289
9/15

991

TID-25085
HEALTH & SAFETY

uc-41

MASTER

EVALUATION OF IMPROVED FIRE RESISTANT GLOVE MATERIALS FOR GLOVEBOXES

A GLOVEBOX FIRE SAFETY APPLICATION

1969

Prepared by
FACTORY MUTUAL RESEARCH CORPORATION
for
UNITED STATES ATOMIC ENERGY COMMISSION

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

EVALUATION OF IMPROVED FIRE RESISTANT
GLOVE MATERIALS FOR GLOVEBOXES

A Glovebox Fire Safety Application

by

P. E. Johnson
Factory Mutual Research Corporation

for

United States Atomic Energy Commission

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price 25 cents

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Fig

ACKNOWLEDGMENT

We gratefully acknowledge the cooperation, assistance, and advice of the U. S. Atomic Energy Commission (AEC) and its contractors throughout this investigation, which was conducted for the AEC Chicago Operations Office under contract AT (11-1)-1393.

FOREWORD

Pursuant to a request from the Division of Operational Safety, Headquarters, U. S. Atomic Energy Commission (AEC), the AEC Chicago Operations Office (CH) contracted with the Factory Mutual Research Corporation (FMRC) to study glovebox fire safety problems relating to activities of the AEC and its contractors.

Most of the work under that contract was reported in "Glovebox Fire Safety, A Guide for Safe Practices in Design, Protection and Operation," TID-24236, issued in 1967. Other FMRC glovebox fire safety work in specialized areas is covered in separate reports such as the one given on the following pages.

Technical administration of the contract was handled largely by L. E. Oldendorf, Safety and Fire Protection Engineer, Safety & Technical Services Division, CH.

D. E. Patterson, Chief
Industrial Safety & Fire
Protection Branch
Division of Operational Safety

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the U.S. Atomic Energy Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty of representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for, damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

DISCLAIMER NOTICE

Any comparison of the design or performance characteristics of manufacturers' products is not to be construed as an endorsement of one product over another. Stated preferences for a particular design or set of performance characteristics are intended solely to establish minimum acceptable specifications for a particular type of product when used in glovebox applications described herein. Any future procurement of products referred to herein by the AEC or its contractors, will be based upon normal competitive procedures. The procuring organization will in all instances specify the minimum specifications required.

EVALUATION OF IMPROVED FIRE RESISTANT GLOVE MATERIALS FOR GLOVEBOXES

I ABSTRACT

Gloves are a weak point in the containment system of gloveboxes because of their combustibility and mediocre fire resistance. In an effort to improve their resistance to loss of containment by heat and fire, various manufacturers of gloves and elastomers were contacted for promising new developments. Tests with a special formulation of silicone rubber sheet showed superior heat and fire resistance to conventional glove materials. Adaptation to glove manufacture and evaluation of other properties essential to glovebox use are needed. Two new materials potentially adaptable to glove manufacture should be investigated.

II SCOPE

The purpose of this investigation was to seek an improvement in the resistance of gloves to loss of containment due to heat and fire. Three methods of approach were proposed, namely:

1. Negotiate a subcontract with a glove manufacturer for the development of a more fire-resistant glove.
2. Negotiate a subcontract with an elastomer manufacturer for the development of a more fire-resistant glove material suitable for glove manufacture.
3. Survey and evaluate the fire resistance of rubber or plastic materials presently available and potentially applicable to glove manufacture.

III BACKGROUND

Gloves have long been recognized as a weak point in glovebox containment systems. Just how susceptible gloves are to failure by heat and fire was determined in a series of heat and fire resistance tests by the Factory Mutual Research Corp., as part of their contract with the U. S. Atomic Energy Commission to investigate glovebox fire and explosion hazards and methods of detection and

suppression^{1,2}. For simplicity and uniformity, the results of only one heat and one fire resistance test from the original investigation were selected as the basis for evaluation of new materials.

Briefly, the heat resistance test consisted of placing a 6-in. square sheet of glove material 6 in. away from a parallel radiant heat panel fired by natural gas and maintained at approximately 1500°F. The materials tested were neoprene, butyl rubber, latex, and polyvinyl chloride, varying in thickness from 0.008 in. to 0.055 in. Failure, indicated by the appearance of a hole, occurred between 15 and 98-1/2 sec.

The fire resistance test consisted of subjecting arm-length gloves of neoprene, butyl rubber, latex, and polyvinyl chloride to an impinging alcohol fire. The fire source was a 0.25-sq.-ft. pan containing 5-3/4 fluid oz. of ethyl alcohol located 5-1/2 in. directly below the glove hand. Under these conditions, gloves ranging in thickness from 0.008 in. to 0.055 in. ignited and failed between 4-1/2 and 41 sec. Failure was taken as the time when a hole appeared in the glove representing loss of containment.

It was evident from even this moderate amount of fire exposure that loss of containment and subsequent spread of radioactive contamination was a very real possibility should gloves become involved in a fire. Furthermore, with direct flame impingement, little time would be available for fire fighting before violation of the gloves.

It was pertinent, therefore, that some effort be made to improve the fire resistance of glove materials. Attempts to negotiate a subcontract with 6 leading glove manufacturers and 6 elastomer manufacturers to develop a material that would last at least 5 min. under this fire exposure were unsuccessful.

The General Electric Co., Silicone Products Department, however, submitted two separate samples of silicone rubber sheet for evaluation as a possible solution to this problem. Since this material had never been made in the form of gloves, a bench-type fire test was, therefore, developed to compare the sheet material with neoprene glove material and yet correlate with the results of the original glove test.

IV TEST METHOD

A Radiant Heat Panel Test

Samples of sheet materials to be evaluated, approximately 5-1/4 in. by 5-1/4 in., were stapled over a 5 in. by 5 in. opening in an asbestos-covered plywood frame (Figure 1). The frame and sample were supported vertically 6 in. away from the center of a 12 in. by 18 in. radiant heat panel. The panel was fired with natural gas and air to produce a surface temperature of approximately 1500°F. Observations were made for the time required for the appearance of smoke, ignition, crinkling, cracks, or holes.

Samples of silicone rubber sheet supplied by the General Electric Co., Silicone Products Division, Waterford, New York and neoprene from a NeoSol neoprene rubber glove sleeve manufactured by Charleston Rubber Co., Charleston, South Carolina were compared.

B Flame Test

Samples of sheet materials to be evaluated, approximately 5-1/4 in. by 5-1/4 in., were stapled to the plywood frame described under Radiant Heat Panel Test. The frame and sample were supported in the horizontal position 3-1/2 in. above the surface of 19 ml of ethyl alcohol contained in a 2-1/4 in. diameter dish (Figure 2). In this position, flame impinged upon the sample. The times required for ignition, cracking, or appearance of holes were noted.

This test was designed such that the performance of neoprene glove material was the same as that previously reported from tests with actual gloves ^{1,2}.

V RESULTS

A Radiant Heat Panel Tests

A sample of neoprene, average thickness 0.016 in., taken from the sleeve of a NeoSol glove manufactured by Charleston Rubber Co., Charleston, South Carolina, started to smoke after 12-sec. exposure and failed due to crinkling after 60 sec. This checks with previously reported results ^{1,2}. After the test, the sample was brittle.

Two samples of silicone rubber, formulation Red 555 (incorporating red iron oxide), average thicknesses 0.021 in. and 0.015 in., withstood the heat exposure without failure for 10 min.-45 sec. and 7 min.-30 sec. respectively, at which times the tests were discontinued. Within the first few seconds, the samples stretched, but upon cooling after the tests, they regained their shape. After the tests, the samples remained resilient except for the edges which became brittle.

B Flame Tests

Detailed test results are included in Table 1. They are summarized and discussed below.

Three samples of 0.015-in. thick neoprene from the sleeve of a NeoSol glove manufactured by Charleston Rubber Co., Charleston, South Carolina failed, that is, developed a hole after an exposure to the alcohol flame for 13.5, 12, and 11 sec. This compares favorably with results previously reported with actual gloves, namely, 14 sec. ^{1,2}.

Four samples of silicone rubber sheet, formulation Red 555 containing red iron oxide, average thicknesses between 0.015 in. and 0.023 in., developed holes after exposures of between 30 sec. and 1 min.-52 sec. All samples sagged within a few seconds. Only two of the samples ignited.

Because of these variations, General Electric Co., submitted another batch of samples for test. This new formulation was designated SE-5537 and also contained red iron oxide. One sample of average thickness 0.030 in. started to smoke after 15 sec., started to crack after 4 min.-5 sec., and failed, that is, flame became visible through a crack, after 6 min.-45 sec. Five samples averaging 0.033 in. thick started to smoke between 10 and 20 sec., started to crack between 1 min.-50 sec. and 4 min.-10 sec., but with no flame showing through, and did not fail up to the point when the fuel burned out between 6 min.-35 sec. and 7 min.-1 sec.

It was noted that most samples sagged approximately 1-1/4 in. after 5 sec. of exposure, but upon cooling after the test, they regained their original shape. After the exposure, each sample continued to crack upon cooling. The cracks widened and areas surrounding the cracks became brittle.

To check the effect of shorter exposures on this cracking and potential violation of the material, the flames were removed from two samples after 3 min. and 5 min. Cracks still developed and widened upon cooling.

This latter formulation of silicone rubber (SE-5537) showed considerably more resistance to heat and fire than neoprene. However, the cracking and subsequent violation of the integrity of the sheet upon cooling after a fire exposure may give cause for concern. It is possible that further development work on this formulation may overcome this objectionable property.

Silicone rubber has not yet been made into a glove and effort is expected on the part of the manufacturer in this direction. Silicone rubber has a lower tensile strength than currently used glove materials, and this must be given some attention. For instance, the tensile strength of SE-5537 silicone rubber is approximately 1400 psi ^{4,5} as compared to the requirement for neoprene of 2500 psi ³. Other properties essential to the suitability of a glove material for glovebox use must also be evaluated, once a glove can be manufactured. Any efforts by General Electric in the further development of this product should be followed up.

V CONCLUSIONS

1. Silicone rubber, SE-5537 with red iron oxide added, manufactured by General Electric Co., Silicone Products Department, Waterford, New York, has demonstrated superior fire and heat resistance compared to neoprene.

2. Investigation should be continued with silicone rubber formulation SE-5537 to further evaluate its applicability to glove manufacture and the suitability of other properties pertinent to its applicability to glovebox use.

3. Communication from Uniroyal Plastic Products, Division of Uniroyal, Inc., Mishawaka, Indiana, states that they have a material that will not burn in one to two atmospheres of oxygen and could possibly be adaptable to glove manufacture. This development looks promising and should be further investigated.

4. CNR Nitroso rubber, manufactured by Thiokol Chemical Corp., Reaction Motors Division, Denville, New Jersey, is reported to be non-flammable in pure oxygen, have an operating temperature range of -40° to +400°F, and be adaptable to glove manufacture ⁷. This material should also be investigated as a potential improvement in gloves for glovebox use.

PEJ/nh

Attached - Bibliography

Table 1

Figures 1 and 2

BIBLIOGRAPHY

1. Fire and Explosion' Protection of Gloveboxes and Their Environments, AEC Contract No. AT(11-1)-1393, FMRC 15357, UC-41, Health and Safety, TID-4500. Factory Mutual Research Corp. Norwood, Mass. 1966.
2. Glovebox Fire Safety - A Guide for Safe Practices in Design, Protection and Operation, AEC Contract No. AT(11-1)-1393, FMRC Serial No. 17314, Factory Mutual Research Corp. Norwood, Mass. 1967.
3. Specifications for Arm Length Gloves - Production Type - Synthetic Rubber PF-1-b (Revision 7). Argonne National Laboratory. Argonne, Illinois, April 2, 1962.
4. SE-5537U-Flame Retardant Silicone Rubber Compound, Preliminary Product Data Sheet. General Electric Co., Silicone Products Department. Waterford, New York.
5. SE-557U-Silicone Rubber Compound, Product Data Sheet. General Electric Co. Silicone Products Department. Waterford, New York.
6. Communication with D. D. M. Streed, Uniroyal Plastic Products Division of Uniroyal Co., Inc. Mishawaka, Indiana. July 21, 1967.
7. Thiokol CNR Nitroso Rubber, Publication No. PI 2-68. Thiokol Chemical Corp., Reaction Motors Division. Denville, New Jersey.

TABLE 1 - FLAME TESTS

TEST NO.	MATERIAL	AVG. THICKNESS-IN.	TIME INTERVAL FROM IGNITION, MIN.-SEC.							REMARKS
			Sagging	Smoking	Cracking	Crinkling	Hole	Failure	Fire Out	
1	Neoprene	0.016				0-21		0-21		Sample 5 1/2" above fuel; too high
2	"	"				0-13.5		0-13.5		
3	"	"				0-09		0-12		
4	"	"				0-07		0-11		
5	Red 555	0.023					0-30	0-30		Top ignited, 36 secs. " " " "
6	"	0.019			0-55			1-52		
7	"	0.015	0-06	0-15				0-36		
8	"	0.015	0-05					0-35		
9	SE-5537	0.030	0-05	0-13	4-05			6-45	7-15	After cooling, 1 crack 1 1/2" x 3/16" max. Several < 1/4" Long
10	"	0.034	0-07	0-16	4-10				6-35	After cooling, 1 crack 2" x 3/16" max., 1 crack 1 1/2" x 1/4" max.
11	"	0.031	0-06	0-20	2-50				6-35	After cooling, 1 crack 2" x 5/8" max.
12	"	0.031	0-05	0-10	1-30				3-00	After cooling, 1 crack 1 1/4" x 1/16" max.
13	"	0.032	0-07	0-10	3-04				7-01	After cooling, 2 cracks 1" x 1/16" max.
14	"	0.033	0-05	0-14					6-40	Bubbling, 3-55. After cooling, 1 crack 1 1/4" x 1/16" max.-3/4" x 1/16" max.
15	"	0.034	0-07	0-18					6-55	After cooling, Several cracks < 1/4" long
16	"	0.032	0-05	0-10	3-12				5-00	After cooling, crack 1 1/2" x 1/16"-Several 1/4" - 1/2" long

FIGURE 1 RADIANT HEAT PANEL TEST

FIGURE 2 FLAME TEST

EVALUATION OF IMPROVED FIRE RESISTANT GLOVE MATERIALS FOR GLOVEBOXES

I ABSTRACT

Gloves are a weak point in the containment system of gloveboxes because of their combustibility and mediocre fire resistance. In an effort to improve their resistance to loss of containment by heat and fire, various manufacturers of gloves and elastomers were contacted for promising new developments. Tests with a special formulation of silicone rubber sheet showed superior heat and fire resistance to conventional glove materials. Adaptation to glove manufacture and evaluation of other properties essential to glovebox use are needed. Two new materials potentially adaptable to glove manufacture should be investigated.

II SCOPE

The purpose of this investigation was to seek an improvement in the resistance of gloves to loss of containment due to heat and fire. Three methods of approach were proposed, namely:

1. Negotiate a subcontract with a glove manufacturer for the development of a more fire-resistant glove.
2. Negotiate a subcontract with an elastomer manufacturer for the development of a more fire-resistant glove material suitable for glove manufacture.
3. Survey and evaluate the fire resistance of rubber or plastic materials presently available and potentially applicable to glove manufacture.

III BACKGROUND

Gloves have long been recognized as a weak point in glovebox containment systems. Just how susceptible gloves are to failure by heat and fire was determined in a series of heat and fire resistance tests by the Factory Mutual Research Corp., as part of their contract with the U. S. Atomic Energy Commission to investigate glovebox fire and explosion hazards and methods of detection and

suppression^{1,2}. For simplicity and uniformity, the results of only one heat and one fire resistance test from the original investigation were selected as the basis for evaluation of new materials.

Briefly, the heat resistance test consisted of placing a 6-in. square sheet of glove material 6 in. away from a parallel radiant heat panel fired by natural gas and maintained at approximately 1500°F. The materials tested were neoprene, butyl rubber, latex, and polyvinyl chloride, varying in thickness from 0.008 in. to 0.055 in. Failure, indicated by the appearance of a hole, occurred between 15 and 98-1/2 sec.

The fire resistance test consisted of subjecting arm-length gloves of neoprene, butyl rubber, latex, and polyvinyl chloride to an impinging alcohol fire. The fire source was a 0.25-sq.-ft. pan containing 5-3/4 fluid oz. of ethyl alcohol located 5-1/2 in. directly below the glove hand. Under these conditions, gloves ranging in thickness from 0.008 in. to 0.055 in. ignited and failed between 4-1/2 and 41 sec. Failure was taken as the time when a hole appeared in the glove representing loss of containment.

It was evident from even this moderate amount of fire exposure that loss of containment and subsequent spread of radioactive contamination was a very real possibility should gloves become involved in a fire. Furthermore, with direct flame impingement, little time would be available for fire fighting before violation of the gloves.

It was pertinent, therefore, that some effort be made to improve the fire resistance of glove materials. Attempts to negotiate a subcontract with 6 leading glove manufacturers and 6 elastomer manufacturers to develop a material that would last at least 5 min. under this fire exposure were unsuccessful.

The General Electric Co., Silicone Products Department, however, submitted two separate samples of silicone rubber sheet for evaluation as a possible solution to this problem. Since this material had never been made in the form of gloves, a bench-type fire test was, therefore, developed to compare the sheet material with neoprene glove material and yet correlate with the results of the original glove test.

IV TEST METHOD

A Radiant Heat Panel Test

Samples of sheet materials to be evaluated, approximately 5-1/4 in. by 5-1/4 in., were stapled over a 5 in. by 5 in. opening in an asbestos-covered plywood frame (Figure 1). The frame and sample were supported vertically 6 in. away from the center of a 12 in. by 18 in. radiant heat panel. The panel was fired with natural gas and air to produce a surface temperature of approximately 1500°F. Observations were made for the time required for the appearance of smoke, ignition, crinkling, cracks, or holes.

Samples of silicone rubber sheet supplied by the General Electric Co., Silicone Products Division, Waterford, New York and neoprene from a NeoSol neoprene rubber glove sleeve manufactured by Charleston Rubber Co., Charleston, South Carolina were compared.