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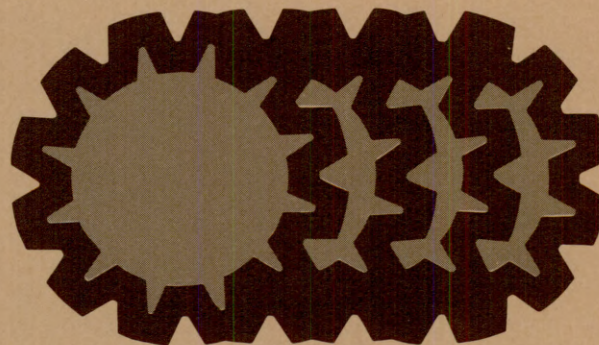
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A REPORT ON THE PERFORMANCE OF LINEMEN'S RUBBER INSULATING GLOVES



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE / Public Health Service
Center For Disease Control / National Institute For Occupational Safety And Health

A REPORT ON THE PERFORMANCE OF LINEMEN'S RUBBER INSULATING GLOVES

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DISCLAIMER

Mention of company name or product names is not to be considered an endorsement by National Institute for Occupational Safety and Health.

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ABSTRACT

This report presents results of tests conducted on a group of specimens representing 12 models of linemen's rubber insulating gloves. The tests were designed to determine the extent to which the gloves met the requirements of the American National Standards Institute (ANSI) J6.6 standard (also known as the ASTM D120-70 standard). Since the 12 models of gloves were randomly selected from a field of 155 available models, they are representative of the range of glove models currently available to the industrial user. In general, the gloves were in compliance with the requirements of the standard, although all but one model failed one or more of the five non-performance packaging and dimensional tests in the series. One model, manufactured from material not permitted by the standard, failed the insulation resistance test. The manufacturer has assured NIOSH that it is no longer being sold.

ACKNOWLEDGMENT

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INTRODUCTION

This report presents the results of tests of linemen's rubber insulating gloves conducted by the National Institute for Occupational Safety and Health (NIOSH), Testing and Certification Branch (TCB). These tests were performed on a group of glove models randomly selected from those models advertised as meeting the American National Standards Institute (ANSI) standard.

The Federal Occupational Safety and Health Act of 1970 requires the use of linemen's rubber insulating gloves in conjunction with other protective equipment by electrical workers exposed to risk of high voltage electrical shock. In normal use, leather protectors are worn over the gloves and cotton liners inside. Federal Regulations (1) specify that linemen's rubber insulating gloves must comply with the requirements of the ANSI J6.6 (also known as ASTM standard D120) (2,3). The ANSI J6.6 standard establishes five classes of gloves, designated 0, 1, 2, 3, and 4, each providing protection against electrical shock from a different range of high voltages (see Table 1).

Using the ANSI J6.6 standard as a guide, NIOSH conducted 6 performance tests and 5 tests designed to evaluate compliance with requirements for packaging and marking. In addition to presenting the results of these tests, this report offers comment on the difficulties presented by the lack of explicitness in some provisions of the ANSI standard.

The development of a body of technical information about personal protective equipment currently available for industrial use is a central program of

the NIOSH Testing and Certification Branch. This report is part of a series concerning devices such as safety helmets, safety-toe shoes, and eye and face protective devices.

SELECTION AND TESTING

Selection

Three manufacturers provide all linemen's rubber gloves offered for sale in the United States. NIOSH compiled a list of the 155 models of gloves available from these manufacturers and selected, at random, 12 models for testing. No preference was given to any style, class, color, or length. The random selection yielded both glove and one-finger mitten styles of Class 1, 2, and 3 gloves. Although no Class 0 or 4 gloves were included, previous testing of these classes indicates failure rates comparable to those for Classes 1, 2, and 3. The group of specimens tested in this series is, therefore, considered representative of the range of gloves available to the user.

The selected gloves were ordered from a distributor or directly from the manufacturer and were received between April 1 and June 11, 1976. If a supplier asked what the devices were to be used for, he was told they were for testing.

Examination and Testing

The examinations and tests to which the gloves were subjected are those specified in the ANSI J6.6 standard. The provisions of the earlier ASTM D120-70 standard -- which includes standard D573-67 (R 1972) for evaluating accelerated aging and standard D412-75 for tension testing -- have been adopted by the ANSI J6.6 committee. The following is a summary of the examinations and tests:

1. Check-in examination -- The ANSI standard specifies that at least 75 percent of the gloves of any model must be seamless and have

a smooth finish, must have rolled or reinforced cuff edges, and must be durably marked with the name of the manufacturer, size of the glove, and voltage class. In addition, Class 0 gloves shall be clearly marked "Class 0, low-voltage glove". The standard further specifies that at least 75 percent of the pairs of gloves shall be packed in a container marked on one end with the name of the manufacturer or seller, voltage class, size, and length. The containers of Class 0 gloves must be marked "Class 0, low-voltage gloves". All specimens were inspected for conformance to these requirements.

2. Dimensional tests

- (a) Glove size was determined by measuring the circumference of the glove at the base of the finger crotches. The standard requires that at least 75 percent of the gloves of any model must have a circumference of 254 ± 6 mm ($10 \pm \frac{1}{4}$ in.) for size 10 gloves. All gloves tested were designated size 10 by the manufacturer.
- (b) All thickness measurements were made with a Sherr-Tumico model CXI dial indicator and recorded to the nearest 0.01 mm. The standard calls for a minimum of 10 thickness measurements; a minimum of 12 measurement points per mitten and 14 points per glove were used in this test series. Six measurements were taken in the area of the fingers and the finger crotches, one was taken on the palm, one on the back of the hand, four in the wrist area, and one each of the front and back of the cuff area. The standard specifies that at least 75 percent of the gloves of any model must meet the thickness requirements given in Table 2.

(c) Glove length was determined by measuring from the tip of the second finger to the outside of the cuff. According to the ANSI standard, at least 75 percent of the gloves of any model shall meet the following length requirements:

Class 0: 267 ± 13 mm ($10 \frac{1}{2} \pm \frac{1}{2}$ in.)

Class 1, 2, and 3: 356 ± 13 mm ($14 \pm \frac{1}{2}$ in.), 406 ± 13 mm ($16 \pm \frac{1}{2}$ in.), or 457 ± 13 mm ($18 \pm \frac{1}{2}$ in.)

Class 4: 457 ± 13 mm ($18 \pm \frac{1}{2}$ in.)

3. Electrical tests -- A Hannon model NA 7565-DC dielectric tester was used to evaluate the electrical properties of the gloves. All tests were performed at room temperature, and only gloves of the same class, style, and length were tested at the same time.

In each test, five gloves were filled with fresh tap water to the levels required by ANSI J6.6 and then lowered into a tank of fresh tap water until the inside and outside water levels were the same (within $\frac{1}{4}$ inch, although our tests have shown that water level differences up to 0.5 inches produce no significant difference in measured proof current). The proof voltage was then applied to the gloves at a rate of 1000 v/sec. until the test voltage was achieved. The test voltage was maintained for three minutes. During the final 20 seconds of the cycle, the proof current for each glove was measured to the nearest 0.5 ma. After completion of the proof test, the water levels were adjusted according to ANSI specifications and voltage was applied to the gloves at 1000 v/sec. until the minimum breakdown voltage was reached or a failure occurred. The voltage was then returned to zero. If a glove failed before

the breakdown voltage was reached, it was removed and the test was completed on the remaining gloves.

Table 1 specifies the electrical and dielectric breakdown requirements of ANSI J6.6. At least 95 percent of the gloves of any model must withstand, for three minutes, the proof test voltage specified in the table without exceeding the allowable proof current levels given in the table.

4. Physical Tests

After all of the electrical tests were completed, the gloves were dried and prepared for physical testing. Nine dumbbell specimens were cut from each glove using the standard ASTM D412-75 Die C (5). Three thickness measurements were made on each specimen and the specimens were labeled and left undisturbed for 24 hours. Three specimens from each glove were used for unaged tensile strength and elongation tests, three for aged tensile strength and elongation, and three for tension set tests. The specimens used in the aged tensile strength and elongation tests were suspended on a rack in an oven at $70^{\circ} \pm 1^{\circ} \text{ C}$ for seven days. During the aging process, unaged tensile strength and elongation and tension set tests were performed. These were completed within 96 hours of the beginning of the aging process for the aged tensile strength and elongation specimens.

A Tinius Olsen tension-compression machine using a 120 pound capacity load cell was used for the tensile strength and elongation

tests. Each specimen was stretched until rupture and rupture force was measured to the nearest 0.5 pound. Elongation was measured to the nearest 5 percent. Tensile strength of each specimen was calculated from the formula

$$\text{Tensile strength (MN/m}^2\text{)} = 0.700 \text{ MN-mm/lb-m}^2 \times \frac{\text{rupture force (lbs.)}}{\text{median thickness (mm)}}$$

Tension set tests were performed on a Custom Scientific tension set tester. A bench marker with one-inch spacing between marking surfaces was used to mark each specimen prior to testing. Each specimen was stretched to 500 percent elongation, held there for 10 minutes, then slowly released and allowed to rest for 10 minutes before measurements were taken. Tension set was recorded as the difference between the final length and 25.4 mm.

After accelerated aging, the designated specimens rested undisturbed for 24 hours before the aged tensile strength and elongation tests were performed. Results were recorded in the same manner as for unaged specimens.

Tensile strength and elongation in the accelerated aging test were expressed for each model as ratios of the median values of the aged to the median values of the unaged specimens.

The following are the ANSI criteria against which the gloves were tested:

- (a) Tensile strength -- not less than 17.5 MN/m² (2500 psi)
- (b) Elongation -- not less than 600 percent

- (c) Tension set -- not greater than 6.4 mm ($\frac{1}{4}$ in.).
- (d) Accelerated aging -- exposure to $70 \pm 1^{\circ}\text{C}$ ($158 \pm 2^{\circ}\text{F}$) for seven days shall not reduce the tensile strength or elongation of the specimens to less than 75 percent of the unaged test result (4).

RESULTS

In general, the gloves tested in this series were in compliance with the requirements of the ANSI J6.6 standard even though all but one model failed at least one of the non-performance packaging and dimensional tests. All models passed the tension set and elongation tests, two models failed the tensile strength test, and one failed the dielectric tests.

It should be pointed out that the two models failing the tensile strength test were constructed of the relatively new, ozone-resistant EPDM material, although the ANSI standard requires that gloves be constructed of cis-1,4 polyisoprene rubber. One of the EPDM gloves, the Charleston Products ET-144 (manufactured by the Norton Company), was not advertised as meeting the ANSI J6.6 standard. The other, the W. H. Salisbury Company 20-14, was labeled as complying with the standard. Although gloves made the EPDM materials cannot comply with the physical specifications of the standard, they offer superior resistance to ozone cutting. Consequently, they are receiving wide use in confined high voltage areas and on very high voltage lines where ozone cutting makes the use of rubber gloves impractical. The usable lifetime of rubber gloves under these conditions may be measured in days rather than months, and the high replacement cost of linemen's gloves (\$20-\$30 per pair) makes EPDM gloves a very attractive alternative to rubber. Both EPDM models received would satisfy the tensile strength requirements for Type II gloves as defined in a draft revision of ANSI J6.6.

When running tensile strength tests, very few of the dumbbell specimens broke between the bench marks on the test specimen. Most specimens broke at the first radius of one end of the reduced area. It was not possible to predict which end of the specimen would break, so dullness of the cutting die was apparently not the cause. The problem has been discussed with other members of the rubber testing community and it is apparent that this is not an isolated problem. However, since rubber gloves rarely fail to comply with the tensile strength requirements of ANSI J6.6 (in spite of this problem), there may be no need to modify the test method.

The sole failure in the very important dielectric tests was also an EPDM glove, the Salisbury 20-14. Half of the gloves of this model failed the electrical breakdown requirements of the standard, and W. H. Salisbury Company representatives have assured NIOSH the EPDM model 20-14 has been recalled from the market and all claims of ANSI compliance have been removed from it.

CONCLUSIONS

The results of this test series indicate that linemen's rubber insulating gloves are generally in compliance with the performance requirements of the standard. In this series, as well as in previous testing, no serious defects were noted. Compliance with the non-performance criteria, however, continues to be a problem which would likely be eliminated by tighter process controls. The fact that labeling on the Salisbury 20-14 gloves (which was actually a Salisbury Orange Salcor model 200-14) indicated compliance with the standard is a serious problem. Even if this glove could have satisfied the electrical and physical requirements of ANSI J6.6, it could not have satisfied the material specifications. It is important to remember that EPDM gloves are intended for special duty use and should not be considered general replacement gloves. They have only about half the tensile strength of rubber gloves and consequently may be more subject to physical damage. In addition, they intend to be somewhat stiffer than rubber. Strict control of the use of compliance markings is absolutely necessary in the linemen's rubber insulating glove industry as it is in the manufacture of all personal protective equipment.

REFERENCES

1. "Occupational Safety and Health Standards." Department of Labor, Occupational Safety and Health Administration, Washington, D.C. Standard 29CFR1910. June 17, 1974. 343 p.
2. "Standard Specification for Rubber Insulating Gloves." American National Standards Institute, 1430 Broadway, New York, NY 10018. Standard No. J6.6-1971. 1971. 8 p.
3. "Standard Specifications for Rubber Insulating Gloves." American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103. Standard No. D120-70. 1970. 8 p.
4. "Standard Method of Test for Accelerated Aging of Vulcanized Rubber by the Oven Method." American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103. Standard No. D573-67 (R1972). 1972. 4 p.
5. "Standard Methods of Tension Testing of Rubber." American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103. Standard No. D412-75. 1975. 13 p.

Table 1: AC Voltage Requirements,

Voltage Class	Proof Test Voltage, rms.	Breakdown Voltage, rms.	Maximum Proof Current, ma			
			10 1/2 in. glove	14 in. glove	16 in. glove	18 in. glove
0	5,000	6,000	8	—	—	—
1	10,000	20,000	—	10	12	14
2	15,000	25,000	—	12	14	16
3	20,000	30,000	—	14	16	18
4	30,000	45,000	—	—	—	20

Table 2: Thickness Requirements.

Voltage Class	Minimum Thickness, mm		Maximum Thickness, mm	
	Crotch Area	Other	Area A*	Area B**
0	0.46	0.53	0.89	1.02
1	0.76	0.89	1.27	1.65
2	0.97	1.14	1.52	2.03
3	1.27	1.52	2.16	2.54
4	1.52	1.91	2.54	2.92

* Area A extends from the ends of the thumb and fingers, excluding the tips, up to an imaginary line around the glove at the thumb crotch.

** Area B extends from the edge of the cuff down to the line at the thumb crotch and also includes the thumb tip and finger tips. The thumb or finger tip is the area of rubber from the extreme tip of the finger to a line around each finger in a plane 13 mm distant axially from the tip.

Table 3: Results of Check-in Dimensional Tests.

Mfr./Model	Voltage Class	Check-in Tests		Dimensional Tests					
		Packaging P/F	Mfg. and Marking P/F	Size		Thickness		Length	
				No. Passt	P/F	No. Passt	P/F	No. Passt	P/F
White 18" mitten	1	F	P	18	P	0	F	17	P
White 18" mitten	3	F	P	20	P	19	P	19	P
White 14" mitten	3	F	P	19	P	7	F	20	P
Charleston* ET-144	1	P	P	15	P	11	F	20	P
Charleston E-146 RB-FC	1	P	P	7	F	0	F	20	P
Charleston E-206 RB	3	P	P	9	F	20	P	20	P
Salisbury 10-14	1	P	P	18	P	0	F	10	F
Salisbury 10-18	1	P	P	20	P	12	F	17	P
Salisbury 15-16	2	P	P	20	P	0	F	20	P
Salisbury** 20-14	3	P	F	20	P	20	P	20	P
Salisbury M15-18	2	P	P	20	P	0	F	19	P
Salisbury M20-16	3	P	P	20	P	20	P	20	P

+ Number passing of 20 tested.

* EPDM glove - no claim of ASTM D120 conformance.

** EPDM glove - claims conformance with ASTM D120.

Table 4: Results of Tensile Strength Tests.

Mfr./Model	Voltage Class	Aged Specimens			Unaged Specimens			Accelerated Aging				
		Ave. λ MN/m ²	Med. λ MN/m ²	Std. Dev.	No. Tested	Ave. λ MN/m ²	Med. λ MN/m ²	Std. Dev.	No. Tested	P/F	Median Aged Med. Unaged	P/F
White 18" mitten	1	25.7	25.7	1.38	57	28.6	28.8	1.24	59	P	0.90	P
White 18" mitten	3	24.8	24.9	2.00	58	26.5	26.8	1.78	60	P	0.94	P
White 14" mitten	3	24.7	24.5	1.53	55	25.4	25.5	1.08	60	P	0.97	P
Charleston* ET-144	1	---	---	---	--	13.5	13.5	0.37	59	F	---	-
Charleston E-146 RB-FC	1	32.5	32.7	1.12	60	31.3	31.2	2.06	59	P	1.04	P
Charleston E-206 RB	3	33.0	33.2	1.18	60	32.4	32.7	1.24	59	P	1.02	P
Salisbury 10-14	1	24.9	25.0	1.31	60	25.3	25.4	1.58	60	P	0.98	P
Salisbury 10-18	1	25.9	25.9	0.95	60	24.5	24.5	1.09	60	P	1.06	P
Salisbury 15-16	2	27.8	27.9	0.72	60	27.3	27.3	0.98	60	P	1.02	P
Salisbury** 20-14	3	14.3	14.2	0.57	49	14.3	14.0	2.08	47	F	1.00	P
Salisbury M15-18	2	25.2	25.2	0.94	60	24.5	24.7	1.18	59	P	1.03	P
Salisbury M20-16	3	22.8	22.7	1.34	60	22.7	22.7	1.12	60	P	1.00	P

* EPDM glove - no claim of ASTM D120 conformance.

** EPDM glove - claims conformance with ASTM D120.

Note: These are not true tensile strength figures since very few specimens broke between the bench marks.

Table 5: Results of Elongation Tests.

Mfr./Model	Voltage Class	Aged Specimens				Unaged Specimens				Accelerated Aging	
		Ave., %	Med., %	Std. Dev., %	No. Tested	Ave., %	Med., %	Std. Dev., %	No. Tested	Median Unaged	P/F
White, 18" mitten	1	712	715	18.63	57	775	780	28.76	59	0.92	P
White, 18" mitten	3	741	740	35.02	58	760	760	23.80	60	0.98	P
White, 14" mitten	3	753	750	48.89	55	798	800	28.16	60	0.94	P
Charleston, ET-144*	1	---	---	-----	--	774	770	27.49	59	----	-
Charleston, E-146RB-FC	1	692	695	26.99	60	753	750	26.00	59	0.92	P
Charleston, E206RB	3	689	690	25.53	60	743	745	28.93	59	0.93	P
Salisbury, 10-14	1	699	700	21.86	60	711	710	22.59	60	0.98	P
Salisbury, 10-18	1	736	740	23.38	60	742	740	24.22	60	0.99	P
Salisbury, 15-16	2	713	710	28.16	60	734	735	17.70	60	0.97	P
Salisbury, 20-14**	3	687	685	21.64	49	691	695	23.44	47	0.99	P
Salisbury, ML5-18	2	762	760	19.96	60	782	780	22.14	59	0.97	P
Salisbury, M20-16	3	695	695	19.39	60	728	730	19.41	60	0.95	P

* EPDM glove - no claim of ASTM D120 conformance.

**EPDM glove - claims conformance with ASTM D120.

Table 6: Results of Insulation Resistance
and Tension Set Tests.

Mfr./Model	Insulation Resistance+				Tension Set++			
	Voltage Class	Ave. Proof Current ma	No. Passing Breakdown	P/F	Ave., mm	Med., mm	Std. Dev.	P/F
White, 18" mitten	1	6.8	20	P	2.4	2.4	0.16	P
White, 18" mitten	3	9.6	20	P	2.0	2.0	0.26	P
White, 14" mitten	3	7.0	20	P	1.6	1.6	0.16	P
Charleston, ET-144*	1	8.4	20	P	1.9	1.9	0.11	P
Charleston, E-146 RB-FC	1	7.4	20	P	2.1	2.1	0.10	P
Charleston, E206 RB	3	9.7	20	P	2.4	2.4	0.09	P
Salisbury, 10-14	1	6.2	20	P	2.0	2.0	0.16	P
Salisbury, 10-18	1	8.2	20	P	2.1	2.1	0.21	P
Salisbury, 15-16	2	9.4	20	P	2.5	2.5	0.18	P
Salisbury, 20-14**	3	8.3	10	F	2.2	2.2	0.16	P
Salisbury, M15-18	2	9.5	20	P	1.8	1.7	0.14	P
Salisbury, M20-16	3	10.3	20	P	2.1	2.1	0.12	P

+ Twenty gloves tested.

++ Sixty specimens tested.

* EPDM glove - no claim of ASTM D120 conformance.

** EPDM glove - claims conformance with ASTM D120.

Table 7: Overall Test Results Summary.

Mfr./Model	Voltage Class	Total No. Tests Failed+	No. Performance Tests Failed++	Overall Rating, P/F*
White, 18" mitten	1	2	0	P
White, 18" mitten	3	1	0	P
White, 14" mitten	2	2	0	P
Charleston ET-144**	1	1	0	--
Charleston, E206 RB	3	1	0	P
Salisbury, 10-14	1	2	0	P
Salisbury, 10-18	1	1	0	P
Salisbury, 15-16	2	1	0	P
Salisbury, 20-14**	3	3	2	F
Salisbury, M15-18	2	1	0	P
Salisbury, M20-16	3	0	0	P

+ Eleven tests performed.

++Six tests performed.

* Based only on performance tests.

**EPDM glove - no claim of ASTM D120 conformance.

**EPDM glove - claims conformance with ASTM D120.

