Proceedings of the 24th International WIRE & CABLE Symposium 1975

PROCEEDINGS OF 24th INTERNATIONAL WIRE AND CABLE SYMPOSIUM

Sponsored by
U.S. Army Electronics Command

Cherry Hill, New Jersey
November 18, 19 and 20, 1975

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24th INTERNATIONAL WIRE AND CABLE SYMPOSIUM

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Joe Neigh, AMP Inc.
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Ronald Soloman, McDonnell Aircraft Co.
George H. Webster, Bell Laboratories

TECHNICAL SESSIONS

Tuesday, 18 November 1975

9:30 a.m.	Session I:	Tutorial on Wire and Cable Considerations in Fires
2:15 p.m.	Session II:	Flammability Consideration in Cables
2:15 p.m.	Session III:	Manufacturing & Processing

Wednesday, 19 November 1975

9:15 a.m.	Session IV:	Cable Applications I
9:15 a.m.	Session V:	Cable Design
2:15 p.m.	Session VI:	Testing & Evaluation
2:15 p.m.	Session VII:	Cable Materials I

Thursday, 20 November 1975

9:15 a.m.	Session VIII:	Cable Applications II
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2:15 p.m.	Session X:	Waterproof Cable

PROCEEDINGS

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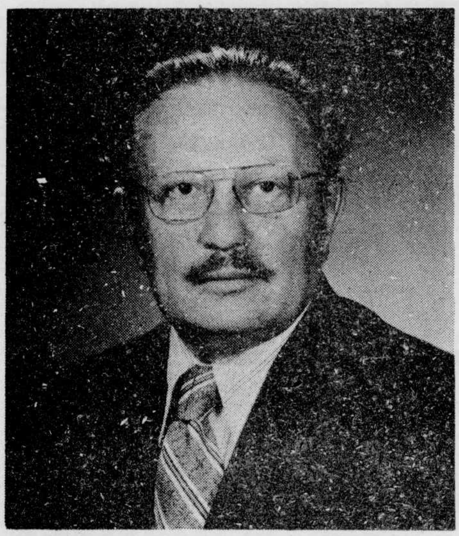
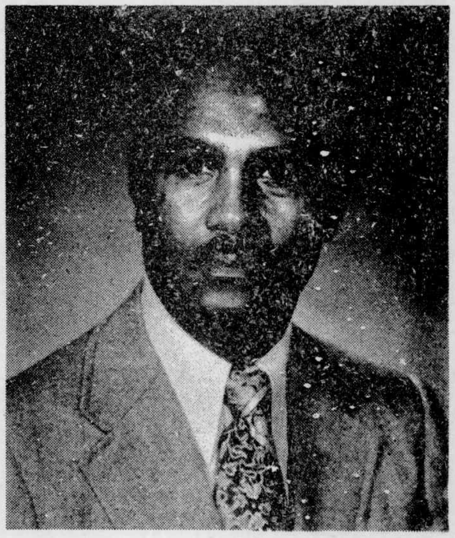
Copies of papers presented in previous years may also be obtained from the National Technical Information Service. Papers from the first 20 years, with their AD numbers are catalogued in the "KWIC Index of Technical Papers, Wire and Cable Symposia (1952–1971)," December 1971.





MESSAGE FROM THE CO-CHAIRMEN

Your co-chairmen heartily welcome you to the 24th International Wire and Cable Symposium. Last year's successful symposium (the 23rd) evoked many favorable comments on the high caliber and timely relevance of the presentations. Participation by countries other than the United States was maintained at the high level achieved in the past two years. Eighteen (18) papers from seven of these countries were presented, 35% of all papers given. We are indeed gratified that this symposium continues to attract such a sizeable representation from the world-wide wire and cable community.

The emphasis this year is being placed on the flammability characteristics of potential cable material. Such considerations are assuming increasing importance in the interest of safety, performance reliability, and economy. The tutorial session and one following session is devoted to this topic. The tutorial session is the only offering in its time slot and we strongly recommend your attendance.

Two of our hard working committe members, Jerome Hager of Northern Petrochemical Company and George Heller of Tensolite Company are retiring from the committee after three years of service. Jerry and George by their efforts and specialized knowledge both contributed materially to the success of the committee's mission. On behalf of the rest of the committee, your co-chairmen wish to thank them both and wish them well in their future activities.

The committee is looking forward to the symposium's first year at its new location, the Cherry Hill Hyatt House. Attractive surroundings, adequate convention facilities, local and nearby urban recreational activities and easily accessible transportation should combine to make this year's symposium a stimulating and pleasant experience. We hope you enjoy it!

M. TENZER, Co-Chairman

E. F. GODWIN, Co-Chairman

AWARDS

Year	*Outstanding Technical Paper*	*Best Presentation*
1968	H. Lubars and J. A. Olszewski, General Cable Corp—"Analysis of Structural Return Loss in CATV Coaxial Cable"	N. Dean, B.I.C.C.—"The Development of Fully Filled Cables for the Distribution Network"
1969	J. B. McCann, R. Sabia and B. Wargotz, Bell Laboratories—"Characterization of Filler and Insulation in Waterproof Cable"	J. D. Kirk, Alberta Government Telephones—"Progress and Pitfalls of Rural Buried Cable"
1970	D. E. Setzer and A. S. Windeler, Bell Laboratories—"A Low Capacitance Cable for the T2 Digital Transmission Line"	Dr. O. Leuchs, Kabel und Metalwerke—"A New Self-Extinguishing Hydrogen Chloride Binding PVC Jacketing Compound for Cables"
1971	R. Iyengar, R. McClean and T. McManus, Bell Northern Research—"An Advanced Multi-Unit Coaxial Cable for Tool PCM Systems"	S. Nordblad, Telefonaktiebolaget LM Ericsson—"Multi-Paired Cable of Nonlayer Design for Low Capacitance Unbalance Telecommunication Network"
		N. Kojima, Nippon Telegraph and Telephone—"New Type Paired Cable for High Speed PCM Transmission"
1972	J. B. Howard, Bell Laboratories—"Stabilization Problems with Low Density Polyethylene Insulations"	S. Kaufman, Bell Laboratories—"Reclamation of Water-Logged Buried PIC Telephone Cable"
1973	Dr. H. Martin, Kabelmetal—"High Power Radio Frequency Coaxial Cables, Their Design and Rating."	R. J. Oakley, Northern Electric Co., Ltd.—"A Study into Paired Cable Crosstalk"
1974	D. Doty, AMP Inc.—"Mass Wire Insulation Displacing Termination of Flat Cable"	G. H. Webster, Bell Laboratories—"Material Savings by Design in Exchange and Trunk Telephone Cable"

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Panel Members
V. Sielert — General Telephone and Electronics Corp.
E. J. Coffey — Underwriters Laboratories, Inc.
G. Landis — Allendale Insurance

Tuesday, November 18, 1975 — 2:15 PM
Gloucester Room

SESSION II: Flammability Consideration in Cables

Chairman — Marta Farago, Northern Electric

Tuesday, November 18, 1975 — 2:15 PM
Hunterdon Room

SESSION III: Manufacturing and Processing

Chairman — J. M. Flanigan, Rural Electrification Administration

Wednesday, November 19, 1975 — 9:15 AM
Gloucester Room

SESSION IV: Cable Applications I

Chairman — J. Neigh, AMP Inc.

Wednesday, November 19, 1975 — 9:15 AM
Hunterdon Room

SESSION V: Cable Design

Chairman — G. H. Webster, Bell Laboratories

Wednesday, November 19, 1975 — 2:15 PM
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SESSION VI: Testing and Evaluation

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Wednesday, November 19, 1975 — 2:15 PM
Hunterdon Room

SESSION VII: Cable Materials I

Chairman — J. E. Hager, Northern Petrochemical

Thursday, November 20, 1975 — 9:15 AM
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Chairman — F. Farrell, 3M Corp.

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SESSION IX: Cable Materials II

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SESSION X: Waterproof Cable

Chairman — J. Kanely, Superior Continental

SOME DIFFERENCES NOTED IN THE FLAMMABILITY OF WIRE CONSTRUCTIONS BETWEEN TESTING AT ROOM TEMPERATURE AND AT ELEVATED CONDUCTOR TEMPERATURE

E. C. Lupton, Jr., C. D. Tahlmore and J. Obsasnik
Allied Chemical Company
Morristown, NJ 07960

SUMMARY

Theoretical and experimental work has indicated that the flammability of a material increases as its temperature at the moment of flame exposure is increased. We have noted that when flammability tests are conducted on various wire types with their conductor at the rating temperature, results are sometimes observed which are substantially different from results at room temperature. These data are discussed.

I. INTRODUCTION

Flammability of wire and cable is becoming an increasingly important consideration for selection of the styles to use for particular applications. In several recent fires, including the telephone switching center fire in New York City[1] and the Brown's Ferry Nuclear Power Plant fire[1], it is believed that the wiring system was either partially or totally responsible for allowing a small fire to propagate, spread and do extremely extensive damage. Many tests are now in use or proposed to help an engineer evaluate the flammability and fire retardance of constructions but we have recently become aware of a possible use condition which none of these tests, to our knowledge, take into account.

In a survey of wire and cable engineers, Watkins[2] found that the temperature rating of a construction is considered the second most important single factor in deciding whether its use is appropriate for a particular application. Constructions are now commonly considered which range in continuous high temperature limit from +60°C or below to +260°C or above. The advantages of high temperature, high performance, small diameter constructions are becoming well understood in terms of space saving, weight saving, conductor diameter reduction, ease of installation, and long service life and these constructions take advantage of higher possible use temperatures. Energy saving consideration, and long service life and these conductor diameter reduction, ease of installations and optimum efficiency of industrial operations can also necessitate higher temperatures. It therefore seems realistic to expect that wire and cable constructions will be in common use in the future at increasingly higher temperatures. There is data in the literature indicating that when the temperature of a material is increased, before it is exposed to flame, the flammability increases also. Johnson[3] has shown that, for a variety of materials, the limiting oxygen index decreases in a predictable way as the temperature of the material increases. (The limiting oxygen index measures the percentage of oxygen required in the atmosphere for an equilibrium downward burning flame to be sustained.) Johnson[3] shows that for several different materials, the limiting oxygen index can be approximately predicted by the use of Table I.

Table I. Effect of Material Temperature upon Oxygen Index

Temperature (°C)	Fraction of 25°C Oxygen Index Retained
25	1.00
100	.92
200	.78
300	.55

While limiting oxygen index does not correlate directly with any flammability properties of wire and cable, these data suggested to us that flame testing on wire and cable constructions which are at their intended use temperature might yield results which are significantly different from room temperature results.

II. SCOPE

The results reported here will involve measurements of several different types on several different constructions. Examples are chosen to illustrate differences between room temperature and elevated temperature results.

It is beyond the scope of this work to delineate exhaustively the safe limits of any construction. It is specifically not our intent to single out constructions as "good" or "bad" but rather to suggest that the observed phenomena are so ubiquitous that they should generally be considered by engineers. For this reason, individual wire styles will not be identified by insulation or conductor type but only as styles A through E. In selecting examples, we chose conditions such as the following which would indicate degredation in the fire retardant properties of wire:

a) Dripping flaming insulation
b) Propagating flame more rapidly

c) Propagating flame for a longer period of time or a greater length

III. RESULTS

All measurements were conducted in a flame hood which was made as draft free as possible. This hood did not have the capability of being raised to elevated temperature, so for the elevated temperature testing a current was passed through the test wire or wires to raise it to its recommended rating temperature. The temperature of the wire was measured by thermocouples placed next to the conductor and on the outside of the insulation and these measurements were confirmed by optical pyrometer. The currents required are higher that would normally be used with these constructions but in the absence of an oven equipped for safe flame testing, this seemed the most appropriate way to attain the required temperatures. The current was measured by a clamp-on ammeter.

Example A - A sample of wire insulated by material A was placed in the draft free hood at an angle canted 30° away from the verticle. A piece of Johnson and Johnson surgical cotton, with no pretreatment or drying, was placed at the base of the wire. A bunsen burner with a flame height of 3 inches was applied to the test wire four inches from its base. The barrel of the burner was parallel to the base of the chamber and pointed as in Figure I. The following results were obtained at room and at rating temperature. The insulation was colorless.

	Affected Length	Afterburn Time	Drips
Room Temp.	3 in.	2 sec.	Yes
Rating Temp.	4 in.	14 sec.	Yes (25% lit the cotton)

Example B - Wire insulated with material B, which is similar in rating temperature and chemical structure, to material A, was tested in a manner similar to material A. The insulation was colorless. The results were:

	Affected Length	Afterburn Time	Drips
Room Temp.	2 in.	0 Sec.	None
Rating Temp.	2.5 in.	0 Sec.	None

Example C - Four wires insulated with material C were twisted together to form a bundle. The bundle was placed in a vertical position. The flame holder was a piece of pipe 4 inches long and 1/16 in inside diameter. It used no premixing of gas with air, so that there was a cold (yellow) flame, which was approximately 3 inches long.

When the flame was applied perpendicular to the wire continuously, the following results are obtained. The times listed are the time to set on fire a marker flag a particular distance above the place of fire introduction.

	6"	12"	18"
Room Temp.	120 Sec.	Never	Never
Rating Temp.	20 Sec.	75 Sec.	180 Sec.

The wires tested at room temperature burned approximately 7 inches above the point of flame exposure. After 200 seconds, the wires tested at rating temperature had to be extinguished for safety reasons, but had propagated upward for approximately 22 inches and were continuing to propagate vigorously.

In another test of the 4 cable bundle of material C the flame was applied for 30 seconds and the afterburn time was determined.

	Afterburn Time
Room Temperature	1-5 Seconds
Rating Temperature	25-55 Seconds

Example D - Wire insulated with material D was tested in a vertical position. When a bunsen burner is exposed to the wire with the flame perpendicular to the wire, the following afterburn times are noted:

	5 Sec. Exposure	10 Sec. Exposure	15 Sec. Exposure
Room Temp.	0 Sec.	3 Sec.	7 Sec.
Rating Temp.	3 Sec.	7 Sec.	11 Sec.

If the small cold flame described in Example C is exposed to the wire for a long duration, the observed results are

	Length of the bare wire, charred or melted insulation
Room Temp.	1 1/2 inches
Rating Temp.	4 inches

Example E - Wire insulated with material E, which is identical in rating temperature to Material D, was tested in a vertical flame test with the flame canted 10° to the test wire. The results are the following:

	Bare, Charred or Melted Insulation	Afterburn
Room Temp.	2 inches	0 Sec.
Rating Temp.	1.5 inches	0 Sec.

CONCLUSIONS

In several different examples it is shown that for some insulation materials under some conditions the following differences are noted between flammability testing at room temperature and at the materials rating temperature:

a) The test wire is charred for a greater portion of its length
b) The wire continues to burn for a longer period of time after the test flame is removed
c) The flame propagates upward more rapidly

For at least one material, the following differences were noted:

d) A construction which would not propagate flame upward at room temperature would at the rating temperature

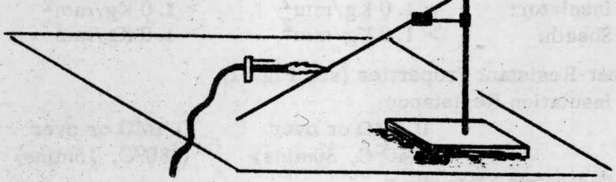
e) A construction dripped flamming insulation at the rating temperature which would not at room temperature

These results suggest that room temperature flammability testing is not always adequate to determine the fire retardance of a wire construction. For those constructions which are intended for use at temperatures significantly above 25°C and which require fire retardance, testing at use temperature would seem to be required in order to assure fire safety.

References

1. L. King, Chemical Tech. 348 (June 1975)
2. W. D. Watkins, U.S. Naval Avionics Facility, Personal Communications
3. P. R. Johnson, Journal of Applied Polymer Science, 18, 491-504 (1974)

Figure I. Testing Arrangement for Examples A & B



Dr. Elmer C. Lupton, Jr. directs fluoropolymer Applications Research for the Specialty Chemicals Division of the Allied Chemical Corporation. He is engaged in development of wire and cable products in several areas including transit, utility, military and computers. Dr. Lupton is a member of the Society of Plastics Engineers, the American Chemical Society, Phi Lambda Upsilan and Sigma Xi and is technical consultant to the NEMA high temperature wire committee and the A2H committee of the SAE. He holds an S. B. degree from MIT and a PhD from Yale University.

Mr. C. David Tahlmore is a research engineer with the Specialty Chemicals Division of the Allied Chemical Corporation. Presently he is responsible for characterizing the electrical properties of a broad line of both thermoplastics and thermosets, with emphasis on line and cable products. Previously his efforts were devoted to thermost compound development for electrical applications.

Mr. Tahlmore is a member of ASTM Committee D-09 on electrical insulation.

Mr. John Obsasnik is a Process Engineer with the Specialty Chemical Division of the Allied Chemical Co. Currently he is developing several improved processes for monomer and polymer synthesis. He has a BS degree from newark College of Engineering and is a member of the American Institute of Chemical Engineers.

HEAT-RESISTANT CABLES FOR FIRE-PREVENTION SYSTEMS

T. MAEZAWA, Y. MURAYAMA and A. YOSHIZAWA

The Furukawa Electlric Co., Ltd, Tokyo, JAPAN

ABSTRACT

It is necessary to effectively connect sensors and indicators to prevent fires in subways, hotels, etc.

The present report describes the details of the designs and the evaluation of the cables for this purpose. This report discusses the following.

1. The cores of the cable are separated by means of the S-shaped heat-resistant tape. (Type 1)

2. The cable is designed simply using cross-linked polyethylene. (Type 2)

3. The cable is designed so as to resist higher temperatures by using silicon rubber. (Type 3)

4. The cable is designed so as to be used also in the frequency ranges beyond the voice frequency. (Type 1, 2 and 3)

1. INTRODUCTION

When a fire breaks out where many people are gathered, for example in subways, hotels, offices, and department stores, there is a possibility that peoples movements by the mob spirit may result in an unexpected disaster. In order to prevent such disaster, it is necessary to systematically and effectively arrange sensors and indicators, and to monitor and control them at required places.

For example, when a sensor, which reacts to the rise in temperature or to the generation of smoke, and a liaison interphone is installed in each room of a hotel, they should be monitored somewhere and adequate instructions should be given through the interphone. If the cable connecting such equipment is damaged and put out of commission by a fire, these many sensors and interphones would become meaningless. Therefore, the construction, materials, and testing methods for the cables that are fit for such purpose are discussed. The materials for such cables are required to be heat-resistant and have good electrical properties when they should be easy. Consequently, glass mica tape, cross-linked polyethylene and silicon rubber have been chiefly examined. Basing on the actual circumstances of Japan, the cables were tested by burning them under two conditions: at 380°C for 15 mins. (Grade B), and at 840°C for 30 mins. (Grade A). A large number of designs for cable construction have been discussed with many materials. As the result, three types of the cables, Type 1, Type 2 and Type 3, have been developed, of which details are described in the present report.

2. REQUIREMENTS

Since the most important property necessary for the cables of a fire-prevention system is to fulfill their functions when a fire breaks out, satisfactory properties at high temperatures are required. And the method of use of the cables, which decides the temperature, should also be duly considered.

The temperature when a fire breaks out depends upon the structure of the building, amount of combustibles, amount of air that flows in, and so on. But in Japan, the standard curve of heating temperature shown in Fig. 1 is generally received. Basing on it, some wiring methods have been developed, such as the wiring by burying a cable in a main fire-retardant construction and the wiring with an adequate heat protection (see Fig. 2 and Fig. 3). These wiring methods can chiefly be adopted when ordinary cables are used for a fire-prevention system, but they can not be adopted where the buildings are not newly-built or the equipment is to be enlarged. Thus, we have developed a new open wiring method, that is wiring cable of the same properties as those used in the above-mentioned methods without buring the cable in the structure.

This method requires the following cable properties.

Table 1 Requirements

	Grade A	Grade B
Tensile Strength		
Conductor:	> 28.0 Kg/mm^2	> 28.0 Kg/mm^2
Insulator:	> 1.0 Kg/mm^2	> 1.0 Kg/mm^2
Sheath:	> 1.0 Kg/mm^2	> 1.0 Kg/mm^2
Heat-Resistant Properties (see Fig. 1)		
Insulation Resistance:	0.2MΩ or over (840°C, 30mins)	0.1MΩ or over (380°C, 15mins)
Dielectric Strength:	AC 250 V/min (840°C, 30mins)	AC 250 V/min (380°C, 15mins)

The heat resistant properties of Grade A are the most severe requirements, which seem hard to be satisfied by usual methods. Of course, the same properties as those of ordinary communication cables are required.

3. HEAT-RESISTANCE TEST

The testing methods for the heat-resistant properties are as shown in Fig. 4, Fig. 5 and Fig. 6. A cable sample is fixed to the heat-resistant board and the insulation resistance is measured after being heated in accordance with the curve of heating temperature shown in Fig. 1. And while the sample is heated, the insulation resistance and dielectric strength are measured.

4. DESIGN AND MANUFACTURE

After the requirements of the heat-resistant cables had been fixed, the cables were designed and manufactured.

For designing the cables, materials and construction of the cables was investigated. The following materials shown in Table 2 were investigated.

Table 2 Heat-Resistant Materials

Material	Application
Heat-resistant polyvinyl chloride (PVC)	Extruding
Cross-linked polyethylene (PE)	Extruding
TFE	Extruding
Polyimide	Coating
Mica polyester tape	Lapping
Silicon glass tape	Lapping
Glass mica tape	Lapping
Silicon rubber	Extruding

Heat-resistant polyvinyl chloride was not considered because it was inferior to polyethylene in its insulation resistance under normal conditions. TFE was also not considered because its extruding was difficult and it was costly. Polyimide was also not considered because it was difficult to remove polyimide, which was used as an insulator, when connecting cables. But this material seems to be useful as an effective heat-resistant material for cables of large-sized conductors. The S-shaped construction as shown in Fig. 8 was adopted for lapping cores with tape in order to make it easy to manufacture cables. It was desirable to insert the tape during twisting of the cores, because the same properties as those of ordinary communication cables were required of the cable. Silicon rubber was employed as an insulating material because the use of special silicon rubber appeared to make it possible to manufacture the cables that satisfy Grade A.

Then, three types of cables shown in Fig. 7, Fig. 8, and Fig. 9 were manufactured and the evaluation tests were made on them. Several kinds of shields and sheaths of the cable were selected and combined. The results of the evaluation tests are shown in Table 3.

As for the cables of Type 1, both the silicon glass tape (glass tape on which silicon rubber is coated) and the mica polyester tape (polyester tape on which mica tape is stuck) short-circuited after the heat-resistance test, which, therefore, was judged to be unsatisfactory. But the glass mica tape (glass tape on which mica tape is stuck) appeared to satisfy the requirements having no reference to the presence of the shield. Therefore, the final design was made using such construction.

Since the cables of Type 2 were affected by the sheath materials, heat-resistant polyvinyl chloride was adopted for the sheath for the final design.

As for the cables of Type 3, the heating temperature reaches as high as 840°C which burns or melts all the materials except copper, and it is very difficult to keep the form of the cable. Therefore, it was desired to keep the cable form to satisfy Grade A, and the construction shown in Fig. 10 was adopted for the final design.

5. EVALUATION

Three kinds of cables of Type 1 of different outside diameters were manufactured and the heat-resistance tests were made on them. These results are shown in Fig. 11. These results considerably exceed the goal values and it is confirmed that this design satisfies Grade B. The results of the measurements of the electrical characteristics are shown in Fig. 12. These results conclude that the cables of Type 1 can be used for Grade B in a similar way as ordinary communication cables.

The cables of Type 2 of three different outside diameters were manufactured, and their heat-resistances and electrical characteristics were measured. The insulation resistances of the heat-resistance tests were lower than those of the cables of Type 1, but they satisfy Grade B. Consequently we estimate that, if great importance is attached to the electrical characteristics under normal conditions, the use of the cables of Type 2 may be more advantageous. The results of the tests are shown in Fig. 13 and Fig. 14.

The cables of Type 3 were manufactured in accordance with the final design and the tests were made on them. The test results, shown in Fig. 15, shows that the cables satisfy Grade A. Only the cables of small outside diameters were manufactured because it is well known, by the former tests when a weight (W in Fig. 4, 5, and 6) of two times cable's own weight is loaded on the cable, that the smaller cables are more readily deformed.

6. CONCLUSION

The open wiring of the heat-resistant cables is possible and the cables of the same degree as those of ordinary communication cables can be manufactured. We made it possible to choose various combinations of the cables depending, especially, on the temperature and time. (For example, if the cable for 380°C, 30mins. is required, it may be obtained by combining the cables of Type 1 and 2.) And the cables that will resist the temperature as high as 840°C are also be obtainable.

We believe that these cables are absolutely necessary for the development of fire-prevention systems.

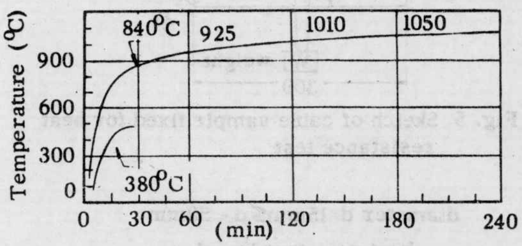


Fig. 1 Standard curve of heating temperature

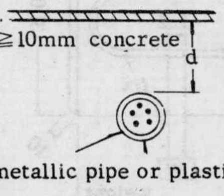


Fig. 2 Wiring in fire retardant main construction

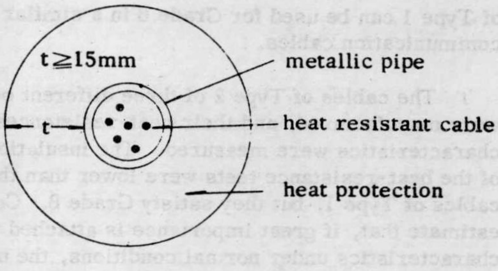


Fig. 3 Heat protection of unburied wiring

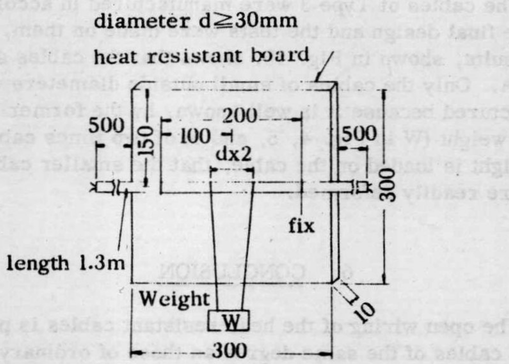


Fig. 4 Sketch of cable sample fixed for heat resistance test

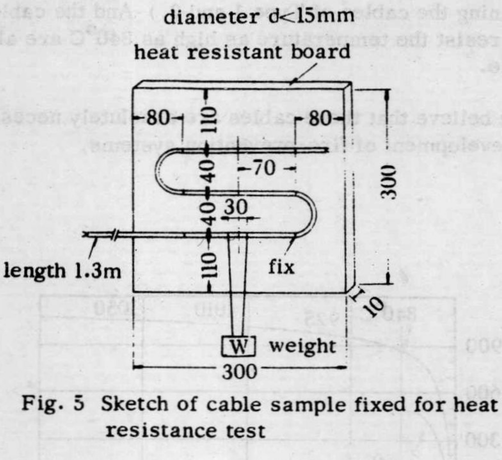


Fig. 5 Sketch of cable sample fixed for heat resistance test

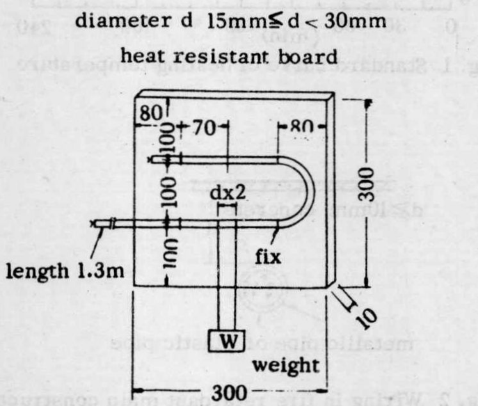


Fig. 6 Sketch of cable sample fixed for heat resistance test

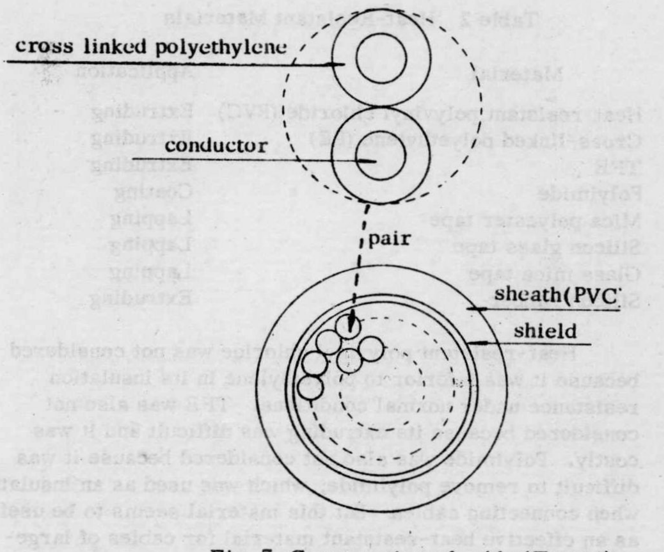


Fig. 7 Construction of cable (Type 2)

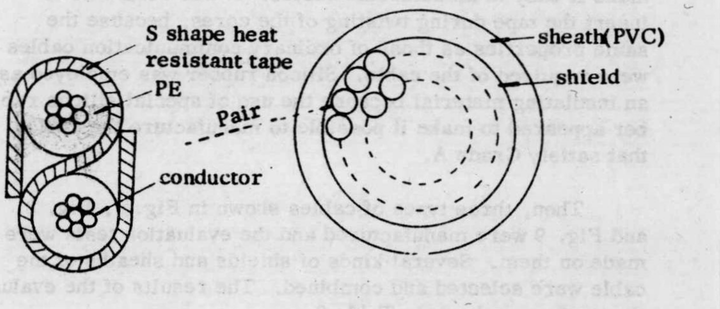


Fig. 8 Construction of Cable (Type 1)

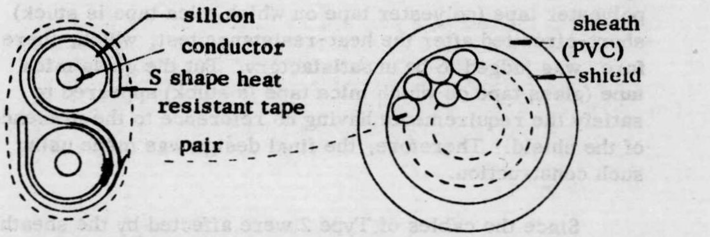


Fig. 9 Construction of cable (Type 3)

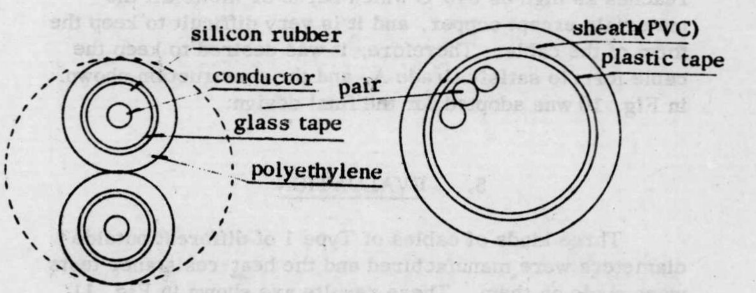


Fig. 10 Construction of cable (Type 3)

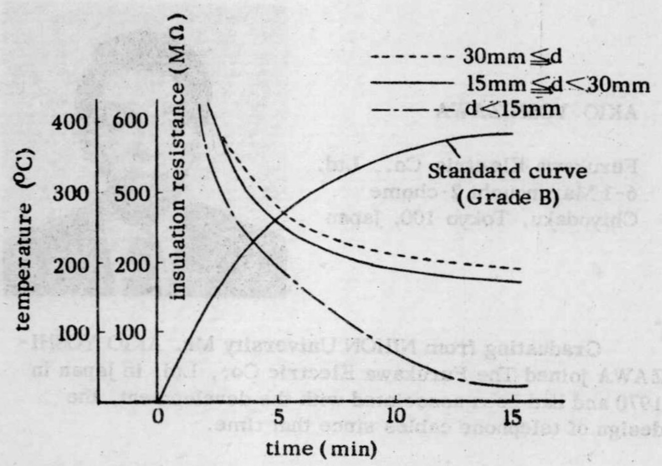


Fig. 11 Heat resistance test

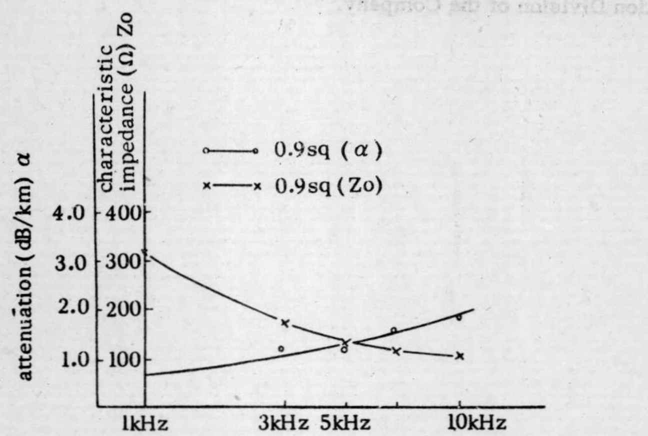


Fig. 12 Frequency characteristic of heat resistant cable

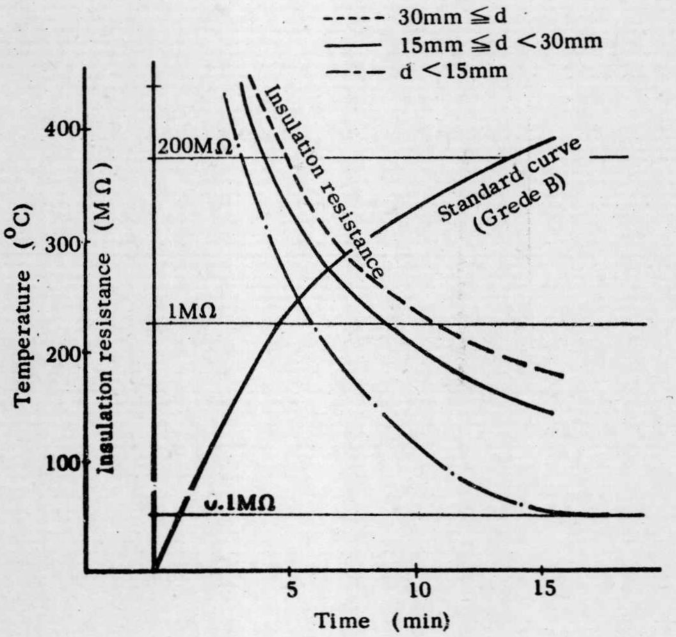


Fig. 13 Heat resistance test

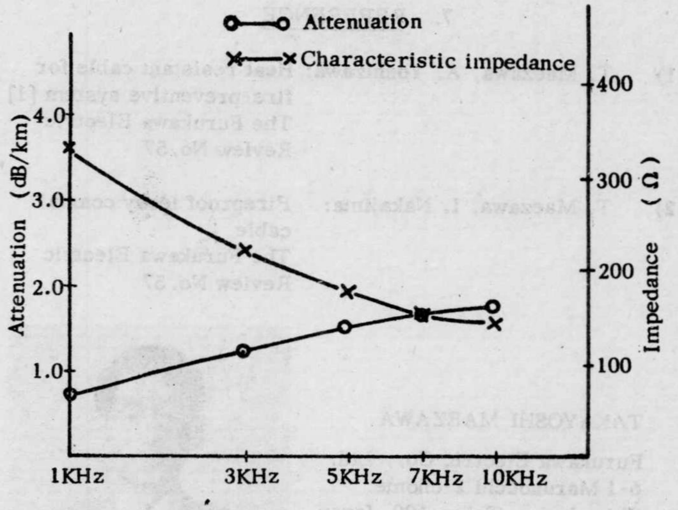


Fig. 14 Frequency characteristic of heat resistant cable

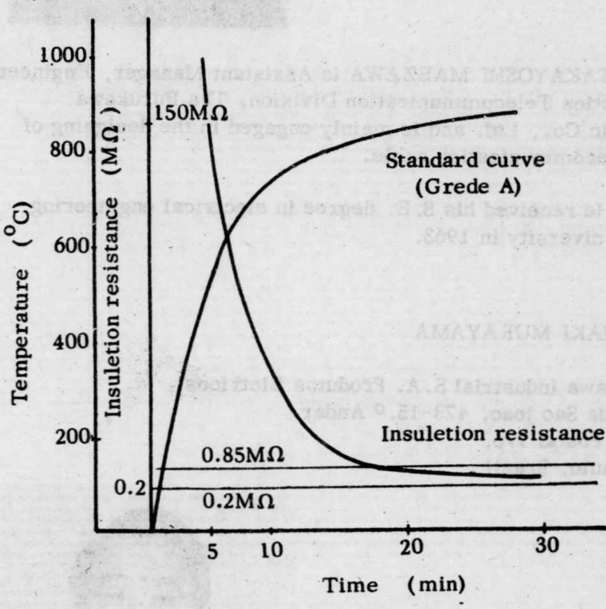
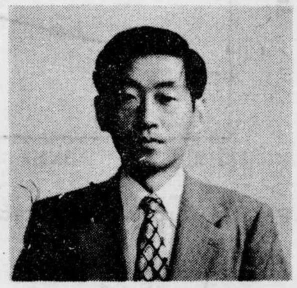


Fig. 15 Heat resistance test

7. REFERENCE

1) T. Maezawa, A. Yoshizawa: Heat resistant cable for fire-preventive system [1] The Furukawa Electric Review No. 57

2) T. Maezawa, I. Nakajima: Fireproof leaky coaxial cable The Furukawa Electric Review No. 57



TAKAYOSHI MAEZAWA

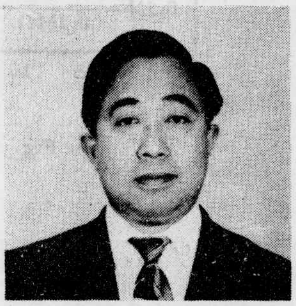
Furukawa Electric Co., Ltd.
6-1 Marunouchi 2-chome
Chiyoda-ku, Tokyo 100, Japan

TAKAYOSHI MAEZAWA is Assistant Manager, Engineering Section Telecommunication Division, The Furukawa Electric Co., Ltd. and is mainly engaged in the designing of the telecommunication cable.

He received his B. E. degree in electrical engineering Keio University in 1963.

YOSHIAKI MURAYAMA

Furukawa Industrial S.A. Produtos Eletricos
Avenida Sao Joao, 473-15.º Andar.
Caixa Postal 176,
Sao Paulo, Brazil

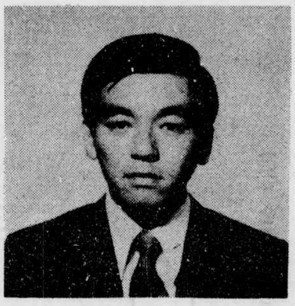


YOSHIAKI MURAYAMA joined the Furukawa Electric Co., Ltd. in Japan in 1954 and had been associated with the development, the design and the manufacture of telephone cables since that time.

In 1975 he transferred to Furukawa Industrial S.A. in Brazil and is now the Manager of the Telephone Cable Engineering Department. He received his B. E. degree in Telecommunication Engineering from Waseda University in 1954.

AKIO YOSHIZAWA

Furukawa Electric Co., Ltd.
6-1 Marunouchi 2-chome
Chiyodaku, Tokyo 100, Japan



Graduating from NIHON University Mr. AKIO YOSHIZAWA joined The Furukawa Electric Co., Ltd. in Japan in 1970 and had been associated with the development, the design of telephone cables since that time.

At present he is Engineering section, telecommunication Division of the Company.

DEVELOPMENT OF IMPROVED FLAME RESISTANT INTERIOR WIRING CABLES

by

S. Kaufman and C. A. Landreth
Bell Laboratories
Norcross, Georgia 30071

ABSTRACT

A PVC flexible jacket compound with an oxygen index of 32% has been developed without sacrificing good low temperature brittleness properties. The high oxygen index was achieved by minimizing the plasticizer level and substituting fine particle size hydrated alumina as a filler/flame-retardant for the inert filler, calcium carbonate. Preliminary data on inside wiring cable jacketed with the new material satisfied the goal of a flame spread classification of 25. A vertical corner test also shows the progress made in improving the cable's resistance to flame spread.

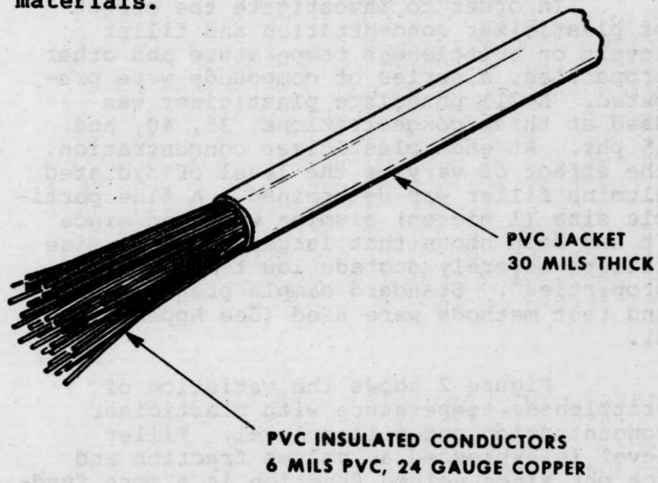
INTRODUCTION

Since flame retardancy is a prime requirement for the Bell System's inside wiring cables, these cables are insulated and jacketed with poly(vinyl chloride) (PVC) compounds. Rigid (unplasticized) PVC is a highly flame retardant polymer (oxygen index 45%), but it is unsuitable for wire insulation and cable jackets. Compounding with 30 phr (parts per hundred of resin) of plasticizer yields a semirigid compound suitable for wire insulation, but the combustible plasticizer causes the oxygen index of the compound to be lowered to approximately 28%. A typical flexible jacket compound containing 45 phr plasticizer and 3 phr of a flame retardant also has an oxygen index of approximately 28%.

In recent years there has been an evolution toward increasingly stringent flame spread standards in building codes, fire codes, and in the Bell System's design standards. At the present time a flame spread classification (FSC) of 25 or less, when the cables are tested in the twenty-five foot tunnel test (ASTM E-84)* is being sought. Bell Laboratories has undertaken a flame resistant PVC project with the objective of developing improved PVC compounds which permit the design of cables that satisfy the FSC of 25. This paper describes the development and testing of an inside wiring cable that has a flame spread classification of 25 as determined in a twenty-five foot tunnel test. Also, the results of a vertical corner fire test are presented. This type of test could be more indicative of the flame spread of vertical cable installations.

CABLE CONSTRUCTION

Inside wiring cable (Figure 1) is primarily used for wiring to key telephone sets. The core is made up of twisted pairs of 24 gauge copper conductors insulated with 6 mils of semirigid PVC compound. Unlike outside plant cables, inside wiring cables do not have a core wrap or shield. The jacket is a 30-35 mil thick (depending on cable size), flexible, light olive grey, PVC compound. Central office cable is of similar construction and uses identical materials.



25 PAIR INSIDE WIRING CABLE

FIGURE 1

The formulation of the current insulation and jacket compounds are shown in Table I. Alternate formulations incorporating other phthalate plasticizers are used, but for convenience only those with a C_7, C_9, C_{11} (711) phthalate are shown. The key properties of the jacket compound are a brittleness temperature of -28°C and an oxygen index of 28%. The wire insulation has the same oxygen index.

* Strictly speaking ASTM-E84 is a building materials test and does not apply to cable. However, appropriate modifications have been made in order to test cable.