increased mechanical resistance causing motors to draw excessive current, and the list goes on.

Fuses behave in predictable ways when subjected to substantial overloads or short circuits, but low overloads exist in a less-predictable realm. For example, at 110 percent of rating a MINI<sup>®</sup> automotive fuse will open somewhere between 100 hours and never. At 135 percent of rating the fuse opening time is between 0.75 seconds and 10 minutes. Published curves of clearing time versus percent of rated current are available from the fuse manufacturer, however typically they apply to overloads in excess of 150 percent, and they show only average characteristics. In fact low-value overloads are not generally considered part of the fuse specifications.

## Applicable Standards

Another source of difficulty is that different technical standards for fuses prescribe different behaviors at low overloads. For example, with one exception (see below) it is impossible for a fuse to satisfy both UL/CSA and IEC ratings. The IEC 60127 Standard calls for a fuse to operate continuously at 100 percent of its rating; a fuse made to UL/CSA/ANCE 248-14 and operated at its rated current will eventually open. For this reason UL fuses are customarily operated at no more than 75 percent of their rated current.

To add to the confusion, automotive fuses are often rated per SAE J2077, which prescribes an opening time of at least 100 hours at 110 percent of rating, but between 0.75 seconds and 10 seconds at 135 percent.

The table below compares opening times prescribed by several standards.

Percent of Rating	SAE J2077 MINI <sup>®</sup>	UL & CSA STD 248-14	IEC Type F Sheet 1, 2	IEC Type T Sheet 3	IEC Type 5 Sheet 5	METI B
110	100 hrs min	4 hr.				
130						1 hr min
135	0.75 s to 10 min.	60 min. max				
150			60 min. min	60 min. min	60 min. min	
160						1 hr max
200	0.15 s to 5 s	2 min. max				2 min max
210			30 min. max	2 min. max	30 min. max	

Despite all the contradictions, there has been one small bit of progress toward consolidation of standards. IEC Publication IEC 60127-4, Universal Modular Fuse-links (UMF) – Through-hole and Surface Mount Types, has been accepted by UL/CSA, making it the first global fuse standard. Note that it uses different fusing gates from IEC 60127-2; fuses must not open in less than one hour at 125 percent of rated current and must open within two minutes at 200 percent of rated current.

## Solutions

When designing a vehicle, consider the effect of an overload small enough that a fuse might not blow for an hour or more. Can the vehicle survive the localized hot spots that may develop?

Fuse selection can be a balancing act between nuisance blowing and lack of protection. In general, select the fuse type and rating so that any foreseeable overload will be sufficient to blow the fuse before damage is done. Pay close attention to the standards that apply to the particular case, but be sure to apply those standards intelligently.

There are protective devices for automotive applications that in some ways resemble fuses, but are intended to provide only short-circuit protection; they are not characterized for low overloads, and provide little or no protection in such situations. The figure shows that under an overload less than 200% the wire will fail before such a protector opens. A true fuse, on the other hand, provides protection across the full current range.

## Benefits

The benefits of choosing the correct fuse are what one would expect: Customer satisfaction, fewer occurrences of nuisance blowing, improved safety, and more reliable products.

## Product Recommendations

The following table lists a number of Littelfuse families, the standards that apply to them, and their opening time at or near 135 percent of rating. The product to use depends on circuit characteristics and the device that needs protection.

Fuse family	Applicable standards	Opening time (at 135% except as noted)
ATO®-32 V Fuse	ISO 8820-3, UL 248-14	0.5 s to 10 min (Per LF specification)
BF Inline		1.5 min to 30 min (at 150%)
BF1-32V, 58V Fuse	ISO 8820-5, UL 248 Special Purpose Fuses	5 min to 60 min (at 150%)
BF2-58 V Fuse	ISO 8820-5, UL 248 Special Purpose Fuses	100 to 250A: 2 min to 30 min 300 A: 1 to 15 s (at 200%)
CablePro® Fuse	SAE J1127(4 & 6 AWG) & SAE J1128(8 and 6 AWG)	2 min to 30 min
FK3 MAXI® Fuse	DIN 72581/3E, SAE J 1888, ISO 8820-3, UL 248 Special Purpose Fuses	1 min to 30 min
FKS ATO® Fuse	DIN 72581-3C, ISO 8820-3	0.75 s to 30 min
TAC ATO® Fuse	DIN 72581-3, UL 248 Special Purpose Fuses, cULus Recognized: File No. E211637	0.75 s to 30 min
JCASE® Fuse	ISO 8820-4	1 min to 30 min
MAXI™ Fuse	DIN 72581-3E, SAE J888, ISO 8820-3	1 min to 30 min
MEGA® Fuse	ISO 8820-5	40 to 250 A : 2 min to 30 min 300 to 500 A: 15 s MAX
MIDI® Fuse	ISO 8820-5	1.5 min to 60 min (at 150%)
MINI® Fuse	SAE J2077, ISO 8820-3	0.75 s to 10 min
TOE ATO® Style Fuse	DIN 72581-3, UL 248 Special Purpose Fuses, cULus Recognized: File No. E211637	0.75 s to 30 min