NWSY TR 77-2

REASSERTION OF COMPOSITION A-3 IN PROJECTILES

NOVEMBER 1977

NWS

NAVAL WEAPONS STATION, YORKTOWN, VIRGINIA 23691

by
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This report presents the results of a study to evaluate postpressing growth or dimensional changes observed in fuze cavities of Composition A-3 loaded 5" projectiles. Because of the introduction of improved press loading procedures during 1970, postpressing growth, or reassertion as it is generally called, is no longer a problem and the waiting time currently imposed between pressing and drilling the fuze cavity should be eliminated.

F O R E W O R D

1. This report presents the results of a study to evaluate the effects of postpressing growth or reassertion in fuze cavities of Composition A-3 loaded 5" Navy projectiles. Because of previously observed changes in fuze cavity dimensions after drilling, waiting periods of up to 24 hours have been imposed after pressing and before drilling. Currently, a 2-hour waiting period is required which should be eliminated as the result of data presented herein.

2. The effort reported herein was authorized and funded under the Naval Sea Systems Command (SEA-9923E) Work Request WR 75456 of 22 Oct 1976.

Released by

W. McBride

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Naval Explosives Development
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Under authority of
LEO A. HIBSON, JR.
Commanding Officer

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REASSERTION OF COMPOSITION A-3 IN PROJECTILES

I. GENERAL

Virtually all explosive compounds processed by pressing have some degree of elasticity that invariably leads to problems for the processor. The expression of this elasticity is called reassertion and refers to dimensional changes that occur after the pressure is removed following the pressing cycle. For example, an explosive cylinder pressed in a closed die set will increase in both diameter and length once it is removed from the die. Since different explosives exhibit different degrees of elasticity, the die designer must know the characteristics of the material prior to designing a die in order to compensate for postpressing growth.

II. REASSERTION OF EXPLOSIVE

Reassertion not only results in exterior dimensional changes but also may produce flaws within the pressed charge in the form of cracks or separations. Cracks are caused by internal stresses great enough to exceed the tensile strength of the explosive material. The die designer must compensate for dimensional change due to reassertion and the processor seeks a pressing technique that will minimize or eliminate internal flaws. Some of the techniques used to reduce cracking are increasing pressure dwell time, preheating the powder, heating the die, and even postcooling cycles to prevent thermal shock.

Dwell time refers to the time that pressure is maintained on the press ram. All major caliber Navy gun ammunition is subjected to a 6-second dwell time for each pressure application. Long dwell times are more likely to result in dense, defect-free loads. Some charges for missile warheads utilize a 15-minute dwell time. Long dwell times are preferable but must be tempered by cost and production schedules. As a result, the processor seeks to reduce the dwell time to a minimum.

Powder preheating is often used to reduce the dwell time. Generally speaking, powder preheating is employed to soften the coating or desensitizer used in most pressed explosives. For example, PBXN-3 has nylon as the desensitizer-binder. Powder must be preheated to 130 degrees Celsius (°C) to soften the nylon to a point where it will flow together under pressure to form a solid bonded mass. During the late 1960's intensive studies conducted by the Naval Explosives Development Engineering Department (NEDED), Naval Weapons Station, Yorktown, Virginia revealed that preheating Composition A-3 (wax coated RDX) would produce denser charges in gun ammunition. As a result, all Composition A-3 used in Navy gun ammunition is now preheated to 68 degrees Fahrenheit (°F) (approximately room temperature) before loading. Waxes are very sensitive to temperature variations and harden rapidly below room temperature. Above room temperature waxes soften rapidly, and at 80°C become fluid. Numerous studies have demonstrated that temperatures between 68° and 90°F seem to be optimum for press loading Composition A-3 in projectiles. Previous reports[1,2] show comprehensive treatment of the effects of temperature.

Postcooling cycles are often used with the newer plastic-bonded explosives. Hot charges are removed from the die and placed in a programmed oven to allow slow cooling and equalizing of internal stresses. This practice is not required when pressing Composition A-3 in projectiles.

III. REASSERTION OF COMPOSITION A-3

Composition A-3 is nothing more than hard RDX crystals physically coated with wax. Neither material by itself has any significant elastic properties and yet, defects frequently found in the explosive filler have pointed to a reassertion problem. For example, cracks will always develop in the 5-inch projectile filler when it is subjected to temperature cycling. Also when the projectile is press loaded, the top surface of the last increment has a shallow area about 1/4 to 3/8 inch deep that consists of so-called pop-up material. The top surface is convex, is usually cracked on top, and radiographs reveal a cracked or separated area about 1/4 to 3/8 inch below the surface. As a result, loading procedures are designed to ensure removal of this pop-up or loose explosive during fuze cavity drilling operations.

Cracks have always been suspect as a potential site where the explosive can be initiated as the result of filler movement during

[1] McGann, E. Yancey, Rothstein, Lewis R., NWSY TR 76-1, *A Safety, Quality and Cost Effectiveness Study of Composition A-3 Press Loading Parameters*, Mar 1976.

[2] McGann, E. Yancey, Rothstein, Lewis R., NWSY TR 77-1, *A Safety, Quality and Cost Effectiveness Study of Composition A-3 Press Loading Parameters (II)*, Mar 1977.

gun launch. Although cracks have never been implicated in a premature event, they are viewed with distrust by the explosive community and efforts will continue towards their elimination.

The question naturally arises, "What causes cracks?" Cracks are one manifestation of reassertion. For many years entrapped air has been suspect as the primary mechanism of reassertion. Composition A-3 is essentially a granular material with the individual granules being spherical in shape. When this material is pressed, it undoubtedly traps air in small spaces that are formed between the spheres. This phenomena can best be visualized by holding a handful of marbles and noting the spaces between the marbles caused by the nonmating surfaces of round objects. Of course, the marbles of Composition A-3 must be visualized as being soft and capable of being deformed. In a pressing operation, the ram exerts a force which causes the spheres or balls to be deformed and eventually mashed completely together into a homogeneous mass. The individual shapes of the spheres are lost. As the spheres are mashed together, the space between them becomes smaller. Air at first escapes until several surfaces begin to blend together to trap remaining small volumes of air. This air is thus highly compressed with pressures probably equal to the loading pressure of approximately 14 to 15,000 pounds per square inch (psi). When the pressure on the press ram is released, the compressed air exerts a force that causes the bond between the individual spheres of Composition A-3 to fail in tension, thus producing a crack. Some evidence exists to lead to a belief that the air will eventually migrate through the filler to the nose area, gradually relieving internal stresses that cause cracks. Higher loading pressures undoubtedly tend to prevent or at least slow down the escape of air, permitting internal stress to exist for a longer time, but are necessary to ensure a dense homogeneous load.

IV. REASSERTION OF SMALL PELLETS

Reassertion is also an expression of the elastic properties of the material. Some materials, such as rubber, have excellent elastic properties while others, such as glass, have virtually none. Most materials fall between these extremes. Composition A-3, being a composite material of a hard crystalline solid and a temperature sensitive wax, has very little elasticity. Even though the elasticity or memory of this material is small, there is no doubt that it contributes to the reassertion seen in Composition A-3. A series of experiments were conducted by NEDED in a closed die to evaluate the elastic response of Composition A-3. Pellets (1-3/8 inches diameter by 1-3/8 inches high) were pressed at 10, 15 and 20,000 psi. The height of the pellet was measured while the pellet was in the die under full ram pressure and then immediately after it was ejected from the die, and the results are shown in Figure 1. It was also measured 15 minutes later. The length or height of the pellet did not change during the 15-minute interval. It was concluded that, for all practical purposes, all reassertion took place immediately upon removal of the pellet from the die. In these experiments and others conducted by NEDED with Composition A-3 and other explosives, the change in diameter does not seem to be affected by changes in ram pressure as the diameter out of the die was the same for the three pressures studied.

V. REASSERTION IN PROJECTILES

Since reassertion in Composition A-3 loaded 5" gun ammunition has been observed at various times, an extensive study was undertaken by NEDED to evaluate the magnitude of the problem. When mandatory loading procedures were imposed in 1970, all projectiles were held for 24 hours after pressing before fuze cavity drilling. An additional waiting period was imposed after drilling before the cavity could be gaged. These time periods were imposed, however, more as the result of reported reassertion problems than as the result of systematic study. Since 1970, thousands of projectiles have been pressed under very carefully controlled conditions and no significant reassertion problems have been noted. Since reassertion of Composition A-3 is no longer reported or observed as it was formerly, it must be concluded that the improved loading procedures and close controls imposed since 1970 are responsible. Since data was needed to support any change in projectile processes that could have serious consequences, the study was designed to investigate all aspects of reassertion. Following is an outline used in conducting the work:

1. Press 25 each 5"/38 6- and 8-increment and 5"/54 6- and 8-increment Composition A-3 loaded projectiles as follows:

   - Temperature 68°F minimum.

   - After pressing, move each projectile immediately to drill. Drill fuze cavity and measure. Minimize time from press to drill. Drill VT cavity 5-1/4 inches deep.

2. Measure fuze cavities every 15 minutes for 2 hours - make one measurement after 24 hours.

3. X-ray all rounds at end of test. Cracked rounds will be excluded or considered separately.

VI. STUDY RESULTS

Figure 2 is a sample of the data sheet used. All projectiles were drilled for the VT fuze configuration. Note that over 100 measurements were made on each projectile fuze cavity and only nose fuze cavity reassertion was studied. Many observations seemed to indicate that some reassertion takes place immediately after fuze cavity drilling, but subsequent measurements indicate a gradual relaxing or return to the drilled dimensions. Undoubtedly some measurements of this type may reflect nothing more than the difficulty of measuring a waxy material like Composition A-3. Needless to say, the measurement accuracy is greater when measuring a rigid material such as steel which cannot be worn away by the measuring instrument. In spite of some slight inaccuracies that undoubtedly occurred during measuring, it is obvious that no major dimensional changes occurred.

Tables I, II, III and IV should be considered "worst case" results. For each projectile, the largest single measurement change for the diameter and depth is recorded. Most changes were less than .005 inch, but one depth change, projectile No. 2, Table I, was .012 inch. Note that some measurements reflect an increase (+) in fuze cavity diameter and depth but most reflect a decrease (-). It should be emphasized that these are the maximum individual dimensional changes recorded, and do not really reflect a true picture of the fuze cavity as a whole.

Figures 3, 4, 5 and 6 are graphs of the dimensional changes for all projectiles within a group. Note that the total depth and dimensional changes after 24 hours were only slightly more than .001 inch. Figures 7, 8, 9 and 10 display this same data over the outline of a fuze cavity to make the impact of such dimensional changes clearer.

Tables V, VI, VII and VIII show total net changes for each measured point. The data reflects an average for all 25 projectiles.

VII. DISCUSSION AND RECOMMENDATIONS

Although some individual data points indicate dimensional changes up to .012 inch, most are much less. Even .012 inch is far less than previously reported dimensional change caused by reassertion. On an average, fuze cavity diameters and depths change less than .002 inch which causes no problem in manufacturing. Some of the exteme dimensional changes are the result of the fuze cavity taking an elliptical shape. As a result, when the major axis and the minor axis of the ellipse are measured and averaged, only a small change is recorded.

Since liberal tolerances are specified in fuze cavity interfaces, it is recommended that the waiting times between pressing and drilling and between drilling and measuring the fuze cavity dimensions be eliminated. Deviations for the latter condition are now routinely being granted as the result of many thousands of observations on the production line.

VIII. REFERENCES

1 McGann, E. Yancey, Rothstein, Lewis R., NWSY TR 76-1, *A Safety, Quality and Cost Effectiveness Study of Composition A-3 Press Loading Parameters*, Mar 1976.

2 McGann, E. Yancey, Rothstein, Lewis R., NWSY TR 77-1, *A Safety, Quality and Cost Effectiveness Study of Composition A-3 Press Loading Parameters (II)*, Mar 1977.

TABLE I

5"/38 PROJECTILE (6-INCREMENT LOAD)
WORST CASE REASSERTION OF COMP A-3 IN FUZE CAVITY

Proj No.	Dia max net change*(in.)	Depth max net change*(in.)
1	+.001	-.003
2	+.002	-.012
3	-.002	-.003
4	-.002	-.002
5	+.003	-.001
6	+.001	+.006
7	-.002	+.003
8	-.001	-.002
9	+.001	-.004
10	-.002	+.001
11	+.006	+.003
12	-.001	-.001
13	-.004	+.007
14	-.003	-.006
15	-.007	-.003
16	-.002	-.006
17	-.008	-.004
18	+.001	-.003
19	-.002	-.002
20	-.002	-.003
21	-.002	-.004
22	+.001	-.003
23	+.003	-.003
24	+.004	-.008
25	+.001	-.003

*Measurements considered worst case. All measurements taken 24 hrs after pressing.

TABLE II

5"/38 PROJECTILE (8-INCREMENT LOAD)
WORST CASE REASSERTION OF COMP A-3 IN FUZE CAVITY

Proj No.	Dia max net change*(in.)	Depth max net change*(in.)
1	-.002	-.004
2	+.001	-.002
3	+.002	-.005
4	-.001	-.003
5	-.002	-.002
6	-.002	-.003
7	+.002	-.002
8	-.002	-.004
9	-.004	-.005
10	+.002	-.003
11	...	...
12	-.002	+.005
13	-.002	-.005
14	-.003	-.004
15	-.001	-.003
16	+.001	-.002
17	+.002	-.004
18	+.002	-.004
19	-.002	-.003
20	-.004	-.004
21	-.003	-.005
22	-.001	-.002
23	-.003	-.004
24	+.002	+.004
25	-.001	-.002

*Measurements considered worst case. All measurements taken 24 hrs after pressing.

TABLE III

5"/54 PROJECTILE (6-INCREMENT LOAD)
WORST CASE REASSERTION OF COMP A-3 IN FUZE CAVITY

Proj No.	Dia max net change*(in.)	Depth max net change*(in.)
1	+.002	-.003
2	-.004	-.003
3	+.007	-.004
4	+.002	+.005
5	+.001	-.001
6	+.001	-.005
7	-.002	+.003
8	+.007	-.003
9	-.001	+.005
10	-.004	-.004
11	-.001	+.003
12	+.002	-.003
13	+.001	+.003
14	-.002	+.004
15	-.007	-.002
16	-.001	+.003
17	-.003	-.002
18	-.001	-.002
19	-.003	+.002
20	+.002	+.004
21	-.001	+.004
22	-.001	+.001
23	-.002	+.003
24	+.003	+.002
25	-.001	-.002

*Measurements considered worst case. All measurements taken 24 hrs after pressing.

TABLE IV

5"/54 PROJECTILE (8-INCREMENT LOAD)
WORST CASE REASSERTION OF COMP A-3 IN FUZE CAVITY

Proj No.	Dia max net change*(in.)	Depth max net change*(in.)
1	+.008	-.005
2	+.003	-.008
3	-.004	-.005
4	-.004	.002
5	-.002	-.001
6	-.004	-.002
7	+.001	-.005
8	+.004	-.001
9	+.002	+.007
10	-.002	-.003
11	-.002	-.004
12	+.001	-.003
13	+.002	-.003
14	-.002	-.003
15	.000	-.002
16	-.002	+.002
17	-.003	-.003
18	-.003	-.004
19	...	...
20	-.004	-.004
21	-.004	-.005
22	+.001	-.004
23	-.002	+.004
24	+.003	-.005
25	-.002	-.004

*Measurements considered worst case. All measurements taken 24 hrs after pressing.

TABLE V

5"/38 PROJECTILE (6-INCREMENT LOAD)
NET REASSERTION OF COMP A-3 IN FUZE CAVITY

Depth (in.)					Dia 0°-180° (in.)			Dia 90°-270° (in.)		
0°	90°	180°	270°	Cen	Top	Mid	Bot	Top	Mid	Bot
-.0005	-.0012	-.0005	-.0005	0005	-.0008	-.0005	-.0007	-.0009	-.0005	-.0003

Note: Avg of 25 projectiles; 24-hr net change.

TABLE VI

5"/38 PROJECTILE (8-INCREMENT LOAD)
NET REASSERTION OF COMP A-3 IN FUZE CAVITY

Depth (in.)					Dia 0°-180° (in.)			Dia 90°-270° (in.)		
0°	90°	180°	270°	Cen	Top	Mid	Bot	Top	Mid	Bot
-.0015	-.0016	-.0017	-.0013	-.0014	-.0006	-.0007	-.0007	-.0007	-.0004	-.0004

Note: Avg of 25 projectiles; 24-hr net change.

TABLE VII

5"/54 PROJECTILE (6-INCREMENT LOAD)
NET REASSERTION OF COMP A-3 IN FUZE CAVITY

Depth (in.)					Dia 0°-180° (in.)			Dia 90°-270° (in.)		
0°	90°	180°	270°	Cen	Top	Mid	Bot	Top	Mid	Bot
-.0001	-.0005	-.0001	+.0001	+.0005	+.0001	-.0003	-.0003	+.0001	+.0002	+.0001

Note: Avg of 25 projectiles; 24-hr net change.

TABLE VIII

5"/54 PROJECTILE (8-INCREMENT LOAD)
NET REASSERTION OF COMP A-3 IN FUZE CAVITY

Depth (in.)					Dia 0°-180° (in.)			Dia 90°-270° (in.)		
0°	90°	180°	270°	Cen	Top	Mid	Bot	Top	Mid	Bot
-.001	-.0011	-.0012	-.0013	-.0006	-.0009	-.0012	-.0005	-.0005	-.0007	-.0005

Note: Avg of 25 projectiles; 24-hr net change.

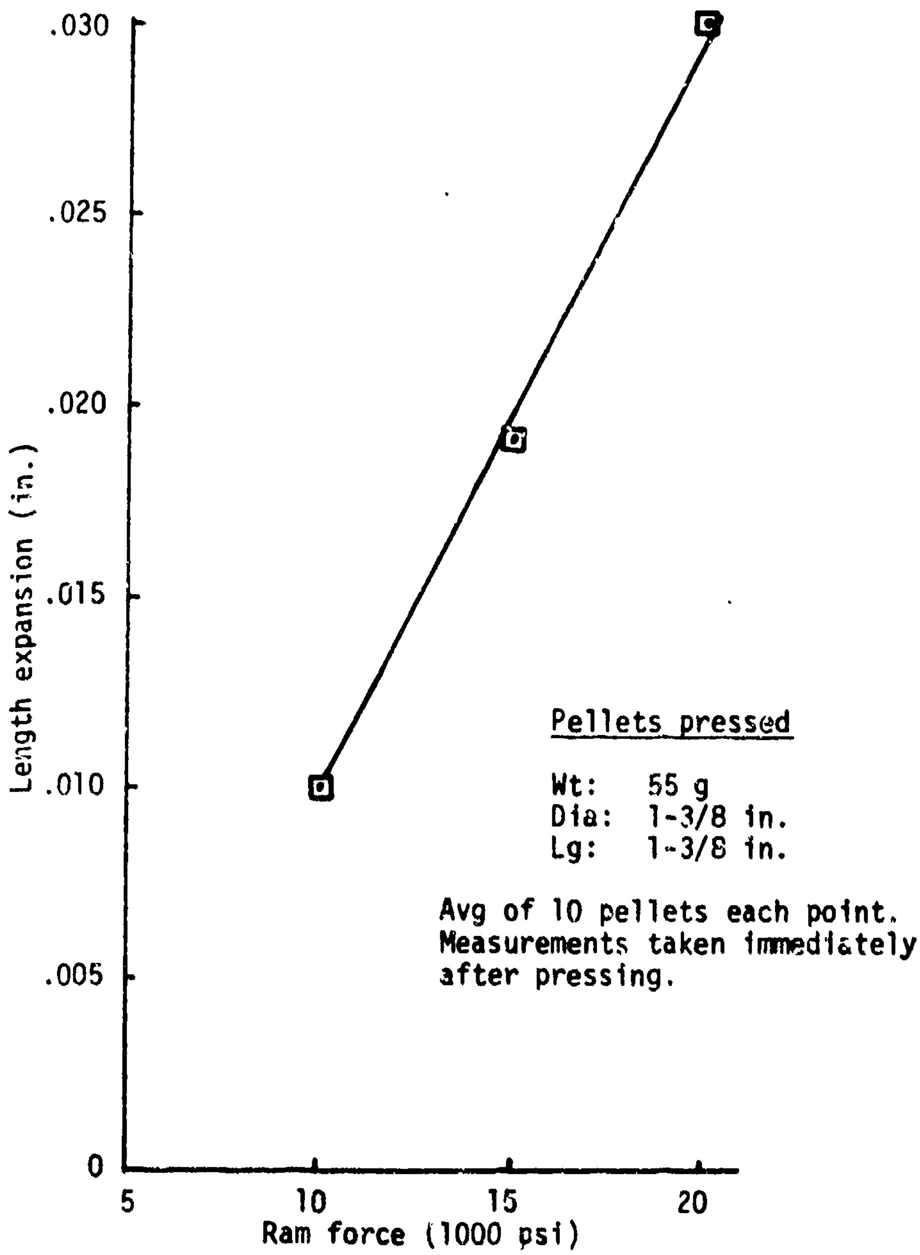


FIGURE 1

REASSERTION OF SMALL COMP A-3 PELLETS

REASSERTION STUDY

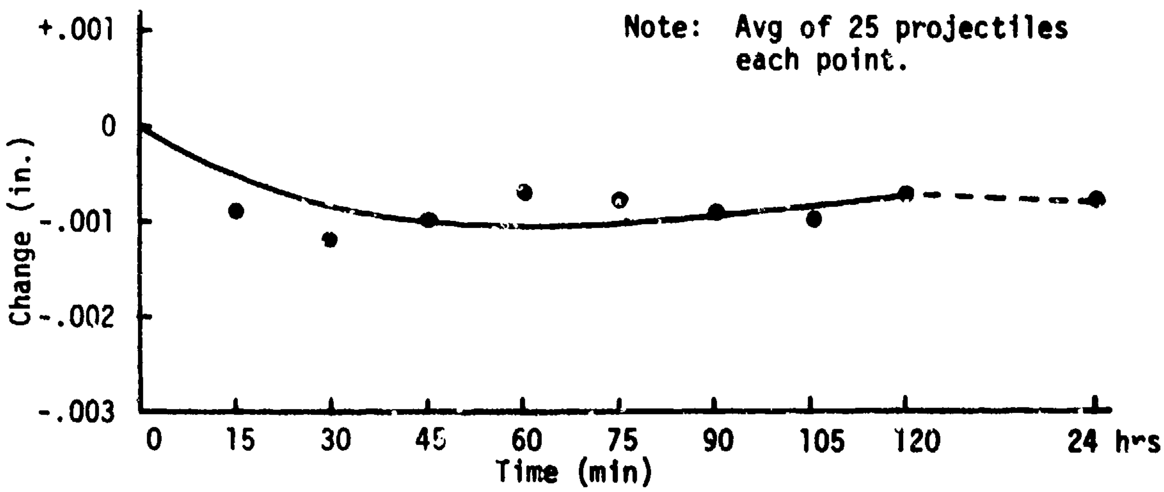
Load press: 23.5 tons   Xpl Lot/Batch: 32-145   Time pressed: 0810   Room temp: 78°

Date: 1/14/76   Xpl: Comp A-3   Projectile: 5"/54 (8-increment load)   Xpl temp: 78°   S/N: RS-4

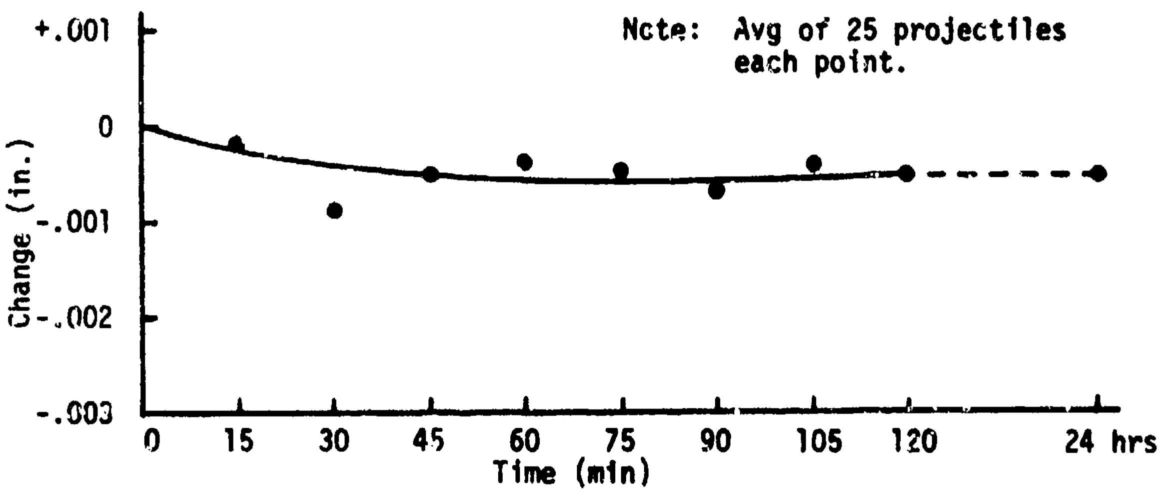
Time	Depth (in.)					Dia 0°-180° (in.)			Dia 90°-270° (in.)			Remarks
	0°	90°	180°	270°	Cen	Top	Mid	Bot	Top	Mid	Bot	
0815	5.255	5.254	5.256	5.257	5.247	2.148	2.150	2.146	2.147	2.147	2.145	Jones
0830	5.254	5.254	5.252	5.255	5.247	2.148	2.148	2.143	2.149	2.148	2.143	Jones
0845	5.250	5.252	5.253	5.253	5.244	2.145	2.147	2.146	2.150	2.147	2.146	Jones
0900	5.254	5.253	5.254	5.254	5.254	2.147	2.146	2.143	2.148	2.146	2.145	Jones
0915	5.255	5.253	5.252	5.254	5.247	2.146	2.146	2.146	2.148	2.148	2.146	Jones
0930	5.254	5.253	5.252	5.255	5.246	2.145	2.145	2.143	2.147	2.147	2.143	Jones
0945	5.255	5.254	5.256	5.254	5.248	2.147	2.148	2.144	2.146	2.146	2.144	Cook
1000	5.255	5.253	5.256	5.254	5.246	2.146	2.147	2.145	2.146	2.148	2.145	Cook
1015	5.254	5.254	5.253	5.255	5.247	2.147	2.147	2.142	2.148	2.148	2.145	Jones
24-hr check 0815	5.255	5.253	5.254	5.256	5.248	2.146	2.146	2.142	2.147	2.147	2.143	Jones
Net change	0	-.001	-.002	-.001	+.001	-.002	-.004	-.004	0	0	-.002	

SAMPLE DATA SHEET

FIGURE 2



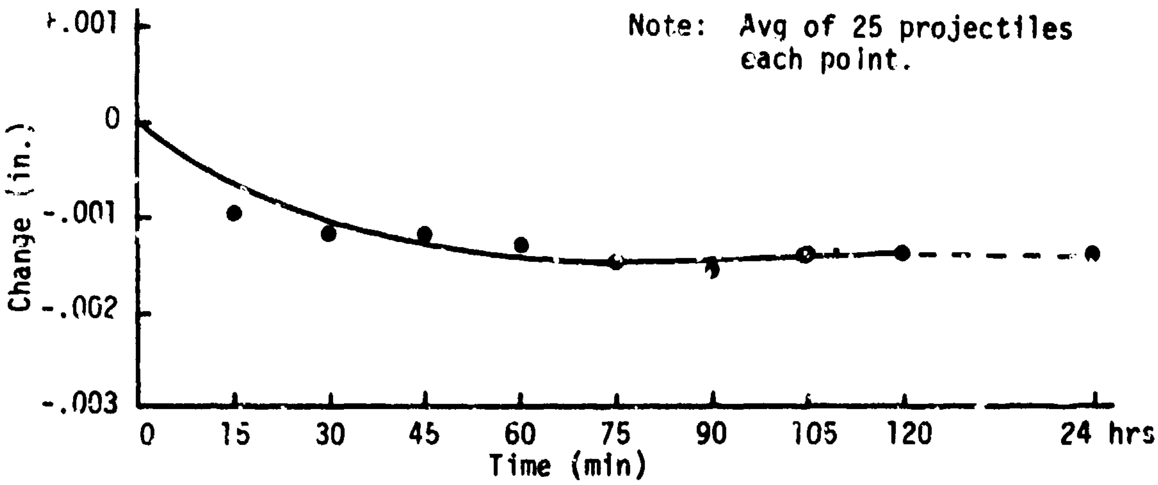
AVG DEPTH CHANGE



AVG DIAMETER CHANGE

FIGURE 3

5"/38 PROJECTILE (6-INCREMENT LOAD)
FUZE CAVITY DIMENSIONAL CHANGES DURING REASSERTION OF COMP A-3



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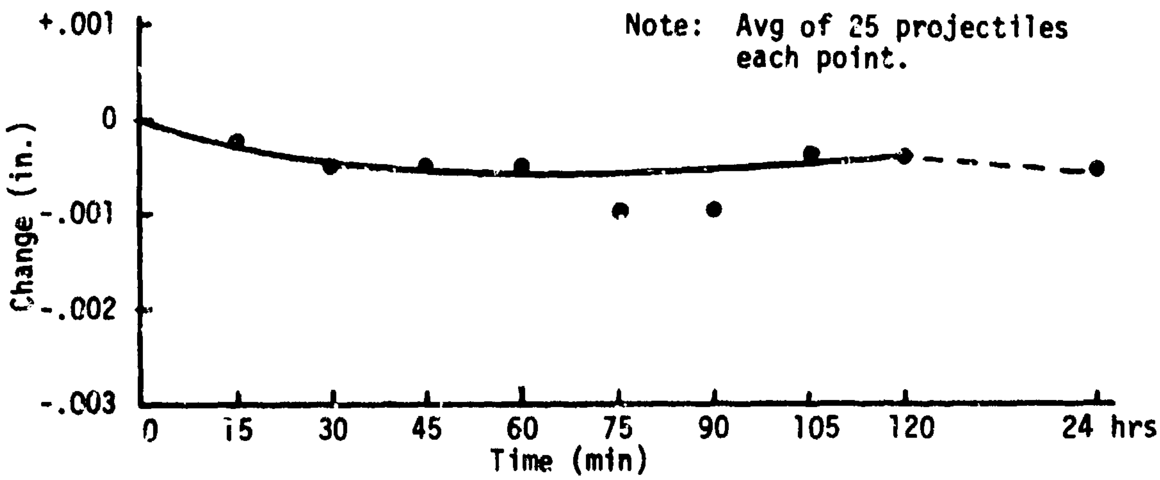


AVG DIAMETER CHANGE

FIGURE 4

5"/38 PROJECTILE (8-INCREMENT LOAD)
FUZE CAVITY DIMENSIONAL CHANGES DURING REASSERTION OF COMP A-3

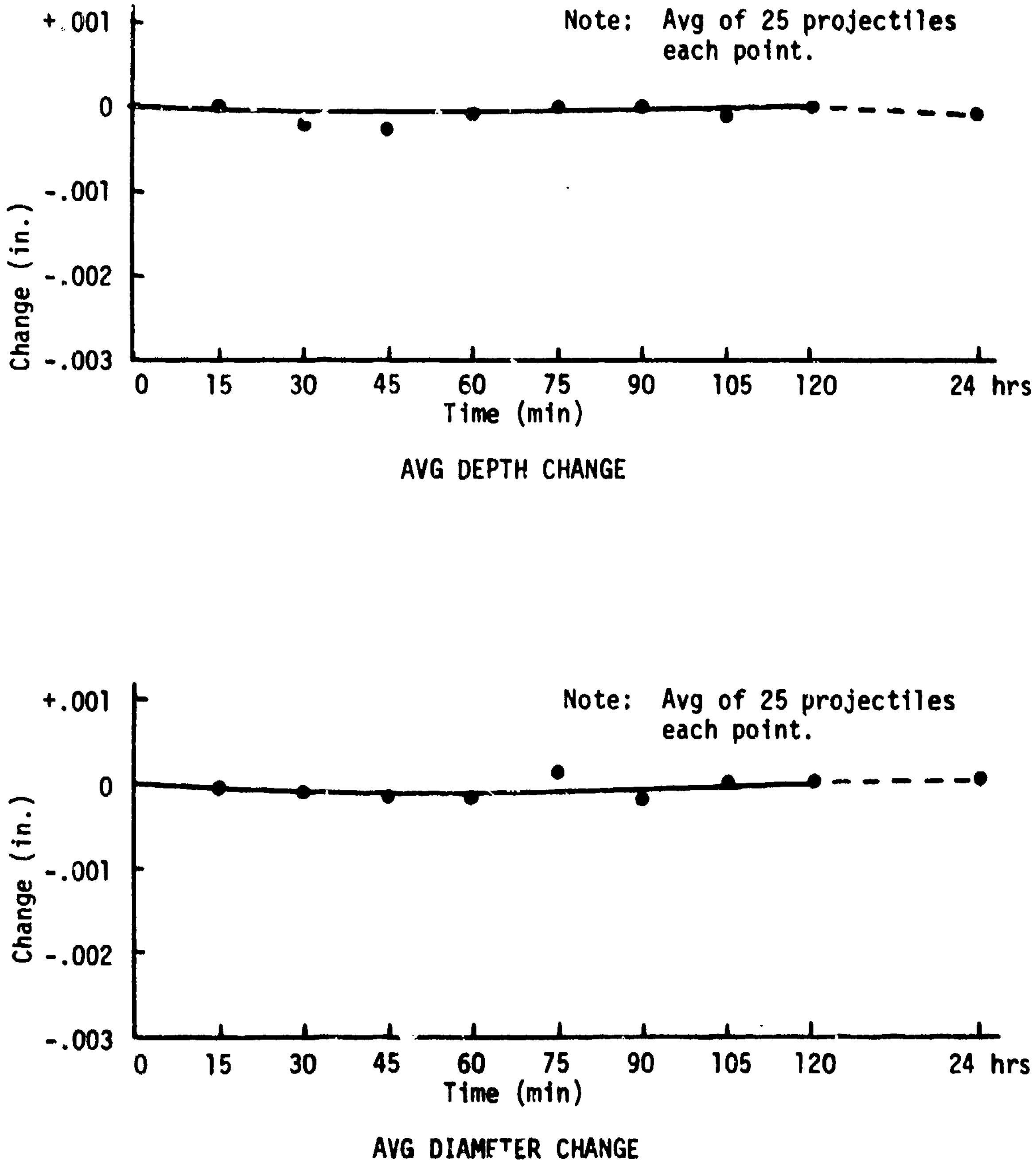
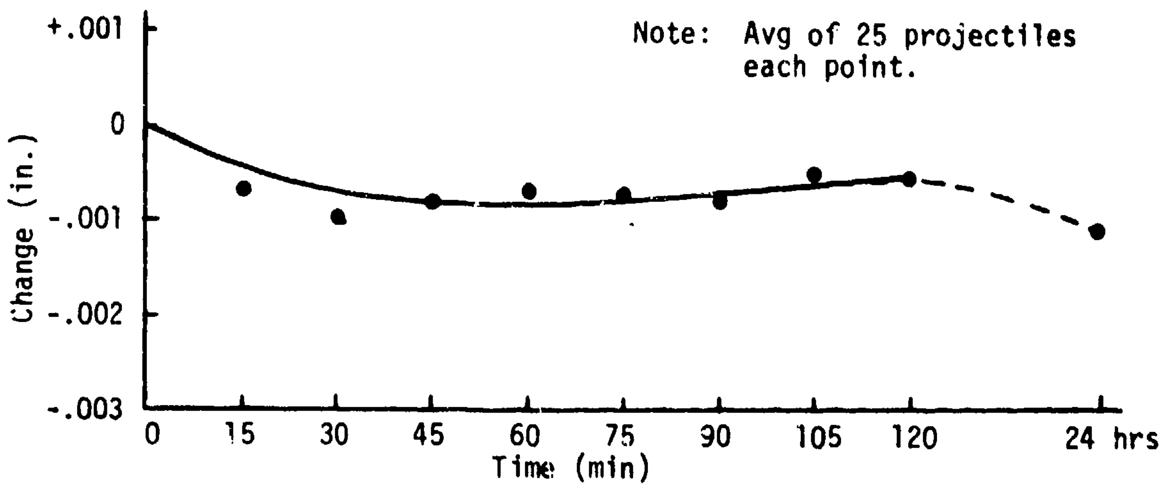


FIGURE 5

5"/54 PROJECTILE (6-INCREMENT LOAD)
FUZE CAVITY DIMENSIONAL CHANGES DURING REASSERTION OF COMP A-3



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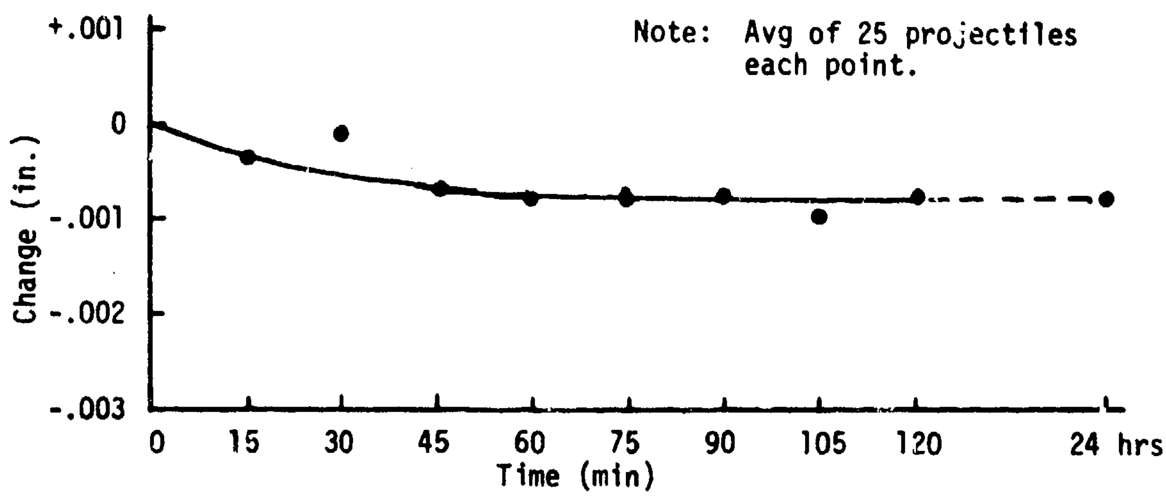

AVG DIAMETER CHANGE

FIGURE 6

5"/54 PROJECTILE (8-INCREMENT LOAD)
FUZE CAVITY DIMENSIONAL CHANGES DURING REASSERTION OF COMP A-3

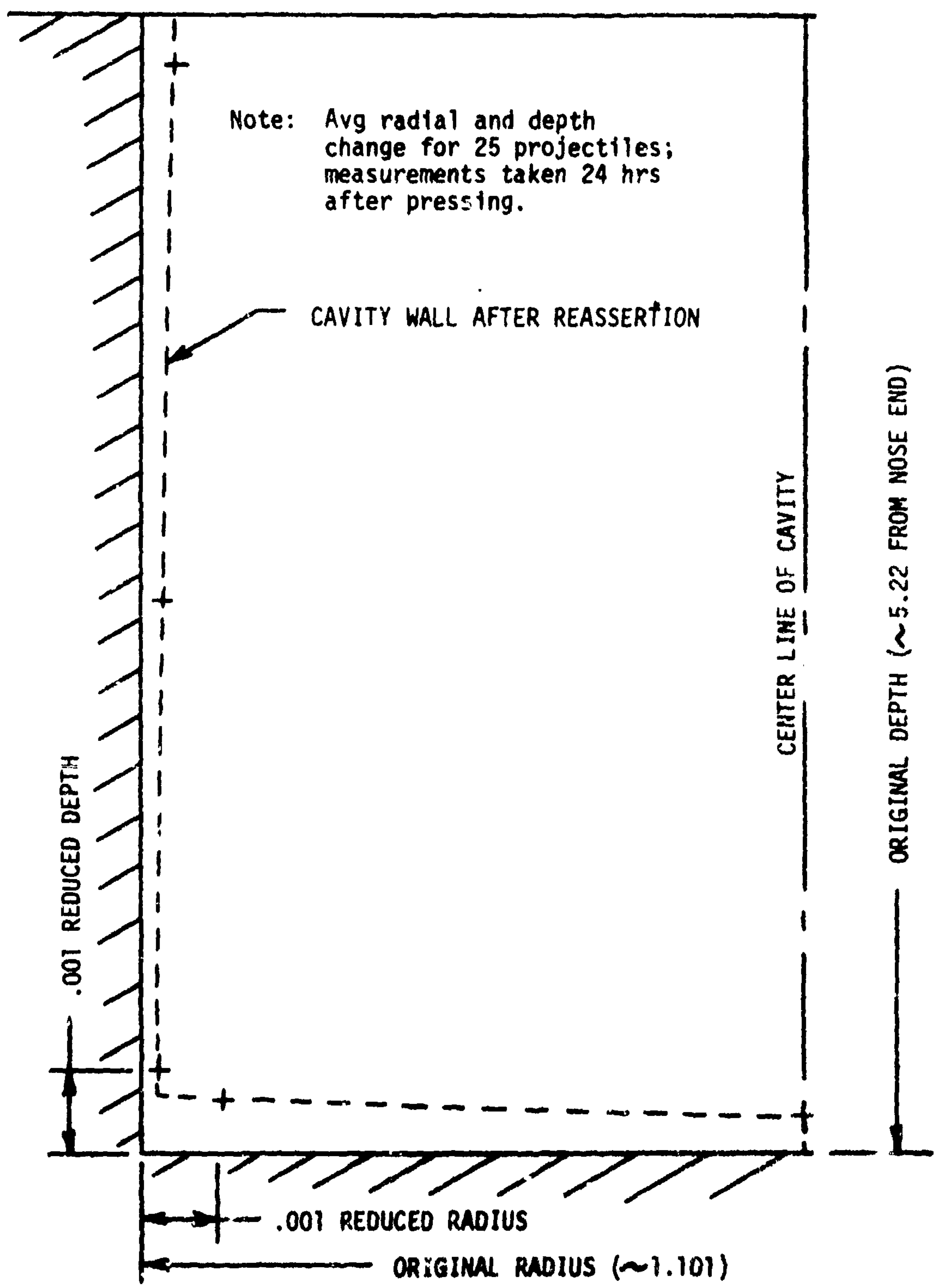

FIGURE 7

5"/38 PROJECTILE (6-INCREMENT LOAD)
FUZE CAVITY CONFIGURATION BEFORE AND AFTER REASSERTION OF COMP A-3

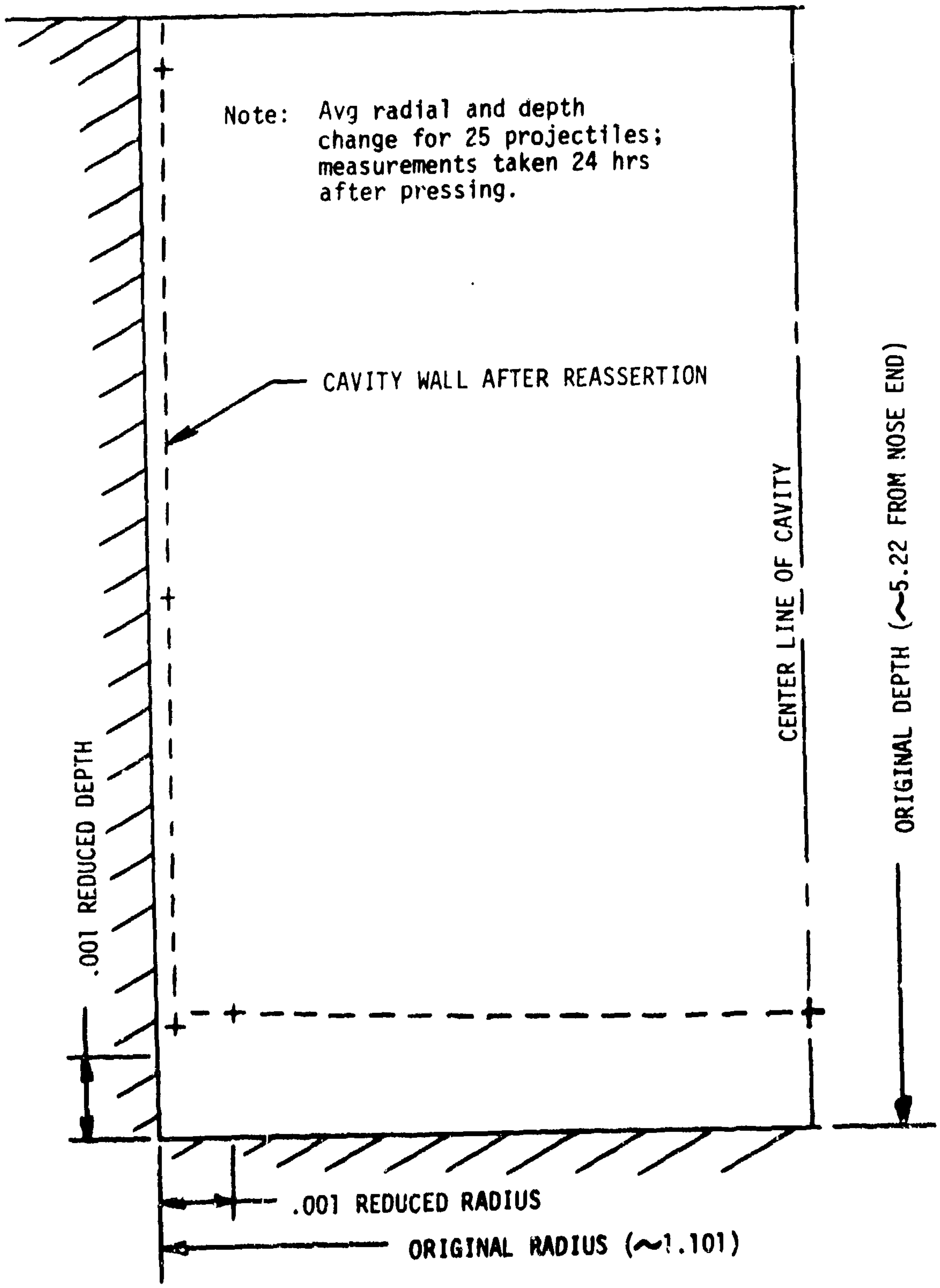

FIGURE 8

5"/38 PROJECTILE (8-INCREMENT LOAD)
FUZE CAVITY CONFIGURATION BEFORE AND AFTER REASSERTION OF COMP A-3

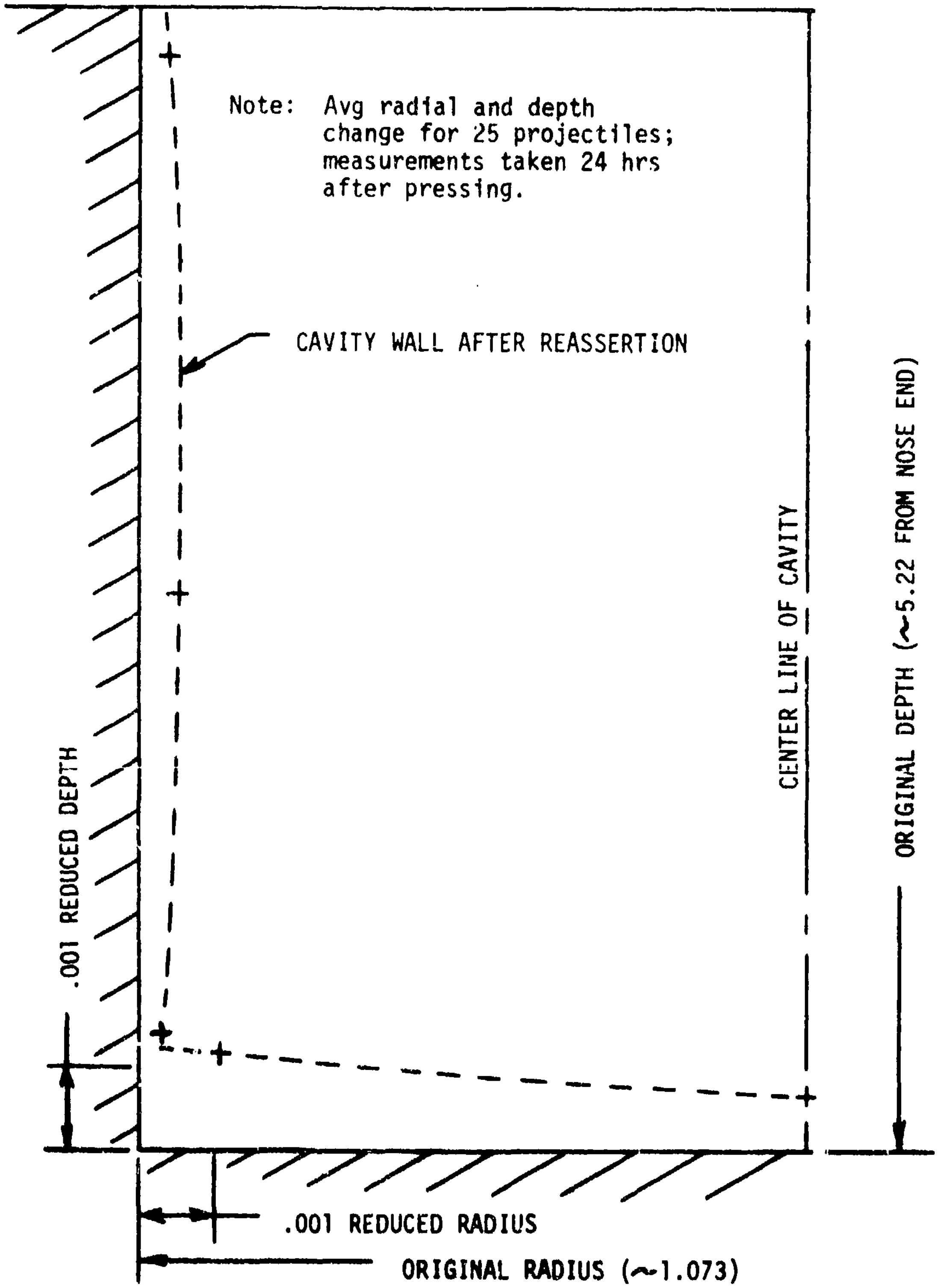

FIGURE 9

5"/54 PROJECTILE (6-INCREMENT LOAD)
FUZE CAVITY CONFIGURATION BEFORE AND AFTER REASSERTION OF COMP A-3

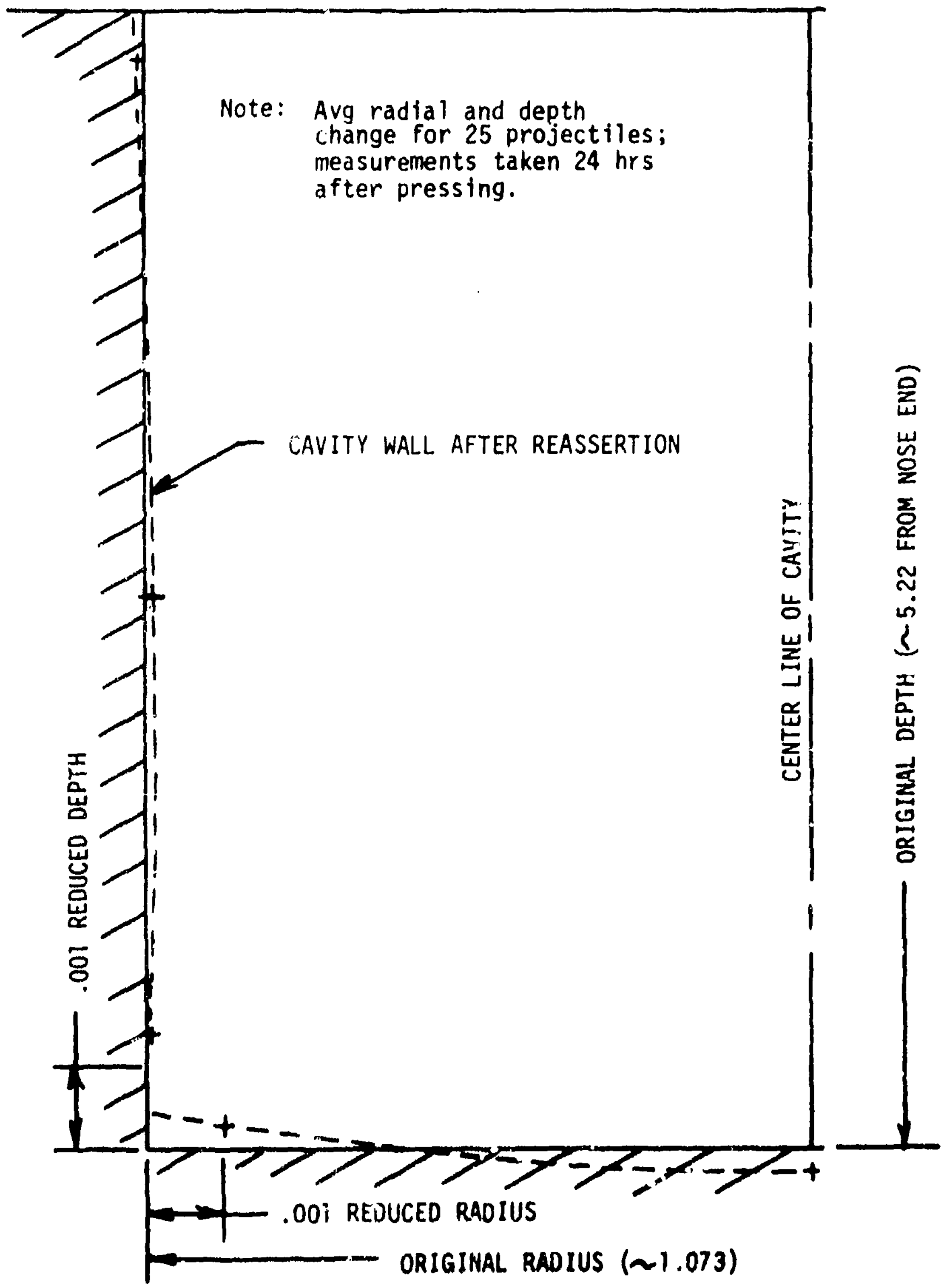

FIGURE 10

5"/54 PROJECTILE (8-INCREMENT LOAD)
FUZE CAVITY CONFIGURATION BEFORE AND AFTER REASSERTION OF COMP A-3

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