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CERTIFICATION OF FIRE-RESISTANT MATERIALS FOR USE IN UNDERGROUND MINES

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by

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ABSTRACT

In 1957 the Canadian Explosive Atmospheres Laboratory (CEAL)was asked to certify fire-resistant conveyor belting for use in underground mines. Prior to this time CEAL had certified only electrical equipment for use in gassy coal mines. Later, other fire-resistant materials such as electric cables, mine ventilation materials and hydraulic fluids were investigated and certified for underground mines.

The reason for the concern about fire-resistance is that a fire in an underground mine can foul the airways with toxic smoke and block escape routes.

This paper describes the evolution of the requirements for fire-resistant materials for use in underground mines in Canada, the preparation of National consensus standards for these materials and the recognition of CEAL's certification service for these materials by the Provincial Inspection Authorities.

Keywords: Fire-resistant, conveyor belting, electric cables, mine ventilation materials, hydraulic fluids, standards.

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HOMOLOGATION DU MATÉRIEL IGNIFUGE UTILISÉ DANS LES MINES SOUTERRAINES

par

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RÉSUMÉ

En 1957, on a demandé au Laboratoire canadien de recherche sur les atmosphères explosives (LCRAE) d'homologuer les courroies de convoyeurs ignifuges utilisées dans les mines souterraines. Auparavant, LCRAE homologuait seulement l'équipement électrique utilisé dans les mines de charbon grisouteuses. Par la suite, d'autres matériaux ignifuges tels que les cables électriques, le matériel de ventilation dans les mines et les fluides hydrauliques ont été examinés et homologués pour leur utilisation dans les mines souterraines.

L'intérêt que suscite la résistance au feu de l'équipement et du matériel provient du fait qu'un incendie dans une mine souterraine produit de la fumée toxique qui pollue les voies d'air et obstrue les sortie de secours.

Le présent rapport décrit l'évolution des exigences pour les matériaux ignifuges utilisés dans les mines souterraines au Canada, l'élaboration de normes nationales sur ces matériaux et la reconnaissance des services d'homologation du LCRAE par les autorités provinciales d'inspection.

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Mots-clés : Ignifuge, courroie de convoyeur, cables électriques, matériel de ventilation de mine, fluides hydrauliques, normes.

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INTRODUCTION

In 1950, the Provincial Ministers of Mines requested the Federal Government to provide a Certification service for Electrical Equipment for use in Coal Mines. Until that time, a Canadian manufacturer of such equipment had to send his equipment to a foreign laboratory for certification because there was no such service available in Canada.

In 1955, the Department of Mines and Technical Surveys (the predecessor of Energy, Mines and Resources Canada) set up the Canadian Explosive Atmospheres Laboratory to perform certification tests for Electrical Equipment for use in Coal Mines. The reason that certification is required is that Electrical Equipment can ignite the methane released by freshly mined coal if it is not properly enclosed or otherwise protected.

A fire in any underground mine can be a disaster if a substantial amount of material is involved. Such a fire can foul the airways with toxic smoke and block escape routes. For this reason, it was not long before the new "Certification Laboratory" was asked to certify fire-resistant material as well.

In 1957, they were asked to certify a fire-resistant conveyor belt for use in underground mines. The same problem of obtaining certification applied to fire-resistant materials as to the equipment for underground coal mines. The provincial inspectors were requesting assurance that the materials were fire-resistant and the only place the manufacturers could get them tested was in a foreign laboratory.

In 1974 certification was granted to fire-resistant electric cables, in 1976 certification was granted to fire-resistant mine duct material and in 1978 certification was granted to fire-resistant hydraulic fluids.

EARLY TESTING PROCEDURES

In the absence of any Canadian Standards on this subject, our first reaction was to use either the test procedures of the United Kingdom or the United States or a combination of both.

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Conveyor belting provides an example of this "Hybrid "testing procedure. Our flame test was copied from the test developed by the U. S. Bureau of Mines and our drum friction test was adapted from the National Coal Board (NCB) test in the U. K. At the same time, a Canadian "flavour" was given to each of these tests by making slight modifications to the procedure. In the case of the flame test, it was found that it could be made slightly more severe if the test was done in both flowing air and still air. (The U. S. test is performed only in flowing air). Figure 1 shows the apparatus used for this test.

The drum friction test was made less severe by running it at a constant tension and not trying to deliberately break the belt. The latter change allowed the rubber and neoprene belts to qualify. This was considered desirable because the only conveyor belts manufactured in Canada were the rubber type and the British drum friction test tended to allow only the PVC type of belt to pass. Figure 2 shows a belt undergoing the drum friction test and Figure 3 shows a typical result for a PVC type of belt. Note that the belt in Figure 3 has broken without showing any sign of ignition.

The tests for hydraulic fluids were also adapted from those of other countries. The U. K. had a test using a heated pressure vessel with an oil burner nozzle to atomize the fluid. This vessel was pressurized to 6.9 MPa (1000 psi) and the apparatus was carried by hand into a simulated mine shaft, the spray directed downstream in the air flow and ignited by an acetylene torch. Factory Mutual (FM) in U. S. A. had a similar test which was done in an empty warehouse with "natural ventilation". When we tried to duplicate these two tests, we had difficulty in obtaining consistent results. The British have since abandoned their test in favour of a more sophisticated test chamber and the FM test has been turned down by the American Society for Testing Materials because round-robin testing in six different laboratories showed almost no correlation. For this reason, we built our own test chamber and developed our own test procedure. Figure 4 shows our pressure vessel and nozzle for the spray ignition test, Figure 5 shows the spray before ignition and Figure 6 shows a flammable fluid burning after ignition.

DEVELOPMENT OF CANADIAN STANDARDS

Although we had developed our own requirements as we began certifying each new product, it is Federal Government policy to use consensus standards wherever possible. We are not a recognised standards writing body and have no intention of becoming one. There are several such bodies in Canada all of which are recognised by the Standards Council of Canada. We were already using a number of standards published by the Canadian Standards Association (CSA) for the certification of electrical equipment for coal mines so they were the first standards body that we considered.

About that same time (1980) CSA re-organized their standards committees and established "Steering Committees" to supervise the work of the "Technical Committees". There was only one committee dealing with mines (Part V of the Canadian Electrical Code - "Electrical Installations in Mines") so they were made a Steering Committee. With the concurence of the Cheif Inspectors of Mines Committee, we approached CSA and asked them to broaden the scope of the new Steering Committee to "Mechanical/Electrical Safety of Mines". This was formalized in 1981 and, since that time, several new Technical Committees have been set up. This year, the scope was broadened even further to cover "Safety and Health in Mines" because they are now preparing a code for mine rescue teams.

The new standards produced by these committees are being published under the M420 series. For example, the subject of Electrical Installations in Mines is now CSA Standard M421. New and proposed standards which have been established by this Steering Committee are as follows:

Number	Title	Status
M422	Fire-Performance and Antistatic Requirements for Conveyor Belting	Published (1987)
M423	Fire-Resistant Hydraulic Fluids	Published (1984) Revised (1987)
M424.1	Underground Diesel Equipment for use in Gassy Mines	Approved for Publication (1987)
M421.2	Underground Diesel Equipment for use in Non-Gassy Mines	Technical Committee
M425	Mine Hoisting	Technical Committee
M426	Electric Blasting Devices	Technical Committee
M427	Fire-Performance and Antistatic Requirements for Mine Ventilating Materials	Technical Committee
M428	Mine Rescue	Technical Committee

In addition to the above subject, for which Technical Committees have already been established, the following subjects are under consideration for future standards work:

1. Mine illumination
2. Mine Cap Lamps
3. Off-Highway, Surface, Mobile, Mining Equipment
4. The Design and Use of Ventilating Equipment
5. Raise Climbers
6. Communication Systems
7. The Storage and Handling of Explosives
8. Code for Installation and Use of Mechanical Equipment
9. Safety Code for Conveyors
10. Mobile Work Platforms
11. Stored Energy Hazards (springs, hydraulics, pneumatics, etc.)
12. Falling Object Protection Systems

While not all of the subjects undertaken by the Steering Committee are of direct use in our Certification, it has been a great help to us in establishing National Standards for the products we certify.

Much of the preliminary work in the development of test requirements performed by the Canadian Explosive Atmospheres Laboratory (CEAL) was used by the Technical Committees. However, when all of the interested parties (ie: manufacturers, inspectors, mine owners, unions and general interest groups) got together, it was necessary to work out a number of compromises in order to obtain consensus.

For example, there were two basis flammability tests originally proposed for hydraulic fluids. The first was the spray ignition test in which the fluid is atomized by forcing it through a nozzle at high pressure and at an elevated pressure. This test is an attempt to simulate a pinhole leak which may be ignited by a spark, flame or a hot surface. The standard test requires that, when ignited, the flame will self extinguish within 30 seconds. Some of the members felt that this was too long but if we shortened the time too much, it would put 90% of the available fluids off the market. To resolve this problem, we established two categories, one which would require the flame to extinguish in 1 second and the second which would require the flame to extinguish in 30 seconds. This leaves room for future improvement of the fire resistance of hydraulic fluids, without upsetting the present state of the art.

A second test proposed for hydraulic fluids was the "wick test". In this test, a specially prepared asbestos wick is soaked in the fluid for one hour and then attempts were made to ignite the wick. One type of fluid which performed well in the spray ignition test, could not pass this test. In addition, this type of fluid was the only Fire-resistant fluid which was compatible with existing hydraulic systems using non-fire-resistant fluids. It was felt that the ease of conversion using this fluid outweighed the hazard posed by the failure to pass the Wick test. Therefore, a third category was established to cover this type of fluid to ease the problems of changing machines from flammable fluids to fire-resistant fluids. Figure 7 shows a hydraulic fluid undergoing the wick test.

Many of the fire-resistant hydraulic fluids on the market are emulsions of oil and water. These fluids have one problem, they can freeze during shipment and storage and some of them tend to separate if subjected to several cycles of freezing and thawing. The Technical Committee had to devise a test that would simulate the worst conditions for separation. We discovered that it took seven cycles of freeze-thaw in order to get the worst separation so this is the criteria for certification in Canada.

Another problem with emulsions is that some tend to separate with time. For this reason, the manufacturer must mark his emulsions with a date indicating that it must be put into service before that date. If it is kept in storage too long, the fluid will separate and if some of a drum is used, it may not be fire-resistant because it is too rich in oil. This is not a problem with fluids in service because frequent use in a hydraulic system keeps the fluid in its emulsion form.

It was felt that some of these hydraulic fluids may contain ingredients that are toxic to persons handling them. The revised edition contains criteria for evaluating acute toxicity, chronic toxicity, skin irritation, eye irritation and sensitization. We do not have the facilities for determining these factors but the manufacturer must give us a list of all the ingredients together with any known toxic effects. This information is then submitted to the Bureau of Chemical Hazards, Health and Welfare Canada for evaluation before certification is granted.

The Conveyor belt standard was a particularly difficult one on which to get concensus. The reason for this is that we could not get agreement between the manufacturers of PVC and Rubber belting. Certain tests were easier for the PVC belts to pass and others were easier for the Rubber and Neoprene belts to pass. The end result was a compromise consisting of three "Types" of fire-resistant belting, A, B and C. Type A belting is intended for use in underground coal mines where both the atmosphere and the product carried are flammable. Naturally, faced with these conditions, the belting must have the highest level of resistance to fire. Type B belting is intended for use in other underground mines where neither the atmosphere or the product carried is flammable. Type C belting represents the level of fire-resistance which existed before the standard was written and in new construction, will probably be limited to surface applications where some fire-resistance is required but a fire may not be a matter of life and death.

The new standard on conveyor belting represents a giant step forward in this field. Previous requirements only addressed the ease of ignition of the belt from friction or flame. A new test, known as the propane gallery test, sets a full size sample on fire and determines whether it will self extinguish or spread the fire if it is involved in a mine fire from another source. Figure 8 shows a sample conveyor belt being subjected to the propane fire and Figure 9 shows the belt after the burner has been removed. Note that the fire has already gone out without spreading beyond the source of ignition.

PROVINCIAL REQUIREMENTS

The regulation of safety and health in mines is a Provincial responsibility. The only exception to this is Federally owned mines such as those operated by the Cape Breton Development Corp. These mines are regulated by Labour Canada.

Provincial regulations for materials used in underground mines varies from Province to Province but where regulations are in existence, the trend is to require EMR Certification. Table 1 shows the utilization of EMR certified products across Canada. It is hoped that, with the publication of National Standards for Fire-resistant materials for use in underground mines, Quebec, Ontario and Manitoba will require the use of these materials in their mines.

Table 1 Requirement for EMR Certified Fire-Restant Materials for Underground Mines in Canada

JURISDICTION	CONVEYOR BELTING	HYDRAULIC FLUIDS	MINE DUCT MATERIAL	ELECTRIC CABLES
NEWFOUNDLAND	YES	YES*	YES	YES
NOVA SCOTIA	NO**	NO	YES	YES
NEW BRUNSWICK	YES	YES	YES	YES
QUEBEC	NO	NO	NO	NO
ONTARIO	NO#	NO#	NO	YES
MANITOBA	NO#	NO#	NO	YES
SASKATCHEWAN	YES	YES	NO	YES
ALBERTA	YES	YES	NO	YES
BRITISH COLUMBIA	YES	YES	YES	YES
NWT	NO	NO	YES	YES
YUKON	YES	YES	NO	YES
LABOUR CANADA	YES	YES	YES	YES

* Required for new mines only.

** Will be required in new regulations.
# Optional - not required if fire suppression system installed.

CONCLUSIONS

1. The trend in testing of fire-resistant materials is toward larger scale tests which give a better indication of how the material will perform in an actual mine fire.

2. Consensus standards are better than requirements set unilaterally by a Federal Government department because they allow for input from all interested parties.

3. Now that we have National Standards for Fire-Resistant materials, the Provincial Inspection Authorities and Mine Owners are more likely to specify that materials used in Underground mines are certified to these standards.

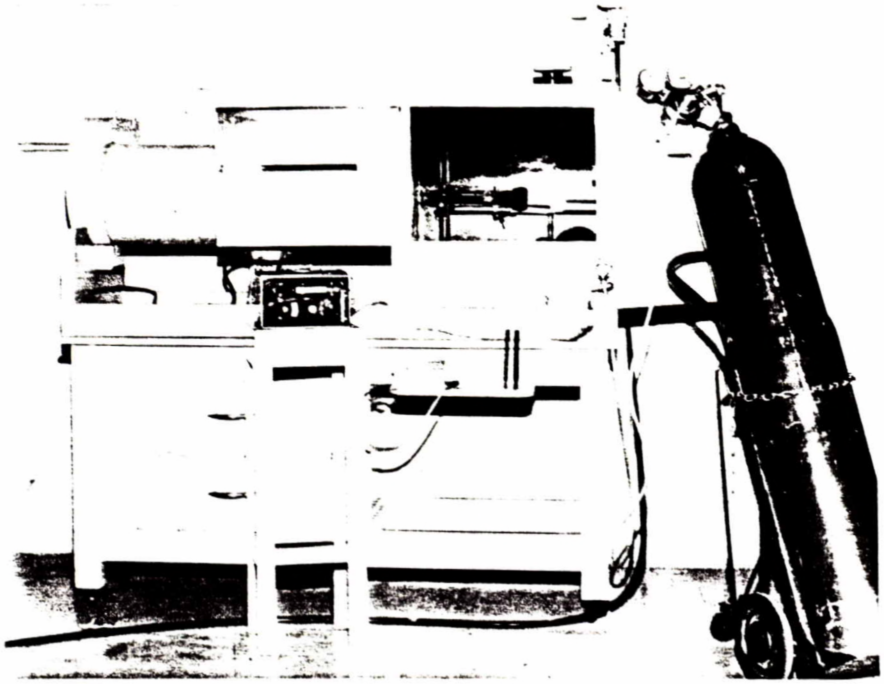

Figure 1. Apparatus Used for Flame Test

Figure 2. Conveyor Belt Undergoing Drum Friction Test

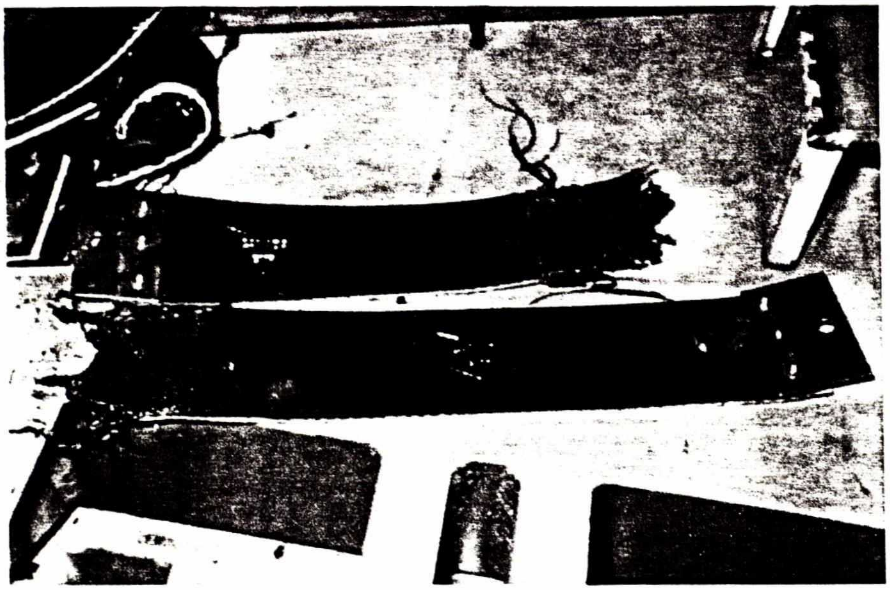

Figure 3. Typical Result of Drum Friction Test for a PVC Belt

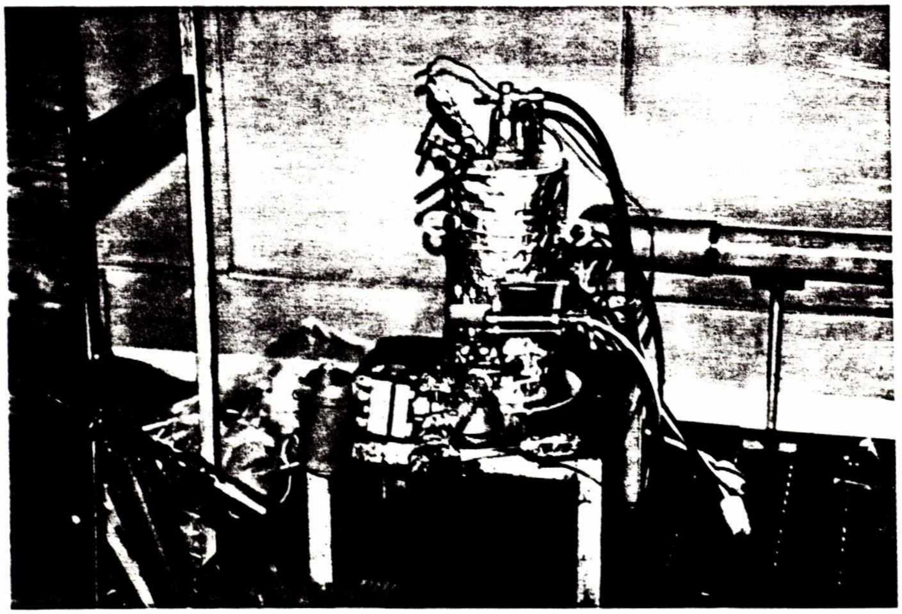

Figure 4. Pressure Vessel and Nozzle for Spray Ignition Test

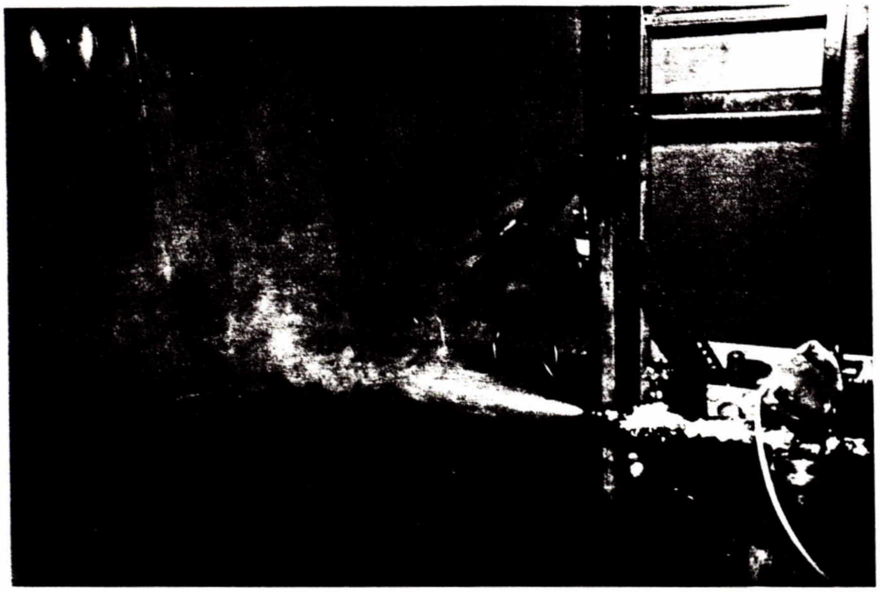

Figure 5. Spray Ignition Test Before Ignition

Figure 6. Spray Ignition Test After Ignition

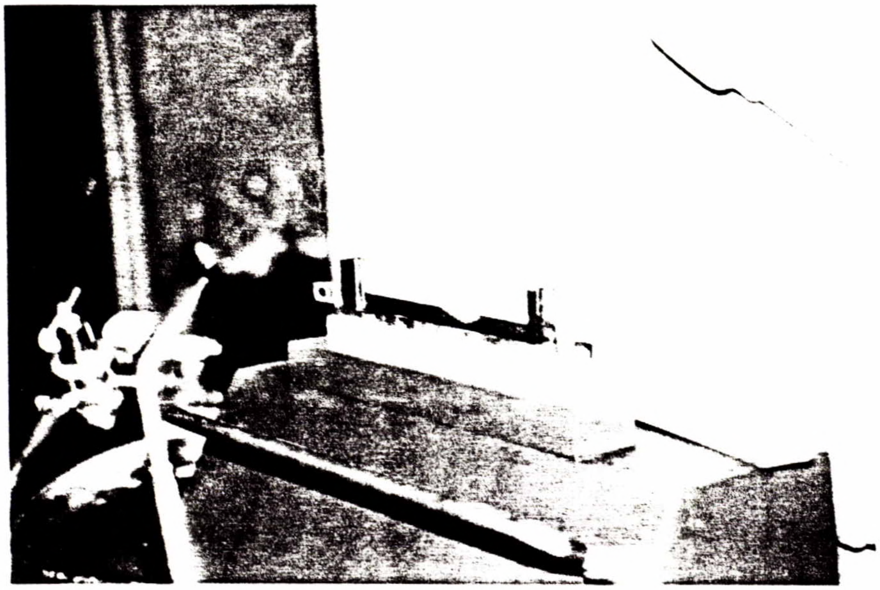

Figure 7. Wick Test

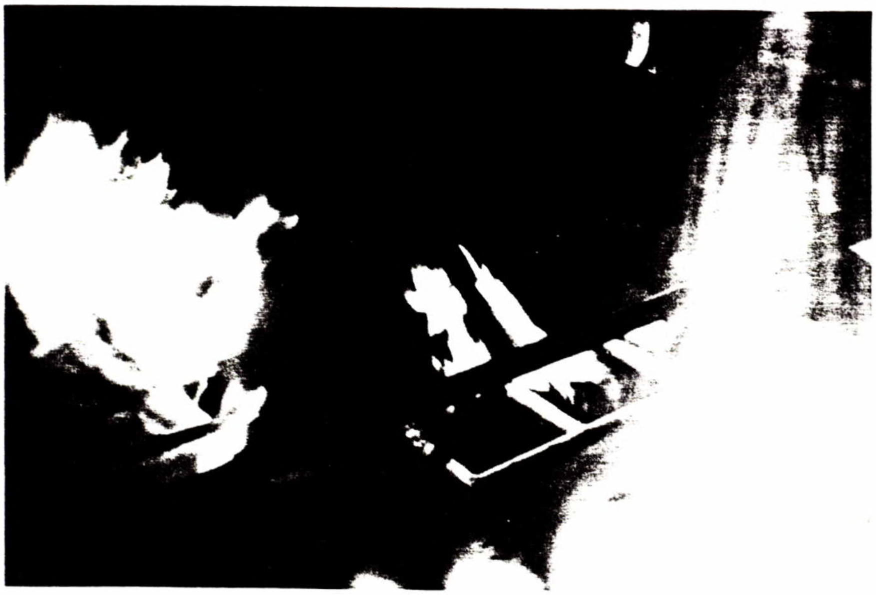

Figure 8. Propane Gallery Test with Ignition Burner On

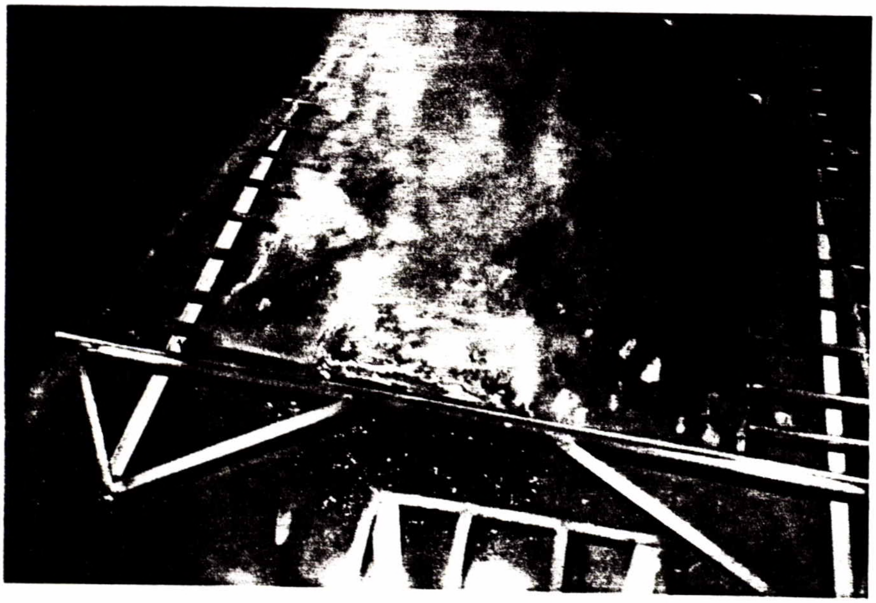

Figure 9. Propane Gallery Test after Ignition Burner Turned Off