CHAPTER 1

AIRCRAFT CABLES

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Introduction

1. The principles of electrical distribution, whereby electrical energy derived from generators, etc., is conveyed, by means of insulated cables, to the 'loads' or consuming equipment of an electrical installation, is described in general terms in A.P. 3275, Section 2, Chapters 5 and 6. Aircraft installations conform in principle to the fundamentals of design applicable to electrical installations in general, but the imperative need for a very high standard of reliability in operation, coupled with restrictions imposed by the 'space factor' in aircraft, have resulted in the design, development and production of highly specialized electrical equipment for use in aircraft. This feature of specialized construction is particularly apparent in electric cables produced for aircraft use—every such cable has been designed, developed and produced to meet either a general or a specialized *aircraft* use, and its capabilities (and its limitations) are known exactly.

2. Apart from considerations of adequate current-carrying ability without unduly heavy loss, and the ability to withstand not only the normal working voltage but also transient voltages which may be far in excess of those generally associated with the service on which the cable is used, full consideration must also be given, in the design of aircraft cables, to the effects of temperature over a very wide range on the insulation and protective covering of the cable—some types of cable in current use can be employed safely in temperatures as low as −75° C. without loss of flexibility, or in temperatures up to 250° C. without risk of insulation failure, while other types, chiefly developed for pyrometric purposes, can operate safely at temperatures up to 1,000° C. or even higher. The effects of various oils and fluids, etc., on the insulation of a cable is also a matter of great importance which, of recent years, has been further aggravated by the introduction of ester-based fluids for various services in aircraft: esters are chemical compounds, formed by the condensation of alcohol and acid and the elimination of water, which are used as the 'base' of certain hydraulic fluids and lubricants, and they are extremely active in attacking rubber and certain synthetic materials which are widely used, in ordinary cables, for insulation purposes. Even the normal 'general-purpose' classes of aircraft cables may be considered as 'special' when compared with cables used for industrial or domestic purposes, while the 'special-purpose' aircraft cables are truly specialized cables, in every sense of the word.

Cable Nomenclature

3. To facilitate identification, every cable used for Service purposes is given a distinctive name which generally indicates the composition of the cable, its approved use if of 'special' type, and its 'rating' (see para. 5). The basis of cable nomenclature is as follows:—

(*a*) The first part of the name, the prefix, indicates the number of cores, as shown in the table below.

Prefix	Cores	Prefix	Cores
Uni-	1	Octo-	8
Du-	2	Nono- (obsolescent) ...	9
Tri-	3	Deca- or Tencore	10
Quadra-	4	Twelvecore	12
Quin- or Quinto- ...	5	Eighteencore	18
Sexto-	6	Twentwocore	22
Septo-	7	Twenfivecore	25

(*b*) The main part of the name indicates either the nature of the outer covering, the particular use of the cable, or both. For example, "-vin" indicates a cable sheathed with polyvinyl chloride, "-met" denotes an overall braiding of copper wire, "-plug" is a special cable for ignition services, while "-plugmet" indicates a similar class of cable with wire-braided covering.

(*c*) A numeral or numerals following the name indicates the 'rating' of the cable. Thus a cable designated as Septovin 4 is a seven-core cable, sheathed in polyvinyl chloride, and designed to carry 4 amperes under normal working conditions (but see para. 5 for 'American-style' rating).

Classification of Cables

4. In commercial and industrial practice cables are classified according to the voltage at which they can be operated safely. Service cables are grouped into two major classifications, viz. low-tension (L.T.) cables, for use in services where the voltage does not exceed 600 volts, and high-tension (H.T.) cables, employed in radio, radar and ignition circuits, where voltages of several thousand volts may be encountered. Low-tension cables are further sub-divided into three specific groups, viz. general-purpose aircraft cables, special-purpose aircraft cables, and ground-equipment cables (for connecting mobile ground equipment to aircraft for servicing purposes, etc.). Further general details of the various classes of aircraft cables are as follows:—

(*a*) *General-Purpose Cables.* As aircraft installations operate at either 28–V d.c., 112–V d.c., or 200–V a.c., the current for a given power is relatively high—this is particularly true of 28–V installations—and the risk of loss of efficiency must always be borne in mind. The conductors of general-purpose cables must be of ample cross-section to carry the rated current without unduly heavy voltage drop; all conductors are of stranded construction to give maximum flexibility and are made up of the appropriate number of strands of fine-gauge annealed electrolytic copper wire or high-purity aluminium wire—the strands of copper are either of 0·0076", 0·012", or 0·018" diameter, while aluminium strands are of 0·020" diameter.

(*b*) *Special-Purpose Cables.* As the name implies, these cables are produced to meet special requirements and the various types differ widely in form of construction, materials, etc. Details of typical special-purpose aircraft cables are given later in this Chapter.

(*c*) *High-Tension Cables.* The extremely high voltages to which cables of this class are exposed calls for exceptionally effective insulation of the cores; insulating materials of high dielectric strength are therefore used in their manufacture, and a considerable thickness of insulation, depending on the type and approved use of the cable, is built up around each core. For such purposes as ignition services the current-carrying ability of the cable is of minor importance, since the actual current likely to pass through it is quite small; cables of this type often have conductors made up of finely stranded stainless steel wire—this material is definitely inferior to copper as a conducting medium, but its high tensile strength and its marked ability to resist corrosion are ample compensation for what is, in these particular circumstances, a very minor inefficiency.

(*d*) *Ground-Equipment Cables*. The major requirement for cables used in ground-supply equipment is the ability to withstand rough usage (as in trailing across the ground), or to withstand prolonged exposure to weather, etc. These cables are notable chiefly for their rugged construction and low I^2R losses when carrying full rated current. Cables designed for use in aircraft should never be used as supply cables for ground equipment.

Rating of Cables

5. As has already been stated in this Chapter, every aircraft cable is identified by a class name which indicates the construction and/or purpose of the cable, and this class name is amplified by a 'rating' number to provide identification between cables of different sizes in the same class. Two different forms of cable rating are at present in use; these are as follows:—

(*a*) *Current Rating*. This form of rating is based on the maximum current that a single-core cable, or each core of a multi-core cable, can carry without exceeding a specified voltage drop per yard run. With the exception of recently-introduced types, all general-purpose and some special-purpose aircraft cables used in the Royal Air Force are rated on this basis; other special-purpose cables are identified, within their respective classes, by suffix numbers which are purely arbitrary.

(*b*) *Cross-Section Rating*. This form of cable rating, which originated in American production, is used for all recently-introduced general-purpose aircraft cables and certain special-purpose cables. The rating suffix is a code number which is indirectly related to the cross-sectional area of the conductor; a high rating number indicates a cable whose conductors are of small cross-sectional area and are, therefore, of restricted current-carrying ability, and each reduction in rating number (down to zero) indicates an increase in conductor cross-section—further increases in cross-section are indicated by multi-zero codes. Thus a Nyvin 2 cable has a conductor of smaller cross-section than a Nyvin 0 cable, while the latter in its turn is smaller than a Nyvin 00 cable.

6. The 'Pren' types of cables (see para. 11) are primarily general-purpose aircraft cables; they were introduced before the American form of classification was adopted, hence they are identified by current-rating. The 'Nyvin' ranges of cables (see para. 16) have been introduced to supersede the Pren cables for general-purpose work, and these cables are identified by the American method. The table below shows selected equivalent cables of the Unipren and Uninyvin ranges.

Conductor Diameter (*Inches*)	Unipren Range	Uninyvin Range
0·033	Unipren 4	Uninyvin 22
0·061	Unipren 12	Uninyvin 16
0·167	Unipren 50	Uninyvin 8
0·272	Unipren 100	Uninyvin 4
0·384	Unipren 150	Uninyvin 1
0·432	Unipren 170	Uninyvin 0
0·490	Unipren 200	Uninyvin 00
0·548	Unipren 230	Uninyvin 000
0·615	Unipren 280	Uninyvin 0000

Storage of Cables

7. So far as is possible, cables should be stored indoors in a cool dry situation. They should not be exposed to direct sunlight, extreme temperatures should be avoided, and they are not to be kept in the vicinity of oils, acids, or other materials which may cause corrosion. Cables which are supplied in cartons or other forms of packaging should be kept in their packing until required for use.

8. When storage of cable in open sheds or in the open air is unavoidable, the reels or packages must be placed on a raised platform or planks to protect them from moisture from the ground. Tarpaulins used for covering must be supported clear of the cable stock to permit free circulation of air. All types of cables should have the ends sealed when in storage to prevent the entry of moisture. Lead-covered cables are effectively protected from this risk by dipping the ends in hot paraffin wax; the same treatment is effective for braided and rubber-sheathed cables. Metal-braided cables should be safeguarded by removing the braid for about one inch, applying sealing tape to the exposed insulation, then continuing to serve the tape over the braiding for a further distance of one inch.

GENERAL-PURPOSE AIRCRAFT CABLES

P.C.P. Cables

9. The P.C.P. series of aircraft cables are designed for general aircraft wiring in circuits where the potential between conductors, between a conductor and the metal braid surrounding it, or between a conductor and the aircraft structure does not exceed 600 volts (r.m.s.) and in which the frequency does not exceed 1,600 c/s. They remain fully effective in conditions which produce stabilized conductor temperatures up to 90° C., and their flexibility is not impaired until the ambient temperature is of the order of −40° C.—they are still perfectly reliable, when used as fixed wiring, in temperatures as low as −75° C. These cables do not support combustion, and they are resistant to aircraft fuels, lubricants, hydraulic fluids, etc., unless these fluids are ester-based (see para. 2).

10. **Construction.** The cores of P.C.P. cables, other than Prenal, consist of stranded flexible conductors of fine-gauge tinned copper wire, covered first with an insulating sheath of glass braid and then with an outer layer of synthetic rubber compound of the polychloroprene (P.C.P.) class. Polychloroprene does not support combustion, and the inner glass braid provides for short-period emergency service after the polychloroprene has been rendered inoperative as an insulant either by mechanical damage or fire.

11. **Types of P.C.P. Cables.**

(*a*) *Pren.* Single-core Pren cables (Unipren) consist of a single core, similar to that described in the previous paragraph; there is no braiding or other protective sheathing over the polychloroprene. Multi-core cables of this type are circular, polychloroprene fillings being used to maintain the shape; the cores and fillings are covered with a further layer of glass braid, lacquered with a fire-, heat- and oil-resistant composition.

(*b*) *Prenal.* This type of P.C.P. cable, which is available only in the single-core (Uniprenal) form, is similar in construction to Unipren except that the conductor is made up of aluminium wires.

(*c*) *Prenmet.* These cables are fundamentally Pren cables to which has been added an outer sheathing of tinned copper braiding. They are available in single-core and multi-core versions.

(*d*) *Prensheath.* These twin- or multi-core P.C.P. cables consist of normal Pren cores, as described in para. 10, laid up with P.C.P. fillers to maintain shape and finally sheathed with P.C.P., instead of the braided outer sheathing used in multi-core Pren cables.

(*e*) *Flexpren.* These cables are available in the single-core form only; they are similar to Unipren cables except that the conductor is of braided construction on a string centre and uses exceptionally fine-gauge wire to give maximum flexibility.

12. **Ranges.** P.C.P. cables, other than Uniprenal and Uniflexpren, embody cores selected from a standard range covering 16 different sizes of conductor: this range, with details of the copper conductor and the permissible voltage drop per yard run when carrying rated current, is listed in the table below.

Rating (*in amperes*)	**Composition of Conductor**	**Voltage Drop** (*per yard at rated current*)
4	19/0·006	0·195
6	19/0·0076	0·182
9	33/0·0076	0·178
12	40/0·0076	0·173
18	70/0·0076	0·149
24	110/0·0076	0·126
35	73/0·012	0·111
50	120/0·012	0·097
70	182/0·012	0·089
100	294/0·012	0·079
135	203/0·018	0·069
150	248/0·018	0·062
170	323/0·018	0·054
200	416/0·018	0·050
230	513/0·018	0·046
280	666/0·018	0·043

The various types of P.C.P. cables are available in the following ranges:—

(*a*) *Unipren*—all ratings.

(*b*) *Uniprenal*—35 A to 200 A in ratings shown above.

(*c*) *Uniprenmet*—4 A to 50 A

(*d*) *Tripren and Triprenmet*—4 A to 24 A.

(*e*) *Uniflexpren, Duprensheath, Triprensheath, and all five-, six-, seven- and nine-core P.C.P. cables*—6 A only.

Note. The conductors of all Prenal cables are made up from 0·020 in. diam. aluminium wire; the voltage drop per yard run at full rated current is slightly higher than that of copper conductors of equal rating.

13. **Current Rating Identification.** All single-core Pren cables with copper conductors up to and including 12 A have the polychloroprene coloured to indicate the nominal current rating according to the following code:—

(*a*) *Red*—4-ampere conductor.

(*b*) *Blue*—6-ampere conductor.

(*c*) *Brown*—9-ampere conductor.

(*d*) *Yellow*—12-ampere conductor.

Uniflexpren cable is coloured black. This coding is also employed for multi-core cables, in which the outer glass braid or polychloroprene is coloured; individual cores of these cables are coloured as described in para. 14. Cables of 18 amperes and above, and single-core cables with aluminium conductors, are coloured blue and yellow respectively, and have the current rating printed in black at intervals along the cable.

14. **Core Identification.** The polychloroprene covering of each core of a multi-core Pren cable is coloured distinctively to simplify circuit tracing and connection—the colours in this case do NOT indicate a specific rating, since the latter is already indicated by the colour of the outer covering. The colour coding for core identification is shown in the table below.

No. of Cores	Colour of Core Polychloroprene
2	Red and blue.
3	Red, blue and yellow.
5	Red, blue, yellow, green and white.
7	Red, blue, yellow, green, white and black.
9	Red, blue, yellow, green, white, black, brown, and violet.

Nypren Cables

15. Nypren cables are standard Pren cables with an outer covering of nylon. This nylon sheath protects the insulation from the active synthetic lubricants and fluids now used in aircraft, and also increases its abrasion resistance. The ranges of single-core cables (Uninypren, Uninyprenmet, and Uninyprenal) are as for corresponding cables in the Pren class; Dunyprensheath and Trinyprensheath are available in 6-ampere and 12-ampere ratings, while Quintonyprensheath and Septonyprensheath are available as 6-ampere cables only. The colour scheme for indicating core rating is as for the Pren ranges, and the same system of colour coding for cores of multi-core cables is adopted.

Nyvin Cables

16. Nyvin cables are available in two ranges, viz. Type A and Type B: both types are designed for general aircraft wiring in circuits where the potential between conductors, between a conductor and a metal braid surrounding it, and between a conductor and the aircraft structure nowhere exceeds 600 volts r.m.s. and in which the frequency does not exceed 1,600 c/s. Type A cables are suitable where any combination of ambient temperature and conductor current does not produce a stabilized conductor temperature in excess of 105° C. For Type B cables the limiting temperature is 90° C. Both types are suitable for fixed wiring in aircraft at temperatures down to −75° C., but should not be used in circumstances where severe flexing is likely to occur at temperatures below −35° C. These cables do not support combustion, and are suitable for use in areas where ester-based fluids are present. They will eventually supersede the corresponding single-core Pren and Nypren cables.

17. The range of Nyvin cables, which are single-core only, is substantially similar to that of single-core Pren-type cables. Uninyvin, which consists of a stranded copper conductor with an insulation of white P.V.C. compound, followed by a layer of glass braid and a final protective covering of colourless nylon, is available in 17 different ratings, each of which, except the smallest, is of similar current-carrying ability to that of a cable in the Unipren range—the smallest cable in the Uninyvin range makes use of a 19/0·0048 conductor. Uninyvinal cable, as the name implies, has a stranded aluminium conductor but is otherwise similar in construction to the Uninyvin cable; this cable is available in eight ratings, each corresponding to a cable in the Uniprenal range. The four smaller cables of the Uniprenmet range are matched, in current-carrying ability, by the Uninyvinmetsheath range of Nyvin

cables, while the four larger cables are comparable to the Uninyvinmet cables. The Nyvinmet cables are simply Nyvin cables to which has been added an outer layer of tinned copper braiding, while the Nyvinmetsheath cables have an additional outer sheathing, comprising a polyester film tape and nylon fibre or ribbon braid, nylon lacquered, over the metal braiding. Nyvin-tape cables are not identified by current rating, but follow the American system of classification by a series of numerals indicative of the conductor cross-sectional area (see para. 6): the cable size is printed in red for Type A cables and in black for Type B cables, at intervals along the length of the cable.

Obsolescent Types

18. In addition to the general-purpose aircraft cables already described, two other types of general-purpose cable may be encountered in certain older types of aircraft. The earlier of these is known as the "-cel" range, from the fact that the V.I.R.-insulated conductor cores, after taping, are sheathed in cellulose-varnished cotton braiding; in the more recent "vin-" range the cores, of similar construction, are protected by an overall sheath of P.V.C. Both ranges are rated on a basis of permissible voltage-drop, per yard run, when carrying nominal rated current; the standard of rating, which is common to both types, is based on a smaller drop-per-yard than in the case of the more modern cables, hence -cel-type or vin-type cables of given conductor cross-section have lower ratings than, say, pren-type cables of the same conductor section—Unicel 7 and Univin 7 both have conductors of 0·052 in. diam., yet the pren-type cable using the same size of conductor is Unipren 12. Cables of these ranges are available in ratings of 2·5-A (-vin range only), 4-A, 7-A, 19-A, 37-A, 64-A, 83-A and 138-A; the three larger ratings in the "cel" range, which are available in single-core form only, are also available with aluminium conductors as Unistartal No. 1, No. 2 and No. 3 respectively.

SPECIAL-PURPOSE CABLES

Introduction

19. Although the general-purpose cables already discussed have very wide applications in the field of aircraft installations, they lack the very special qualities that are essential in certain circumstances or for certain particularly onerous duties. They are, in fact, good all-rounders, but they are not specialists. Several ranges of cables have been developed to fill the various gaps; some are outstanding for their inherent ability to withstand extremely high temperatures or even active flame conditions without damage, others are very flexible at very low temperature yet are capable of operating effectively at temperatures which are well above those associated with general-purpose cables, while others are designed to cope with unusually difficult electrical phenomena. It must, however, be realized that these exceptional qualities have, in every instance, been obtained at the expense of one or more of the good points of the general-purpose cable ranges. These special cables have definitely been developed for special purposes where the sacrifice of certain qualities is of secondary importance; they are supplementary to the general-purpose cables to fill a special need, and they must never be used in conditions where a general-purpose cable can operate effectively.

Glasil Cables

20. The Glasil range of special-purpose cables are suitable for use in aircraft circuits installed in positions where high temperatures are liable to develop. They remain fully effective in conditions where the conductor temperature may rise to 150° C., and they retain a high degree of flexibility at low temperatures (down to −75° C.). The working voltage limitations are as for Pren cables. These cables are not impervious to fluids, and they must not be installed in situations where the wiring is liable to come into contact with fuel, lubri-

cants, hydraulic fluids, etc. Their use is justified only by difficult temperature conditions, and Pren, Nypren or Nyvin cables are to be used in preference if the temperature conditions permit.

21. Glasil cables are of single-core, twin-core and three-core types; the cores in all cases consist of stranded copper conductors (the composition of the conductors for various current ratings is as for Pren cable cores), with insulation of silicone rubber, an intermediate covering of asbestos roving, and a final covering of glass braiding impregnated with silicone varnish. Uniglasil cables consist simply of a single core such as has already been described with the final glass braiding coloured red. Duglasil and Triglasil cables consist of two or three single-core cables, respectively, laid together with a further impregnated glass braid applied overall: the glass braid over each core is coloured red or blue (Duglasil) or red, blue or yellow (Triglasil) for circuit identification, the overall braid being red as in Uniglasil cables.

22. Uniglasil cable is available in the ranges applicable to Unipren (4 amperes up to 200 amperes, but omitting the 6-ampere cable), while Duglasil and Triglasil are both available in 4-, 9- and 12-ampere ratings. Indication of current rating is given by black numerals on the outer surface of the cable at intervals of five inches. Voltage drop per yard run is slightly less than in comparable Pren cables.

P.T.F.E. Cables

23. Cables insulated with P.T.F.E. (polytetrafluorethylene) are designed for aircraft wiring in areas where the temperature liable to develop is outside the limits catered for by general-purpose or Glasil cables. They are primarily for use in high-temperature zones (150° C.—200° C.) and at low temperatures between −30° C. and −75° C. where a high degree of flexibility combined with good resistance to engine fuels, hydraulic fluids and synthetic ester-based liquids is required. The cables are suitable for use in circuits where the potential between conductors does not exceed 250 volts (r.m.s.) at a frequency of not more than 1,600 c/s.

24. These cables are made in single-core form only. Uni-ef cables, which have current ratings of 4, 9, 12 and 24 amperes, consist of a stranded nickel-coated copper conductor, insulated with P.T.F.E.—the insulation is coloured to give indication of current rating, viz. Uni-ef 4 cable insulation is coloured red, Uni-ef 9 is brown, Uni-ef 12 is yellow, and Uni-ef 24 is green. Larger cables (ratings from 35 amperes to 200 amperes) have an outer braiding of glass fibre, impregnated with silicone varnish in a natural buff colour, over the P.T.F.E. insulation; these cables are referred to as Glasef, and they are available in 35-, 50-, 100-, 150- and 200-ampere ratings. The composition of the stranded conductor is the same as for Pren cable conductors of similar rating. Indication of current rating is given, in the Glasef range, by numerals in black on the outer surface of the cable.

25. When handling and installing these cables, care should always be taken to avoid bending the cables on small radii, since this practice is likely to cause cracking of the insulation. In general, the bending radius should, whenever possible, be not less than twenty times the outside diameter of the cable. This is particularly important when installing Uni-ef cables.

Warning . . . .

When P.T.F.E. is heated above 400° F. (205° C.) toxic compounds are evolved. **These compounds can give rise to serious injury or death.** P.T.F.E. cables should, therefore, be prepared only in well-ventilated rooms fitted with effective exhaust arrangements. Smoking is absolutely forbidden to personnel engaged in cutting or working P.T.F.E. in such a way as to produce loose chips or particles of the material; to avoid contamination no cigarettes, pipes, or tobacco should be brought into the vicinity, and all particles of P.T.F.E. should be removed from the hands and clothing immediately on completion of the work.

Tersil Cables

26. Cables of Tersil type are suitable for the wiring of circuits where the working voltage does not exceed 600 volts (r.m.s.) and the frequency of supply is not more than 2,400 c/s. They can withstand a stabilized conductor temperature of not more than 190° C. for continuous service; they are also capable of operating for one short period at temperatures of the order of 1,100° C., and are thus suitable for circuits which must operate during or after a fire. They retain full flexibility at temperatures down to −55° C., and they are suitable for fixed wiring at temperatures of −75° C. The insulation does not support combustion, and the cables are resistant to ester-based oils and hydraulic fluids, kerosine, aromatic fuels and hydraulic fluids—they will eventually supersede cables of the Glasil range.

27. Tersil cables are made in single-core form only and they follow the American system of classification instead of being rated by current. There are three distinct types of cable in this range, viz.:—

(*a*) *Unitersil.* These cables make use of standard stranded-copper conductors (the conductor make-up is as for Pren conductors), over which is a protective coating of polyethylene terephthalate, glass, and other suitable materials. Some cables may have an inner insulation of glass braiding adjacent to the conductor. The exterior finish is orange in colour, and identification is given by the word Tersil, followed by the appropriate numerals, printed in black at intervals along the cable length. The range, which is identical (so far as conductor sizes are concerned) with the Unipren range, extends from Unitersil 22 (conductor size 19/0·006) to Unitersil 0000) conductor size 666/0·018).

(*b*) *Unitersilal.* These cables are similar in construction to the Unitersil cables but use stranded aluminium conductors. The range is from Unitersilal 8 (conductor size equivalent to that of Uniprenal 35) to Unitersilal 0000 (equivalent to Uniprenal 200); the word Tersilal, followed by the appropriate numerals, is printed along the cable at intervals for identification.

(*c*) *Tersilmet.* These are Tersil cables, to which has been added an outer layer of tinned copper braiding. The range is from Unitersilmet 22 to Unitersilmet 8 (conductor size 120/0·012, equivalent to Pren 50).

Efglas Cables

28. Efglas cables are a more recent and improved version of the P.T.F.E. cables described earlier; they are suitable for use in circuits where the working voltage does not exceed 600 volts (r.m.s.) and the frequency is not higher than 2,400 c/s, and where the stabilized temperature of the conductor, under continuous service, does not exceed 240° C.—they also maintain full flexibility at temperatures down to −75° C. These cables are made in single-core form only; they are fully resistant to all fluids likely to be encountered in aircraft service, and they will eventually supersede cables of the Uni-ef and Uniglasef ranges.

29. Efglas cables make use of the same range of conductor sizes as the Pren range, with Uniefglas cables covering the full range and Uniefglasmet covering the eight smaller sizes of conductor. This range of cables, like all recent introductions, is identified by the American system of classification; the two ranges thus run from Uniefglas 22 to Uniefglas 0000, and from Uniefglasmet 22 to Uniefglasmet 8. A Uniefglas cable consists of the usual stranded copper conductor covered with a composite insulation of glass and P.T.F.E.—this insulation normally consists of layers of unsintered P.T.F.E. and glass braids, which are subsequently heated to produce a compact sintered mass of P.T.F.E. and glass braid. Uniefglasmet

cables have the same form of core, with an additional outer layer of nickel-plated copper braiding. Identification of the cables is by a colour code applied to the insulation; details of this code are shown below.

Colour of Insulation	Identifies Cable as
Red	Uniefglas 22, Uniefglas 10, or Uniefglas 0.
Blue	Uniefglas 20, Uniefglas 8, or Uniefglas 00.
Brown	Uniefglas 18, Uniefglas 6, or Uniefglas 000.
Yellow	Uniefglas 16, Uniefglas 4, or Uniefglas 0000.
Green	Uniefglas 14, or Uniefglas 2.
Black	Uniefglas 12, or Uniefglas 1.

Note . . . .

The precautions mentioned in para. 25 are applicable to Efglas cables.

Pyrotenax Cables

30. Pyrotenax cables are designed for use in areas, such as the engine bays of certain aircraft, where very high temperatures may develop. Cables of this type are capable of withstanding temperatures of up to 500° C. for short periods; they should not, however, be subjected continuously to temperatures in excess of 250° C., since the outer sheathing material is adversely affected by protracted exposure to such heat.

31. Three-core and seven-core versions of Pyrotenax cables are available, both versions having a core current rating of six amperes. The conductors, which unlike other aircraft cables are of *solid* copper, are enclosed in an aluminium alloy outer sheath, and are insulated from each other and from the sheath by a filling of compressed magnesium oxide. Provided the ends are properly sealed, the cable is not affected by oils, fuels or other fluids, and is proof against corrosive influences except such acids and alkalis as normally attack aluminium. Although extremely robust and resistant to mechanical damage, Pyrotenax cables can be bent to suit the cable run when installing, but repeated bending is not advisable since this action tends to break up the mineral insulant.

Fire-Resistant Cables

32. The cables described in this and subsequent paragraphs have been developed specifically for use in aircraft fire detector circuits and in circuits which are required to function during or after a fire. There are three such cables in current use, viz. Unifire-red 7, Unifire-F 12, and Unifiredet 7; all are single-core cables, and in each type the conductor is laid up with 40 wires, each of 0·0076″ diam., as in Pren 12 cables.

33. **Unifire-red 7.** This cable is still in use in some earlier forms of fire circuits; it is suitable only for circuits in which the voltage does not exceed 30 volts d.c. It consists of a stranded copper conductor covered with successive layers of insulation as follows:—

(*a*) Glass braid, impregnated with silicone varnish.

(*b*) Asbestos felting, impregnated with silicone varnish.

(*c*) Glass braid, impregnated with silicone paste.

(*d*) Glass braid, coated with non-inflammable dope coloured red.

34. **Unifire-F 12.** This cable is suitable for use at the nominal current rating in an ambient temperature of 200° C., and for one short period at 1,100° C., in circuits where the voltage

does not exceed 208 volts (r.m.s.) and frequency is not above 2,400 c/s. The stranded nickel-plated copper conductor is sheathed with a composite insulation of asbestos, glass, silicones, and P.T.F.E. or other materials. The cable is coloured white. Unifire-F 12 cable is superseding the earlier Unifire-red 7.

35. **Unifiredet 7.** This cable is used only for the wiring of a proprietary fire-detector system in which the voltage does not exceed 30 volts d.c. The stranded copper conductor is sheathed with an insulation of glass tape impregnated with silicone varnish, and over this sheath is placed an outer layer of glass braid, also impregnated with silicone varnish. The colour of Unifiredet 7 cable is neutral.

Warning . . . .

The precautions described in para. 25 are applicable to personnel engaged on work with Unifire-F 12 cable, since this cable is insulated, in part, with P.T.F.E.

High-Tension Ignition Cables

36. Extremely high voltages and frequencies are inherent in the various forms of electrical ignition systems fitted to piston engines and gas turbine engines used in aircraft, hence the cables used in such circuits must be specially developed for this particularly arduous form of duty. The ability to carry current is of secondary importance—the actual current in a practical ignition system is quite small by normal distribution standards—hence the stranded annealed high-conductivity copper conductor of other cables previously discussed in this Chapter can be replaced by a conductor designed to give good tensile strength, a high resistance to mechanical fatigue and to corrosion, and even, in some cases, an element of resistance (electrical). The emphasis in this class of cable is definitely on insulating properties; these must be maintained under conditions in which several kilovolts are applied at very considerable frequencies, with temperatures in the vicinity of the cables reaching into the 'difficult' range where preservation of insulating properties is a major problem. The various types of high-tension ignition cables in general aircraft use are described in subsequent paragraphs

37. **Uniplugcotton, No. 2.** This cable has a stranded (19/0·12) stainless steel conductor covered with insulation of vulcanized rubber and an outer lacquered cotton braiding to give reasonably sound oil, ozone and heat-resisting properties. It is used in the ignition systems of certain types of piston engines where the ambient temperature in the vicinity of the cable does not exceed 120° C.

38. **Uniplugmet, No. 1.** The stranded (19/0·012) tinned copper conductor of Uniplugmet cable is insulated with vulcanized rubber, which is subsequently lapped with oil-resisting cambric tape and finally covered with an outer layer of tinned phosphor-bronze braiding. Its use is as for Uniplugcotton.

39. **Uniplughitemp.** This range of ignition cables is available in the various forms described below:—

(*a*) *Uniplughitemp, No.* 3. This version of the Uniplughitemp cables has a stranded (37/0·012) tinned copper conductor sheathed with a layer of ozone-resisting material followed by a layer of vulcanized rubber and a final sheath of lacquered cotton or glass braiding coloured red. This cable is used in high-energy ignition systems for gas turbine engines, at temperatures up to 140° C.

(*b*) *Uniplughitemp, No.* 4. Similar in construction to No. 3, but with a stranded (19/0·012) stainless steel conductor. Used for certain piston-engine ignition systems, and in some gas turbine ignition systems embodying H.T. booster coils, at temperatures up to 140° C.

(*c*) *Uniplughitemp, No.* 5. As for No. 4, but with a smaller (7/0·012) stainless steel conductor.

(*d*) *Uniplughitemp, No.* 6. This cable has a stranded (37/0·012) nickel-plated copper conductor with insulation of natural-coloured P.T.F.E.; it is used in high-energy ignition systems, and is suitable for employment at temperatures between 140° C. and 220° C.

(*e*) *Uniplughitemp, No.* 7. This cable makes use of the same conductor as No. 6, with a layer of silicone rubber adjacent to the conductor. The outer protective covering is of polyethylene terephthalate, glass, and other suitable materials; the exterior is off-white, and has the wording Hightemp 7 printed in black at intervals along the length of the cable. It is suitable for use in high-energy ignition systems where the potential between the conductor and the supporting structure does not exceed 4 kV (peak) and the ambient temperature does not exceed 190° C.

All uniplughitemp cables have good resistance to aviation turbine fuels, hydraulic fluids, etc., other than those of ester-based type—Uniplughitemp 7 only is to be trusted where ester-based fluids are likely to be encountered. Remember that Uniplughitemp 6 is fundamentally a P.T.F.E. cable—the precautions detailed in para. 25 must be applied when working with this particular ignition cable.

40. **Uniplugsheath.** There are two versions of this cable, viz., Uniplugsheath No. 1 and Uniplugsheath No. 2; both are similar in construction, with No. 1 using a 7/0·012 stranded steel conductor and No. 2 a 19/0·012 conductor of the same material. The conductor is covered with a layer of ozone-resisting material; this in turn is covered by a layer of vulcanized rubber, followed by an outer waterproof braiding of cotton or glass, and the final sheath is of black polychloroprene (P.C.P.). This cable is used in the ignition systems of piston engines, at temperatures up to 120° C. (No. 1) or 140° C. (No. 2).

Cable Groups

41. For convenience in determining the appropriate "standard" cable termination (lug, ferrule, etc.) to be fitted to the ends of cables of various types and ratings, all cables approved for aircraft use are "grouped" according to the diameter and cross-sectional area of their conductors. For example, the stranded copper conductors of -cel 7 and -vin 7 cables have a

Cable Group	Conductor Diam. (in.)	Typical 'Make-Up'	Ratings of Cables			
			-vin, -cel and -rubber	*-pren and -nypren*	*P.T.F.E. and Glasil*	*-nyvin, -tersil and -efglas*
C1	0·033	19/006	2·5	4		22
C2	0·041	19/0076		6	4	20
C3	0·048	23/0076	4			
C4	{ 0·052	33/0076	7	9	9	18
	0·061	40/0076		12		16
C5	0·078	70/0076	12	18	12	14
C6	0·096	110/0076	19	24	18	12
C7	0·122	73/012		35	24	10
C8	0·162	120/012		50	35	8
C9	0·167	135/012	37			
C10	0·218	182/012		70	50	6
C11	0·272	294/012		100		4
C12	0·312	163/018	64			
C13	0·345	203/018		135	100	2
C14	0·384	248/018	83			
C15	0·432	323/018		170	150	0
C16	0·490	416/018	138	200		00
C17	0·548	513/018		230	200	000
C18	0·615	666/018		280		0000

diameter of 0·052 in. and a cross-sectional area of 0·0006 sq. in., and similar conductors are also used in -pren 9, -nypren 9, Uni-ef 9, -glasil 9, -tersil 18, -efglas 18 and -nyvin 18: all these cables thus belong to the same cable group (in this case Group C4), and the same "standard" end-fittings are suitable for all of them. There are 18 such groups for cables with copper cores (see table opposite), and eight groups (A1 to A8) for aluminium-cored cables. The details of each cable group (conductor diameter and cross-sectional area, number and diameter of strands, i.e. 'make-up', etc.) are given in A.P. 4343, Vol. 1, Section 12; equivalent details for each rating of each individual type of aircraft cable are to be found in the appropriate Chapters of A.P. 4343C, Vol. 1, Section 5, and by co-relating these details the cable group of any specific cable can be determined. The table opposite shows the cable groups of the various ratings of cables (copper conductors) in current aircraft use.