TECHNICAL REPORT

PERSONAL PROTECTIVE EQUIPMENT
TEST DEVELOPMENT AND VALIDATION

Prepared for
National Institute for OccupationalSafety and Health
Division of Safety Research

Contract No. 210-78-0073

Prepared by

Franklin Research Center
Philadelphia, Pennsylvania 19103

February 1981

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1. SUMMARY

Six tests were evaluated to determine the reproducibility of test results either by interlaboratory or intralaboratory tests of the "round robin" type. In four of the tests, a degree of subjectivity in making the determinations led to significant differences in the results and rewriting of the test specifications was required to remove, insofar as possible, the subjectivity in the measurements. One test method was completely rewritten in order to eliminate ambiguties which caused technicians to fail to understand the test sequence.

A test method and apparatus was developed for a ballistic impact test for full facepiece respirators.

Two Appendices give the test methods in their proposed final form (Appendix A) and the description and design modifications for the ballistic impact apparatus (Appendix B).

2. INTRODUCTION

The work described in this report was undertaken to develop, test, and validate the following test methods:

1. Optical Definition of Clear, Flexible Fitting Goggle Lenses.
2. Spherical and Cylindrical Refractivity of Clear, Flexible Fitting Goggle Lenses.
3. Flammability of Head Mounted Personal Protective Equipment.
4. Compression Test for Safety Toe Footwear Using Feeler Gauge.
5. Determinator of Toe Box Deflection under Fixed Load for Safety-Toe Footwear.
6. Ballistic Impact Test for Full Facepiece Respirators.

The following sections describe the findings on each of the tests and discuss the results.

3. OPTICAL DEFINITION OF CLEAR, FLEXIBLE FITTING GOGGLE LENSES

3.1 Basic Test

This test consists of the telescopic observation of an NBS Resolution Test Chart through the test lens. (See detailed method in Appendix A.) The number of the highest number test pattern which can be brought into focus is recorded.

3.2 Results of Comparison Tests

The raw data as recorded by five separate operators using the same lenses and the same test points on the lenses are shown in Table 3-1 and the means, variance, and estimated standard deviation of the mean for each set of observations is shown in Table 3-2.

3.3 Discussion of Comparison Tests

The test pattern numbers and the difference (Δ) between the pattern numbers are:

Pattern No.	(Δ)
80	
68	12
56	12
48	8
40	8
34	6
28	6
24	4
20	4
17	3
14	3
12	2

In view of the differences it is questionable whether the calculated variance or the standard deviation (14.19) can be used to interpret the results. Of far more significance is the pattern which emerges from the examination of the raw data. Of the five test technicians, using exactly the same test set-up, technicians C and E were able to resolve the 56 pattern in all, or a majority of the cases. Technician D resolved the 48 pattern in a majority of cases while technicians A and B were able to resolve only the wider pattern lines from 20 to 40. These observations held true even when the test pattern was observed directly through the telescope with no test lens in place. The range of pattern resolution appears to result not from focusing of the telescope, but in how various technicians focus their eyes. Astigmatism may be a partial cause of the phenomenon, but to answer this question will require medical and psychological determination of how different people "see". The limiting pass-fail pattern 20 was distinguished in all cases by all five technicians.

3.4 Recommendations

In the absence of medical and psychological data, and in view of the fact that all technicians were capable of resolving the number 20 pass-fail pattern, a caution should be incorporated into the test method to the effect that no individual, incapable of resolving at least the number 28 pattern by direct telescopic observation of the NBS target with no test lens in place, be allowed to perform this test. This cautionary note has been added to the test method in two places.

Table 3-1
Definition Data

Observer	A	B	C	D	E
Lens		Test Pattern Resolved			
1R	40	24	56	48	56
1L	40	24	56	48	56
2R	34	24	56	48	56
2L	34	24	56	48	56
3R	34	24	56	48	56
3L	34	24	56	48	56
4R	34	24	56	56	56
4L	34	24	56	48	56
5R	40	24	56	48	56
5L	34	24	40	40	56
6R	34	24	56	48	56
6L	34	24	56	48	56
7R	34	20	40	20	56
7L	28	24	56	48	56
8R	34	24	56	48	56
8L	34	24	56	40	56
9R	34	20	40	24	56
9L	28	24	40	48	56
10R	34	24	56	48	56
10L	34	24	56	48	56
11R	34	24	56	48	56
11L	34	24	56	40	56
12R	34	20	56	48	56
12L	34	20	56	40	56

Table 3-2

Definition Data Reduction

Lens	ΣX	$\bar{X}$	$(\Sigma X)^2$	ΣX^2	V	S
IR	224	44.8	50176	10752	179.2	13.38
1L	224	44.8	50176	10752	179.2	13.38
2R	218	43.6	47524	10308	200.8	14.17
2L	218	43.6	47524	10308	200.8	14.17
3R	218	43.6	47524	10308	200.8	14.17
3L	218	43.6	47524	10308	200.8	14.17
4R	226	45.2	50176	11140	231.2	15.21
4L	218	43.6	47524	10308	200.8	14.17
5R	224	44.8	50176	10752	179.2	13.38
5L	194	38.8	37636	8068	135.2	11.63
6R	218	43.6	47524	10308	200.8	14.17
6L	218	43.6	47524	10308	200.8	14.17
7R	170	34.0	28900	6692	228.0	15.10
7L	212	42.4	44944	9936	236.8	15.39
8R	218	43.6	47524	10308	200.8	14.17
8L	210	42.0	44100	9604	196.0	14.0
9R	174	34.8	30276	6868	203.2	14.25
9L	196	39.2	38416	8400	179.2	13.39
10R	218	43.6	47524	10308	200.8	14.17
10L	218	43.6	47524	10308	200.8	14.17
11R	218	43.6	47524	10308	200.8	14.17
11L	210	42.0	44100	9604	196.0	14.0
12R	214	42.8	45796	10132	243.2	15.59
12L	206	41.2	42436	9428	260.2	16.13.
12L	206	41.2	42436	9428	260.2	16.13

$(\bar{\bar{X}}) = 42.35$

$\bar{V} = 202.3$

$\bar{S} = 14.19$

*Terms are defined on Page 6.A.

Where:

$\overline{X}$ = mean of all readings for given lens

$\overline{\overline{X}}$ = mean of all readings for given lenses

V = variance of all readings for given lens

$\overline{V}$ = mean of variance for all lenses

S = standard deviation of mean for given lens

$\overline{S}$ = mean of standard variation for all lenses

$$V = \frac{n\Sigma x^2 - (\Sigma x)^2}{n(n-1)}$$ where n = number of observations

$$S = \sqrt{V}$$

4. SPHERICAL AND CYLINDRICAL REFRACTIVITY OF CLEAR FLEXIBLE FITTING GOGGLE LENSES

4.1 Basic Test

The test consists of observing a standard target through a test lens by means of a calibrated telescope. The target is an 80 millimeter diameter array of spokes (see test method in Appendix A). The telescope is calibrated between +1/16 diopter and -1/16 diopter in steps of 1/160 diopter.

4.2 Results of Comparison Tests

The results of tests made by five observers on the same test lens using the identical test equipment are shown in Table 4-1 for cylindrical refractivity and Table 4-3 for spherical refractivity. The calculated mean values and estimated standard deviations are shown in Tables 4-2 for cylindrical refractivity and 4-4 for spherical refractivity.

4.3 Discussion of Comparison Tests

Since each technician made only a single reading on each lens through the same part of the lens, the means shown are the results of five single observations and the standard deviation is the estimated standard deviation of the mean of five single observations made by five different technicians. The estimated standard deviation in these calculations is the same as the mean error of a single observation and is slightly greater than one for cylindrical refractivity and slightly less than one for spherical refractivity. If a value of +1 is accepted for the mean error of a single observation, then the probable error of a single observation is also approximately one. The results obtained by the five technicians are consistent with this observation except for the case of technician E, especially in the case of cylindrical refraction. Technician E also could consistently resolve the number 56 pattern in the Optical Definition test while the other technicians could not. In all cases, however, the test lenses are acceptable.

4.4 Recommendations

In both tests, the problem of how an individual sees a pattern and/or interprets what he sees exists. Since four of the five technicians are within the calculated probable error of one, it is recommended that the stated pass/fail level be reduced to 9 if 10 is still to be regarded as the acceptable maximum. In order to avoid rejection of a lens by an individual who "sees" as does technician E, a provision for re-test of a rejected lens by two other technicians should be made. The mean of the three determinations should then be used to determine the acceptability of the test lens or lenses.

These recommendations have been incorporated into the test method in Appendix A.

Table 4-1

Cylindrical Refraction Data

Observer	A	B	C	D	E
Lens	Cylindrical Refractivity				
3R	1	0	0	0	3
3L	0	1.5	1	0	3
4R	2	0	2	.5	3
4L	0	2	0	0	2
5R	1	1	1	0	3
5L	0	1.5	1	.5	4
6R	2.5	0	0	0	2
6L	.5	1.5	2	.5	2
7R	2	1.5	0	1	4
7L	1	.5	1	1.5	3
8R	1	1	1	0	3
8L	1	2	0	1	3
9R	1	.5	1	.5	3
9L	1.5	.5	3	.5	2
10R	1	.5	1	0	1
10L	1	1.5	0	1.5	3
11R	1.5	0	1	1	3
11L	1	1.5	0	1	4
12R	1	.5	0	.5	3
12L	.5	1	0	0	3

Table 4-2

Cylindrical Refraction Data Reduction

Lens	ΣX	$\bar{X}$	$(\Sigma X)^2$	X^2	V	S
3R	4	0.8	16	10	1.7	1.3
3L	5.5	1.1	30.25	12.25	1.55	1.24
4R	7.5	1.5	56.25	17.25	1.5	1.22
4L	4	.8	16	8.0	1.2	1.1
5R	6	1.2	36	12.0	1.2	1.1
5L	7	1.4	49	19.5	2.42	1.56
6R	4.5	.9	20.25	10.25	1.55	1.24
6L	6.5	1.3	42.25	10.75	.58	.76
7R	8.5	1.7	72.25	23.25	2.2	1.48
7L	7	1.4	49	13.5	.92	.96
8R	6	1.2	36	12.0	1.2	1.1
8L	7	1.4	49	15.0	1.3	1.14
9R	6	1.2	36	11.5	1.08	1.04
9L	7.5	1.5	56.25	15.75	1.12	1.06
10R	3.5	.7	12.25	3.25	.2	.48
10L	7	1.4	49	14.5	1.17	1.08
11R	6.5	1.3	42.25	13.25	1.2	1.1
11L	7.5	1.5	56.25	20.25	2.25	1.5
12R	5	1.0	25	10.5	1.38	1.17
12L	4.5	.9	20.25	10.25	1.55	1.24

$(\bar{\bar{X}}) = 1.21$

$\bar{V} = 1.36$

$\bar{S} = 1.14$

*Terms are defined on Page 6A

Table 4-3

Spherical Refraction Data

Observer	A	B	C	D	E
Lens	Spherical Refractivity				
3R	.5	0	0	.5	2
3L	1	2	2	0	2
4R	1.5	0	1	.5	2
4L	.5	2	1	0	2
5R	1	1	1	0	2
5L	1	2	1	1.5	3
6R	2	.5	0	.5	2
6L	.5	1.5	1	.5	1
7R	1	1	0	1.5	3
7L	.5		1	1	2
8R	1.5	1	1	0	2
8L	1	1	0	1	2
9R	1.5	1.5	1	1.5	2
9L	1	1.5	2	1	1
10R	1	.5	1	.5	1
10L	.5	1.5	1	1	2
11R	1.5	0	2	1	2
11L	1	1.5	1	1	3
12R	1	.5	1	.5	2
12L	.5	1	1	0	2

Table 4-4

Spherical Refraction Data Reduction

Lens	ΣX	$\bar{X}$	$(\Sigma X)^2$	X^2	V	S
3R	3	.6	9	4.5	.675	
3R	3	.6	9	4.5	.675	.82
3L	7	1.4	49	13.0	.8	.89
4R	5	1.0	25	7.5	.625	.79
4L	5.5	1.1	30.25	9.25	.8	.89
5R	5	1.0	25	7.0	.5	.71
5L	8.5	1.7	72.75	17.25	.675	.82
6R	5.0	1.0	25	8.5	.875	.94
6L	4.5	.9	20.25	4.75	.175	.42
7R	6.5	1.3	42.25	13.25	1.2	1.1
7L	5.5	1.1	30.25	7.25	.3	.55
8R	5.5	1.1	30.25	8.25	.55	.74
8L	5.0	1.0	25	7.0	.5	.71
9R	7.5	1.5	56.25	11.75	.125	.35
9L	6.5	1.3	42.25	9.25	.2	.45
10R	4.0	.8	16.0	3.5	.08	.27
10L	6.0	1.2	36.0	8.5	.325	.57
11R	6.5	1.3	42.25	11.25	.7	.84
11L	7.5	1.5	56.25	14.25	.75	.87
12R	5.0	1.0	25.0	6.5	.375	.61
12L	4.5	.9	20.25	6.25	.55	.74

$(\bar{\bar{X}}) = 1.14$

$\bar{V} = .539$

$\bar{S} = .704$

*Terms are defined on Page 6A

5. FLAMMABILITY OF HEAD MOUNTED PERSONAL PROTECTIVE EQUIPMENT

5.1 Basic Test

The flammability test consists of application of a standard size flame to parts of head mounted protective equipment mounted as-worn on a standard wooden head form. The flame is applied to selected test points of the protective equipment for times which increase by increments of one second. After each application of the flame, five seconds are allowed before observing whether the test point is burning. If no burning is observed, a further five seconds is allowed before applying the flame for the next increased exposure time. Ultimately, the shortest time of flame exposure is found. (See test method in Appendix A.)

5.2 Results of Comparison Tests

All tests on face shields produced burning times of three and four seconds.

5.3 Discussion of Test Results

Test results show a range of one second in burning time which is the difference of one time increment. The tests however could not be conducted until extensive modifications were made to the written test method. This was caused by problems which arose by confusion of burning time with time of flame application and elapsed time, the selection of the number of test points, setting the standard flame, and selection of edges as test points.

5.4 Recommendations

Problem areas in interpreting the test specification which were encountered by technicians and the corrections which were made are as noted in the following:

5.4.1 In Section 3. APPARATUS, paragraph 3.4 covering the elevation stand required clarification with regard to the height of the stand. The height should be such that the lowest point of the protective equipment under test clears the bench top by a minimum of six inches.

5.4.2 In Section 4. PROCEDURE, paragraph 4.1.2 regarding the choice of test points required modification to indicate a maximum and minimum number of test points as well as a guide line for position of the test points on the equipment under test.

5.4.3 In Section 4. PROCEDURE, paragraph 4.2.3, the procedure for adjustment of the burner flame required more detail.

5.4.4 In Section 4. PROCEDURE, paragraph 4.3.1, was completely rewritten as paragraphs 4.3 "General Testing" and 4.4 "Testing". This was required to clarify the testing sequence by detailing the procedure with regard to the number of test points to be tested on subsequent samples, the timing sequence, and the interpretation of burning and ignition time. A new table showing the command sequence times for tape preparation was prepared and referenced in the procedure.

5.4.5 In Section 5. REPORTING, paragraph 5.1 describing the data to be recorded was modified and a new data sheet was prepared.

5.4.6 All of the above corrections were made and are incorporated in the test specification in Appendix A.

6. COMPRESSION TEST FOR SAFETY-TOE FOOTWEAR USING FEELER GAUGE

6.1 Basic Test

The compression test consists of compressing the toe box of a prepared shoe specimen between platens of a specified size and at a specified loading rate. The toe box of the test shoe is compressed to a height of 0.5 inches as determined by a feeler gauge. The load required to compress the specimen to the gauge height is recorded. (See test method in Appendix A)

2. Results of Comparison Tests

The results of tests conducted at FRC and at seven other test laboratories are shown in Table C-1. Ten shoes were tested at each laboratory and the ten shoes were composited in order to eliminate day to day production line differences.

6.3 Discussion of Compression Tests

The data from seven outside laboratories and from the ten shoes tested at FRC were analyzed using available computer programs. Mean values were tested using Analysis of Variance. Homogeneity of variances were tested using Bartlett-Box F test.

For all laboratories the analysis of variance gave a probability of 0.0000. If the null hypothesis (means are not significantly different) is rejected, there is very nearly no chance of being wrong. Likewise, the probability in the test for homogeneity of variances give 0.0000 for the Bartlett-Box F test. It is very nearly certain that the test results show factors other than chance variations are acting on the results.

An additional analysis was made using the Multiple Range test which breaks down the means into homogeneous subsets. Thus, Lab G, Lab B, and Lab F form Subset 1; FRC, Lab C, and Lab A form Subset 2; Lab E is Subset 3; and Lab D is Subset 4. Comparisons were made for the means and variances of the Subsets with the FRC data.

Subset 1 gives a probability of 0.0000 for the analysis of variance while the homogeneity of variances gave a probability of 0.009 for the Bartlett-Box F tests. Again, for both means and variances there is little chance for error if the null hypothesis is rejected. There is a significant difference in the means and variances between laboratories.

Subset 2 shows a probability of 0.9297 for the analysis of variance and a probability of 0.224 for the Bartlett-Box F. If the null hypothesis for means (means not significantly different) is rejected, there is nearly a 93 percent chance of being in error. For the homogeneity of variances, rejection of the null hypothesis (variances not significantly different) gives a 22.4 percent chance of error by the Bartlett-Box F test. For this Subset, the means and variances may be considered not significantly different.

Subset 3 gives a 0.0000 probability for the analysis of variance and a 0.044 probability for the Bartlett-Box F test. The means and the variances are significantly different.

Subset 4 gives a probability of 0.0000 for the analysis of variance, and a probability of 0.000 for the Bartlett-Box F test. Again, there is a significant difference between means and variances.

There are two types of factors at work in the interlaboratory tests, those producing high results and those producing low results when compared to FRC data, and work was carried out to determine the probable causes. The probable causes considered were:

1. Faulty calibration of test machine.
2. Failure to position the test shoe properly.
3. Failure to observe the proper contact point with the feeler gauge.
4. Over-shoot of end point by using a higher load rate or failure to cut off the test machine immediately at the firm contact point.

The calibration of the test machines at FRC, Lab A, Lab B, and Lab D were checked at the 4000 pounds level with a proving ring loaned by ALOSH. The variation at the 4000 pounds load level was $\pm$ 100 pounds. It is felt that the calibration discrepancy is insufficient to cause the effects noted.

Tests were conducted on additional shoes at FRC to determine the effect of positioning of the toe box on the bottom platen and the effect of compressing the toe box until the feeler gauge was completely immovable by hard pulling of the gauge beyond what was considered "firm finger pressure". No effect was noted by inexact positioning of the toe box within what was considered a reasonable positioning error (0.75 inches off center). It was possible to obtain readings as high as 4800 pounds by going beyond the "firm finger pressure" point to a point as noted above.

If the correct load rate is used and the contact point is interpreted correctly, a three second delay in stopping and reversing the load results in a 150 pound overshoot. In order to obtain high results the delay in cut-off may be a contributing factor but is, of itself, inadequate to explain readings in excess of 5000 pounds.

6.4 Recommendations

Failure to interpret "firm finger pressure" properly is probably the major factor in giving the high-low spread of mean values. This is borne out by the fact that Labs B, D. E, F. and G received only the test specification and the test shoes with no further discussion of the method. Labs A and C questioned the meaning of "firm finger pressure" after receiving the test specification and the test shoes, and there was telephone discussion with FRC personnel. The data reduction showed that there was no significant difference in the results obtained by FRC and these two laboratories. Either a break-away feeler gauge or an electrical contact feeler gauge should be designed and incorporated into the test procedure in order to remove the subjectivity involved in determining the correct end point for contact. Until this is done, the statement concerning "firm finger pressure" should be amplified to remove any doubt in interpretation.

An additional point of clarification in the test specification should be to note that the test requires two operators, one operating the test machine and one operating the feeler gauge. This requirement should prevent overshoot of the end point.

These changes have been incorporated into the test method in Appendix A.

Table 6-1
COMPRESSION TEST DATA - FEELER GAUGE

Laboratory	No. of Shoes	Mean Load lbs.	Est. Std Dev. (lbs.)
FRC	10	4136	± 164
Lab A	10	4175	± 279
Lab B	10	3572	± 543
Lab C	10	4171	± 290
Lab D	10	5986	± 793
Lab E	10	5389	± 335
Lab F	10	3598	± 330
Lab G	10	3254	± 284

7. DETERMINATION OF TOE BOX DEFLECTION UNDER FIXED LOAD FOR SAFETY-TOE FOOTWEAR

7.1 Basic Test

The test consists of placing a formed soft clay cylinder in the toe box of a prepared test shoe and compressing the toe box between two platens at a specified load rate until the designated test load is reached. The load is then released, the cylinder is removed, and the height of the cylinder is measured by means of a micrometer. (See test method in Appendix A).

7.2 Results of Comparison Tests

The results of comparison tests by five technicians are shown in Table 7-1. Each technician tested 10 shoes (5 pairs).

7.3 Discussion of Comparison Tests

An analysis of variance for the tabulated results gave a probability of 0.0000. If the hypothesis that the means are not significantly different is rejected,, there is virtually no chance of being wrong. Bartlett-Box F test for testing the homogeneity of variances gave a probability 0.075. If the hypothesis that the variances are not significantly different is rejected, there is a 7.5 percent chance of being wrong. Since 5 percent or less is the usual level for rejection of the null hypothesis, the variances are not significantly different. The analysis indicates that some outside factor causes a significant difference in the means but does not affect the variability of the results.

7.4 Recommendations

The analysis of the data gives results typical of a measurement in which touch determines the point at which measurment is made. The differences between the means obtained by the five technicians most probably result from application of different forces on the spindle of the micrometer. The variabilities would be the same but the end points would be different. The use of a precision dial micrometer with a standard weight so that measurements are made using reproducible forces should be employed rather than a hand held micrometer. These instruments are described in ASTM D1777. In this case a presser foot (spindle) and anvil diameter of 0.25 inches should be adequate and the ends should be rounded to a 0.125 inch radius. The applied load is subject to experiment but for the interim the load should be such that the pressure developed is 0.6 psi. This change is incorporated into Section 3 APPARATUS, paragraph 3.8 in the test specification in Appendix A.

Table 7-1

RESULTS OF COMPARISON TESTS TOE BOX
DEFLECTION UNDER FIXED LOAD

	Cylinder Height in Inches				
Technician	A	B	C	D	E
	.735	.737	.766	.705	.761
	.705	.754	.724	.700	.716
	.716	.747	.761	.698	.704
	.700	.735	.714	.703	.715
	.700	.737	.745	.694	.717
	.707	.786	.767	.702	.785
	.704	.771	.748	.715	.714
	.710	.768	.738	.712	.746
	.717	.785	.724	.700	.742
	.700	.738	.751	.735	.744
Mean	.710	.756	.744	.706	.734
Standard Deviation	.0109	.0202	.0186	.0118	.0256

8. BALLISTIC IMPACT TEST FOR FULL FACEPIECE RESPIRATORS

8.1 Basic Test

The test consists of propelling a standard projectile by means of a helium powered air rifle at the facepiece of a full facepiece respirator, mounted on a standard headform in an as-worn position. The facepiece is positioned so that it is perpendicular to the flight path of the projectile in the vertical plane and in the horizontal plane. Curved facepieces are positioned in the horizontal and vertical planes so that the tangents, vertical and horizontal, at the impact point are perpendicular to the flight path of the projectile. The velocity of each shot is recorded. Velocities are selected to be below the penetration at the beginning of the test and are increased by increments of velocity until penetration of the facepiece by the projectile point is achieved. (See detailed method in Appendix A).

8.2 Tests of the Ballistic Impact Device

8.2.1 Projectile Reproducibility

The Ballistic Impact Test Device as described in Appendix B was subjected to tests to determine the uniformity of velocities which could be achieved using standard pressure settings for the helium gas charge. Also, the mass uniformity of the projectiles was determined. A total of 40 projectiles was produced in two lots. Lot "A" consisting of 11 projectiles gave a mean projectile mass of 1.596 grams with a standard deviation of 0.0112 grams. Lot "B" of 29 projectiles gave a mean projectile mass of 1.604 grams and a standard deviation of 0.009 grams. A comparison of variances between the two lots gives an F ratio of 1.55 which is less than the 2.19 value required at the 0.05 probability level. The variabilities are thus the same in each lot. Comparison of the mean masses by the "t" test gives a value 2.34 which is significant at 0.05 probability level. The range of masses within the lots are: 1.579 to 1.619 grams for Lot "A" and 1.586 to 1.619 grams for Lot B. The target for acceptance of a projectile in order to avoid excessive rejection rates in production quantities should be 1.6 grams $\pm$ 2%.

8.2.2 Velocity Reproducibility

The test device was subjected to a number of firings to determine the reproducibility of projectile velocity as a functiuon of the helium charge pressure. The data are shown in Table 8-1. The mean standard deviation is 0.925. If a standard deviation of 1.0 is assumed Table 8-2 shows the upper and lower limit of the mean for $\pm$ 3s (three standard deviations) and the velocity difference (Δ V) between each mean value. In the pressure regions above 225 psig, the velocity increments decrease rather rapidly for the same difference in pressure (Δ P), and the upper and lower limits overlap. In this region steps of 50 psig would more nearly produce the velocity increments brought about by a 25 psig step at lower pressures and velocities.

8.2.3 Penetration Velocity

In early tests to determine that high pressures (in excess of 500 psig) would produce velocities in excess of 150 meters per second (the proposed pass-fail level) it was found that penetration of the target facepiece occurred in all cases. Tests were made using the final gun and projectile configurations to determine just where the facepieces would fail. The data are shown in Table 8-3. The facepieces which are 0.125 inches thick polycarbonate are penetrated at velocities of 62 to 63 meters/second.

8.3 Discussion of Test

Two things must be noted about the test. First, the pass/fail level of 150 meters per second which was suggested appears to be far too high for the facepieces. Numbers of different facepieces should be tested in order to arrive at an acceptable pass/fail level. At this time the pass/fail level is omitted from the specification. Second, the velocity displayed by the chronograph is the average velocity of the projectile over the 30 centimeters of barrel between the measuring points. It is not the true impact velocity, although a relationship exists between the two. Since the new pass/fail level will be set up using the average velocity as measured in the barrel, the velocity values need not be calculated to the true impact velocity.

8.4 Recommendations

The pass/fail level should be temporarily omitted from the test specification pending test results on facepieces of different designs and materials. It should further be noted in the test specification that the measured average velocity is the velocity criterion and that it is not the true impact velocity.

Table 8-1

VELOCITY AS A FUNCTION OF CHARGE PRESSURE

Charge Pressure (psig)	Velocities (V) M/sec					$\bar{V}$	S
75	30.4	34.2	34.7	34.2	34.4		
	33.7	34.7	34.7	34.3	34.5	33.9	1.2
100	41.2	41.9	41.4	41.0	41.6		
	41.0	42.0	40.8	41.3	42.0	41.4	0.4
125	49.0	50.2	48.7	49.3	49.5		
	49.3	50.2	49.5	50.3	48.7	49.4	0.5
150	56.1	57.6	56.9	57.2	56.9		
	55.7	57.5	56.3	57.2	56.9	56.8	0.6
175	63.6	65.7	64.5	64.5	64.2		
	63.4	63.1	63.1	63.1	62.1	63.7	1.0
200	69.2	71.8	70.7	71.2	70.3		
	69.4	71.3	70.7	70.4	70.3	70.5	0.8
225	75.3	78.1	76.5	76.3	75.1		
	75.4	77.6	76.1	77.0	76.8	76.4	0.9
250	80.3	84.8	83.1	81.8	82.7		
	80.9	82.6	82.7	82.5	83.0	82.4	1.2
275	87.8	87.5	87.3	87.8	88.4		
	89.1	89.2	89.4	87.4	86.9	88.0	0.8
300	92.6	94.4	93.0	92.9	92.2		
	93.0	94.4	93.8	93.0	92.3	93.1	0.7
325	96.3	98.4	97.8	97.1	97.9		
	94.7	99.2	96.4	98.0	97.9	97.3	1.2
350	101.4	102.9	101.5	101.3	99.9		
	96.5	103.0	101.1	101.7	102.4	101.1	1.8

Table 8-2

VELOCITY LIMITS AS FUNCTION OF CHARGE PRESSURE

Charge Pressure (psig)	$\overline{V}$	$\overline{V}$ Upper Lim.	$\overline{V}$ Lower Lim.	ΔV	ΔP
75	33.9	36.9	30.9		
100	41.4	44.4	38.4	7.5	25
125	49.4	52.4	46.4	8	25
150	56.8	59.8	53.8	7.4	25
175	63.7	66.7	60.7	6.9	25
200	70.5	73.5	67.5	6.8	25
225	76.4	79.4	73.4	5.9	25
250	82.4	85.4	79.4	6	25
275	88.0	91.0	85.0	5.6	25
300	93.1	96.1	90.1	5.1	25
325	97.3	100.3	94.1	4.2	25
350	101.1	104.1	98.1	3.8	25

Table 8-3

FACEPIECE PENETRATION TESTS

Test No.	Shot No.	Pressure (Psig)	Velocity (M/sec)	Result
1	1	75	32.0	No Pen.
1	2	100	39 3	No Pen.
1	3	125	45.0	No Pen.
1	4	150	56.4	No Pen.
1	5	175	62.1	Pen.
2	1	75	30.9	No Pen.
2	2	100	39.5	No Pen.
2	3	125	48.0	No Pen.
2	4	150	54.6	No Pen.
2	5	175	62.6	Pen.

APPENDIX A

Method
Date

DETERMINATION OF THE OPTICAL DEFINITION OF CLEAR, FLEXIBLE FITTING GOGGLE LENSES

1. SCOPE

1.1 This method is designed for use in determining the optical definition of clear, flexible fitting goggle lenses.

NOTE: No person, incapable of resolving at léast the No. 28 pattern by direct telescopic observation of the NBS target with no test lens in place, shall perform this test.

2. TEST SPECIMENS

2.1 The test specimens shall consist of flat, flexible, one piece, plastic lenses for use in protective goggles.

3. APPARATUS

3.1 Optical telescope with 14X eyepiece with cross hairs, 200 millimeter objective focal length, and a 19 millimeter objective aperture diameter. The telescope shall have knob focusing. (Gaertner Model M522-MDC or equivalent)

3.2 Optical bench having a minimum length of 45 centimeters (Ealing 22-5169 or equivalent) with leveling screws.

3.3 Optical bench mount for telescope, "V" block and clamp type.

3.4 Optical bench mount for flat specimens, rigid frame with spring clips.

3.5 Light source

3.6 Definition target, NBS circular C533. Available from National Bureau of Standards, Washington, D.C. (Figure 1)

3.7 Target mounting with light source

3.8 Staticmaster brush

3.9 Lens tissue

3.10 Lens cleaning solution

3.11 Optical alignment system

3.11.1 Auto-collimator

3.11.2 First surface mirror optical flat

4. PROCEDURE

4.1 Telescope system alignment

4.1.1 Auto-collimator

4.1.1.1 Attach the optical bench mount for flat specimens to the optical bench at a point approximately 7 centimeters (2.75 inches) from the telescope objective lens. The clips on the mount should face away from the telescope.

4.1.1.2 Attach the first

surface mirror to the clip side of the specimen holder with the reflecting surface facing the telescope.

4.1.1.3 Replace the telescope with the auto-collimator

4.1.1.4 Adjust the specimen holder until the first surface mirror is perpendicular to the optical axis of the telescope as indicated by coincidence of the target and its image in the auto-collimator.

4.1.1.5 Remove the auto-collimator and the first surface mirror and replace the telescope. NOTE: Care must be exercised from this point on not to disturb the system alignment.

4.2 Specimen preparation

4.2.1 Wash the samples with soap and water. Rinse with distilled water. To avoid scratching, do not rub or clean a dry lens. NOTE: Some lenses covered with an anti-fog coating scratch very easily. Extra care should be taken in handling them.

4.3 Equipment preparation

4.3.1 Position the optical bench with the telescope and specimen holder facing the illuminated NBS target. The distance from the target to the objective lens of the telescope shall be 10.75 meters (35 feet, 3 inches) and the specimen holder shall be positioned approximately 7 centimeters (2.75 inches) in front of the objective lens of the telescope.

4.3.2 Position the illuminated NBS target so that the center of the target coincides with the intersection of the cross hairs.

4.3.3 Align the sample holder perpendicular to the optical axis of the telescope using the auto-collimator (4.1). Recheck the alignment after testing has been completed.

4.3.4 Use the staticmaster brush to remove any dust from the telescope lenses and from each specimen prior to placing it in the holder.

4.4 Testing

NOTE: No person, incapable of resolving at least the No. 28 pattern by direct telescopic observation of the NBS target with no test lens in place, shall perform this test.

4.4.1 All data shall be recorded on a data sheet identical with that shown in Figure 2.

4.4.2 A Control Number shall be assigned to the specific specimens to be tested in order to identify the manufacturer, model, and shipment. The Control Number shall be entered on the data sheet.

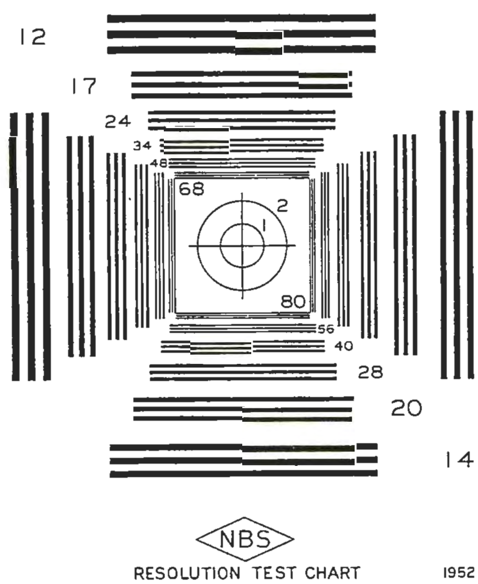
4.4.3 Each sample shall be inspected for Visible Defects by holding it at arms length and observing a straight-edged surface 6 to 8 feet away. A lens shall have a visible defect if a localized defect, or slight or severe distortion of the straight-edged surface is noted. Mark the position of any localized defects on the lens except those that are within 13 millimeters (0.5 inch) of the samples edge. Note the presence of visible defects by a checkmark in the appropriate column of the data sheet.

4.4.4 Samples without localized defects will be tested by looking through their centers. Samples with localized defects will be tested by looking through the defect.

4.5 Focus the telescope on the illuminated NBS definition target. Record on the data sheet under "Definition Test" opposite the specimen number the number of the pattern which can be resolved. (The observer should be able to determine with confidence the number of lines in the pattern. Both horizontal and vertical patterns should be resolved but not necessarily at the same focus dial setting.

5. REPORTING

5.1 The number 20 pattern should be resolved. Specimens which do not resolve the number 20 pattern are considered to have failed (F). Those which resolve the number 20 pattern or better are considered to have passed (P). Record the number of specimens passing and failing at the bottom of the data sheet.


12
17
24
34
48
68
2
1
80
56
40
28
20
14
NBS
RESOLUTION TEST CHART
1952

FLEXIBLE FITTING GOGGLES

CONTROL NO. ______________ OPERATOR ______________ DATE __________

SPEC-	VISIBLE DEFECTS				
IMEN	LOCAL-	DISTORTION			
NO.	IZED	SLIGHT	SEVERE		

DEFINITION P F

REMARKS:

Method
Date

DETERMINATION OF THE SPHERICAL AND CYLINDRICAL REFRACTIVE POWER OF CLEAR, FLEXIBLE FITTING GOGGLE LENSES

1. SCOPE

1.1 This method is designed for use in determining the spherical and cylindrical refractivity of clear, flexible fitting goggle lenses.

2. TEST SPECIMENS

2.1 The test specimens shall consist of flat, flexible, one piece, plastic lenses for use in protective goggles.

3. APPARATUS

3.1 Optical telescope with 14X eyepiece with cross hairs, 200 millimeter objective focal length, and a 19 millimeter objective aperture diameter. The telescope shall have knob focusing. (Gaertner Model M522-MDC or equivalent)

3.2 Optical bench having a minimum length of 45 centimeters (Ealing 22-5169 or equivalent) with leveling screws.

3.3 Optical bench mount for telescope, "V" block and clamp type.

3.4 Optical bench mount for flat specimens, rigid frame with spring clips.

3.5 Light source

3.6 Refractive power target (Figure 1)

3.7 Target mounting with light source

3.8 Staticmaster brush

3.9 Lens tissue

3.10 Lens cleaning solution

3.11 Optical alignment system

3.11.1 Auto-collimator

3.11.2 First surface mirror optical flat

4. PROCEDURE

4.1 Telescope calibration

4.1.1 Bring the cross hairs into focus by adjusting the eyepiece.

4.1.2 Mount the telescope on the optical bench by means of the "V" block bench mount.

4.1.3 Place the illuminated refractive power target 10.75 meters (35 feet, 3 inches)[1] in front of the telescope objective lens.

4.1.4 Focus the telescope and eliminate parallax[2] between the cross hairs and the target.

4.1.5 Mark the position of the telescope focusing dial corresponding to the fixed mark on the telescope body.

4.1.6 Repeat steps 4.1.3 to 4.1.5 with the telescope objective at a distance of 6.48 meters (21 feet, 3 inches) from the target. Measure the distance from the second mark to the first mark and place a third mark equidistant from the first mark on the opposite side of the first mark.

4.1.7 The center mark is the zero setting while the outer marks represent plus and minus 1/16 diopter. Divide the spaces between the zero point and each of outer marks into 10 equal increments. Each increment represents 1/160 diopter.

4.1.8 The calibration of the telescope should be rechecked at one month intervals.

4.2 Telescope system alignment

4.2.1 Auto-collimator

4.2.1.1 Attach the optical bench mount for flat specimens to the optical bench at a point approximately 7 centimeters (2.75 inches) from the telescope objective lens. The clips on the mount should face away from the telescope.

4.2.1.2 Attach the first surface mirror to the clip side of te specimen holder with the reflecting surface facing the telescope.

4.2.1.3 Mount the auto-collimator in the telescope mount.

4.2.1.4 Adjust the specimen holder until the first surface mirror is perpendicular to the optical axis of the telescope as indicated by coincidence of the target and its image in the auto-collimator.

4.2.1.5 Remove the auto-collimator and the first surface mirror and replace the telescope. NOTE: Care must be exercised from this point on not to disturb the system alignment.

4.3 Specimen preparation

4.3.1 Clean the samples with lens cleaning solution. To avoid scratching, do not rub or clean a dry lens. NOTE: Some lenses covered with an anti-fog coating scratch very easily. Extra care should be taken in handling them.

4.4 Equipment preparation

4.4.1 Position the optical bench with the telescope and specimen holder facing the illuminated refractive power target. The distance from the target to the objective lens of the telescope shall be 10.75 meters (35 feet, 3 inches) and the specimen holder shall be positioned approximately 7 centimeters (2.75 inches) in front of the objective lens of the telescope.

4.4.2 Position the illuminated refractive power target so that the center of the target coincides with the intersection of the cross hairs.

4.4.3 Align the sample holder perpendicular to the optical axis of the telescope using the auto-collimator (4.2). Recheck the alignment after testing has been completed.

4.4.4 Use the staticmaster brush to remove any dust from the telescope lenses and from each specimen prior to placing it in the holder.

4.5 Testing

4.5.1 All data shall be recorded on a data sheet identical with that shown in Figure 2.

4.5.2 A Control Number shall be assigned to the specific specimens to be tested in order to identify the manufacturer, model, and shipment. The Control Number shall be entered on the data sheet.

4.5.3 Each sample shall be inspected for Visible Defects by holding it at arms length and observing a straight-edged surface 6 to 8 feet away. A lens shall have a visible defect if a localized defect, or slight or severe distortion of the straight-edged surface is noted. Mark the position of any localized defects on the lens except those that are within 13 millimeters (0.5 inch) of the samples edge. Note the presence of visible defects by a checkmark in the appropriate column of the data sheet.

4.5.4 Samples without localized defects will be tested by looking through their centers. Samples with localized defects will be tested by looking through the defect. In the latter case the sample should be marked to indicate how it was positioned. Whenever a lens fails or gives inconclusive results, its exact position in the sample holder should be marked. This same position will be used for any remaining tests.

4.5.5 A Refractive Power Survey shall be conducted to identify those specimens whose spherical and cylindrical powers are significantly less than the 1/16 diopter allowable maximum. A lens having a refractive power 3/5 of 1/16 diopter is considered passing (P), or inconclusive (I) if the refractive power is 3/5 of 1/16 diopter or if the pattern cannot be resolved.

4.5.5.1 Place the specimen in the holder and attempt to locate an axis of cylinder. An axis of cylinder is observed when all spokes of the refractive power target will not focus simultaneously for a single setting of the telescope dial. The axis of cylinder is represented by two groups of spokes, 180° apart, that come into focus first when turning the telescope dial from an out-of-focus position to an in-focus position. If an axis of cylinder is observed, proceed to 4.5.5.2. If an axis of cylinder is not observed, proceed to 4.5.5.3.

4.5.5.2 If an axis of cylinder is observed, determine the two positions of the telescope dial for which the spokes of the refractive power target along the axis and perpendicular to the axis are the clearest. If the two readings are between +6 and -6 inclusive, record (P for spherical power on the data sheet. If either of the readings is >+6 or <-6, record (I) for spherical power. If the difference between the two readings is ≤ 6 increments record (P) for cylindrical power on the data sheet. If the difference is >6 increments, record (I) for cylindrical power.

4.5.5.3 If an axis of cylinder was not observed, determine the single setting of the telescope dial for which the spokes of the refractive power target are clearest. If this reading is between +6 and -6 inclusive, record (P) for the spherical power. If the reading is +6 or -6 record (I) for spherical power. Record (P) for cylindrical power.

4.5.5.4 If a sample received P's for both parts of the refractive power survey, testing is completed. However, if either part of the survey was found to be inconclusive, the complete Refractive Power Test will be performed immediately, before the sample is removed.

4.5.6 A Refractive Power Test shall be conducted on all samples rated (I) in the Refractive Power Survey.

4.5.6.1 If an axis of cylinder was observed, locate the axis by focusing the telescope on the refractive power target spokes and rotate the draw tube until one of the cross hairs is parallel to the axis

4.5.6.2 Eliminate parallax along the axis of cylinder and record the telescope setting as $R_{\parallel}$.

4.5.6.3 Focus the telescope until the spokes of the refractive power target perpendicular to the axis are in focus. Eliminate parallax perpendicular to the axis and record the telescope setting as $R_{\perp}$.

4.5.6.4 If an axis of cylinder was not observed, set the telescope cross hairs in a vertical-horizontal position by rotating the draw tube.

4.5.6.5 Eliminate parallax between horizontal cross hair and the spokes of the refractive telescope setting as $R_{\perp}$.

4.5.6.6 Eliminate parallax between the vertical cross hair and the spokes of the refractive power target. Record the telescope setting as $R_{\parallel}$.

4.5.6.7 With the test specimen removed from the holder, focus the telescope on the refractive power target. Record the telescope setting as R_0.

5. REPORTING

5.1 Spherical power

5.1.2 Spherical power (S) is computed as:

$$S = (R_{\parallel}-R_0) \text{ or } (R_{\perp}-R_0)$$

whichever has the largest absolute value.

5.1.2 S must be not exceed 9.0 for the specimen to pass.

5.2 Cylindrical power

5.2.1 Cylindrical power (C) is computed as:

$$C = |R_{\perp} - R_{\parallel}|$$

5.2.2 C must not exceed 9.0 for the specimen to pass. If the pass/fail level of 9.0 is exceeded, the lens shall be retested by two additional technicians and the average of all three results shall be used in determining the acceptability of the test lens.

5.3 Indicate the number of passing and failing samples at the bottom of the data sheet. The passing or failing of samples for which $R_{\perp}$ and $R_{\parallel}$ were recorded shall be determined solely by the values of S and C.

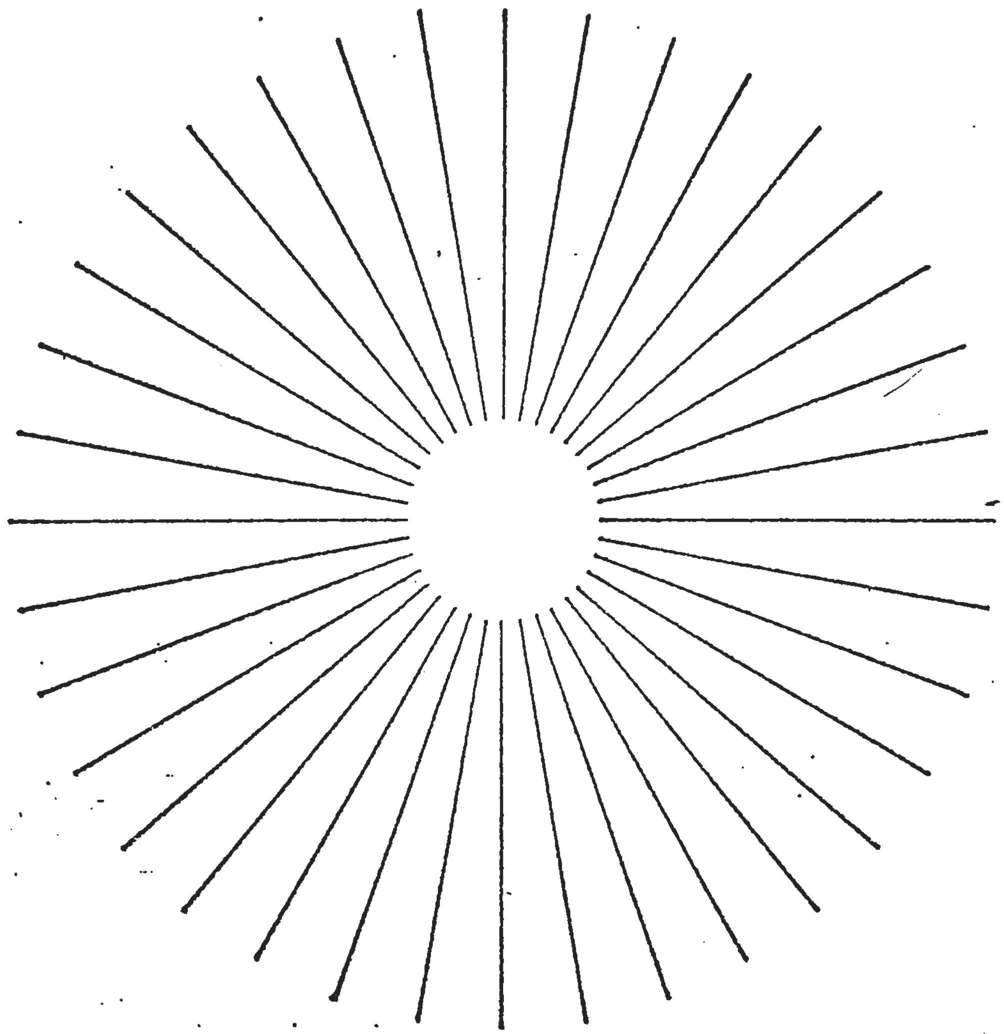
Notes:

1) In situtations where such distances cannot be practically achieved this distance can be reduced.

2) Parallax results when the cross hairs do not lie in the same plane as the image formed by the objective lens. It can be deteceted by moving the viewing eye up and down or from side to side. Should parallax exist the cross hairs will be observed to move relative to the image. If the cross hairs appear to move in the same direction as the eye the image is located behind the cross hairs and the telescope must be focused in the negative direction. When the cross hairs appear to move in a direction opposite to that of the eye the image lies in front of the cross hairs and the telescope should be focused in the positive direction.

The eyepiece should always be adjusted for the best definition of the cross hairs.

REFRACTIVE POWER TARGET



Target is shown oversize: Actual outer diameter is 80mm.

FLEXIBLE FITTING GOGGLES

OPTICAL POWER TESTS

CONTROL NO. ____________ OPERATOR ____________ DATE ____________

SPEC-	VISIBLE DEFECTS			REFRACTIVE		REFRACTIVE POWER TEST				
IMEN	LOCAL-	DISTORTION		POWER SURVEY		(IF REQUIRED)				
NO.	IZED	SLIGHT	SEVERE	SPHERE	CYL.	R_0	R_{II}	$R_{\perp}$	S	C

REFRACTIVE POWER: SPHERICAL P F

CYLINDRICAL P F

REMARKS:

SAFETY-TOE FOOTWEAR COMPRESSION TEST PROCEDURE USING FEELER GAUGE

1. SCOPE

1.1 This method is designed for use in determining the force required to compress the toe box of safety-toe footwear to a predetermined height as measured by a feeler gauge.

2. TEST SPECIMENS

2.1 The test specimens are safety-toe footwear corresponding to Class 75, Class 50, or Class 30 of ANSI z41.2-1967 (R 1972).

3. APPARATUS

3.1 Compression test machine with 5440 kilogram (12000 pounds) capacity load cell. (Tinius-Olsen or equivalent).

3.2 Compression platen, 10.16 centimeters (4.0 inches) diameter.

3.3 12.7 millimeter (0.5 inch) diameter gauge rod, three inches in length and having rounded ends with 6.36 millimeter (0.25 inch) radius. (Figure 2, ANSI z41.1)

3.4 Compression block

3.5 Band saw or linoleum knife

3.6 Safety glasses or face shield

4. PROCEDURE

4.1 Calibrations

4.1.1 The test machine and load cell shall be calibrated annually for conformance to ASTM E4-72. (American Society for Testing and Materials Standard Method for Verification of Testing Machines, ASTM E4-72, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

4.1.2 The gauge rod should be annually checked for conformance to the requirements of ANSI z41.1-1967 (R 1972). (American National Standard for Men's Safety Toe Footwear, ANSI z41.1-1967 (R1972), American National Standards Institute, 1430 Broadway, New York, NY 10018.)

4.2 Glossary of testing terms

4.2.1 Insole - A sole of leather or other material to which the upper and outsole are attached.

4.2.2 Lining - A term used to describe all the various lining parts used for the inside of the upper of the shoe.

4.2.3 Outsole - The bottom sole of the shoe which has its outer surface exposed to wear.

4.2.4 Toe-box - A rigid stiffener material designed to provide protection for the wearer as required by the z41.2 standard.

4.2.5 Upper - All of the upper parts of a shoe including the before use. Recoat after testing is completed.) While the load is being applied, firmly pull the gauge rod back and forth using thumb and forefinger making sure the motion is along the longitudinal axis of the toe box. Stop the compression when the gauge rod can no longer be moved along the longitudinal axis with firm finger pressure. Read the applied force and record it on the data sheet.

4.5.5 Remove the specimen and repeat 4.5.2 through 4.5.4 for additional specimens. (NOTE: If a failure of the footwear model being tested occurs, immediately stop the testing and contact the designated person in charge of testing after securing the specimen shoes in the storage room.)

4.5.6 Upon completion of testing, follow the guidelines as specified in section 4.3.1 on proper handling of shoes.

5. REPORTING

5.1 Minimum compresive strength

5.1.1 A Class 75 shoe must have an average minimum compression strength of 1134.0 kilograms (2500 pounds); a Class 50 shoe, 783.8 kilograms (1750 pounds); a class 30 shoe 453.6 kilograms (1000 pounds) to satisfy the performance requirements.

5.2 Data reduction

5.2.1 Compliance will be determined by the use of the Student t test (one-sided) at 0.05 level of significance. Ten specimens shall be tested.

outside and lining of the shoe.

4.2.6 Vamp - The complete lower part of a shoe upper which is attached to the sole or welting.

4.2.7 Welting - A strip of leather stitched into the seam between the sole and upper of the shoe.

4.3 storage of specimens

4.3.1 All specimens shall be stored in a locked storage room. Never leave shoes in the testing room when testing is not in progress or when a long period of time will elapse before testing will be continued; i.e., overnight or during a breakdown in testing. Remove the shoes from the testing room and return them to the storage room if circumstances call for delayed testing or if testing is completed.

4.3.2 All shoe tests will be performed in the testing room.

4.4 Specimen preparation

4.4.1 The material forming the vamp and upper shall be cut away as shown in Figure 2 to facilitate placement of the feeler gauge. At least 2.5 centimeters +0.3 centimenter (1 inch +1/8 inch) of vamp and lining material shall be retained behind the top edge of the toe box as shown in Figure 1.

4.4.2 Mark the specimen with any marking device available (silver ink or pencil lead ususally produces satisfactory results).

4.4.3 Cut the marked specimen with the band saw or a knife, being careful not to cut the insole. NOTE: A face shield or safety spectacles must be worn while the band saw is in use.

4.4.4 Record all preliminary information on data sheet. (See Figure 2, Sample Data Sheet).

4.5 Testing

4.5.1 The test shall be performed by two operators, one operating the test machine, and the second handling the gauge rod.

4.5.2 The toe portion of the specimen shall be positioned on the compression block of the test machine so that the highest point of the toe-box is on the loading axis of the machine.

4.5.3 The test load shall be applied at a rate of approximately 22.7 kilograms per second (50 pounds per second) after contact has been made. Use the 1360 kilogram (3000 pound) range for Class 30 and 50 and the 5440 kilogram (12,000 pound) range for Class 75.

4.5.4 At the start of load application, insert the 112.7 millimeter (0.5 inch) gauge rod completely into the center of the box. (NOTE: Remove all oil or rust preventive from the gauge rod

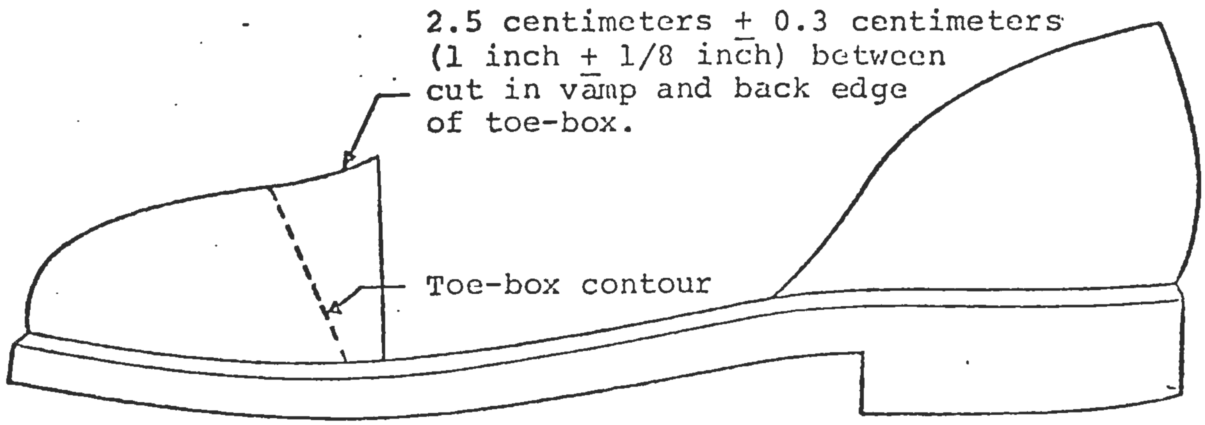


Figure 1: Footwear prepared for compression testing.

COMPRESSIVE STRENGTH
SAFETY TOE FOOTWEAR

Date
Manufacturer
Style
Class

Serial Number		Compressive Strength (pounds)
1	Right	
	Left	
2	Right	
	Left	
3	Right	
	Left	
4	Right	
	Left	
5	Right	
	Left	

Mean $(\overline{X})$ =

Standard Deviation (S) =

Figure 2 Data Sheet

Method
Date

DETERMINATION OF TOE BOX DEFLECTION UNDER FIXED LOAD FOR SAFETY-TOE FOOTWEAR

1. SCOPE

1.1 This method is designed to provide a measure of the toe box deflection of safety-toe footwear under a fixed load.

2. TEST SPECIMENS

2.1 The test specimens are safety-toe footwear corresponding to Class 75, Class 50, or Class 30 of ANSI z41.1-1967 (R 1972).

3. APPARATUS

3.1 Compression test machine with 5440 kilogram (12000 pounds) capacity load cell. (Tinius-Olsen or equivalent).

3.2 Compression platens having a marked center position, and a minimum of 76 millimeters (3 inches) in diameter.

3.3 Band saw or linoleum knife

3.4 Safety glasses or face shield

3.5 Sculptor's modeling clay (Plasticene or equivalent)

3.6 Metal plate 30.5 x 30.5 x 0.3 centimeters (12 x 12 x 0.125 inches)

3.7 Sharp knife or thin wire cheese cutter

3.8 Dial micrometer, as described in ASTM D1777, having a presser foot (spindle) and anvil diameter of 0.25 inches, both rounded to a 0.125 inch radius. The applied load should be such to produce a contact pressure of 0.6 psi.

4. PROCEDURE

4.1 Calibrations

4.1.1 The test machine and load cell shall be calibrated annually for conformance to ASTM E4-72. (American Society for Testing and Materials Standard Method for Verification of Testing Machines, ASTM E4-72, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

4.1.2 The micrometer shall be calibrated prior to each test series against a 19 millimeter (0.75 inch) gauge block.

4.2 Glossary of testing terms

4.2.1 Insole - A sole of leather or other material to which the upper and outsole are attached.

4.2.2 Lining - A term used to describe all the various lining parts used for the inside of the upper of the shoe.

4.2.3 Outsole - The bottom sole of the shoe which has its outer surface exposed to wear.

4.2.4 Toe-box - A rigid stiffener material designed to provide protection for the wearer as required by the z41.2 standard.

4.2.5 Upper - All of the upper parts of a shoe including the outside and lining of the shoe.

4.2.6 Vamp - The complete lower part of a shoe upper which is attached to the sole or welting.

4.2.7 Welting - A strip of leather stitched into the seam between the sole and upper of the shoe.

4.3 Storage of specimens

4.3.1 All specimens shall be stored in a locked storage room. Never leave shoes in the testing room when testing is not in progress or when a long period of time will elapse before testing will be continued; i.e., overnight or during a breakdown in testing. Remove the shoes from the testing room and return them to the storage room if circumstances call for delayed testing or if testing is completed.

4.3.2 All shoe tests will be performed in the testing room.

4.4 Specimen preparation

4.4.1 The material forming the vamp and upper shall be cut away as shown in Figure 1. At least 2.5 centimeters ±0.3 centimeter (1 inch +1/8 inch) of vamp and lining material shall be retained behind the top edge of the toe box as shown in Figure 1.

4.4.2 Mark the specimen with any marking device available (silver ink or pencil lead usually produces satisfactory results).

4.4.3 Cut the marked specimen with the band saw or a knife, being careful not to cut the insole. NOTE: A face shield or safety spectacles must be worn while the band saw is in use.

4.4.4 Record all preliminary information on data sheets.

4.5 Preparation of clay cylinders

4.5.1 Prepare a rough cylinder of modeling clay approximately 38 millimeters (1.5 inches) in diameter and 10 centimeters (4 inches) in length by rolling the clay by hand on a metal plate. Trim off rough ends of the cylinder using a sharp knife or thin wire cheese cutter.

4.5.2 Further reduce the diameter of the cylinder to approximately 2.5 centimeters (1 inch) diameter by rolling it by hand on the metal plate.

4.5.3 Using a sharp knife or thin wire cheese cutter, cut several cylinders 3.0 centimeters (1-3/16 inch) in length from the long cylinder.

4.5.4 Prepare ten such cylinders and set aside for use.

4.6 Testing

4.6.1 Position one of the clay cylinders vertically under the approximate center of the toe box and in contact with the back edge of the toe box. A light squeeze on the walls of the cylinder will usually deform it sufficiently to make contact.

4.6.2 Place the test specimen with the clay cylinder between the compression platens in such a position that the highest point on the toe box is on the loading axis of the test machine.

4.6.3 Apply the test load at 22.7 kilograms (50 pounds) per second after initial contact between the specimen and the loading platens. Test loads are: Class 75, 11120 Newtons (2500 pounds); Class 50, 7784 Newtons (1750 pounds); Class 30, 4448 Newtons (1000 pounds).

4.6.4 After the test load is reached, return the load to zero, remove the clay cylinder, measure its thickness at its lowest point to the nearest 0.5 millimeter (0.019 inch), and record the measurement.

4.6.5 Repeat steps 4.6.1 to 4.6.4 inclusive for additional specimens until ten specimens have been tested. (NOTE: If a failure of the footwear model being tested occurs, immediately stop the testing and contact the designated person in charge of testing after securing the specimen shoes in the storage room.)

4.6.6 Upon completion of testing, follow the guidelines as specified in section 4.3.1 on proper handling of shoes.

5. REPORTING

5.1 Calculate the mean value of compressed height, $\bar{h}$, for the ten specimens.

$$\bar{h} = \sum h/10$$

5.2 Calculate the standard deviation of the mean, $S(\bar{h})$, as:

$$S(\bar{h}) = \sqrt{\frac{10\sum h^2 - (\sum h)^2}{90}}$$

5.3 Calculate (M), the low side of the 95% confidence interval of the mean as

$$M = \bar{h} - (2.26)S(\bar{h})$$

5.4 The sample is considered to pass if (M), the low side of the 95% confidence interval of the mean, exceeds the Pass/Fail level of 12.5 millimeters (0.5 inch).

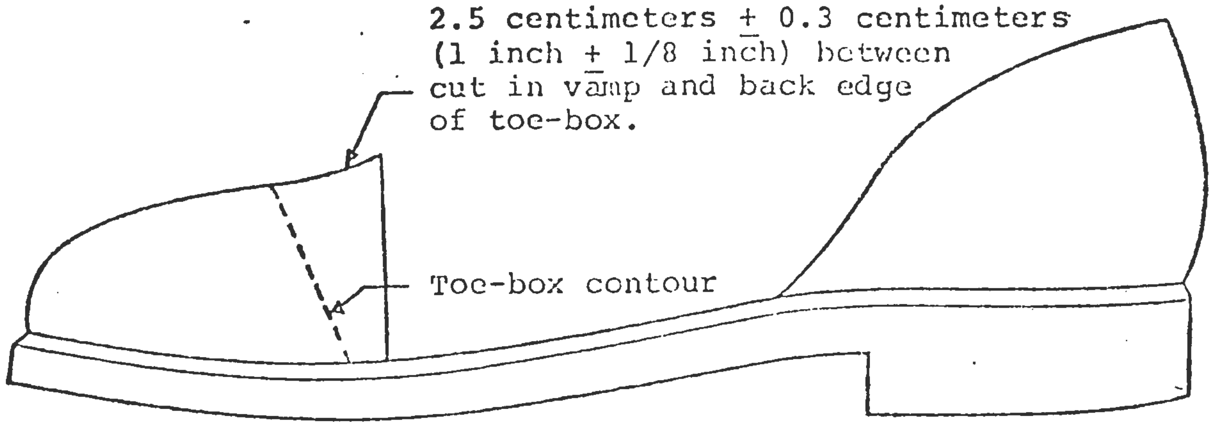


Figure 1: Footwear prepared for compression testing.

DATA SHEET

TOE BOX DEFLECTION UNDER FIXED LOAD

SPECIMEN NO.	COMPRESSION HEIGHT (IN) L	R
1		
2		
3		
4		
5		

$\bar{h}$ __________

$S(\bar{h})$ __________

M __________

Method
Date

BALLISTIC IMPACT TEST FOR FULL FACEPIECE RESPIRATORS

1. SCOPE

1.1 This test is designed to determine the relative resistance to penetration by ballistic particles of the facepiece portion of full facepiece respirators.

1.2 Projectiles of standard mass having a standard penetration point are fired at the facepiece under test by means of an air gun, the projectile velocity is measured, and firing continues until the mean penetration velocity is ascertained.

2. TEST SPECIMENS

2.1 The test specimens are facepieces for full facepiece respirators.

2.2 The specimens are mounted in the head piece in which they normally are used and the head piece is fitted on a standard head form in an as-worn position.

3. APPARATUS

3.1 Ballistic impact test apparatus as described in Appendix "B" of FRC report F-C5061, "Personal Protective Equipment Test Development and Validation", NIOSH Contract No. 210-78-0073.

3.2 Fifty projectiles as shown in Figure 1, having an individual mass of 1.6 ± .032 grams.

3.3 Alderson 50th percentile male headform.

4. PROCEDURE

4.1 Set Up.

4.1.1 Set up the test apparatus as described in paragraph 3.1.

4.1.2 Attach the helium tank to the regulator valve and hose.

4.1.3 Attach the hose to the inlet of the charging valve on the control panel.

4.1.4 Close the relief valve on the control console.

4.1.5 With the charging valve closed, open the helium tank valve.

4.1.6 Crack the charging valve, charge the system to 150 psig, and close the charging valve.
NOTE: Air gun bolt must be closed.

4.1.7 With the system charged to 150 psig, observe the pressure gauge for any drop in pressure. A drop in pressure signifies a leak in the system. If a leak is observed, check the system and correct the leak.

4.1.8 Depressurize the system by opening the relief valve on the control panel followed by firing the air gun.

CAUTION: Under no circumstances may the air gun be fired when the pressure gauge indicates pressure.

4.1.9 Turn on photodetector lights and the chronograph.

4.2 Charging and Firing Procedure

4.2.1 Complete the set up procedures in paragraph 4.1

4.2.2 Crack the charging valve until the pressure gauge registers the desired pressure, then close the charging valve.

NOTE: If the pressure overshoots the desired setting after closing the charging valve, relieve pressure with the pressure relief valve followed by firing the air gun. The charging process is then repeated.

4.2.3 With the system charged to the desired pressure, load the projectile into the air gun and close the bolt.

4.2.4 Vent the charging system by opening the relief valve.

4.2.5 Fire the air gun.

4.3 Test Procedure

4.3.1 Mount the facepiece to be tested in its proper head piece.

4.3.2 Mount the head piece on the standard headform in an as-worn position.

4.3.3 Position the headform inside the safety chamber with the test point in line with the air gun muzzle and with the surface perpendicular to the muzzle center line in both the vertical and horizontal planes. Close the door of the safety chamber.

4.3.4 Turn on the chronograph and the photodetector lights.

4.3.4 If required, set the chronograph to zero.

4.3.5 Charge and fire the system following the procedure of paragraph 4.2

4.3.6 Immediately after firing record the velocity shown on the chronograph readout in the appropriate place on the data sheet (See Sample Date Sheet - Figure 2).

4.4 Velocity Levels

4.4.1 Each facepiece may be impacted at 10 different positions.

4.4.2 The first impact position shall be impacted using a charge pressure of 100 psig. This corresponds to a velocity of approximately 41 meters/second. The actual velocity is shown on the chronograph readout.

NOTE: The velocity shown on the chronograph is the average velocity over the last 30 centimeters of travel of the projectile and is not the true impact velocity.

4.4.3 Depending upon the result

of the first test, the second test point will be tested at a higher or lower velocity level. If penetration was achieved, the second test will be made at a charge pressure of 75 psig. If penetration was not achieved the second test will be made at a charge pressure of 125 psig.

4.4.4 Continue firing at sequential test points using the pressure levels dictated by whether the test shot penetrates the facepiece until all 10 points have been tested (See sample on Sample Data Sheet - Figure 2).

4.4.5 A total of 5 facepieces shall be tested.

5. REPORTING

5.1 For a given facepiece, examine the velocity record to find the first velocity at which penetration occurred (In the example of Figure 2, this occurs at test number 4). Calculate the mean velocity using the test velocity just prior to the first penetration and all subsequent test velocities. (In the example, the average velocity is calculated using tests 3 through 10).

5.2 Calculate the mean velocity for all five facepieces ($\overline{V}$)

$$\overline{V} = \frac{\Sigma V}{n}$$

where n is the number of included data points as outlined in 5.1.

5.3 Calculate the standard deviation (S) of the mean velocity

$$S = \sqrt{\frac{n \Sigma V^2 - (\Sigma V)^2}{n(n-1)}}$$

where n is the number of included data points.

5.4 Calculate (M), the low side of the 95% confidence interval of the mean as:

$$M = \overline{V} - (2.26)S$$

5.5 The sample is considered to pass if (M) exceeds the Pass/Fail level.

Fiqure 2. Sample Data Sheet

BALLISTIC IMPACT TEST

Manufacturer:

Cat No. or S.N:

Material:

				Facepiece No. 2			3			4			5		
Test No.	PSI	Vel. M/S	G/NG	PSI	Vel. M/S	G/NG	PSI	Vel. M/S	G/NG	PSI	Vel. M/S	G/NG	PSI	Vel. M/S	G/NG
1	100	32 0	NG												
2	125	45.0	NG												
3	150	56.4	NG												
4	175	62.1	G												
5	150	57 5	NG												
6	175	63.1	G												
7	150	57.2	NG												
8	175	63.1	G												
9	150	56.9	NG												
10	75	64.5	G												

Points Included n = 8 3-10

$\overline{V}$ = 60.1 M/S

Low 56.4 M/S

High 64.5 M/S

S = 3.39

M = 52.44 M/S

Appendix A

Method
Test

DETERMINATION OF FLAMMABILITY OF
HEAD-MOUNTED PERSONAL PROTECTIVE EQUIPMENT

1. SCOPE

1.1 This method is designed to determine the flammability resistance of a wide range of head-mounted personal protective equipment.

2. TEST SPECIMENS

2.1 Test specimens shall consist of complete unmodified head-mounted personal protective devices.

3. APPARATUS

3.1 Bunsen burner, 13 ± 2 millimeters in diameters.

3.2 Spark lighter, or equivalent.

3.3 Wooden headform with facial features sized to the configuration of an Aero Medical Laboratory head circumference headform.

3.4 Elevation stand constructed of non-flammable material. The platform of the stand shall be 25.4 centimeters (10 inches) by 15.24 centimeters (6 inches) and shall be of sufficient height to allow the lowest point of the head-mounted protection equipment to clear the bench top by a minimum of 15.24 centimeters (6 inches).

3.5 A flame gauge with the general configuration of a three pronged fork with non-flammable prongs and a handle approximately 8 inches long. The outer prongs of the flame gauge shall be 50 mm apart to measure the outer cone ofthe flame. The center prong to outer prong distance shall be 25 millimeters to measure the inner cone of the flame.

3.6 A tape recorder with the prerecorded testing sequence described in section 4.3.1.

3.7 A ruler marked in inches with the smallest increment being at least as small as one-thirty-second of an inch.

3.8 A felt tip pen to mark specimen test points.

3.9 A laboratory fume hood.

4. PROCEDURE

4.1
Preparation of specimen.

4.1.1 Label or mark each specimen with a number for documentation.

4.1.2 Indicate the test points (points of flame application) on each test specimen using a marking pen. The same test points are to be indicated on each specimen.

Choose a minimum of 7 test points and no more than 10 test points. Test points shall be a minimum of two inches apart. The points chosen as test points will vary depending on the kind of device under test, but the points chosen should be those which by geometry (corners, edges) and material (vulcanized fiber, plastic) seem most likely to be ignited in the shortest time.

4.1.3 Each specimen shall have the mounting (head band, strap) adjusted to fit the headform.

4.2
Positioning and adjustment of test apparatus.

4.2.1 The device to be tested should be placed on the headform in an "as worn" position.

4.2.2 The headform should be placed on the elevation stand and the test point should face the operator.

4.2.3 The bunsen burner should be adjusted to achieve a 50 mm ± 3 mm long blue flame with an inner cone of 25 mm ± 2 mm length. The flame lengths shall be judged using the flame gauge (see 3.5). When using the flame gauge, be sure the gauge does not disturb the pattern of the flame. This is best accomplished by holding the gauge with the points slightly outside the flame. Adjustment of the flame is aided by carrying out the adjustment in a dim light.

4.2.4 Set the controls on the hood to the appropriate positions for eliminating drafts prior to testing each test point.

4.3 General Testing

4.3.1 This test is designed for multiple exposures of a test point to the test flame. The time during which the flame contacts the test point is increased on each exposure by one second, starting with a one second exposure. Thus, a given test point is exposed for one second on the first exposure, for two seconds on the second, for three on the third, and so on until the test point ignites and burns. The test point is considered to be ignited and burning if it continues to burn for five seconds after the flame has been withdrawn. If, after the five seconds, the point is not ignited and burning, an additional five seconds is allowed before the next exposure to the test flame.

4.3.2 In order to keep the time sequence of flame application, five second observation of burning/not burning, and five second rest interval in proper sequence, a recorded sequence of commands keyed to tone signals is employed. The commands are:

START (tone) - (At the tone signal apply the flame to the test point).

STOP (tone) - (At the tone signal remove the flame from the test point).

OBSERVE (tone) - (At the tone

signal observe whether the test point is burning).

The full sequence together with times is shown in Table 1. This table should be used when making the command recording and shows the time in seconds at which the various commands and tones are given, beginning with the START command and tone for the first flame exposure at time zero.

4.4 Testing

4.4.1 All selected test points shall be tested on the first sample.

4.4.2 With the device in place on the headform and with the proper burner adjustment, start the command recording.

4.4.3 At the sound of the tone following the START command apply the tip of the cone of the inner burner flame to the first test point. (NOTE: The test flame shall be applied to the test point with the burner held at an angle of 45 degree from the test surface, with the flame upward. Should melting of the sample occur, keep the flame applied to the upper portion or edge of the melted area.)

4.4.4 At the sound of the tone following the STOP command, remove the flame from the test point.

4.4.5 At the sound of the tone following the OBSERVE command, determine if the test point is burning. (NOTE: The OBSERVE command is followed by a number. The number is the Exposure number and is the same as the time in seconds during which the flame was applied.)

4.4.6 If the test point is burning, record the Exposure Number on the data sheet under the appropriate test point number, stop the recorder, rewind the tape, and go on to the next test point. If the test point is not observed to be burning, continue to follow the recorded commands until at some OBSERVE command the point is observed to be burning. Record the Exposure Number (the number following the OBSERVE command), stop the recorder, rewind the tape, and go on to the next test point. (NOTE: The longest time of flame application is 30 seconds. If a point has not ignited at that time, stop the test and proceed to the next test point.)

4.4.7 Continue testing the test points in sequence until all points on the first sample have been completed.

4.48 Based on the results from the first sample, the operator will select the four points having the shortest ignition times. These points only will be tested in the second and third samples.

4.4.9 Based on the ignition times for the second and third samples, a single point having the shortest ignition time will be chosen by the operator for test in the fourth and subsequent samples in the test.

5. REPORTING

5.1 The data to be recorded shall consist of a test point location diagram showing the location and number of each test point selected. The ignition times shall be recorded for each point tested in the appropriate column of the data sheet. A sample data sheet is shown in Figure 1.

5.2 Rating the Model. The time at which a test point burns will determine an individual "ignition time". To determine a rating for the model being tested, the testing sequence is repeated until * ignition times are generated. The final rating for the model will be the average of the * ignition times.

* The number of "ignition times" required for rating a particular device will be based on the typical standard deviation for similar devices.

Table 1. Command Sequence Times (Seconds)

Exposure No. (Exposure Time)	Start	Stop	OBSERVE (Exposure No.)
1	0	1	6
2	11	13	18
3	23	26	31
4	36	40	45
5	50	55	60
6	65	71	76
7	81	88	93
8	98	106	111
9	116	125	130
10	135	145	150
11	160	171	176
12	181	193	198
13	203	216	221
14	226	240	245
15	250	265	270
16	275	291	296
17	301	318	323
18	328	346	351
19	356	375	380
20	385	405	410
21	415	436	441
22	446	468	473
23	478	501	506

Table 1 - Continued

Exposure No. (Exposure Time)	START	STOP	OBSERVE (Exposure No.)
24	511	535	540
25	545	570	575
26	580	606	611
27	616	643	648
28	653	681	686
29	691	720	725
30	730	760	765

DATA SHEET

FLAMMABILITY TEST

Device:

Manufacturer:

Lot Number/Serial Number:

Test Data:

Test Technician:

TEST POINT NUMBER

Sample No.	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Test point location diagram:

Figure 1

APPENDIX B

TEST DEVICE FOR DETERMINING THE BALLISTIC IMPACT RESISTANCE OF FACEPIECES FOR FULL FACEPIECE RESPIRATORS

1. General Description

The test device consists of a modified standard Crossman Model 2200 pump operated air rifle. The pump action was eliminated and provision was made for operation from a helium gas pressure source. The selection of helium as the propellant gas was made to take advantage of the low viscosity of helium which allows more rapid flow of the propellant gas and, hence, a larger impulse can be given to the projectile. A barrel extension consisting of a second barrel, modified to attach to that of the air rifle, allows measurement of the average velocity of the projectile over the last 30 centimeters of the barrel extension. This is accomplished by use of a chronograph (Oehler Model 33) using photodetectors which view the passage of the projectile by appropriately placed holes in the barrel extension. The velocity of the projectile is displayed on an electronic read-out. The projectile then impacts the target.

2. Air Gun System

The standard Crossman Model 2200 was modified in the following manner:

2.1 Gas Chamber Modification

The gas chamber on the standard air rifle is a small cylinder with a valve on each end. (Valve assembly, Manufacturer's Part No. 2200A021). In normal operation, air from the air pump enters the chamber through a check valve. The compressed air is allowed to exit from the chamber into the breech of the air rifle by means of a valve which is opened by the firing mechanism. The air pressure in the breech acts on the base of the projectile and accelerates the projectile along the barrel. In order to obtain high velocities of the projectile but still not exceed the design pressure of the air rifle, it is necessary to furnish a larger volume of pressurized gas. In this way, peak gas pressures remain higher during the projectile acceleration period. An increase in the gas chamber volume is obtained by disassembly of the original chamber by unscrewing the cylinder and replacing it with a cylinder of longer volume. The cylinder from the original chamber contains the inlet check valve from the air pump. The new, longer cylinder is threaded to take a standard check valve which is the final part of the gas charging system. The original gas chamber extension is shown in Drawing No. 1. This chamber was found to have too great a volume and the Volume Reducing Plug shown in the Insert in Drawing No. 1 was inserted in the chamber to reduce the volume. The firing valve spring inside the chamber requires an end support washer in the longer chamber. The washer is shown in Drawing No. 2.

2.2 Gas Chamber Support

The original gas chamber was supported against the impact of the hammer on firing by the end of the air pump piston. Since the air pump was eliminated, the support function is carried out by the chamber support which bears on the closed end of the longer chamber and on the rear of the forward rifle support. The support consists of a two section brass rod which can be adjusted to the correct length and then locked in position. This assembly is shown in Drawing No. 3.

2.3 Barrel Modification

A barrel extension was fitted to the original barrel in order that velocity measurements could be made while still having the impact target (facepiece) close to the muzzle in order to minimize free flight tumbling or other instability of the projectile.

The barrel extension is fabricated from a standard replacement barrel (Manufacturer's Part No. 2200B025). Approximately one inch is removed from the breech end of the extension and it is reamed through to an I.D. of 0.221 inch (No. 2 Reamer). Drawing No. 4 shows the modifications to the barrel muzzle and the extension breech required to join these pieces.

After the pieces are joined the No. 2 Reamer should again be run through the extension and perhaps 1/32 inch into the barrel to clean up the joint area. The muzzle end of the extension is then trimmed to yield an overall length of 39-5/16 inches. Two holes are drilled vertically through the barrel extension with of #25 drill. The front hole is located 4 inches from the muzzle end of the extension and holes are spaced 30.0 cm apart. These holes are for the velocity sensors. See Drawing No. 5.

2.4 Bolt Modification

The standard bolt (Manufacturer's Part No. 2200-015) is fitted with a nylon bolt face to ensure proper seating of the projectile in the barrel. The flat on the edge of the bolt face provides for clearance of the gas port and should face the gas port in a proper assembly. The bolt face is shown in Drawing No. 6.

3. Gas Charging System

The gas charging system is designed to allow precise charging of pressurized helium into the gas chamber. The system is shown schematically in Figure 1.

The helium supply is connected to the charging system through a regulator valve and pressure hose. The regulator valve is used to restrict changing system pressure to approximately 500 psig. Helium tank pressures are usually 2200 psig when the tank is fully charged. Charging is accomplished by means of a micrometer needle valve which, when opened slightly, allows pressurized gas to bleed into the gas chamber of the air rifle. Gas bleed is continued until the desired pressure is indicated on the pressure gauge. The check valve at the inlet to the air rifle gas chamber prevents loss of pressure once the chamber has been charged. The system relief valve serves a dual purpose of venting the charging system after the rifle gas chamber has been charged to the desired pressure and of preventing accidental overpressure in the system.

4. Velocity Measurement System

4.1 Projectile velocity is measured by means of an Oehler Model 33 chronograph using two photodetectors mounted on the top of the barrel extension shroud. Holes drilled 30 centimeters apart in the barrel extension allow the photodetectors to detect the passage of the projectile and the chronograph displays the average velocity in meters per second. Light for the photodetectors is provided by illuminators mounted on the bottom of the barrel extension shroud. The chronograph automatically displays the velocity whenever a projectile passes the detectors and need not be reset between shots. The number of the shot is also displayed with the velocity.

4.2 An additional feature of the chronograph is the ability to store data from a series of shots and present a data summary at the end of the series. By repeatedly pressing the "SUMMARY" button, the chronograph will display in sequence:

- a) Lowest velocity in the series
- b) Highest velocity in the series
- c) Average velocity in the series (mean)
- d) Extreme spread (range)
- e) Standard deviation of mean

Pressing the "FORGET" button allows any atypical velocity to be excluded from the summary.

4.3 If the second detector does not send a signal within 65 milliseconds of the first detector's signal, the chronograph will display "ERROR". In electrically noisy environments "ERROR" may be displayed spontaneously without firing of the air rifle. If the velocity displayed before the "ERROR" signal has not been copied the data may be lost. Velocity data may also be lost if a second shot is taken before the data from the previous shot has been recorded. Velocity data must be recorded immediately after each shot.

5. Mounting and Positioning System

The mounting and positioning system consists of the headform adapter, the fixed base, the pivoting base, and the headform spacer. The headform adapter is an angled wooden piece affixed to the bottom of the headform to tilt it forward from its normal position. This facilitates aligning the surface of the facepiece perpendicular to the projectile's flight path. Two holes in the bottom of the adapter accept the locating pins on the pivoting base and lock the headform in the correct test position. The pivoting base can be rotated in the horizontal plane to bring the desired segment in front of the gun muzzle. Because the pivot point is located at the center of curvature of the facepiece, the distance from the muzzle to the facepiece remains constant through the rotation. All items are supported on the fixed base which also forms the floor of the test enclosure.

In use, the headform with the respirator in place is mounted on the pivoting base. The respirator is then adjusted to ensure that the facepiece is parallel to the front of the enclosure in the vertical plane. There are four marks on the fixed base which when aligned with the edge of the pivoting base will position the facepiece for four impact points spaced approximately 7/8 inch apart. The spacer, which is inserted between the adapter and the pivoting base, raises the headform so that four additional impact points, 3/4 inch below the first set, are available.

6. Enclosure and Interlock System

The projectile flight path and the target are entirely enclosed to eliminate danger from either directly fired or ricocheting projectiles. A metal plate swings in front of the gun muzzle whenever the door of the test chamber is opened. This prevents a projectile from entering the chamber while the operator is installing or adjusting the headform.

7. Projectiles

The projectiles consist of a brass cylindrical body, nominally 0.2175 inches in diameter and 0.560 inches in length. A Singer No. 200/25 sewing machine needle is embedded in one end of the cylinder to a depth of approximately 0.157 inches with the point projecting 0.229 inches beyond the cylinder. The other end of the cylinder is drilled with a No. 7 drill to a depth of 0.320 inches. Drilling the base of the projectile improves stability and aids in forming a gas seal between the barrel and the projectile. The projectile design is shown in Drawing No. 7.

8. Assembly Photographs

Figures 2 and 3 shown front and rear views respectively of the overall Ballistic Impact Test Device.

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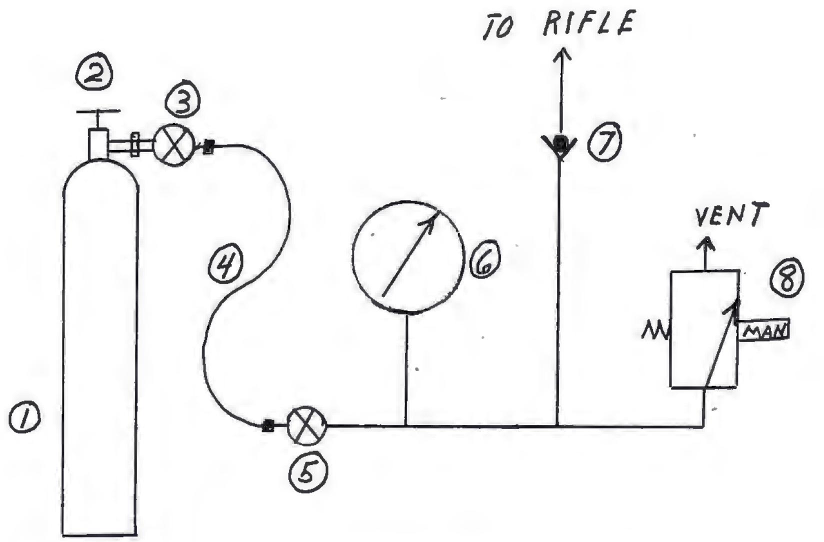
Project	Page

Title FIGURE 1 - CHARGING SYSTEM



1. HELIUM TANK
2. TANK VALVE
3. PRESSURE REGULATOR
4. HOSE
5. NEEDLE VALVE (CHARGING VALVE)
6. PRESSURE GAUGE
7. CHECK VALVE
8. RELIEF VALVE, MANUAL VENTING

FORM 207-10M-4-74-CP

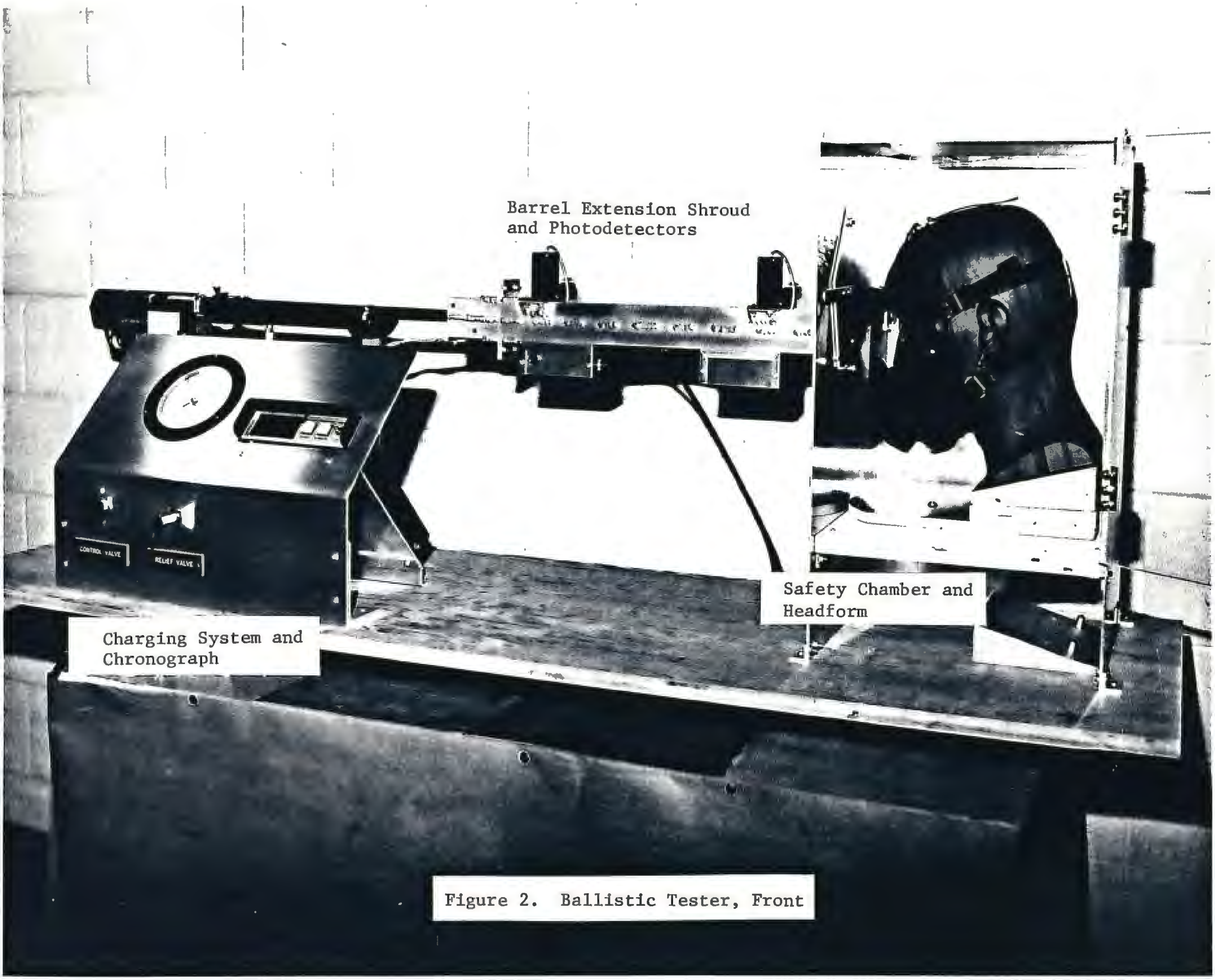


Figure 2. Ballistic Tester, Front

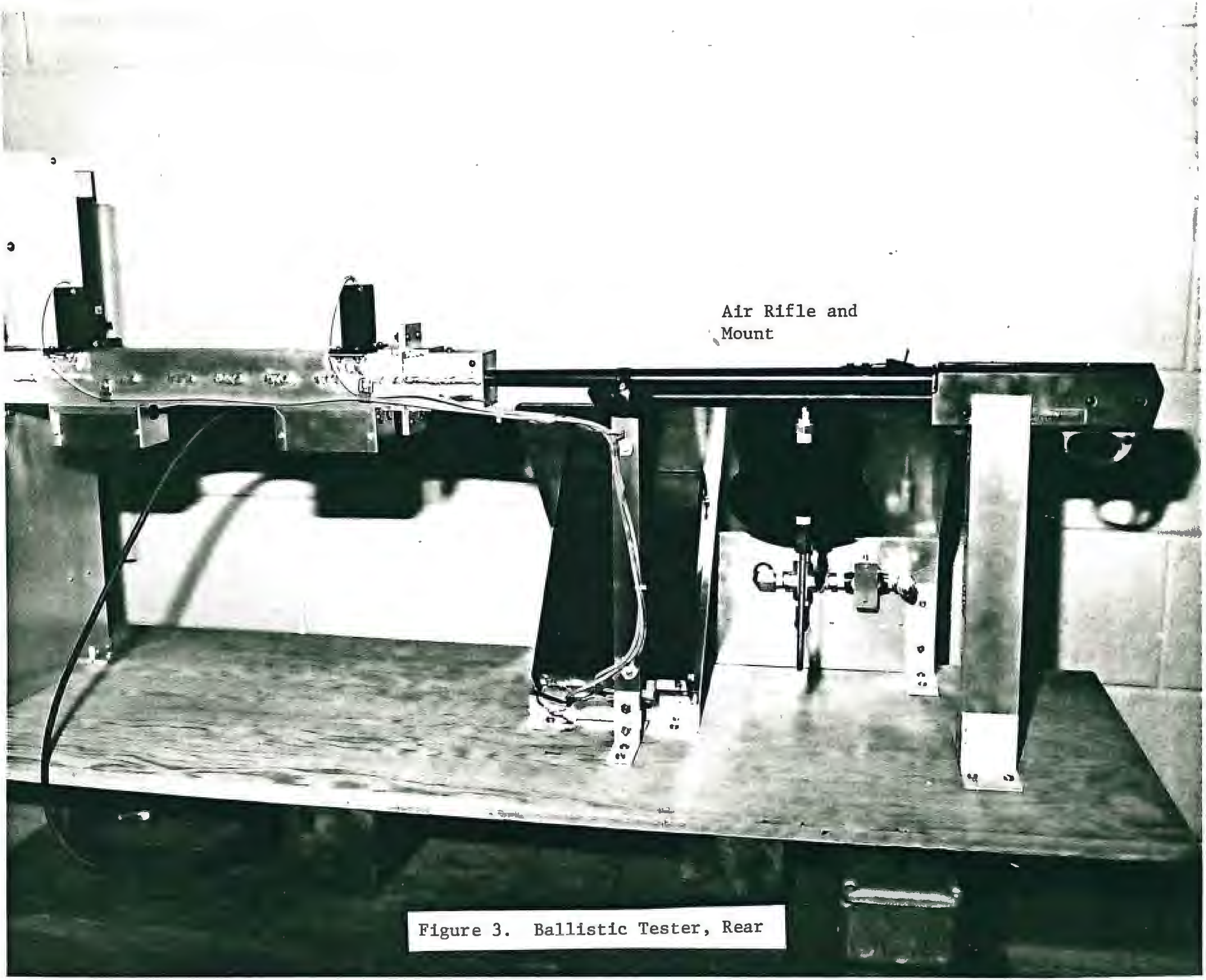
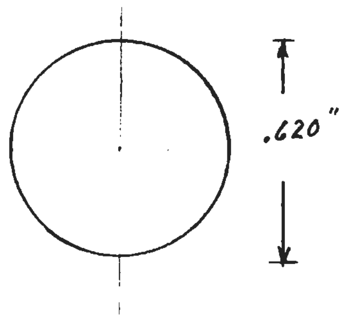
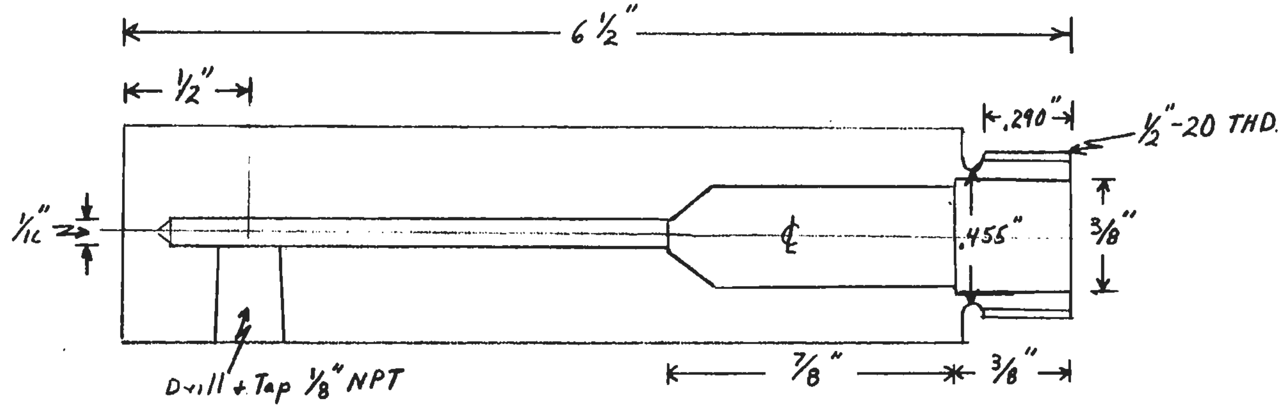
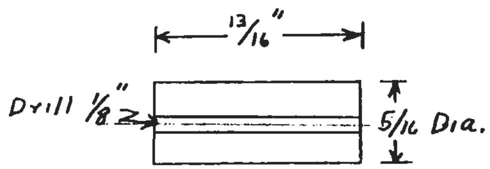


Figure 3. Ballistic Tester, Rear

ITEM	QUAN.	IDENT.	DESCRIPTION	DWG. NO. OR MAT.







INSERT

REV. NO.	DATE	DESCRIPTION	REV'D BY	CHK'D BY

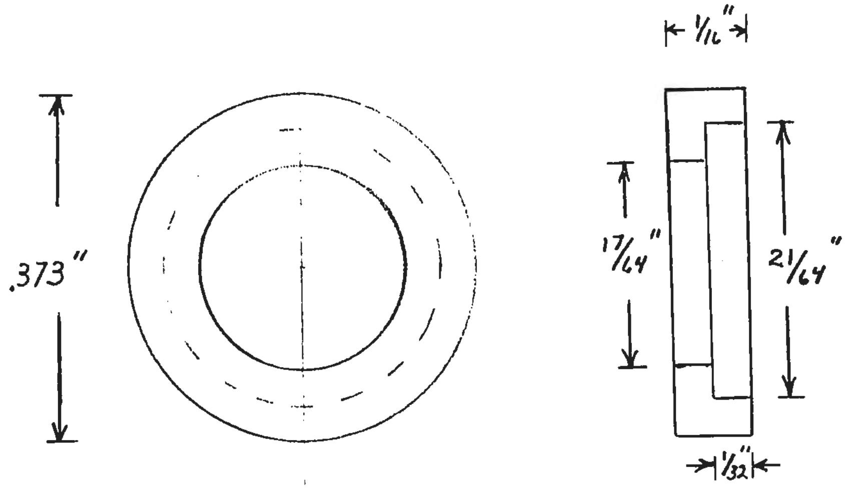
THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

THE BENJAMIN FRANKLIN PARKWAY • PHILADELPHIA, PENNSYLVANIA 19103

TITLE GAS CHAMBER EXTENSION DWG. NO. 1

TOLERANCES UNLESS OTHERWISE NOTED	DRAWN	DATE	SCALE NONE		MATERIAL BRASS
DIM. 0.00 = ± .01 DIM. 0.000 = ± .005 FRACTIONAL DIM. = ± 1/64 ANGLES = ± 30'	CHECKED	DATE	APPVD.	DATE	REFERENCE
REMOVE BURRS, SHARP EDGES	DWG. NO. C5061-1				

ITEM	QUAN.	IDENT.	DESCRIPTION	DWG. NO. OR MAT.



REV. NO.	DATE	DESCRIPTION	REV'D BY	CHK'D BY

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

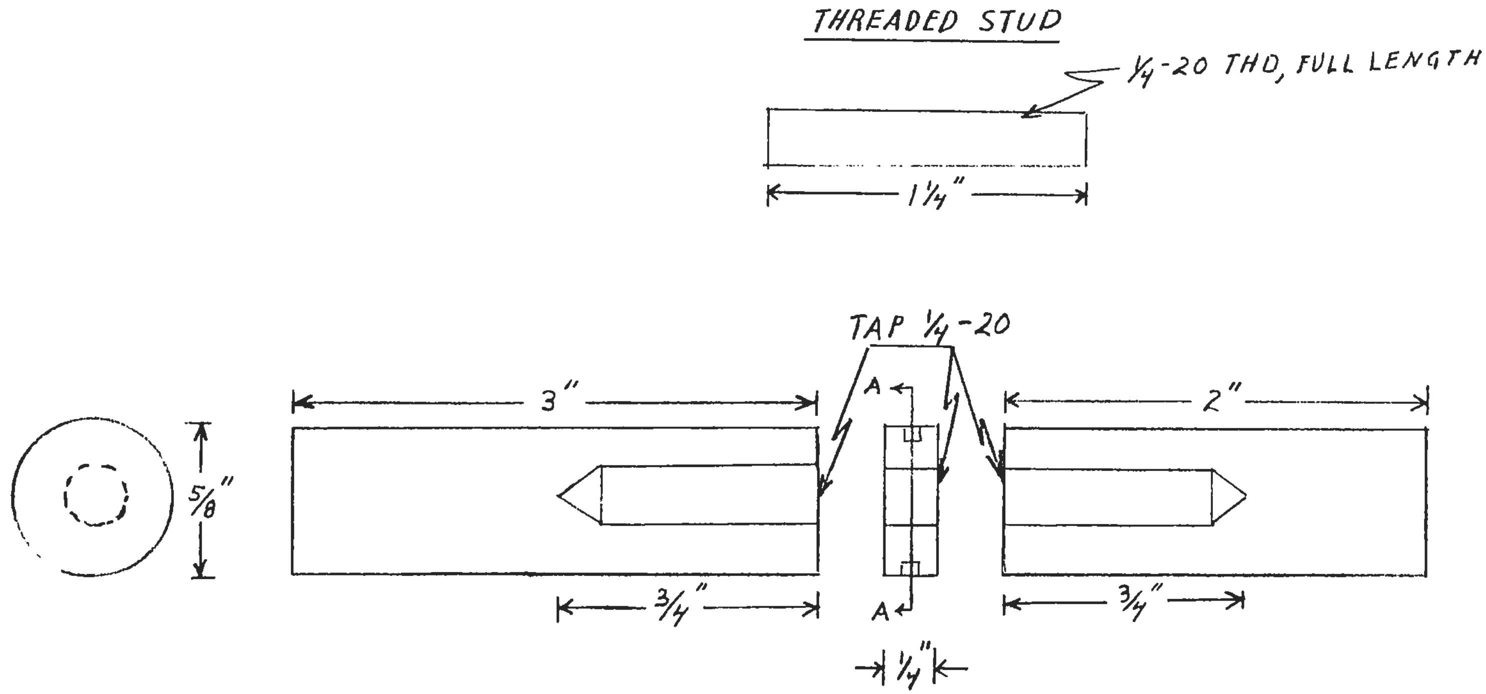
THE BENJAMIN FRANKLIN PARKWAY • PHILADELPHIA, PENNSYLVANIA 19103

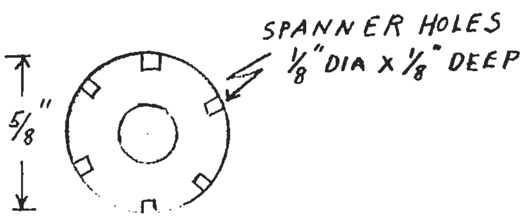
TITLE

SPRING SUPPORT WASHER DWG NO. 2

TOLERANCES UNLESS OTHERWISE NOTED DIM. 0.00 = ± .01 DIM. 0.000 = ± .005 FRACTIONAL DIM. = ± 1/64 ANGLES = ± 30' REMOVE BURRS, SHARP EDGES	DRAWN DATE	SCALE NONE	MATERIAL STAINLESS
	CHECKED DATE	APPVD. DATE	REFERENCE
	DWG. NO. C5061-2		

ITEM	QUAN.	IDENT.	DESCRIPTION	DWG. NO. OR MAT.





SECTION A-A
LOCKNUT

REV. NO.	DATE	DESCRIPTION	REV'D BY	CHK'D BY

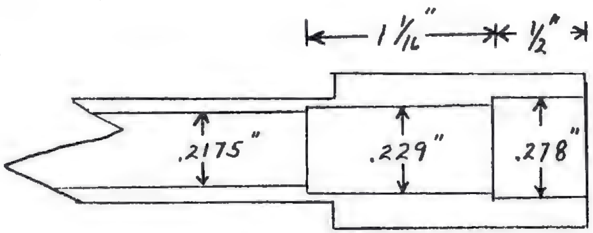
THE FRANKLIN INSTITUTE RESEARCH LABORATORIES
THE BENJAMIN FRANKLIN PARKWAY • PHILADELPHIA, PENNSYLVANIA 19103

TITLE GAS CHAMBER SUPPORT DWG NO. 3

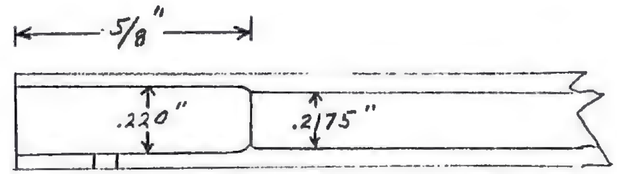
TOLERANCES UNLESS OTHERWISE NOTED	DRAWN DATE	SCALE NONE	MATERIAL BRASS
DIM. 0.00 = ± .01 DIM. 0.000 = ± .005 FRACTIONAL DIM. = ± 1/64 ANGLES = ± 30'	CHECKED DATE	APPVD. DATE	REFERENCE
REMOVE BURRS, SHARP EDGES	DWG. NO. C5061 -3		

63

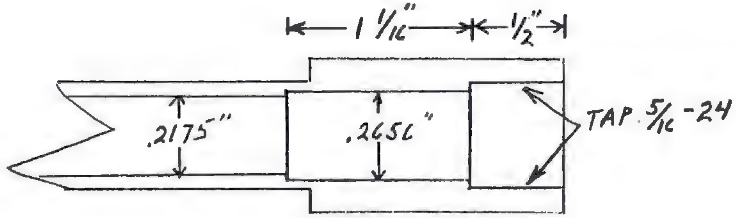
ITEM	QUAN.	IDENT.	DESCRIPTION	DWG. NO. OR MAT.



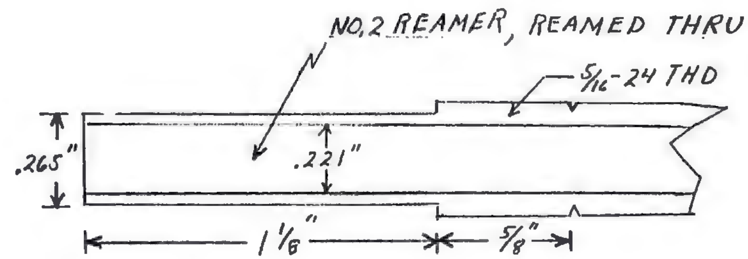
MUZZLE END - ORIGINAL BARREL



BREECH END - EXTENSION BARREL, UNMODIFIED



MUZZLE MODIFICATION



BREECH END - EXTENSION BARREL, MODIFIED

NOTE: MODIFICATION CONSISTS OF TURNING OFF 1" OF BREECH END FOLLOWED BY TURNING & THREADING TO GIVE SPIGOT FIT IN MODIFIED MUZZLE

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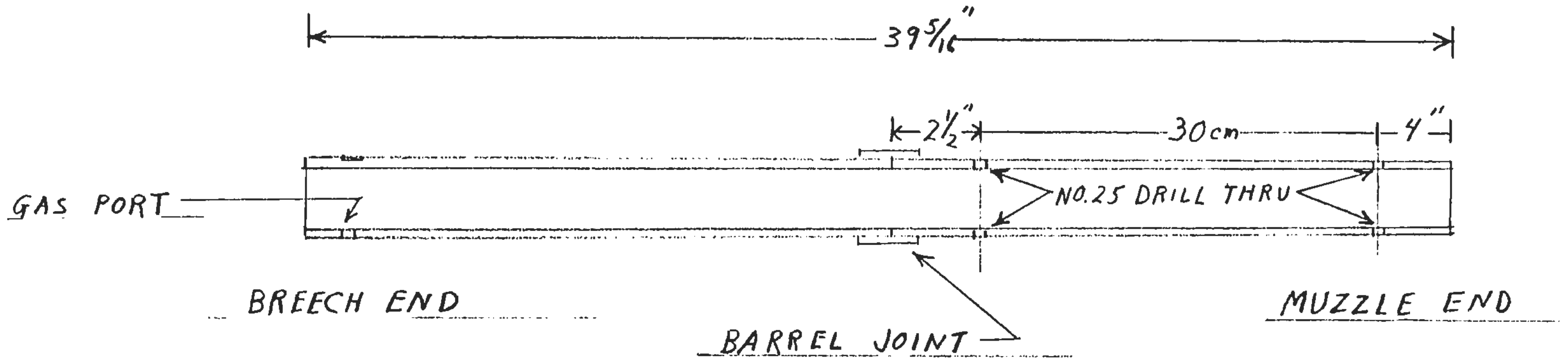
TITLE MUZZLE MODIFICATION AND BARREL EXTENSION DWG NO. 4

TOLERANCES UNLESS OTHERWISE NOTED	DRAWN	DATE	SCALE NONE		MATERIAL
DIM. 0.00 = ± .01 DIM. 0.000 = ± .005 FRACTIONAL DIM. = ± 1/64 ANGLES = ± 30'	CHECKED	DATE	APPVD.	DATE	REFERENCE
REMOVE BURRS, SHARP EDGES	DWG. NO.	C5061-4			

ITEM	QUAN.	IDENT.	DESCRIPTION	DWG. NO. OR MAT.



REV. NO.	DATE	DESCRIPTION	REV'D BY	CHK'D BY

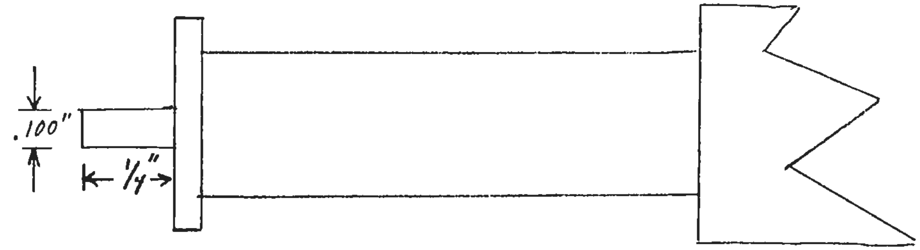
THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

THE BENJAMIN FRANKLIN PARKWAY • PHILADELPHIA, PENNSYLVANIA 19103

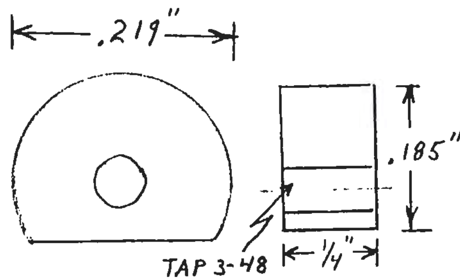
TITLE BARREL EXTENSION DWG NO. 5

TOLERANCES UNLESS OTHERWISE NOTED	DRAWN	DATE	SCALE NONE	MATERIAL
DIM. 0.00 = ± .01 DIM. 0.000 = ± .005 FRACTIONAL DIM. = ± 1/64 ANGLES = ± 30' REMOVE BURRS, SHARP EDGES	CHECKED	DATE	APPVD. DATE	REFERENCE
	DWG. NO. C5061-5			

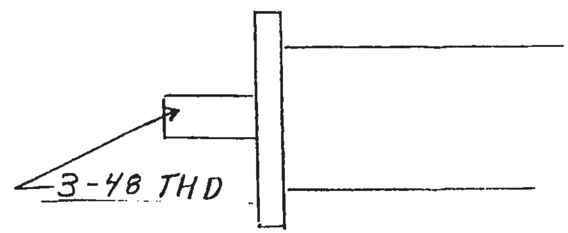
ITEM	QUAN.	IDENT.	DESCRIPTION	DWG. NO. OR MAT.



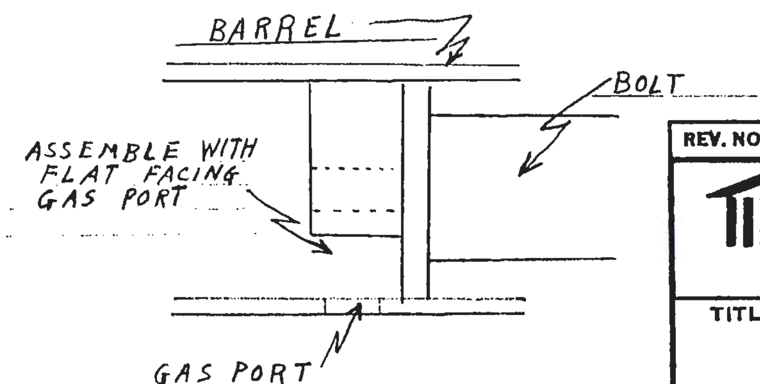
UNMODIFIED BOLT



BOLT FACE - NYLON



BOLT MODIFICATION



REV. NO.	DATE	DESCRIPTION	REV'D BY	CHK'D BY

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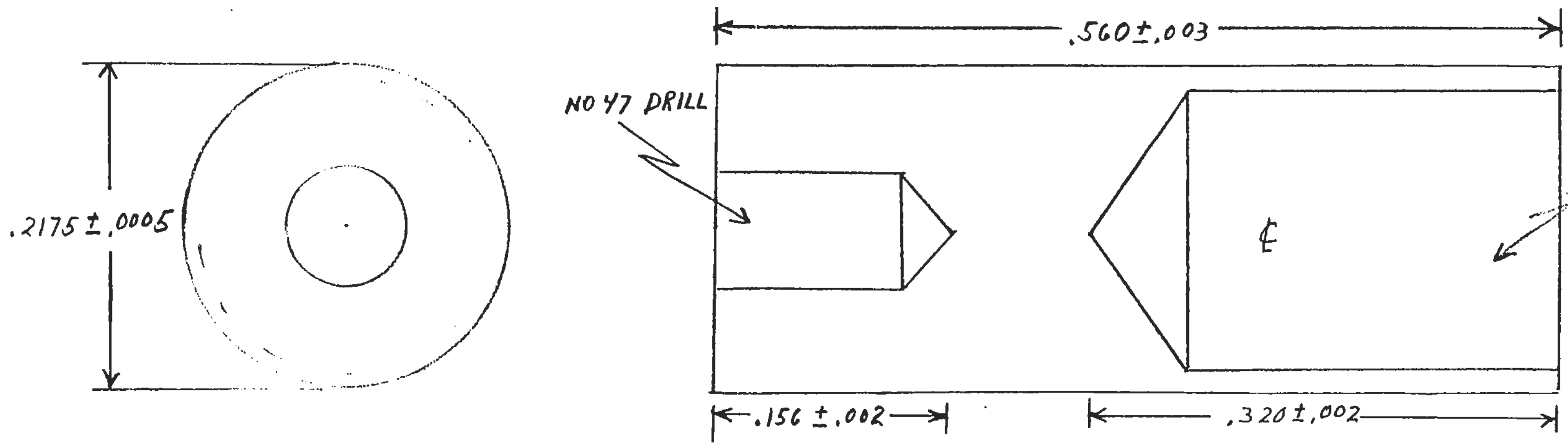
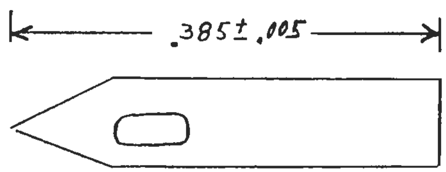
TITLE BOLT FACE DWG NO. 6

TOLERANCES UNLESS OTHERWISE NOTED DIM. 0.00 = ± .01 DIM. 0.000 = ± .005 FRACTIONAL DIM. = ± 1/64 ANGLES = ± 30' REMOVE BURRS, SHARP EDGES	DRAWN DATE	SCALE NONE	MATERIAL
	CHECKED DATE	APPVD. DATE	REFERENCE
	DWG. NO. C 5061-6		

ITEM	QUAN.	IDENT.	DESCRIPTION	DWG. NO. OR MAT.



PROJECTILE BODY



PROJECTILE POINT

REV. NO.	DATE	DESCRIPTION	REV'D BY	CHK'D BY

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

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TITLE PROJECTILE DWG NO. 7

TOLERANCES UNLESS OTHERWISE NOTED			
DIM. 0.00 = ± .01 DIM. 0.000 = ± .005 FRACTIONAL DIM. = ± 1/64 ANGLES = ± 30' REMOVE BURRS, SHARP EDGES	DRAWN DATE	SCALE NONE	MATERIAL
	CHECKED DATE	APPVD. DATE	REFERENCE
	DWG. NO. C 5061-7		