Signal 480
Application No. 4501501
February 21, 1946
REPORT
on
FIRE-DETECTING WIRE
Protectowire Company
Hanover, Mass.
PRODUCT COVERED:

USL, CNL protectowire fire-detecting wire, types EPC, EPN, *and EPR in the ordinary (155°F), intermediate (190°F), high (280°F) and extra high (356°F) rating.

GENERAL CHARACTER:

Protectowire is a heat-sensitive cable composed of two conductors, each coated with a thermoplastic. The conductors are assembled in spiral windings and are wrapped with two layers of cellophane tape over which a covering of conventional cotton braid is woven and finally lacquered.

*The EPR type cable is similar to the EPC and EPN Cable except the EPR cable is provided with an outlet jacket constructed from extruded polypropylene rubber.

The wire is ordinarily furnished in coils of any footage up to 500 ft, and in the ordinary, intermediate and high temperature ratings.

CNL indicates investigation to Canadian Standard CAN/ULC-S530-M91.
CONSTRUCTION DETAILS:

Conductors - Spring or music wire.

Conductor Insulation Combining with Thermo-Responsive Function - Ethyl cellulose with an appropriate plasticizer to permit temperature response.

Wrapping - Moisture and flame resisting cellophane tape.

Braid - Conventional cotton braid tightly applied over cellophane tape wrapping. Exterior surfaces coated with lacquer.

SPECIFICATIONS

The wire should be adequately protected from abusive treatment while in storage or in the process of manufacture.

No product intended for shipment should show indications of injurious abrasions, kinks incidental to sharp bends or the like, nicks or battered areas.

MATERIALS AND DIMENSIONS:

Conductors - Spring steel (music wire, either plated or bright), 0.035 in. in diameter. Limits 0.034 to 0.037 in. Surface of conductors should show no rust or foreign scale coatings.

Thermoplastic Insulation on Conductors - Conductors to be individually coated with an ethyl cellulose compound, an appropriate plasticizer being added to produce proper thermo responsiveness.

Coatings to be uniform in thickness and continuous on each conductor and be from 0.0065 to 0.0085 in. in thickness.

Conductor Wrapping - Moisture and flame resistant "Cellophane" 3/8 in. wide tape spirally wrapped at 1.8 in. pitch (approximately).
Braid - Conventional cotton braid tightly applied over cellophane tape wrapping. Exterior surfaces coated with lacquer. Covering to be complete and continuous.

Packaging - All wire to be supplied in coils of not less than 10 in. diameter suitably wrapped and prepared for shipment.

Marking - The braid of the ordinary degree rating is a solid red, brown, or white-colored. Wire of the intermediate rating is identified by solid red with two white tracers, solid white with single brown tracer or solid brown with single white tracer. Wire of the high rating is identified by solid red with brown tracer.

Refer to the installation manual for ratings and required ambient temperatures. For the Types EPC and EPN heat-sensitive cable, the following ambient temperature ranges are: rated 155°F wire up to 100°F, rated 190°F wire - to 150°F, rated 280°F wire and rated 356°F wire - to 221°F. An installation manual is provided with each wire.

The required marking for the cotton braid construction appears on a durable moist resistant tag attached to each coil by a 3/8 in. wide piece of cotton braid. The tag is spun-bound olefin with a metal eyelet welded to the tag. The tag is manufactured by Dennison, Part No. SL-11-422. The approximate dimensions are 2 by 3-1/4 by 1-5/8 in. See ILL. 1 for the exact marking. The date code should be the day, month, and year.
QUARTERLY TESTS TO BE CONDUCTED BY THE FIELD REPRESENTATIVE:

Operating Temperature - Sections of wire are to be suspended in a water bath, the temperature of which gradually increases until the samples operate. Each sample to be connected to a suitable power source rated 30 V rms, 42.4 V dc and means of indicating contact of the conductors upon operation such as light or buzzer. The temperatures of the bath to be controlled to a rise of 1°F per min after attaining 140 and 170°F for the ordinary and intermediate degree ratings, respectively.

The bath liquid should be stirred throughout the test and the temperature should be measured by a reasonably accurate thermometer calibrated for shallow immersion.

Limitations - The samples under test should operate in the following ranges:

<table>
<thead>
<tr>
<th>COTTON BRAID</th>
<th>Limits</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rating</td>
<td>Minimum</td>
</tr>
<tr>
<td>Water Bath</td>
<td>Ordinary</td>
<td>155</td>
</tr>
<tr>
<td>Water Bath</td>
<td>Intermediate</td>
<td>190</td>
</tr>
<tr>
<td>Oil Bath</td>
<td>High</td>
<td>280</td>
</tr>
</tbody>
</table>

* Types EPC, EPN, and EPR Limits

<table>
<thead>
<tr>
<th></th>
<th>Limits</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EPN</td>
<td>EPC</td>
</tr>
<tr>
<td>Water Bath</td>
<td>Ordinary</td>
<td>155</td>
</tr>
<tr>
<td>Water Bath</td>
<td>Intermediate</td>
<td>190</td>
</tr>
<tr>
<td>Oil Bath</td>
<td>High</td>
<td>280</td>
</tr>
<tr>
<td>Oil Bath</td>
<td>Extra High</td>
<td>356</td>
</tr>
</tbody>
</table>

Dielectric Tests - Tests should be conducted on all of the products by the manufacturer.

All of the products should be subjected to a potential of 1250 V ac for 1 min without breakdown applied as follows:

A. Between conductors (separate conductors at end for 6 in.).

B. Between the conductors tied together and aluminum foil wrapped around the conductor assembly except for 6 in. at end.
SAMPLES FOR ANNUAL INSPECTION (NORTHBROOK OFFICE):

The field representative shall select one 25 ft length sample of each temperature rating from material that has been produced since the previous inspection. These samples should be properly labeled for identification, well packed and shipped to the Casualty and Chemical Hazards Department, Northbrook Office, without delay.

This material is to be used for countercheck tests and should be representative of the commercial product in all essential details.

CASUALTY AND CHEMICAL HAZARDS DEPARTMENT TESTS (ANNUAL):

1. Detailed Examination - An examination shall be made of each rating. The construction shall be in conformity with the requirements under Material and Dimensions.

2. Operating Temperature - Five 2 ft lengths of each rating shall be tested in a water bath. See Operating Temperature Test for the test description and operating limits.

3. Dielectric Strength Test - Five 3 ft samples of each rating shall be subjected to a 1250 V ac potential applied as follows:

   A. Between conductors. (Separate conductors at end for 6 in.).

   B. Between the conductors tied together and aluminum foil wrapped around the conductor assembly, except for 6 in. at each end.

4. Qualitative Infrared Analysis - Infrared analysis shall be conducted on the clear coating (ethyl cellulose with plasticizer) of each temperature rating. The spectrums obtained shall indicate the original investigation of this material dated January 8, 1980 for ordinary degree rating, January 9, 1980 for intermediate degree rating and January 10, 1980 for high degree rating.
MANUFACTURER'S TEST PROGRAM:

GENERAL

To assure compliance with these requirements in production, the manufacturer shall provide the necessary production control inspection and tests. The program shall include at least the operating temperature test. A record of accepted detectors and the detector serial number or equivalent is to be maintained.

OPERATING TEMPERATURE TEST

A minimum of three 3 ft long samples from each production run from each "drum" of insulation material shall be subjected to the test to determine response to temperature. The samples shall be immersed in a water reservoir or tank and the heat source used to increase the temperature of the water shall be an electric range or equivalent. The temperature shall be increased as specified under the operating temperature test conducted by the field representative during the quarterly inspection. The measured values shall be within limits specified under the same test.
TYPES EPC, EPN, AND EPR
FIG. 1 (K93-2287)

Type EPC - Employs outer jacket of cotton braid. Otherwise constructed as described previously in this Report. The PVC cable Types PHSC 155 are Lyncor Type 263, Globe Type 3130, and Blane Type 375FR. The PVC for cable Types PHSC 190, PHSC 280 and PHSC 356 are Lyncor 746, Globe Type 1055, and Blane Type 309C.

Type EPN - EPN is identical to Type EPC except has 0.01 in. thick Du Pont Zytel 157HSLBK010A jacket over the PVC jacket specified above.

Type EPR is similar to Type EPN except the outer jacket is 0.02 in. thick SARLINK 3145D manufactured by DSM thermoplastic Elastomer Inc. Refer to ILL. 5 for additional construction details and ILL. 6 for markings.
## TYVEK TAG

**MAT'L:** SPUN-BONDED OLEFIN W/METAL EYELET  
**MFR:** DENNISON  
**PART NO:** S1-11-442  
**SIZE:** #2 - 3 1/4 x 1 1/8
OUTER JACKET COLOR | COMPANY NAME | TYPE OF DEVICE | FACTORY MUTUAL MARK | EXTRUDED PLASTIC COVERING | FIXED (TRIP) TEMP. | UNDERWRITERS LABORATORIES INC. MARKINGS | MARKING INK COLOR
--- | --- | --- | --- | --- | --- | --- | ---
155°F Regular - BLACK | PROTECTOWIRE LINE HEAT DETECTOR | FM | EPN 155°F | & | LISTED 931G | WHITE
190°F Intermediate - BLACK | PROTECTOWIRE LINE HEAT DETECTOR | FM | EPN 190°F | & | LISTED 931G | WHITE
280°F High Temp. - BLACK | PROTECTOWIRE LINE HEAT DETECTOR | FM | EPN 280°F | & | LISTED 931G | WHITE
356°F Extra High - BLACK | PROTECTOWIRE LINE HEAT DETECTOR | FM | EPN 356°F | & | LISTED 931G | WHITE

LETTERING SIZE 0.062" HIGH MIN.
MARKINGS TO REPEAT EVERY 18" MAX.

PROTECTOWIRE
PROTECTOWIRE LINE HEAT DETECTOR
TYPE-EPN—OUTER JACKET MARKINGS

A 1/1993 ADD EX. HI. TEMP. | OWN | W.F.D. | DATE 4-2-93
B 1/7/90 ADD UL MARKINGS | APPD | |
TEMPERATURE RATINGS AND COLOR CODINGS

155°F Regular - RED
- PROTECTOWIRE LINE HEAT DETECTOR ▶ FM ◀ EPC 155°F ▶ LISTED 931G

190°F Intermediate - WHITE
- PROTECTOWIRE LINE HEAT DETECTOR ▶ FM ◀ EPC 190°F ▶ LISTED 931G

280°F High Test - BLUE
- PROTECTOWIRE LINE HEAT DETECTOR ▶ FM ◀ EPC 280°F ▶ LISTED 931G

356°F EXTRA HIGH - LT. BLUE or RED
- PROTECTOWIRE LINE HEAT DETECTOR ▶ FM ◀ EPC 356°F ▶ LISTED 931G

LETTERING SIZE 0.062" HIGH MIN.
MARKINGS TO REPEAT EVERY 24" MIN.

PROTECTOWIRE
PROTECTOWIRE LINE HEAT DETECTOR
TYPE - EPC - OUTLET JACKET MARKING

A 9/25/81 SIZE W.S. 0.083" DOW NF.C.
B 8/6/81 ADD EX. H.TEMP. DATE 8-10-80
C 5/7/82 ADD UL MARKING APPD 5/7/82

THE PROTECTOWIRE CO. INC. DWG NO 603 REV 3
Features

- Line coverage... continuous sensitivity.
- Four temperature ratings.
- Withstands moisture, alkalis, dust, low temperatures.
- Approved for hazardous locations.
- No contacts to foul.
- Easy to install and test.
- Economical, no maintenance expense.
- Compatible with other initiating devices on same circuit.

Protectowire Linear
Heat Detector

Application

Protectowire Linear Heat Detector is a proprietary cable that detects heat anywhere along its length. An entire system wiring is turned into a continuous fire detector.

Ideally suited to industrial high risk hazards, the Detector is used extensively in steel mills, power generation plants, pulp and paper mills, chemical, cement, aluminum and coal preparation plants. Linear detection has unique advantages when used in areas of limited access and surveillance, pollution, dust and corrosion — where early detection of a fire can be of inestimable value.

Equally adaptable to commercial applications, Linear Heat Detection is widely used in schools and colleges, churches, historic sites, municipal buildings, government installations and agricultural buildings.

The Detector can be run throughout all parts of a building including all rooms, halls, storage areas, basements, lofts and accessible spaces. Stairways, elevator shafts, closets and chutes may also be protected.

Detection is assured at any point along the run.
Fast, dependable, proven fire protection

Line coverage point sensitivity
Protectowire Linear Heat Detector is comprised of two actuators individually encased in a heat sensitive material. The encased actuators are twisted together to impose a spring pressure between them, then spirally wrapped with a protective tape and finished with an outer covering to suit the environment of use.

At installation a device is connected to one end of the actuators so that when a power source is added a small monitoring current passes continuously through the detector and supervisory circuit. At the critical or operating temperature the heat sensitive material yields to the pressure on it, permitting the actuators to move into contact with each other.

This action takes place at the first heated point anywhere along the Detector. The heat does not have to result from open flame, nor produce any specified density of smoke, nor increase at any particular rate. Heat alone causes the alarm.

Special hazard applications...
- Cable trays
- Conveyors
- Power distribution apparatus:
  - Switchgear, Transformers,
  - Substations, Motor control centers,
  - Resistor banks
- Dust collectors/ baghouses
- Cooling towers
- Government installations
- Warehouse rack storage
- Mines
- Pipelines
- Bridges, piers, marine vessels
- Refrigerated storage
- Tank farms
- Hangars
- Computer rooms

Protectowire Linear Heat Detector pinpoints the exact locations of an overheating condition anywhere in these high risk hazards and will withstand their aggressive atmosphere with little or no maintenance. Vital systems are kept in operation.

The Detector meets intrinsically safe standards when used with Protectowire control panels FM approved for Class I, II, or III, Div.1, Applicable Groups A, B, C, D, E & G hazardous areas.

Irradiation tests prove no Detector embrittlement or insulation breakdown when exposed to gamma radiation at a rate of 3.6 x 10^7 rads/hour.

Typical Protectowire fire alarm system

Sprinkler OS & Y valve
Conveyor motor controller
Deluge valve
Alarm bells
Manual station
Fire pull
Remote annunciator

Control panel

End of line resistor
WFS
Smoke detectors
Fire pull
Protectowire Linear Heat Detector

Batteries

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Sec. 1
ILL. 4
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Simple installation

The Detector is installed in continuous runs without taps or branches in accordance with applicable sections of NFPA Standard 72, National Electric Code and local codes and ordinances. Except for zoning requirements (alarm source indication) the length of runs is limited only by the electrical characteristics of the control equipment with which the Detector is associated. The Detector can be placed on the ceiling of the area to be protected or on the walls within 20 inches of the ceiling.

Messenger wire

On long runs in areas where mounting is difficult, the use of Protectowire Linear Heat Detector on a carrier or messenger wire is recommended. When using messenger wire to support the Detector, turnbuckles and eyebolts should be employed at each end of a run to prevent tension on the carrier wire. The maximum run length should be 250 feet (76m), but the messenger wire should also be supported with approved fasteners at a maximum of 50 foot (15m) intervals to reduce the sag or droop.

Messenger wire is available on special order, with any type of Protectowire. It consists of high tensile strength stainless steel wire, which is wound around the Detector at the rate of one turn per foot.

Specifications

The Detector is made in different temperature ratings to allow for differences in normal or ambient temperature. Guidelines for selecting the proper rating to be installed in a given area are the same as for automatic sprinklers and other heat actuated devices. Refer to the chart shown below for installation temperature limits. Regular, Intermediate, High and Extra High Detectors all have the same principle of actuation and are easily spliced together in series with PWS or PWSC splicing devices. Each will operate at its specific alarm temperature without influence from adjacent Detectors that are rated differently.

Flexible leads or compression fittings are required for connecting the Detector to copper wire or terminals. Electrical rating is 30VAC, 42.4VDC or peak voltage. Resistance is approximately 1 ohm per 5 feet (1.5m) of twisted pair.

Temperature ratings and model numbers

<table>
<thead>
<tr>
<th>Rated temperature</th>
<th>155°F (68.3°C) Regular</th>
<th>190°F (87.8°C) Intermediate</th>
<th>280°F (137.8°C) High</th>
<th>350°F (180°C) Extra High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum ambient temperature where Detector will be installed</td>
<td>Up to 100°F (37.8°C)</td>
<td>Up to 150°F (65.6°C)</td>
<td>Up to 200°F (93.5°C)</td>
<td>Up to 225°F (107°C)</td>
</tr>
<tr>
<td>Standard service (indoor)</td>
<td>PHSC-155 Red braid (see note 1)</td>
<td>PHSC-190 White braid, brown tracer (see note 2)</td>
<td>PHSC-280 Red braid, brown tracer</td>
<td>N/A</td>
</tr>
<tr>
<td>Multi-purpose industrial use Type EPC</td>
<td>PHSC-155-EPC Extruded red PVC</td>
<td>PHSC-190-EPC Extruded white PVC</td>
<td>PHSC-280-EPC Extruded blue PVC</td>
<td>PHSC-355-EPC Extruded blue PVC</td>
</tr>
<tr>
<td>Abrasion and chemical resistant Type EPN</td>
<td>PHSC-155-EPN Black weather resistant nylon over PVC</td>
<td>PHSC-190-EPN Black weather resistant nylon over PVC</td>
<td>PHSC-280-EPN Black weather resistant nylon over PVC</td>
<td>PHSC-355-EPN Black weather resistant nylon over PVC</td>
</tr>
</tbody>
</table>

NOTES:
1. Available on special order with white or brown braid.
2. Available on special order with red braid, white tracer, or brown braid, white tracer.
3. All types of Protectowire can be supplied on Messenger Wire. Add suffix "M" to above model number(s).

Approvals/Maximum listed spacing

<table>
<thead>
<tr>
<th>Standard service</th>
<th>Type EPC</th>
<th>Type EPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL (25 ft./7.6m)</td>
<td>UL (25 ft./7.6m)</td>
<td>UL (25 ft./7.6m)</td>
</tr>
<tr>
<td>ULC (15 ft./4.6m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FM (25 ft./7.6m)</td>
<td>FM (25 ft./7.6m)</td>
<td>FM (25 ft./7.6m)</td>
</tr>
</tbody>
</table>
Installation
Numerous accessories are approved for the installation of Protectowire Linear Heat Detector. These include several types of clips and straps, drive rings, beam clamps, cable standoffs and tension wire. Their proper use assures a neat and workmanlike installation. Only installation hardware supplied or approved by The Protectowire Company shall be used.

Splicing
The different ratings of Protectowire Linear Heat Detectors all have the same size conductors and are readily spliced together by means of PWS or PWSC splicing devices, which are manufactured to close tolerances for this specific purpose and are the only approved methods of splicing the Detectors. The use of wire nuts for any Protectowire connections is prohibited.

Accessories
The Protectowire Company offers an assortment of fasteners and splicing devices to facilitate installation for a wide variety of applications.

Special application items
Cable tray installations
PC-2 mounting clips
Will clamp to trays .030" (.76mm) to .065" (1.65mm) in thickness
CC-2N mounting clips
Will clamp to material between .16" (4.06mm) to .25" (6.35mm)
Also available:
CC-2W mounting clip
Will clamp to material between .16" (4.06mm) to .25" (6.35mm)

Sprinkler related installations
PM-3 series - Pipe mounting straps
Catalog Pipe size
PM-3A .75" (19.1mm) to 2" (50.8mm)
PM-3B 2.5" (63.5mm) to 3.5" (88.9mm)
(Larger sizes also available)

System capabilities
Protectowire Linear Heat Detector is a component of a complete family of systems manufactured by The Protectowire Company - a leader in fire detection for over fifty years.

Capabilities include meeting any fire defense need from multiple alarm zones to auxiliary equipment shutdown and automatic extinguishing. Modular in design, Protectowire detection systems meet specific individual requirements and allow for system expansion at any time, providing long range economy. For further information, call or write:

The Protectowire Co., Inc.
Post Office Box A, Hanover, MA 02339-0360 USA
617-826-3878, Fax 617-823-2045
Special hazard fire detection systems
HEAT SENSITIVE INSULATION: (.008" ± .002")

CONDUCTORS: Steel Wire (.035" dia.)

CONDUCTORS TWISTED (approximately every 1")

POLYESTER (MYLAR) WRAPPING (.5" wide X .0008" thick)

APPROX. .150 DIA.

POLYPROPYLENE ELASTOMER OUTER JACKET .020" ± .003" thk.
COLOR: GRAY or BLACK
TEMPERATURE RATING AND OUTER JACKET COLOR

| 155°F Regular | GRAY | * | PROTECTOWIRE LINE HEAT DETECTOR <!> FM <!> EPR 155°F <!> UL Listed 931G |
| 190°F Intermediate | GRAY | * | PROTECTOWIRE LINE HEAT DETECTOR <!> FM <!> EPR 190°F <!> UL Listed 931G |
| 280°F High Temp. | GRAY | * | PROTECTOWIRE LINE HEAT DETECTOR <!> FM <!> EPR 280°F <!> UL Listed 931G |
| 356°F Extra High | BLACK | ** | PROTECTOWIRE LINE HEAT DETECTOR <!> FM <!> EPR 356°F <!> UL Listed 931G |

MARKING INK COLOR

| BLACK |

LETTERING SIZE 0.062” HIGH MIN.
MARKING TO REPEAT EVERY 18” TO 24”.

* STANDARD JACKET COLOR IS GRAY WITH BLACK MARKING
FOR DETECTORS RATED 155°F, 190°F and 280°F
ALTERNATE JACKET COLOR WILL BE BLACK WITH WHITE MARKING.

** STANDARD JACKET COLOR FOR DETECTOR RATED 356°F (EXTRA HIGH)
IS BLACK WITH WHITE MARKING. ALTERNATE COLOR WILL BE GRAY WITH BLACK MARKING.
TEST RECORD NO. 1

INSTALLATION TESTS:

METHOD

The instructions given by the manufacturer and installations incidental to operating tests were the source of data for these tests.

RESULTS

While a certain degree of care was required to prepare the ends of the wire for their connection to terminals and in making splices, the experience gained indicated that the operation was not particularly difficult. A pair of pliers, a knife, and a screwdriver were the only tools required, and attachment to the sleeves held the ends of the wire sufficiently secure for substantial electrical contact.

The sleeves used in making splices were found to securely grip the copper leads. Tensile strength tests of the sleeve-lead connection gave values varying from 33 to 37 lb and in each case, the lead wire broke before the sleeve yielded its grip. Tests of connections between the sleeves and steel wire gave tensile strength values rating from 6 to 15 lb. Following are data regarding the joint strength between sleeves and steel wire.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Length of Steel Wire Inserted in Sleeve, in.</th>
<th>Number of Nicks With the Cutting Edge of Pliers</th>
<th>Tensile Strength, lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15/16</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>15/16</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>15/16</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>15/16</td>
<td>4</td>
<td>8-1/2</td>
</tr>
<tr>
<td>5</td>
<td>7/8</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>15/16</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>15/16</td>
<td>5</td>
<td>9-1/2</td>
</tr>
<tr>
<td>8</td>
<td>15/16</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>15/16</td>
<td>5</td>
<td>9-1/2</td>
</tr>
<tr>
<td>10</td>
<td>15/16</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>
The installations made show that it is practicable to install the wire with ordinary tools and care on the part of the installer. The operations described by the manufacturer's instructions were readily carried out and resulted in acceptable installations. Tests of the sleeve type of connectors disclosed a lack of tensile strength but sufficient if strain relief is provided by the clips usually placed near the spliced ends.

Consistent with all linear type fire alarms, consideration should be given to protect the runs of wire from mechanical injury, building settlement, expansion and contraction, and tight staples.

**SENSITIVENESS TESTS:**

**METHOD**

The Laboratories' thermostat testing oven was utilized for these tests. Sections of wire were prepared and these sections, were in turn, placed both longitudinally and crosswise in the air stream. The ends of the sections of wire were, in each case, passed through the cover of the oven and connected to a power source and an alarm device to indicate operation. The effective length of samples prepared for installation crosswise in the oncoming air stream was 7 in. long, while the effective length of the longitudinal samples was 12 in.

**RESULTS**

<table>
<thead>
<tr>
<th>Spacing - Exposing Temperature Condition</th>
<th>Sample Number and Position in Oven</th>
<th>Time of Operation, s</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 by 15 ft 206°F, 2 min</td>
<td>Crosswise in air stream - Mounted on ceiling of oven</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>143-12</td>
</tr>
<tr>
<td></td>
<td>Mounted 1/4 in. from surface of oven ceiling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>120-1/2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>101-1/2</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>102</td>
</tr>
</tbody>
</table>

Table continued
### Spacing - Exposing Temperature Condition

<table>
<thead>
<tr>
<th>Sample Number and Position in Oven</th>
<th>Time of Operation, s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lengthwise in air stream mounted on ceiling of oven</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>168</td>
</tr>
<tr>
<td>2</td>
<td>320 +</td>
</tr>
<tr>
<td>3</td>
<td>232</td>
</tr>
<tr>
<td>4</td>
<td>200</td>
</tr>
<tr>
<td>5</td>
<td>217</td>
</tr>
<tr>
<td>Mounted 1/4 in. from surface of oven ceiling</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>171</td>
</tr>
<tr>
<td>2</td>
<td>162</td>
</tr>
<tr>
<td>3</td>
<td>168</td>
</tr>
</tbody>
</table>

| 12-1/2 by 12-1/2 ft, 2 min | Crosswise in air stream - Mounted on ceiling of oven | |
|---------------------------|-----------------------------------------------------|
|                           | 1                                                    |
|                           | 2                                                    |
|                           | 3                                                    |
| Mounted 1/4 in. from surface of oven ceiling | |
| 1                          | 99                                                  |
| 2                          | 106                                                 |
| 3                          | 106                                                 |

| Lengthwise in air stream - Mounted on ceiling of oven |                      |
| 1                                                        | 178-1/2              |
| 2                                                        | 178                  |
| 3                                                        | 186                  |

| Mounted 1/2 in. from surface of oven ceiling |                      |
| 1                                                        | 137-1/2              |
| 2                                                        | 135                  |
| 3                                                        | 133-1/2              |

---

The variation in the operating time presented in this sample was judged to result from an intimate contact with the ceiling surface of the oven. Additional tests undertaken with the sample likewise installed showed the same characteristic performance.
The results show that the operation of the wire is influenced by the position of the sample in the oven. Because the wire is a line type alarm device, tests for spacing limitations were supplemented by fire tests to permit installation of longer sections of wire. However, the results showed successful operation of 26 short samples totalling approximately 23 linear feet. The time of operation obtained in the tests where the wire was crosswise in the air stream and 1/4 in. from the oven ceiling surface qualified the device for 15 by 15 ft spacings, but results obtained in tests where the wire was lengthwise in the air stream or installed in contact with the ceiling showed slower response. Tests of linear fire alarm wire are conducted in the oven to develop operating characteristics rather than spacing limitations.

**FIRE TESTS:**

**METHOD**

Installation of the wire was made in one of the Laboratories' fire test rooms which was 18 ft wide, 19 ft long, by 10 ft, 8 in. high. The room was equipped with automatic sprinklers installed on regular branch lines 10 ft apart extending with the long dimension of the room. Four sprinklers were installed on fittings in the branch lines, spaced 10 ft apart, in the upright position with their deflectors 4 in. from the ceiling surface. The wire was installed on the ceiling in four sections, each 15 ft in length. The sections were arranged so that the breaks between the lengths were located midway between the corners of a 15 ft square described on the ceiling. Each of the four sections was in turn connected to a power source and lamp bank for indicating operation.

Temperature measurements were obtained in the region adjacent to one of the sprinklers and at the companion corner of the wire as installed on the ceiling.

The arrangement of the wire and identification are shown on the following curve sheet.

Alcohol fires in a 3 by 3 ft pan centered on the floor of the test room constituted the exposure. The fuel was introduced to the pan through a pipe extending to the exterior of the room. The flow of alcohol was controlled to produce fires of gradually increasing severity.
The wire was installed on the ceiling by means of the clips and drive loop hangers submitted by the manufacturer. When installed under the clips, the wire was held close to and in many sections in contact with the ceiling surface whereas the installation of wire in the drive loops placed the wire approximately 1/2 in. from the ceiling surface.

The tests were designed to show the sensitiveness or speed of operation of the wire, the operation of automatic sprinklers being a means of comparison.

RESULTS

The data are shown by Fig. 1 which shows graphically the temperatures measured at the southeast sprinkler and at the corner of the wire diagram involving the southeast section. Operation of the devices is indicated by arrows on the temperature curves.

The following table gives the approximate temperature rise at the sprinkler and the southeast section of wire after the first minute of the test. About 1 min elapsed before ascending temperature conditions were definitely established at the thermocouples. The distance on the diagonal from the center of the fire pan to the thermocouple at the sprinkler was 11 ft, 8 in. and the couple at the wire sample was 14 ft, 4 in.

<table>
<thead>
<tr>
<th>Rate of Flow of Alcohol cc/min</th>
<th>Test No.</th>
<th>Estimated Fuel Required to Cause Operation, cc</th>
<th>Approximate Rate of Temperature Rise 1 Min After Starting Test, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sprinkler</td>
<td>Wire</td>
</tr>
<tr>
<td>1000</td>
<td>3</td>
<td>4830</td>
<td>3830</td>
</tr>
<tr>
<td>1000</td>
<td>2</td>
<td>4300</td>
<td>3043</td>
</tr>
<tr>
<td>1500</td>
<td>1</td>
<td>6000</td>
<td>4925</td>
</tr>
<tr>
<td>2000</td>
<td>4</td>
<td>6099</td>
<td>5089</td>
</tr>
</tbody>
</table>

Except for two instances, the wire operated prior to the highly responsive pilot sprinklers. Comparison of the operation of the wire with sprinklers classified as having average responsiveness showed that the wire functioned from 21 to 41 s prior to the pilot sprinklers. The overall average difference in the time of operation of the sprinklers and the time of operation of the wire was 30 s.
The following table presents comparative data:

<table>
<thead>
<tr>
<th>Responsiveness Grading of Pilot Sprinklers</th>
<th>Location of Sprinklers and Section of Wire</th>
<th>Time of Operation, Minutes and Seconds</th>
<th>Difference in Time of Operation Between Sprinklers and Wire, s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Southeast</td>
<td>3 min, 25 s 2 min, 55 s</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Northwest</td>
<td>3 min, 45 s 3 min, 17 s</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>Southeast</td>
<td>4 min, 7 s 3 min, 25 s</td>
<td>41</td>
</tr>
<tr>
<td>4</td>
<td>Northwest</td>
<td>3 min, 35 s 3 min, 14 s</td>
<td>21</td>
</tr>
<tr>
<td>Least responsive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Southwest</td>
<td>4 min, 0 s 3 min, 9 s</td>
<td>51</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>4 min, 18 s 3 min, 21 s</td>
<td>57</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>4 min, 50 s 3 min, 38 s</td>
<td>72</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>3 min, 3 s 2 min, 21 s</td>
<td>42</td>
</tr>
<tr>
<td>Highly responsive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Northeast</td>
<td>3 min, 4 s 3 min, 1 s</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>3 min, 11 s 3 min, 19 s</td>
<td>-8</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>3 min, 46 s 3 min, 50 s</td>
<td>-4</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>2 min, 27 s 2 min, 24 s</td>
<td>3</td>
</tr>
<tr>
<td>Overall average</td>
<td></td>
<td>3 min, 38 s 3 min, 8 s</td>
<td>30</td>
</tr>
</tbody>
</table>

The results of these tests showed no material differences in operation when the wire was installed close to the ceiling (Tests 1 and 2), and when installed in the drive loops with the wire 1/2 in. from the ceiling surface (Tests 3 and 4).

The results show that alarms were given prior to the operation of automatic sprinklers in all but two cases, even though the wire was installed at greater spacings (sprinklers 10 by 10 ft, wire 15 by 15 ft). The results also show that operation of the wire preceded that of the sprinkler of average responsiveness by an average of 30 s, but was on a par with the most sensitive sprinkler (two sections of wire operated 3 s prior to pilot sprinklers while two sections operated 4 and 8 s later than the pilot sprinklers).
OPERATING TEMPERATURE TESTS:

METHOD

Sections of the wire were suspended in a water bath, the temperature of which was gradually increased until all of the samples operated. Each sample was individually connected to a signal lamp and current source, and the temperature of the bath at the instant of operation was recorded.

RESULTS

<table>
<thead>
<tr>
<th>Sample From</th>
<th>Operating Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outside End of Coil</td>
</tr>
<tr>
<td></td>
<td>Inside End of Coil</td>
</tr>
<tr>
<td>1</td>
<td>158</td>
</tr>
<tr>
<td>2</td>
<td>163</td>
</tr>
<tr>
<td>3</td>
<td>160</td>
</tr>
<tr>
<td>4</td>
<td>157.5</td>
</tr>
</tbody>
</table>

(1 - Aged for 79 days at normal temperatures - 163)

Tests of samples from coils of the intermediate degree wire gave the following results.

<table>
<thead>
<tr>
<th>Temperature Rating</th>
<th>Sample From Coil No.</th>
<th>Operating Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate</td>
<td>1</td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>186</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>198</td>
</tr>
</tbody>
</table>

The results showed fairly consistent performance and agreement with the temperature ratings.

HIGH TEMPERATURE EXPOSURE TESTS:

METHOD

10 ft of the ordinary and 10 ft of the intermediate degree wire were separately wound into coils approximately 10 in. in diameter and suspended in ovens maintaining temperatures of 125°F for the ordinary degree rating and 150°F for the intermediate degree rating wire. Connections were made to a power source and a recording instrument to indicate operation.
A 10 ft section of ordinary degree rated wire was mounted on a panel of veneer so as to contain eight sharp right angle bends. The wire was attached to the surface of the panel with small unprotected staples driven firmly over the wire. An additional 10 ft sample was similarly installed on the panel and contained 19 bends having an approximate radius of 1-1/2 in.

The data were studied to ascertain whether the wire would be apt to operate prematurely, and if the stability of the wire was influenced adversely by stresses set up in sharp bends and the like.

RESULTS

No signals were received while the samples were subjected to high temperature (125°F) during a period of 80 days in the oven. The sections of wire including the sections having sharp bends and tight staple attachments withstood the treatment without producing an alarm.

### Dielectric Strength Tests of Samples Subjected to High Temperature

<table>
<thead>
<tr>
<th>Temperature Rating</th>
<th>Exposure Temperature, °F</th>
<th>Duration Days</th>
<th>Breakdown Potential, V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary</td>
<td>125</td>
<td>47</td>
<td>13,500</td>
</tr>
<tr>
<td>Ordinary</td>
<td>Normal</td>
<td>47</td>
<td>22,125</td>
</tr>
<tr>
<td>Ordinary</td>
<td>125</td>
<td>79</td>
<td>13,000</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Normal</td>
<td>79</td>
<td>27,500</td>
</tr>
<tr>
<td>Intermediate</td>
<td>150</td>
<td>30</td>
<td>20,500</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Normal</td>
<td>30</td>
<td>21,250</td>
</tr>
</tbody>
</table>

As no alarms were received recording operation of the samples being subjected to high temperature, it is reasonable to conclude that the wire will withstand ordinary ceiling temperatures indefinitely.

The dielectric strength values showed that samples subjected to temperatures in excess of that recommended for the two ratings yielded some of the insulating value. The loss was approximately 40 percent in the case of the ordinary degree rating sample subjected to a temperature of 125°F for 79 days, but in spite of the loss, the insulation still withstood a potential up to 13,000 V.
LOW TEMPERATURE EXPOSURE TEST:

METHOD

A 10 in. section of wire which was approximately one year old was stripped of braid and cellophane wrapping and the ends were hooked together so that each strand formed a circle approximately 3 in. in diameter.

The loops were suspended in a deep freezer maintaining a temperature of -40°F. After one, two and 10 days, the samples were removed and the ends were unhooked which permitted the sample to change from a circular shape to nearly a straight position. While still cold, each sample was flexed and distorted from its natural shape.

The tests were undertaken to ascertain if the plastic insulating material over the steel wires became brittle and susceptible to cracking when cold.

RESULTS

Upon removal of the samples from the refrigerator after exposures of one, two and 10 days at -40°F, no changes were observed in the insulating coating. Flexing the samples while still cold produced no visible cracks and no change in the coating was apparent under a magnifying glass.

Low temperatures are not likely to affect the wire adversely as is shown by the lack of any cracking or flaking of the plastic coating when the wires were flexed while cold.

CORROSION TESTS:

Two 5 ft sections of wire were each subjected to the Laboratories' standard salt spray and sulphurious acid vapor corrosion for a period of 30 days.

When the exposures were completed, the samples were permitted to remain in normal atmosphere for 10 days, after which sections were tested in the operating oven, following the routine established for tests for sensitiveness under the standard rate of temperature rise condition for 12-1/2 ft spacings. Sections of wire were also subjected to dielectric strength tests to ascertain the effect of corrosion on the insulating material.
The samples subjected to corrosive influences were in each case intact and the conductors were insulated from each other when tested with a magneto bell ringer. The exterior of the braid was slightly loaded with salt crystals in the salt spray exposed samples and the samples treated with sulphurous acid vapor were slightly faded in color.

The exposed ends of the conductors were in each case severely rusted. In the samples treated with sulphurous acid vapor, the deterioration penetrated the insulated covering over the individual conductors and a slight discoloring of the conductors was noticeable. In the samples subjected to salt spray, the deterioration of the conductors ended abruptly, at the ends of the exposed wire and no material rusting or discoloring of the wire surfaces was found under the plastic insulation in any section.

The plastic coatings revealed no important physical change and remained ductile and intact on the wires.

Samples were tested for operation in the oven by applying the temperature condition prescribed for 12-1/2 by 12-1/2 ft spacings. In each instance, the samples were installed 1/4 in. from the oven ceiling and crosswise of the on-coming air stream.

<table>
<thead>
<tr>
<th>Corrosion Treatment</th>
<th>Sample No.</th>
<th>Time of Operation, s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt spray</td>
<td>1</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>82-1/2</td>
</tr>
<tr>
<td>Sulphurous acid vapor</td>
<td>1</td>
<td>161</td>
</tr>
<tr>
<td></td>
<td></td>
<td>121</td>
</tr>
<tr>
<td></td>
<td></td>
<td>95</td>
</tr>
</tbody>
</table>

The sections of wire subjected to gradually increased potential for dielectric strength were found to break down at the following voltages.
The results showed that some deterioration took place in the material subjected to sulphurous acid vapor. The vapors apparently penetrated the plastic coating and discolored the conductors, resulting in an increase of the operating time in the oven in two or three samples tested, and a reduction in the dielectric values in one of two samples tested.

Even though the salt spray exposure caused a constant wetting of the samples for 30 days, no material effect was observed on the operation or dielectric strength, a condition indicative of moisture resistance.

The results are sufficiently favorable to show that the wire should withstand deteriorating influences ordinarily encountered in service.

**GREASE LOADING TEST:**

**METHOD**

Two lengths of wire were immersed in mineral and vegetable oil grease for a period of 30 days after which dielectric strength and operating temperature tests were conducted to observe if any change took place in the wire coverings.

**RESULTS**

Operating temperature tests of the treated samples gave the following.

<table>
<thead>
<tr>
<th>Treatment of Samples</th>
<th>Operating Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral oil grease</td>
<td>162</td>
</tr>
<tr>
<td>Vegetable oil grease</td>
<td>162</td>
</tr>
<tr>
<td>Normal storage</td>
<td>163</td>
</tr>
</tbody>
</table>
Dielectric strength data obtained after treatment gave the following.

<table>
<thead>
<tr>
<th>Treatment of Samples</th>
<th>Breakdown Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral oil grease</td>
<td>26,250</td>
</tr>
<tr>
<td>Vegetable oil grease</td>
<td>28,000</td>
</tr>
<tr>
<td>Normal storage</td>
<td>27,500</td>
</tr>
</tbody>
</table>

The above results showed that the treatment resulted in no change in the properties of the coverings of the wires, which indicates that the wire would not be adversely affected by grease and similar loadings in service.

ROUGH USAGE TEST:

METHOD

Samples of the wire were subjected to abusive treatment, after which dielectric strength tests were conducted on them to show the effect of the treatment. Three samples 20 in. long were also tested while under line voltage of 24 V ac while connected to an electric bell.

Sections of the wire were mounted on 1 by 6 in. boards, 20 in. long and were subjected to the following treatment.

Sample No. 1 - Two sections of wire were installed on the board. One of which was held to the board by four clips placed 6 in. apart. Common bare iron staples were used to retain the remaining section of wire on the board. The staples were placed 6 in. apart and were driven snugly against the wire.

Sample No. 2 - This panel mounted one section of wire 30 in. long and included ten relatively sharp right angle bends. Eight clips were used to hold the sample in place.

Sample No. 3 - Four 20 in. sections were installed on the surface of the board, two of which were under clips and the two remaining lengths were held to the board by common small staples spaced 6 in. apart. The driving of the staples was gauged so that in one section they were snugly fitted over the wire while in the other they were driven tight, but not sufficient to break the braid or distort the wire.
One section of the wire sample under clips was struck blows with the face of a claw hammer, five blows being delivered over a section of wire 10 in. long. The companion sample was subjected to five blows of the edge of the hammer so as to nick the wire. The blows were such as to drive the wire into the surface of the board about 1/64 in.

Samples 1, 2 and 3 - They were prepared and stored 32 days before dielectric strength tests were conducted to gauge the extent of injury resulting from the rough treatment.

Sample No. 4 - It was made up of two sections of wire 22 in. long which were mounted under clips at each end on a 1 by 6 in. board, 20 in. long. Each sample was in turn connected to a 24 V ac power source and bell. The board and mounted sections of wire were laid on a bench and the wire was struck hammer blows to ascertain the effect of rough treatment incidental to installation and unusual rough service.

Two small staples were roughly driven into the board over a sample of the wire and the resulting damage was observed.

RESULTS

Sample No. 1 - Representing normal installations gave the following breakdown voltage values.

Installation under clips - 25,000 V.

Installation under unprotected iron staples driven firmly over the wire - 24,000 V.

Sample No. 2 - Representing installations under clips, but with wire formed into relatively sharp bends, broke down at the following voltage.

Sample having 10 right angle bends - 25,500 V.

Sample No. 3 - Four lengths of wire mistreated after installation.

Sample held by four unprotected staples driven snugly over wire - 28,000 V.

Sample held by four unprotected staples driven tightly over wire so as to indent the covering to a slight degree - 17,000 V.
Sample of wire struck five blows with the face of a hammer - 13,500 V.

Sample of wire struck five blows with the edge of the hammer face - 11,000 V.

In tests of Sample No. 4 in which the wire was mounted on the surface of the board and struck with the hammer, it was found that 27 and 30 blows over a length ranging from 2 to 3 in. were required to produce an alarm. In each case, the wire was driven into the surface of the board to a depth of 5/64 in.

Two bare staples were roughly driven into the board, over the wire, and five and six blows were required to produce an alarm. The staples and included section of the wire were depressed by the stapling so as to be flush with the board surface.

A sample of wire was struck, over a section approximately 3/4 in. in length, with the edge of the hammer face and eight rather sharp blows were required to produce an alarm. The wire in the area mistreated was based, the insulation broken and the conductors were exposed prior to the final blow causing the alarm.

Two blows were delivered to a section of wire resting on a metal surface and 2-1/2 in. of the sample was battered and injured before an alarm was given.

The results show that the wire is capable of resisting such ordinary rough usage as is anticipated during installation and use.

**DIELECTRIC STRENGTH TEST:**

**METHOD**

An alternating current potential of 1120 V was gradually applied between current-carrying parts and held for 1 min. Breakdown values were obtained by applying a gradually increased potential to the conductors until breakdown occurred.

**RESULTS**

A potential of 1120 V was applied to the pair of conductors and maintained for 1 min without breakdown.

KS/PS:lam
Libry
In tests of a 5 ft sample from each of four coils of the ordinary degree and one coil of the intermediate degree rating wire, the electrical breakdown occurred as follows.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Roll No.</th>
<th>Breakdown Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary</td>
<td>1</td>
<td>19,500</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>16,500</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>23,000</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>29,500</td>
</tr>
<tr>
<td></td>
<td>(Sampled aged for 80 days)</td>
<td>27,500</td>
</tr>
<tr>
<td>Intermediate</td>
<td>1</td>
<td>20,500</td>
</tr>
<tr>
<td></td>
<td>(Sampled aged for 80 days)</td>
<td>21,250</td>
</tr>
</tbody>
</table>

As judged from these values, it is apparent that the material is acceptable for use under potentials ordinarily encountered and that the dielectric values are not reduced through aging.

The manufacturer requests Listing at 50 V or less, 1 A, AC or DC.

**FLAME TESTS:**

**METHOD**

Standard flame tests of wire were conducted and, in addition, wire installed on a ceiling was ignited and observations were made as to the nature of the fire and rate of spread.

**RESULTS**

In the standard flame test, the wire burned freely.

Tests of the wire while installed showed that a lighted match was sufficient to cause ignition which produced an alarm. The wire supported a candle-like flame which traveled slowly and involved a section of wire 15 in. long in a period of 5 min.
This wire differs in its use from that ordinarily employed for power supplies in that no electrical energy worthy of classification as a hazard is employed in the circuit. Should the wire ignite for any reason, a fire alarm would be produced.

**RECORD IN SERVICE**

The manufacturer presented the following information:

"Millions of feet of 'PROTECTOWIRE' Heat-Sensitive Cable are now in use. Scores of incipient fires have been detected, and so far as known not one has been missed. Among the places where the successful detection of one or more fires has been reported are Grenier Field, Manchester, N.H.; Radiation Laboratory, Massachusetts Institute of Technology; Camp Edwards, Falmouth, Mass.; Shelby Air Base (Housing Project) Shelby, Ohio; Federal Public Housing Authority, Ft. Worth, Texas; Federal Public Housing Authority, Seattle, Washington."

**THE SUBMITTOR**

The manufacturer supplied the following data regarding his organization:

"THE PROTECTOWIRE CO. has been continuously engaged in the manufacture of 'PROTECTOWIRE' Heat-Sensitive Cable and associated equipment since 1938."

**FACTORY METHODS:**

The machine tools and testing equipment necessary for commercial production of the device are available.

**SUPERVISION OF PRODUCT BY UNDERWRITERS LABORATORIES INC.:**

This device will be placed under Reexamination Service.
SAMPLES:

Samples of line type heat detector wire rated 190°F, constructed as described in the preceding section of this Report, were submitted by the manufacturer and subjected to the following limited test program to determine compliance with the Fourth Edition of UL 521.

OVEN TEST:

METHOD

Samples of the heat detector were separately installed in UL's thermostat testing oven. The detectors were positioned such that they formed two 4 in. concentrically wound loops with the bottom of the loops approximately 6 in. from the top of the oven. The samples were allowed to remain in the oven for at least 5 min at 85°F prior to starting each trial. The temperature of the oven was increased following a 15 ft spacing curve. The time and temperature at which the units went into alarm were monitored.

RESULTS

The following times and temperatures were recorded:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Spacing, ft</th>
<th>Operating Temperatures, °F</th>
<th>Operating Time, s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>186</td>
<td>86</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>197</td>
<td>102</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>195</td>
<td>103</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>192</td>
<td>95</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>198</td>
<td>104</td>
</tr>
</tbody>
</table>

Since the units complied with the requirements of this test, the fire tests were not required to be conducted.
TEST RECORD NO. 3

SAMPLES:

Samples of line type heat detector wire rated 155, 190, 280 and 356°F, Type EPC employing outer PVC for PHC are Lyncor Type 263, Globe Type 3130 and Blane Type 375FR. The PVC for PHSC 190, PHSC 280 and PHSC 356 are Lyncor 746, Globe Type 1055 and Blane Type 309C jacket and Type EPN employing 0.01 in. thick Du Pont Zytel nylon No. 157HSLBK010A outer jacket over the PVC jacket specified above were submitted by the manufacturer and subjected to the following limited test program to determine compliance with the Fourth Edition of UL 521. The samples were otherwise constructed as described previously in this Report.

BATH TEST:

METHOD

Ordinary degree temperature rated 155°F samples of Model EPC were placed in a water bath and higher degree temperature rated samples are placed in an oil or glycerine bath.

The heat sensitive cable samples, 3 ft length, are concentrically wound in a coil having a maximum diameter of 4 in.

The samples and the thermometer were submerged in the liquid, which was agitated at a rate sufficient to insure uniform temperature throughout the liquid. A load equal to the minimum load rating of the link was applied to the samples by a series of pulleys, cables, and weights. The temperature of the bath was increased to within 15°F of the temperature rating and was then increased at the rate of 1°F/min until the samples operated.

RESULTS

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>158</td>
</tr>
<tr>
<td>2</td>
<td>155</td>
</tr>
</tbody>
</table>
METHOD

Ordinary degree temperature rated 190°F samples of Model EPC were placed in a water bath and higher degree temperature rated samples are placed in an oil or glycerine bath.

The heat sensitive cable samples, 3 ft length, are concentrically wound in a coil having a maximum diameter of 4 in.

The samples and the thermometer were submerged in the liquid, which was agitated at a rate sufficient to insure uniform temperature throughout the liquid. A load equal to the minimum load rating of the link was applied to the samples by a series of pulleys, cables, and weights. The temperature of the bath was increased to within 15° of the temperature rating and was then increased at the rate of 1°F/min until the samples operated.

RESULTS

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

METHOD

Ordinary degree temperature rated 280°F samples of Model EPC were placed in a water bath and higher degree temperature rated samples are placed in an oil or glycerine bath.

The heat sensitive cable samples, 3 ft length, are concentrically wound in a coil having a maximum diameter of 4 in.

The samples and the thermometer were submerged in the liquid, which was agitated at a rate sufficient to insure uniform temperature throughout the liquid. A load equal to the minimum load rating of the link was applied to the samples by a series of pulleys, cables, and weights. The temperature of the bath was increased to within 15° of the temperature rating and was then increased at the rate of 1°F/min until the samples operated.
RESULTS

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>298</td>
</tr>
<tr>
<td>2</td>
<td>298</td>
</tr>
</tbody>
</table>

METHOD

Ordinary degree temperature rated 356°F samples of Model EPC were placed in a water bath and higher degree temperature rated samples are placed in an oil or glycerine bath.

The heat sensitive cable samples, 3 ft length, are concentrically wound in a coil having a maximum diameter of 4 in.

The samples and the thermometer were submerged in the liquid, which was agitated at a rate sufficient to insure uniform temperature throughout the liquid. A load equal to the minimum load rating of the link was applied to the samples by a series of pulleys, cables, and weights. The temperature of the bath was increased to within 15° of the temperature rating and was then increased at the rate of 1°F/min until the samples operated.

RESULTS

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra High</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>360</td>
</tr>
<tr>
<td>2</td>
<td>359</td>
</tr>
</tbody>
</table>

METHOD

Ordinary degree temperature rated 155°F samples of Model EPN were placed in a water bath and higher degree temperature rated samples are placed in an oil or glycerine bath.

The heat sensitive cable samples, 3 ft length, are concentrically wound in a coil having a maximum diameter of 4 in.

The samples and the thermometer were submerged in the liquid, which was agitated at a rate sufficient to insure uniform temperature throughout the liquid. A load equal to the minimum load rating of the link was applied to the samples by a series of pulleys, cables, and weights. The temperature of the bath was increased to within 15° of the temperature rating and was then increased at the rate of 1°F/min until the samples operated.
RESULTS

Sample No.  Temperature, °F

Regular
1          156
2          158

METHOD

Ordinary degree temperature rated 190°F samples of Model EPN were placed in a water bath and higher degree temperature rated samples are placed in an oil or glycerine bath.

The heat sensitive cable samples, 3 ft length, are concentrically wound in a coil having a maximum diameter of 4 in.

The samples and the thermometer were submerged in the liquid, which was agitated at a rate sufficient to insure uniform temperature throughout the liquid. A load equal to the minimum load rating of the link was applied to the samples by a series of pulleys, cables, and weights. The temperature of the bath was increased to within 15° of the temperature rating and was then increased at the rate of 1°F/min until the samples operated.

RESULTS

Sample No.  Temperature, °F

Intermediate  1    198

METHOD

Ordinary degree temperature rated 280°F samples of Model EPN were placed in a water bath and higher degree temperature rated samples are placed in an oil or glycerine bath.

The heat sensitive cable samples, 3 ft length, are concentrically wound in a coil having a maximum diameter of 4 in.

The samples and the thermometer were submerged in the liquid, which was agitated at a rate sufficient to insure uniform temperature throughout the liquid. A load equal to the minimum load rating of the link was applied to the samples by a series of pulleys, cables, and weights. The temperature of the bath was increased to within 15° of the temperature rating and was then increased at the rate of 1°F/min until the samples operated.
RESULTS

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>291</td>
</tr>
<tr>
<td>2</td>
<td>289</td>
</tr>
</tbody>
</table>

METHOD

Ordinary degree temperature rated 356°F samples of Model EPN were placed in a water bath and higher degree temperature rated samples are placed in an oil or glycerine bath.

The heat sensitive cable samples, 3 ft length, are concentrically wound in a coil having a maximum diameter of 4 in.

The samples and the thermometer were submerged in the liquid, which was agitated at a rate sufficient to insure uniform temperature throughout the liquid. A load equal to the minimum load rating of the link was applied to the samples by a series of pulleys, cables, and weights. The temperature of the bath was increased to within 15° of the temperature rating and was then increased at the rate of 1°F/min until the samples operated.

RESULTS

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra high</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>361</td>
</tr>
<tr>
<td>2</td>
<td>361</td>
</tr>
</tbody>
</table>
ALCOHOL FIRE TEST:

METHOD

Alcohol fire tests were conducted on representative samples of Models EPC and EPN at a rated temperature 155°F in the Laboratories' East fire test room. The room is approximately 60 by 60 ft with a smooth 15 ft, 9 in. ceiling.

The test samples were installed on the ceiling on a 25 ft spacing schedule.

A heat sensitive cable of 20 ft (6.09 m) length is to be installed on the ceiling to form a 90° angle, with two legs, each 10 ft (3.05 m) long located at 90°. The fire source shall be located at a 45° angle from the point of intersection of the two legs.

Denatured alcohol was used as a fuel for the fire tests. The alcohol was burned in two steel pans each approximately 3 by 3 ft.

Two tests were conducted on each sample to determine the sensitivity of the detectors to rising temperature conditions when installed on a 25 ft spacing schedule. Temperature was monitored on a chart recorder and compared to a standard curve.

RESULTS

The fires were within a standard time versus temperature profile. The profile was representative of a control fire in which a 160°F ordinary rated sprinkler head responded within 120 ± 10 s from the time of ignition. Each sample responded before the maximum 120 ± 10 s from the time of ignition.

HIGH TEMPERATURE EXPOSURE TEST:

METHOD

Samples of the Type EPN combination rate-of-rise fixed temperature heat sensitive cable, a 3 ft (0.91 m) length, concentrically wound in a coil having a maximum diameter of 4 in. (102 mm), having a fixed temperature rating of 190°F, were placed in an oven with a constant ambient temperature of 175°F for a period of 30 days. The samples were removed from the test ovens after 30 days and were allowed to remain at room temperature for 24 h after which they were subjected to an oven test using the 15 ft spacing curve. The units were connected to the control panel and monitored for false alarms.
RESULTS

No signals indicative of device operation were produced while the samples remained under the high temperature exposure conditions.

The units responded within 50 percent of the average of the as received samples (179°F, 74 s).
SAMPLES:

Samples of the EPR type cable constructed as described in the preceding pages of this Report were submitted by the manufacturer. Due to similarities of the EPR type cable with the Listed EPC and EPN type cable, only the following limited test program was deemed necessary.

OPERATING TEMPERATURE TEST:

METHOD

The heat sensitive cable samples, 3 ft length, are concentrically wound in a coil having a maximum diameter of 4 in., and installed in an air-circulating oven and the temperature of the oven increased by 1°F/min until operation occurred. Each sample was individually connected and the temperature inside the oven was recorded at the instant of detector operation.

RESULTS

The operating temperature results were recorded as follows:

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Rating</th>
<th>Operating Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>155</td>
<td>155</td>
</tr>
<tr>
<td>2</td>
<td>155</td>
<td>156</td>
</tr>
<tr>
<td>3</td>
<td>155</td>
<td>157</td>
</tr>
<tr>
<td>1</td>
<td>190</td>
<td>191</td>
</tr>
<tr>
<td>2</td>
<td>190</td>
<td>194</td>
</tr>
<tr>
<td>3</td>
<td>190</td>
<td>194</td>
</tr>
<tr>
<td>1</td>
<td>280</td>
<td>285</td>
</tr>
<tr>
<td>2</td>
<td>280</td>
<td>287</td>
</tr>
<tr>
<td>3</td>
<td>280</td>
<td>292</td>
</tr>
<tr>
<td>1</td>
<td>356</td>
<td>364</td>
</tr>
<tr>
<td>2</td>
<td>356</td>
<td>366</td>
</tr>
<tr>
<td>3</td>
<td>356</td>
<td>366</td>
</tr>
</tbody>
</table>
ALCOHOL FIRE TEST:

METHOD

Alcohol fire tests were conducted on representative samples of type EPR cable rated at 155°F in the Laboratories' East fire test room. The room is approximately 60 by 60 ft with a smooth 15 ft, 9 in. ceiling.

The test samples were installed on the ceiling on a 25 ft spacing schedule.

A heat sensitive cable of 20 ft (6.09 m) length is to be installed on the ceiling to form a 90° angle, with two legs, each 10 ft (3.05 m) long located at 90°. The fire source shall be located at a 45° angle from the point of intersection of the two legs.

Denatured alcohol was used as a fuel for the fire tests. The alcohol was burned in two steel pans each approximately 3 by 3 ft.

Two tests were conducted on each sample to determine the sensitivity of the detectors to rising temperature conditions when installed on a 25 ft spacing schedule. Temperature was monitored on a chart recorder and compared to a standard curve.

RESULTS

The fires were within a standard time versus temperature profile. The profile was representative of a control fire in which a 160°F ordinary rated sprinkler head responded within 120 ± 10 s from the time of ignition. Each sample responded before the maximum 120 ± 10 s from the time of ignition.
CONCLUSIONS

PRACTICABILITY:

This wire can readily be packed and safely shipped in the usual manner, and it can be installed without material injury.

A study of the design and consideration of the test data show that this wire is sufficiently rugged to withstand ordinary handling.

A study of the design and the results of the tests show that only ordinary tools and a reasonable amount of care are required on the part of the installer in placing the wire in service.

DURABILITY:

This wire is capable of withstanding for reasonable periods of time ordinary wear and tear and is not unduly susceptible to corrosion and loading.

Paint and dirt loadings may have some heat insulating effect, but there is no prospect of thus stalling operation when sufficiently exposed to heat. Operation of the wire is not dependent upon the functioning of any mechanism and the thermo-responsive material and conductors are fully enclosed.

The results of the corrosion tests and consideration of the known properties of the materials employed show that the wire will not be unduly susceptible to deterioration ordinarily encountered in service.

STRENGTH:

Consideration of the known properties of the materials employed, a study of the design, and the results of strength tests show that the parts are made of suitable materials and are of such size and form that they will withstand the stresses ordinarily imposed upon them.
The tests showed that splices of the sleeve type will require a measure of strain relief such as would result from the installation of clips adjacent to splices. As the wire can be supplied in long lengths, the need for splices is materially reduced.

Use of steel wires 0.035 in. in diameter will afford adequate strength for strands between supports at reasonable spacings.

RELIABILITY OF OPERATION:

The wire is positive in action adequately sensitive.

In all tests in which the wire was subjected to heating, no failures were encountered and the operation was prompt and positive.

From a study of the design and operation tests, it is evident that the wire will operate properly while in any position and installations on uneven surfaces and reasonable bends in the wire will not be apt to cause failure of the wire to operate when heated.

A study of the test data indicates that the wire operates with sufficient speed to permit installation on smooth ceilings, in large bays, free from structural obstructions, at spacings of 15 ft under ordinary hazard conditions.

The results of the corrosion tests and consideration of the design of the wire show that the wire is likely to remain ready to operate under ordinary service conditions, and that moderate corrosion and calcimine or paint coatings will not necessarily render it inoperative.

UNIFORMITY:

No variations were found which were detrimental to the successful operation of the wire.

Because of the simple production processes employed for the manufacture of this wire, it is reasonable to expect that the product can be produced uniformly.
CONFORMITY:

This wire is made of such materials and the form and arrangement of the parts are such as to conform to acceptable practice for the production of wire of this type. The design, construction, and performance of the wire are considered to be in compliance with Underwriters Laboratories Inc.'s Guide for Judging Thermostats.

The thermo-responsive material used in this wire is a new application, but, as judged from the performance of the wire as tested under the various conditions, the material complies with present day requirements.

The operation of the wire is not dependent upon critical mounting or installation. The operating temperature of the device cannot be altered at will and is not subjected to change resulting from an extended period in service.

SUMMARY

From the conclusions drawn, it will be noted that it is practicable to pack and ship, install and maintain the fire detecting wire; that the material will withstand for reasonable periods of time the deteriorating effects of ordinary wear and tear and reasonable corrosion and loading; that the assembled wire will withstand all stresses to which it is likely to be subjected under normal conditions of service; that the wire is sufficiently sensitive and reliable in operation; and that the parts and complete wire are made and assembled with the requisite degree of uniformity.
RECOMMENDATION

TO THE FIRE COUNCIL OF UNDERWRITERS LABORATORIES INC.: 

We recommend promulgation of the following notice to subscribers and the action indicated thereby:

Guide No. 3819 I6.20    February 21, 1946    File S480

Protectowire Co., Mfr.
Hanover, MA

Thermostat

"Protectowire" fire-detecting wire, fixed temperature type, having two conductors, electrically insulated from each other with a thermo-responsive plastic. When subjected to heat from a fire, the conductors make contact with each other thereby closing an electrical circuit. For use in signal circuits 50 V (DC or AC), 1 A or less. Temperature ratings: Ordinary (155°F) and intermediate (190°F) degrees. Resistance approximately 20 ohms per 100 ft of cable.

Marking: Ordinary degree red braid.
Intermediate degree, two white tracers in red braid.
Fire-detecting wire to be installed to comply as to locations, distribution, and spacing with the following requirements:
Where necessary, the fire detecting wire shall be protected against mechanical injury as may be required by authorities having jurisdiction.
Lines of fire-detecting wire shall be so disposed throughout the protected area that they will be not more than 15 ft apart, nor more than 7-1/2 ft from any wall or partition extending to the ceiling.
Fire-detecting wire may be placed directly upon ceiling or upon side walls, if placed not more than 20 in. below the ceilings or it may be placed on the lower sides of timbers or projections.

Listed - Reexamination Service.

See description of Reexamination Service on guide card.

Tests by: E. P. Benjamin
Report by: E. P. Benjamin
Assistant Engineer
Hydraulic Department

Reviewed by: R. W. Hendricks
Engineer
Hydraulic Department

SUBMITTED:
R. W. Hendricks
Engineer
Hydraulic Department

The foregoing Recommendation has been accepted

UNDERWRITERS LABORATORIES INC.

Secretary