FUSE AND WIRING RATINGS- PART ONE - FUSES

This article illustrates the relationship between wire and fuse sizing/selection. The information may be used to select suitable wire and fuse sizes for a given application. The tabulated data is typical of what can be expected, but in every case the motorcyclist must verify with the supplier, the actual fuse and wire ratings as purchased.

The fuse:

The primary task of a fuse is **to protect the circuit wiring** that is connected to it, against overload and short circuit. The circuit fuse **is not intended to protect the terminal devices** that the circuit suppliers; terminal devices, such as indicators etc, are usually of much smaller current capacity than the wire itself, and would therefore need smaller fuses than the main circuit fuse for protection. Usually the terminal devices on a classic bike are not individually protected by fuses.

It is best to locate the main circuit fuse as close to the bike's battery as possible; this fuse should cover all the wiring on the bike, including tail and stop lamps. A fuse that is too large can, at worst, allow the wiring to overheat in the event of a fault or overload, damage the wiring insulation and possibly cause a fire and severe damage to the bike.

Fuses have fairly wide operating tolerances as indicated in tables 1 and 2 below. These tables indicate the current at which the particular fuse will operate and isolate the circuit within the times shown from inception of a fault. It is also apparent that there is a difference between the two types of fuse listed in the tables; the semi enclosed fuse is open to ambient effects such as cooling due to the air that is in direct contact with the fused element. This will obviously delay the time it takes to operate for a given fault level. The enclosed fuse will not be as affected, and its performance will therefore be somewhat more precise.

The columns indicate the following information;

- Column No.1 gives typical continuous current ratings of the fuses.
- Column No. 2, 3 and 4 give the fault current at which the fuse will operate, within the times given in each column i.e. 0.1secs, 5secs, and +1.5 hours.
- Column No. 5 gives the minimum wire size (cross sectional area of the wire) that can be used with each fuse size and with each fuse type.
- Columns No. 6 and 7 give the minimum wire sizes that can be used for each fuse size, and for the type of wire insulation shown. The continuous rating of the wiring is determined by the limiting temperature of the insulation.

The PVC insulated copper wire in the above tables could operate quite safely and continuously at a conductor temperature of 70°C and, the thermosetting rubber insulated copper wire could operate at a conductor temperature of 85°C when carrying the rated current in free air.

While the fuse ratings and fusing times of tables 1and 2, will be found to be fairly typical and quite close to what can be purchased from automotive and motor cycle suppliers, it is imperative to obtain the actual ratings from the supplier as these can vary depending on the type of fuse.

SEMI OPEN TYPE FUSES To BS 3036						
Nominal Fuse Rating (amps)	**Fusing Current (amps)** Operating time Seconds/Hours. 0.1secs.	5.0secs	+1.5hrs.	**Min. Wire Rating** (amps)	**Min. PVC ins. Wire size** (mm²)	**Min. Rubber ins. Wire size** (mm²)
5	45	13	9	7	**1**	**0.75**
15	180	43	28	21	**2.5**	**1.5**
20	260	60	40	28	**4**	**2.5**
30	450	87	55	41	**6**	**4**
45	900	145	100	62	**16**	**10**
		TABLE	**No.1**			
col. 1	col. 2	col. 3	col. 4	col. 5	col. 6	col. 7

ENCLOSED OR SEALED FUSES. To BS 1361						
Nominal Fuse Rating (amps)	**Fusing Current (amps)** Operating time Seconds/Hours. 0.1secs.	5.0secs	+1.5hrs.	**Min. Wire Rating** (amps)	**Min. PVC ins. Wire size** (mm²)	**Min. Rubber ins. Wire size** (mm²)
5	30	14	8.5	5	**0.75**	**0.75**
15	97	46	28	15	**1.5**	**1**
20	180	82	39	20	**2.5**	**1.5**
30	280	125	56	30	**4**	**2.5**
45	550	240	84	45	**6**	**6**
		TABLE	**No.2**			
col. 1	col. 2	col. 3	col. 4	col. 5	col. 6	col. 7

Note: Information based on 85ºC rubber insulation and 70ºC PVC insulation.
For 60ºC rubber insulation wiring, increase 85ºC wire size by 35%.

A few rules of thumb;

- Open or sealed fuses can be expected to fuse at approximately one and a half to two times the listed continuous rating.
- Wiring protected by open or semi open fuses must have a continuous current rating approximately 40% larger than the fuse rating.
- Wiring protected by sealed fuses may have the same continuous current rating as the fuse.

End of Part One

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FUSE AND WIRING RATINGS- PART 2 - WIRE SIZES

This article illustrates the relationship between wire and fuse sizing/selection. Part one deals with the fuses and fuse ratings The information may be used to select suitable wire and fuse sizes for a given application. The tabulated data is typical of what can be expected, but in every case **the motorcyclist must verify with the supplier, the actual fuse and wire ratings as purchased.**

Wire (conductor) sizes:

The size (i.e. cross sectional area) of wire to be used will be mainly dictated by the load current it has to carry and the type of insulation on the wire.

To arrive at the load one needs to add up all the individual loads that could be switched on at the same time e.g. Headlight + pilot light + tail light + Stop lamp + hooter + indicators etc. **The total load must be less than the rating of the wire selected from table No. 3 below, for either PVC or rubber insulated wires.**

Table 3 lists wire ratings given in BS7671:2001 16th edition for wires installed in conduit. This installation condition can be taken as being thermally similar to having the wires on a bike run in a harness or a loom, together with other wires that are not carrying any current at all, or are carrying currents somewhat less than the maximum allowable. With classic bikes this is usually the case as the most heavily loaded wire in the loom is usually the headlight feed.

COPPER WIRE RATINGS (at 30°C in free air)			
Wire Size (mm²)	**85deg.C rubber insulat.** (amps)	**70 deg. C PVC insulat.** (amps)	**Volt drop in millivolts/** ampmeter
0.75	10	6	62
1	17	13.5	44
1.5	22	17.5	29
2.5	30	24	18
4	40	32	11
6	52	45	7.3
10	72	57	4.4
col 1	col 2	col 3	col 4

TABLE No. 3

It will be noticed from tables 1 and 2 of part one of this article, and the above table 3 that the continuous current rating of the wires is always equal to or larger than the continuous current ratings of the corresponding fuses. In practice it will be found that the wiring sizes tend to work out to be larger than the fuse rating when current load and volt drop is taken into account. **Thus the fuse should always operate before the wire can be damaged by long duration overloads.**

Volt drop: A difference in voltage occurs from one end of a wire to the other as electric charge moves through the wire. This movement of charge is called current and the difference in voltage, end to end, is called the volt drop across the wire. The volt drop is also affected by the resistance of the wire and hence its temperature.

The volt drop figures in col.4 table 3 are valid for two conductors, the outgoing and the return, operating at maximum permissible load and temperature. So a given conductor operating at lower current levels would obviously reduce the volt drop.

To calculate the volt drop:

Consider a 2 meter long circuit of 1.5mm² conductor carrying 22 amps. To get the volt drop, multiply the given volt drop figure in table 3 by the load current and the length in meters, then divide by 1000 to convert millivolts to volts;

i.e. $$Voltdrop = 2\times \;.\times\; 9 \div \; 000 = \;.28 Volts$$

This volt drop at approximately 21% for a 6 volt system and 11% for a12 volt system is too high. It is therefore necessary to try a 2.5mm² conductor which reduces the volt drop to approximately 0.8 volts at the 22 amp loading. For a 6 volt system this is still on the high side at 13% of the available voltage as it leaves only 5.2 volts to do the job it needs to do.

In practice it is possible to halve the volt drop figures given in Table 3 (and the above calculation) as the frame of the bike acts as the return wire. However all terminal devices and wiring connections to the frame must be tinned and soldered to avoid high resistance connections which would increase the volt drop.

Selecting a fuse to protect this wire;

- Table 1 col. 1 shows that a 20 amp open type fuse would just be able to cope with a load of 22 amps continuously. However columns 5 and 6 indicate that the 2.5 mm² wire would not be suitable for the fusing factor of this fuse which requires a minimum wire rating of 28 amps and therefore a 4 mm² wire.

- To avoid using a large 4 mm² conductor, and later having multi wire termination problems, Table 2 indicates that a sealed type 20 amp fuse and a 2.5 mm² PVC insulated wire (which is rated at 24 amps in Table 3) exceeds the minimum wire rating of 20 amps as shown in column 5.

<u>SUMMARY OF OVERALL SELECTION PROCESS:</u>

1) Calculate the required maximum load current.

2) Select a suitable wire type and size from table 3 or other source.

3) Select suitable fuse type and rating from either table 1 or 2 or from the supplier.

4) Verify compatibility of the selected wire and fuse using tables 1 and 2.

5) Check fuse and wire ratings and compatibility with the supplier of the equipment.

<u>EXPLANATORY NOTES:</u>

- Current cannot flow. Current is a rate of flow of electric charge per second.

- Voltage is the amount of energy required from a battery, (or generator) to move electric charge around a circuit and back to the battery.

- So low voltage, due to volt drop, reduces the amount of energy available, and hence the amount of charge that can be transferred; this means a smaller current, dim head lights and/or difficult starting with a coil ignition system.

End of Part 2

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