SYSTEM PROTECTION DIVISION

G&W ELECTRIC CO.

APPLICATION GUIDE for the

PAF®

Power Assisted Fuse

The G&W Electric Company PAF® Power Assisted Fuse is a very high continuous current protection device with current limiting capabilities. It offers standard ratings of 200, 300, 400 and 600 amperes continuous at voltages of 2.8, 5.5, 8.3, 15.5, 27 and 38kV. Its standard interrupt rating is 40kA rms, symmetrical. Special versions are available for a higher interrupt duty. Please refer to the catalog for a basic description of the device's operating means.

USES:

The fuses are commonly applied to protect underrated switchgear lineups. They also permit the specifying of lower rated switchgear on new installations as an effective cost savings tool. They protect capacitor bank switches while handling the high frequency inrushes of that bank.

PAFs may be used for bypassing of reactors to eliminate voltage regulation problems and losses. By paralleling the reactor with a PAF, the user maintains system continuity in the event of a fault and the equivalent protection levels of the reactor but eliminates the reactor's negative effects.

The PAF is also an effective damage limiter and can potentially prevent the secondary catastrophic failure of fluid-filled enclosures or minimize damage to extremely expensive cogeneration equipment, drive systems or large motors.

OPERATING CHARACTERISTICS:

The PAF utilizes a triggering scheme to initiate the interruption process. A pyrotechnic charge (non-venting) is used to sever the primary conductor and insert the current limiting element. One must therefore be aware of the device's triggering response characteristics in order to ensure its proper application.

There are 2 primary means of triggering the standard version of the PAF®. First, it will trigger in the event that the sensing element is melted. This generally occurs on lower level faults in which

the PAF will not be operating in its current limiting mode. This is essentially governed by the minimum melt and total clearing curves provided for these units which begin at .01 seconds.

The second triggering means is responsible for the device's low let-thru characteristic despite the high continuous current rating. The PAF will also trigger in response to a high instantaneous current through the device without melting of the sensing element. What this means is an extremely quick response and current limitation at higher fault levels.

Since the "standard" PAF can respond in such a manner it is necessary to judge the application based upon the peak instantaneous inrushes that it is intended to pass without a response. If no substantial inrushes are present one may generally apply the device in accordance with its continuous current rating. Where substantial inrushes to motors, transformers or capacitive charging may be a factor one may need to apply a somewhat higher rated fuse (600A continuous) or a specialized device (such as the desensitized PAF). It should be pointed out that the let-thru levels of even the highest rated device are generally regarded as quite low for most protection requirements.

THE DESENSITIZED PAF®

The following is a description of the "desensitized" PAF®. It is only available as a 600A rated unit. Its operation is like that of the standard version, but with increased inrush capability. The "standard" unit can trigger by virtue of reaching the required melting I^2t of the sensing element or by reaching an instantaneous current value whereby the voltage drop across this sensing element is sufficient to cause triggering. The "desensitized" unit is triggered by virtual melting of the sensing element. It is better judged by the melting I^2t of the wave. It is designed to handle inrushes of 490,000 Ampere-squared-seconds or greater in the .01 second (or less) timeframe.

The "desensitized" unit has greater inrush capability when assessing capacitor bank inrush applications with high magnitude, high frequency (but limited I^2t) waveforms which would trigger the standard design. It also has enhanced inrush capabilities when assessing peak transformer magnetization currents.

The "desensitized" version is rated for a higher interrupt duty of 60kA rms, sym. instead of 40kA for the "standard." "Desensitized" units utilize dual shunt fuses and have a width of 7.5 in. with 6 in. over the exposed terminals. The dual shunt fuses result in a somewhat higher let-thru current. Consult factory for let-thru characteristics and availability.

INTERRUPT CAPABILITIES:

The PAF is tested in accordance with applicable portions of NEMA and ANSI standards. The PAF shunt fuse and interrupter combination is "full-range" from the standpoint that it will clear steady state circuits meeting the Series 3 test requirements for current limiting fuses in ANSI C37.41. The shunt fuses, however, are of a "back-up" type, meaning that they will clear fault currents and overloads of certain types. They will clear continuous currents under conditions prescribed in C37.41, down to a 100 ampere minimum. They may not clear the residual currents, not meeting this criteria, following a transient triggering of the interrupter. This could result in a failure of the shunt fuse.

COORDINATING WITH THE INRUSH OF DOWNSTREAM DEVICES:

MOTORS - When assessing motor inrushes one should look at the asymmetrical crest of the starting currents (not the rms value) for the short term. The starting currents should also be evaluated against the minimum melt curves for the longer term conditions while accelerating the mass. Since there is much variance in motor design it is suggested that the motor manufacturer be contacted.

TRANSFORMERS - Current limiting fuses are commonly applied with transformers with the stipulation that the fuse be capable of carrying 12 times the continuous current rating of the transformer at the 0.1 second mark of the minimum melt curve. It must also carry 20 times the continuous current value at 0.01 seconds. A proper application of the PAF necessitates a 3rd parameter. Since the above values are rms values and the PAF responds to instantaneous currents as well, one must assess the peak inrush of the 1st major loop which is often well beyond these values. The instantaneous peak currents (which are predominantly heavy in 2nd harmonic content) may reach 30 times the rms, sym continuous current value or even higher. If this exceeds the instantaneous response characteristic of the PAF, it will fire undesirably.

The peak inrushes are dependent upon the residual magnetism of the core. The higher the current level when last deenergized, the higher the residual magnetism level and in-turn, the inrush. It is a statistical phenomenon (dependent on the interrupt and closing angles) as well as a characteristic of the transformer's manufacture. The high peak inrushes during a re-energization are a result of saturation of the core in response to the level of residual magnetism. In short, if currents substantially beneath the continuous current rating of the transformer are expected, the multiplier of 30 times may be excessively conservative.

CAPACITIVE CHARGING - Usually one is concerned with capacitor banks when evaluating the PAF for capacitive inrush capability. This can be readily determined from ANSI guidelines established in standard C37.012.
One should also consider an often neglected characteristic in the system. This is the capacitive charging of "stray" or "lumped" system capacitances. These are the bushings, bus, cables etc. They typically are a modest level of capacitance; however, they can cause substantial currents at rather high frequencies. It is most likely to cause a problem when energizing an adjacent bus through a tie breaker where little reactive impedance exists between these 2 buses. It is similar to a back-to-back capacitor switching case for analysis purposes.

One other phenomenon which bears notice is the switching characteristic of the system. Restriking switchgear on capacitive systems can yield a multiplying effect on bus voltages and subsequent transient current waveforms. This is not uncommon during the interruption of a capacitor bank and has the potential of occuring during the prestrike of a switch closure as well.

PAF® INRUSH CAPABILITIES

The PAF can be expected to handle the following instantaneous inrushes of a 60Hz wave without triggering. Note that the desensitized unit is in terms of I^2t:

	STANDARD SENSING	DESENSITIZED (PAF 600 only)
PAF 200	2.4kA ½ cy Peak Instantaneous	
PAF 300	3.4kA " " "	
PAF 400	4.5kA " " "	
PAF 600	7.2kA " " "	490,000 A^2sec

GENERAL

It is within the user's (specifier's) scope of responsibility to assure a proper analysis and application of these devices. G&W is not responsible for the characteristics of the user's system; however, we will certainly assist the user to ensure a satisfactory installation.
When in doubt of any PAF characteristic or if discussion of the user's system characteristics is warranted, the G&W engineering staff should be contacted at 708/388-5010.

For shipments of PAF® interrupters the customer should recognize that these products contain a pyrotechnic charge for initiation of the interruption process. While an ignited pyrotechnic charge is fully contained by the enclosing tube, they must still be shipped as a hazardous cargo per U.N. Shipping Designation - Fuzes, detonating, UNO257 and Classification Code - 1.4B (airfreight on cargo planes is permitted). For overseas orders, the user of these devices may be required by their government to obtain a permit for entry and transport of these goods within that country. That government may also (in rare cases) require a permit for possession of those goods. Permits are the responsibility of the user and must be applied for by the resident company. They are generally not difficult to obtain. G&W will assist the users in this process.

The PAF is a unique product with excellent system protective capabilities. We at G&W look forward to the opportunity of working with you in meeting your protection needs.