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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) (1rs)

This report presents a comprehensive documentation of experimental data generated for the ACT (Automatic Cannon Technology) Program (behind-armor data for long rod penetrators in the 20-40mm size). An adequate kinetic energy penetrator performance data base for long rod penetrators of various designs has been established. In addition, for some of the rounds, behind-target debris has been analyzed to supply a partial basis for debris characterization.

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I. INTRODUCTION

The purpose of this report is to present a comprehensive documentation of experimental data generated in a small scale firing program within the ACT Project*. Chief objectives were:

- to assure an adequate kinetic energy penetrator performance data base for various long rod penetrator designs and

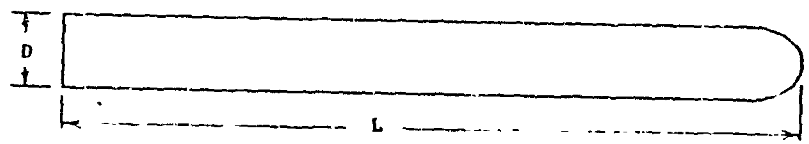
- to describe behind-target debris - mass, trajectory, speed and type of individual fragments - associated with some rounds and to thereby supply a partial basis for debris characterization.

Targets used in the firing program were single plate rolled homogeneous armor (RHA) measuring 15.24 x 30.48cm for normal impact shots and 15.24 x 45.72cm for oblique incidence with thicknesses ranging from 1.91 to 5.08cm. Penetrators were rods (right circular cylinders with hemispherical noses) having length to diameter (L/D) ratios of 5, 10 and 20. The predominant penetrator composition was of monolithic AISI-S7 tool steel of finished hardness R_c 55 but other designs and other materials were used to some extent; c.f. Figure 1 for penetrator characteristics. Impact obliquities were 0°, 45° and 60°.

In large part, the essence of this report is confined to the five appendices; indeed, our most compelling purpose is to disseminate, for the first time in anywhere near complete form, data that this program has been sporadically yielding over several years.

Basic raw data from the shots is provided in Appendix A and is partitioned, according to penetrator/target situation, into 23 series labelled ACT 1 through ACT 20 and ACT 1.1, ACT 3.1 and ACT 3.2. Twenty-two of these series (all but ACT 3.2, in which there is only one round with an acceptable level of yaw) were considered suitable for determination of V_s, V_r curves and limit velocities. Derived V_s, V_r curves for these 22 cases are given in Appendix B. A summary of processed behind-target fragmentation data for selected rounds is supplied in Appendix C. In Appendix D we attempt, in a sequence of rough sketches, to illustrate the pre-impact and residual penetrators in perspective with an appropriate target plate section for each round of ACT 19. Appendix E provides (for the later set of shots) for a comparison between derived V_s, V_r curves and a predictive model that has been formulated for dealing with long rod penetrators.

**The wide-ranging "Automatic Cannon Technology" project of which the effort of concern here was but a small part.*



ACT 1, 2, 3, 4, 5, 6 :

L = 6.48 CM, D = 1.30 CM (L/D = 5)

AISI S7 TOOL STEEL, FINISHED HARDNESS - R_c55

ACT 7, 8, 9, 10, 11, 3.2 :

L = 10.16 CM, D = 1.02 CM (L/D = 10)

AISI S7 TOOL STEEL, FINISHED HARDNESS - R_c55

ACT 16, 19 :

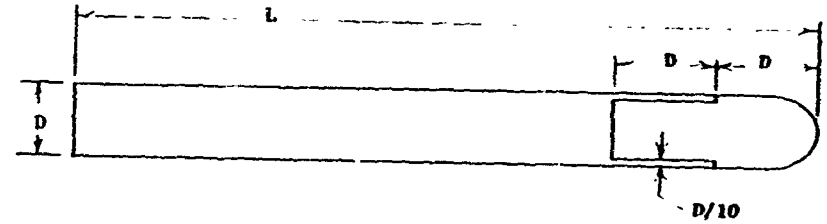
L = 10.16 CM, D = 1.02 CM (L/D = 10)

STEEL*, FINISHED HARDNESS - R_c55

ACT 12, 13, 14, 15, 1.1, 3.1 :

L = 16.19 CM, D = 0.81 CM (L/D = 20)

AISI S7 TOOL STEEL, FINISHED HARDNESS - R_c55



ACT 17 :

L = 10.16 CM, D = 1.02 CM (L/D = 10)

STEM — STEEL*, FINISHED HARDNESS - R_c55

CAP — STEEL*, FINISHED HARDNESS - R_c55

ACT 18, 20 :

L = 9.68 CM, D = 0.97 CM (L/D = 10)

STEM — STEEL*, FINISHED HARDNESS - R_c55

CAP — TUNGSTEN ALLOY**, FINISHED HARDNESS - R_c42

* This was VIMVAR-processed and would have been AISI S7 Tool Steel but for the lack of molybdenum as an alloying element.

** 90% W, 7% Ni, 3% Fe, swaged 24%

FIGURE 1. NOMINAL PENETRATOR CHARACTERISTICS

This program has unfolded in three phases involving distinctly different time periods, different range personnel and practices, and different project managers; such diversity has regrettably and inescapably been adverse to an orderly, coherent, productive effort. It is, for example, exceedingly difficult now to adjudge the quality of data generated early in the program, to interpret cryptic notes on old data sheets, or retrieve misplaced information. The case for standardization in data organization and in testing is clear.

II. RESULTS AND COMMENTS

The experimental setup and multiple flash x-ray system used to record ballistic performance data are described in BRL Technical Note 1634[1]. A summary of ballistic limits and geometries for the various test series is given in Table I. Minutiae are to be found in Appendices A-E. In perusing the data, the following remarks should be kept in mind:

a. The parameters a, p, and V_ℓ of Table I are derived from the "good" data of the series. By a "good" round is meant a shot for which total initial penetrator yaw does not exceed 2.5°.

b. The penetrators in ACT 1 through ACT 15 (including ACT 1.1, ACT 3.1 and ACT 3.2) were of monolithic AISI-S7 tool steel having finished hardness of R_c 55. The steel for ACT 16 through ACT 20 was also of finished hardness R_c 55 and would have been AISI-S7 but for the inadvertent lack of molybdenum as an alloying agent.

c. ACT 16 and ACT 19 employed monolithic steel penetrators; ACT 17 penetrators were of two-piece steel (steel cap on steel stem); and, in ACT 18 and ACT 20, the penetrators were steel (R_c 55) with tungsten alloy caps (R_c 42).

d. The steel used in rounds 231 through 268 (ACT 16 through ACT 20) was VIMVAR* processed. The difference made by this change in processing is especially noticeable when comparing data for The steel used in some of the penetrators of ACT 11 had a very high inclusion rate (Figure 2), contributing no doubt to the large scatter in the data for this series. ACT 19 is a recreation of ACT 11 (with the slight difference in penetrator material noted previously and the different processing).

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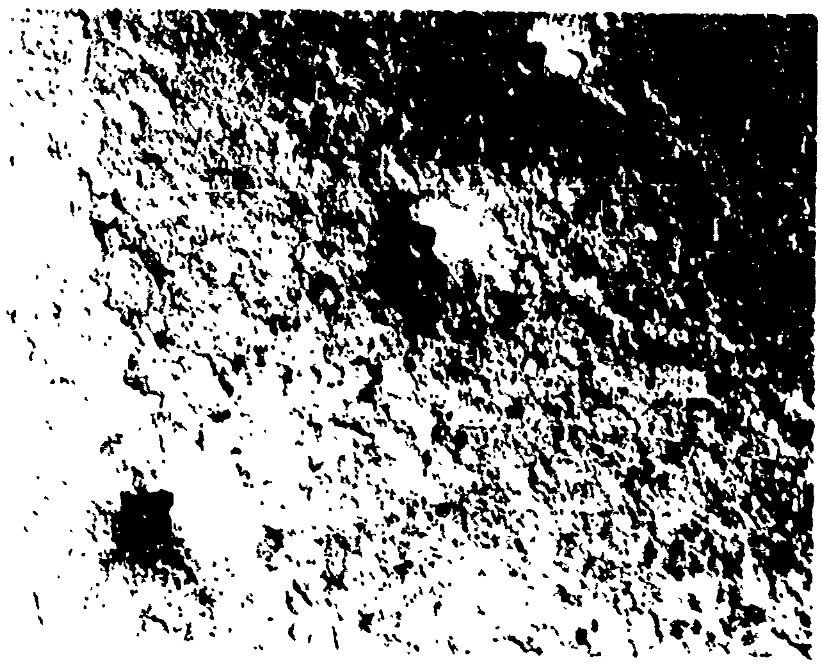
[1]*Grabarek, C. and Herr, L., "X-Ray Multi-Flash System for Measurement of Projectile Performance at the Target", BRL TN 1634, September 1966 (AD 377657).*

**Vacuum Induction Melt, Vacuum Arc Remelt.*

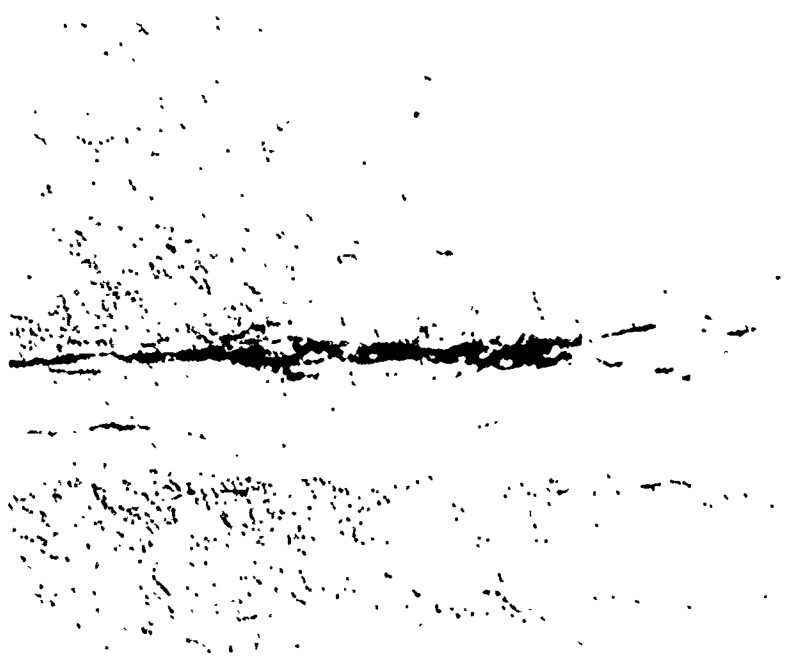
Table I. Ballistic Limit Velocities and Series Characteristics

Series	M	D	L/D	θ	T	H	V_ℓ	a	p
ACT 1	64.8	1.30	5	0	1.91	364	720	0.94	2.9
ACT 2	64.9	1.30	5	0	2.54	340	906	0.70	3.3
ACT 3	64.8	1.30	5	0	3.18	321	1130	1.00	2.0
ACT 4	64.8	1.30	5	0	3.81	321	1304	1.00	2.9
ACT 5	64.8	1.30	5	0	5.08	286	1568	1.00	1.8
ACT 6	64.8	1.30	5	60	2.54	340	1451	0.80	2.0
ACT 7	63.7	1.02	10	0	1.91	364	798	1.00	2.7
ACT 8	63.8	1.02	10	0	2.54	340	916	0.83	3.2
ACT 9	63.7	1.02	10	0	3.81	321	1234	0.93	3.8
ACT 10	63.7	1.02	10	0	5.10	288	1411	1.00	2.2
ACT 11	64.0	1.02	10	60	2.54	340	1296	1.00	1.9
ACT 12	64.7	0.81	20	0	2.54	340	997	1.00	3.3
ACT 13	64.7	0.81	20	0	3.81	321	1157	1.00	3.7
ACT 14	64.6	0.81	20	0	5.08	291	1296	1.00	2.8
ACT 15	64.5	0.81	20	60	2.54	340	1234	1.00	3.1
ACT 16	64.2	1.02	10	45	2.55	364	1095	0.94	3.4
ACT 17	64.1	1.02	10	0	3.83	331	1216	1.00	3.0
ACT 18	64.4	0.97	10	0	3.82	331	1097	1.00	3.4
ACT 19	64.3	1.02	10	60	2.54	358	1225	0.80	3.3
ACT 20	64.4	0.97	10	60	2.53	372	1229	0.82	5.4
ACT 1.1	64.7	0.81	20	0	1.91	364	879	1.00	5.8
ACT 3.1	64.7	0.81	20	0	3.18	321	1045	0.90	3.7

M - penetrator mass (g)
D - penetrator diameter (cm)
L - penetrator length (cm)
θ - obliquity
T - target thickness (cm)
H - target hardness (BHN)
V_ℓ, a, p- parameters derived from V_s, V_r data and defined in Appendix B



C. Bearcat Trans. (Edge) 400X (P.L.)



C. Bearcat Long. 400X (P.L.)

Figure 2. Steel with High Inclusion Rate

e. Finally, we note that the V_s, V_r tests from ACT 16 on are significantly more economical of shots -- there were no shots lost (in the sense of being unsuitable for deriving a V_s, V_r curve) due to excessive yaw. Indeed, in rounds 231 through 268, only one round (234) proved unsuitable.

III. FUTURE PLANS

Further exploitation of the data generated in the ACT program continues. A report on penetrator residual mass variation with impact energy and target geometry may be anticipated.

ACKNOWLEDGMENT

The author acknowledges the contributions of Messrs. Antonio J. Ricchiazzi and Peter G. Morfogenis, the previous principal investigators for the terminal ballistics portion of the ACT Program. Thanks are also due to Messrs. John Koval and Dale Smith under whose supervision the experimental data was generated in the Terminal Ballistics Division Small Caliber Ranges. Messrs. Frank Dubois, John Cullum and Robert Schnick, among others, assisted in the reduction of the data.

APPENDIX A

BASIC RAW DATA

APPENDIX A: BASIC RAW DATA

Notation:

#	Round number
M	Penetrator mass, grams
L	Penetrator length, centimeters
D	Penetrator diameter, centimeters
T	Target thickness, centimeters
H	Target hardness, BHN
α	Vertical penetrator yaw at impact, degrees
β	Horizontal penetrator yaw at impact, degrees
δ	Total penetrator yaw at impact, degrees
V_s	Striking penetrator velocity (speed), meters/second
V_r	Residual penetrator velocity (speed), meters/second
M_r'	Recovered residual penetrator mass, grams
M_r''	Estimated (from radiographs) residual penetrator mass, grams
Δ	Mass loss of target plate, grams
λ	Cone angle of residual penetrator path, degrees
ϕ	Phase angle of residual penetrator path, degrees
-	Indicates that item is not applicable; e.g., cone angle, etc. if $V_r = 0$
$\wedge$	Indicates that item is applicable but unknown

Key to Remarks:

1 - Total yaw exceeds 2 1/2°, round not used in V_ℓ determination

2 - Perforation but V_r not obtainable, round not used in V_ℓ determination

3 - Non-perforation, small bulge in rear target surface

4 - Non-perforation, large bulge in rear target surface

5 - Non-perforation, rear target surface fractured

6 - Rod slightly bent at launch

7 - Perforation, penetrator severely shattered

8 - Penetrator made from "dirty material"

ACT 1 $\theta = 0$ L/D = 5

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
81	64.82	6.49	1.30	1.91	364	0.3	1.5	1.5	682	0	-	-	20	-	-	3
86	64.74	6.48	1.30	1.91	364	0.8	1.0	1.3	690	0	-	-	15	-	-	
82	64.76	6.49	1.30	1.91	364	0.4	-1.2	1.3	721	81	^	^	50	^	^	
80	64.59	6.48	1.30	1.91	364	0.7	0.4	0.8	748	384	^	43.0	40	12.1	315	
79	65.01	6.48	1.30	1.91	364	-0.1	1.2	1.2	763	429	^	42.3	^	3.7	332	
84	64.87	6.48	1.30	1.91	364	0.2	-1.3	1.3	909	609	^	46.7	55	3.4	304	
83	65.03	6.48	1.30	1.91	364	0.7	2.6	2.6	917	548	^	42.2	^	2.6	306	1
85	64.77	6.47	1.30	1.91	364	-1.9	-1.9	2.7	1053	730	^	40.2	^	3.5	337	1

ACT 2 $\theta = 0$ L/D = 5

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
20	65.03	6.47	1.30	2.54	340	-0.5	-1.5	1.6	858	0	-	-	29	-	-	3
19	64.98	6.49	1.30	2.54	340	-0.7	-2.7	2.8	879	249	22.3	30.0	46	7.9	4	1
18	64.68	6.48	1.30	2.54	340	1.9	-0.2	1.9	913	213	19.7	28.0	60	6.3	15	
17	64.81	6.48	1.30	2.54	340	0.3	-0.7	0.8	942	363	17.8	26.1	46	7.0	16	
16	65.07	6.48	1.30	2.54	340	0.6	0.9	1.0	966	367	28.1	33.0	103	6.8	42	
15	64.81	6.47	1.30	2.54	340	0.1	0.4	0.4	987	474	25.4	33.6	62	1.7	276	
14	65.06	6.48	1.30	2.54	340	-0.9	1.0	1.3	1022	525	^	36.6	68	6.0	192	
13	64.98	6.48	1.30	2.54	340	-1.0	0.6	1.2	1124	624	^	^	55	^	^	
12	65.02	6.48	1.30	2.54	340	0.6	1.0	1.2	1272	797	^	34.1	124	1.2	173	

ACT 3 θ = 0 L/D = 5

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
48	64.90	6.48	1.30	3.18	321	0.0	-0.3	0.3	1111	0	-	-	^	-	-	4
47	64.71	6.48	1.30	3.18	321	-0.4	-0.7	0.8	1130	36	22.0	34.3	^	4.1	290	
46	65.05	6.48	1.30	3.18	321	-2.0	-0.2	2.0	1137	65	^	34.4	^	11.2	210	
45	64.52	6.47	1.30	3.18	321	-2.1	0.1	2.1	1164	223	22.9	18.4	^	3.8	45	
44	64.78	6.47	1.30	3.18	321	-2.3	1.2	2.6	1185	314	18.8	26.8	65	5.1	104	1
43	65.00	6.48	1.30	3.18	321	-1.2	0.4	1.3	1241	465	^	31.4	65	7.9	168	
42	64.73	6.47	1.30	3.18	321	0.6	-0.3	0.6	1304	661	^	34.2	46	3.5	276	
41	64.38	6.47	1.30	3.18	321	0.6	0.4	0.7	1352	849	^	36.8	52	3.5	136	

ACT 4 θ = 0 L/D = 5

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
26	64.71	6.48	1.30	3.81	321	-1.8	0.0	1.8	1259	0	-	-	^	-	-	4
29	64.79	6.48	1.30	3.81	321	-1.8	0.5	1.8	1283	0	-	-	^	-	-	4,5
28	64.84	6.48	1.30	3.81	321	-0.2	0.4	0.4	1306	199	^	25.3	^	10.9	80	
27	64.78	6.48	1.30	3.81	321	-0.6	-0.1	0.6	1330	514	21.3	25.3	22	5.2	222	

ACT 5 $\theta = 0$ L/D = 5

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
105	64.91	6.47	1.31	5.08	203	7.5	-3.5	8.3	1455	0	-	-	40	-	-	1,3
106	64.92	6.47	1.31	5.08	286	-1.5	-2.8	3.1	1470	0	-	-	^	-	-	1,3
107	64.75	6.48	1.29	5.08	286	0.0	1.8	1.8	1503	0	-	-	^	-	-	4,5
108	64.92	6.46	1.31	5.08	203	-0.5	2.5	2.6	1512	0	-	-	^	-	-	1,4
109	64.96	6.48	1.30	5.08	203	1.5	-0.5	1.6	1526	0	-	-	^	-	-	4
136	64.71	6.48	1.30	5.08	286	0.8	-0.8	1.1	1553	0	-	-	37	-	-	
134	64.70	6.48	1.30	5.08	286	2.3	2.0	3.2	1555	0	-	-	18	-	-	1
133	65.03	6.47	1.30	5.08	302	-0.3	0.0	0.3	1566	0	-	-	^	-	-	
111	64.65	6.48	1.30	5.08	286	-1.5	5.0	5.2	1567	0	-	-	^	-	-	1,4,5
135	64.92	6.48	1.30	5.08	286	-0.8	-1.5	1.7	1567	162	^	^	20	^	^	
120	64.45	6.48	1.30	5.08	293	-5.5	-2.8	6.2	1585	0	-	-	^	-	-	1,5
110	64.95	6.48	1.30	5.08	286	-4.7	3.4	5.8	1591	^	^	^	^	^	^	1,2
125	64.92	6.47	1.30	5.08	302	-0.4	-16.3	16.8	1595	0	-	-	0	-	-	1
131	64.68	6.47	1.30	5.08	286	1.5	0.5	1.6	1595	143	^	^	27	^	^	
114	64.22	6.42	1.30	5.08	286	6.0	11.0	12.5	1598	0	-	-	19	-	-	1,4
121	64.85	6.47	1.30	5.08	293	8.0	1.9	8.2	1611	298	^	16.9	^	7.2	133	1
126	64.63	6.48	1.30	5.08	302	3.8	7.8	8.7	1618	0	-	-	^	-	-	1
130	64.61	6.47	1.30	5.08	286	1.3	1.3	1.8	1620	0	-	-	60	-	-	
128	64.84	6.47	1.30	5.08	302	0.7	0.0	0.7	1620	^	^	^	55	^	^	2
123	64.85	6.48	1.30	5.08	293	-4.4	-0.4	4.5	1629	^	^	^	45	^	^	1,2
122	64.73	6.48	1.30	5.08	293	-4.4	-0.4	4.5	1630	44	^	^	24	^	^	1

ACT 5 (Continued)

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
118	64.97	6.38	1.30	5.08	302	1.0	-4.6	4.7	1630	474	^	9.8	84	7.7	66	1
129	64.68	6.47	1.30	5.08	302	1.0	-4.8	4.9	1632	478	^	^	45	^	^	1
112	64.87	6.48	1.30	5.08	286	-4.0	-0.5	4.0	1634	0	-	-	40	-	-	1,5
119	65.22	6.48	1.30	5.08	302	1.2	-3.7	3.9	1638	^	^	^	45	^	^	1,2
132	64.70	6.48	1.30	5.08	302	-2.5	-2.3	3.4	1639	262	^	^	59	^	^	1
124	64.76	6.48	1.30	5.08	302	-2.5	-3.8	4.5	1642	0	-	-	4	-	-	1,4,5
117	64.76	6.47	1.30	5.08	302	-1.7	-1.0	2.0	1644	308	^	9.9	58	^	^	
115	64.81	6.47	1.30	5.08	286	-0.9	-8.0	8.0	1646	128	^	10.5	40	3.7	277	1
171	64.59	6.47	1.30	5.08	293	-2.0	-1.8	2.7	1650	373	^	^	38	^	^	1
127	64.80	6.48	1.30	5.08	302	-2.3	1.3	2.6	1652	517	^	10.7	^	7.8	282	1
116	64.84	6.48	1.30	5.08	302	-0.3	0.5	0.5	1667	391	^	15.7	106	15.0	0	
113	64.45	6.48	1.30	5.08	286	0.3	-0.8	0.8	1679	532	^	^	40	^	^	7
172	64.62	6.48	1.30	5.08	302	0.0	-0.3	0.3	1832	973	^	^	65	^	^	
137	64.85	6.48	1.30	5.08	286	0.5	-0.5	0.7	1941	1283	^	^	40	^	^	

ACT 6   θ = 60   L/D = 5

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
189	64.98	6.48	1.30	2.54	340	3.3	2.8	4.3	1349	0	-	-	40	-	-	1
205	65.11	6.48	1.30	2.54	340	10.0	-1.3	10.1	1448	0	-	-	44	-	-	1
192	64.73	6.48	1.30	2.54	340	-2.0	0.3	2.0	1451	0	-	-	70	-	-	
191	63.84	6.38	1.30	2.54	340	0.5	3.5	3.5	1461	277	11.6	^	115	^	^	1
193	64.90	6.48	1.30	2.54	340	0.9	1.2	1.5	1462	197	^	16.2	119	44.0	0	
206	64.91	6.46	1.30	2.54	340	0.5	0.8	0.9	1505	348	14.1	^	148	^	^	
190	64.65	6.48	1.30	2.54	340	0.2	-0.1	0.2	1520	398	12.5	20.9	150	40.1	356	
199	64.54	6.48	1.30	2.54	340	2.6	-2.1	3.3	1546	568	^	16.9	165	34.7	13	1
198	64.71	6.47	1.30	2.54	340	-0.7	0.2	0.7	1558	351	^	17.5	195	41.7	0	
194	64.97	6.48	1.30	2.54	340	-5.0	-5.3	7.3	1565	0	-	-	88	-	-	1
200	64.86	6.48	1.30	2.54	340	-0.4	2.0	2.1	1575	453	^	15.1	180	39.1	0	
197	64.85	6.48	1.30	2.54	340	0.7	1.6	1.7	1576	470	^	17.4	140	39.5	0	
195	64.66	6.48	1.30	2.54	340	3.0	4.7	5.6	1581	^	^	^	112	^	^	1,2
203	64.75	6.47	1.30	2.54	340	-2.8	-1.3	3.1	1712	704	^	12.1	175	26.8	17	1,7
201	64.39	6.48	1.30	2.54	340	2.0	7.6	7.8	1753	901	^	15.0	215	21.3	346	1
204	64.60	6.44	1.30	2.54	340	0.5	-1.2	1.3	1841	948	^	15.1	235	29.8	2	

ACT 7 $\theta = 0$ L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
66	63.90	10.24	1.02	1.91	364	-1.5	0.8	1.7	625	0	-	-	7	-	-	
67	63.88	10.15	1.02	1.91	364	-0.5	-0.5	0.7	671	0	-	-	11	-	-	
68	63.95	10.15	1.02	1.91	364	-1.8	-0.8	1.9	738	0	-	-	17	-	-	
72	63.55	10.13	1.02	1.91	364	-0.3	0.5	0.6	751	0	-	-	21	-	-	3
87	63.53	10.15	1.02	1.91	364	0.5	-1.3	1.3	783	0	-	-	5	-	-	
73	63.89	10.13	1.02	1.91	364	0.8	0.3	0.8	786	0	-	-	^	-	-	3
75	63.80	10.16	1.02	1.91	364	0.0	1.0	1.0	789	0	-	-	10	-	-	
78	63.75	10.17	1.02	1.91	364	0.0	-0.5	0.5	792	0	-	-	10	-	-	
74	63.74	10.15	1.02	1.91	364	.8	-0.5	0.9	800	0	-	-	^	-	-	3
71	63.42	10.15	1.02	1.91	364	-0.2	0.0	0.2	801	379	30.8	31.3	^	6.3	240	
69	63.80	10.19	1.02	1.91	364	-0.3	-0.3	0.4	811	0	-	-	17	-	-	
88	63.67	10.16	1.02	1.91	364	2.1	-1.2	2.5	828	493	^	28.9	46	11.4	312	
70	63.82	10.19	1.02	1.91	364	0.0	1.2	1.2	852	467	^	39.7	42	2.4	358	
77	63.60	10.16	1.02	1.91	364	-0.1	1.1	1.1	1002	712	^	42.4	40	0.6	164	
76	63.69	10.16	1.02	1.91	364	0.5	0.7	0.9	1361	1229	^	22.5	65	0.8	111	

ACT 8 θ = 0 L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
10	63.62	10.16	1.02	2.54	340	2.0	0.0	2.0	915	0	-	-	41	-	-	3
8	63.3[illegible]	10.16	1.02	2.54	340	2.0	5.3	5.6	930	0	-	-	33	-	-	1,3
11	63.60	10.16	1.02	2.54	340	^	^	^	937	0	-	-	14	-	-	1,3
9	63.63	10.16	1.02	2.54	340	-1.2	-0.8	1.4	955	432	23.2	25.3	50	9.1	179	
7	63.67	10.16	1.02	2.54	340	0.8	^	^	936	246	19.3	21.6	60	3.1	29	1
6	63.52	10.15	1.02	2.54	340	-0.[illegible]	[illegible].5	4.5	984	317	24.7	26.7	48	3.4	155	1
5	64.48	10.16	1.02	2.54	340	-1.2	-1.6	2.0	1053	594	25.8	30.8	50	9.5	262	
4	63.57	10.16	1.02	2.54	340	-0.7	1.4	1.6	1103	690	32.7	36.1	65	1.6	133	
3	63.55	10.16	1.02	2.54	340	-[illegible]	2.8	4.2	1137	753	31.6	35.6	67	6.3	141	1
1	63.63	10.16	1.02	2.54	340	-1.7	-0.6	1.8	1219	910	^	39.1	82	2.9	191	

ACT 9 θ = 0 L/D = 10

#	M	I	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
35	63.58	10.16	1.02	3.81	321	-1.0	0.5	1.1	1195	0	-	-	15	-	-	4,5
34	63.56	10.16	1.02	3.81	321	-1.3	-2.3	2.6	1211	128	19.0	21.0	31	12.4	290	1
33	63.63	10.16	1.03	3.81	321	-1.0	1.0	1.4	1237	313	12.1	15.0	30	6.0	78	
32	63.66	10.16	1.02	3.81	321	-0.5	0.7	0.8	1243	501	18.5	23.0	20	7.4	112	
31	63.68	10.17	1.02	3.81	321	-0.1	0.9	0.9	1366	907	20.5	21.8	26	11.3	179	
30	63.61	10.15	1.02	3.81	321	5.6	2.6	6.1	1384	868	24.4	27.2	47	12.4	18	1

ACT 10 $\theta = 0$ L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
94	62.94	10.26	1.02	5.16	302	-7.6	-3.1	8.2	1294	0	-	-	4	-	-	1
100	63.57	10.17	1.03	5.21	286	9.1	2.2	9.3	1312	0	-	-	17	-	-	1
96	64.33	10.17	1.03	5.44	293	-3.7	-7.5	8.4	1318	0	-	-	^	-	-	1
98	63.65	10.06	1.04	5.38	286	4.5	-1.7	4.8	1374	0	-	-	^	-	-	1
143	64.30	10.16	1.02	5.08	286	0.5	0.3	0.6	1383	0	-	-	^	-	-	
147	60.85	10.15	0.97	5.08	286	-0.3	1.5	1.5	1402	0	-	-	^	-	-	3
99	63.73	10.16	1.02	5.38	286	-2.7	7.6	8.0	1405	0	-	-	^	-	-	1
145	64.24	10.16	1.02	5.08	286	-0.8	0.3	0.8	1410	^	^	^	^	^	^	2
142	64.00	10.17	1.02	5.08	286	0.3	1.0	1.0	1414	290	^	^	78	^	^	
141	64.03	10.14	1.02	5.08	286	-2.0	0.8	2.1	1416	0	-	-	^	-	-	4,5
146	64.28	10.17	1.02	5.08	286	-2.3	-0.3	2.3	1418	0	-	-	5	-	-	4,5
144	63.71	10.15	1.01	5.08	286	0.5	0.5	0.7	1422	255	^	^	33	^	^	
140	64.31	10.15	1.02	5.08	286	0.0	-0.5	0.5	1422	375	^	^	40	^	^	
102	63.56	10.17	1.03	5.21	302	-1.0	1.0	1.4	1439	^	^	^	30	^	^	2
139	64.18	10.16	1.02	5.08	286	0.0	-0.3	0.3	1450	251	^	^	^	^	^	
138	64.10	10.17	1.02	5.08	286	-0.8	0.0	0.8	1454	628	^	^	49	^	^	
103	63.79	10.06	1.02	5.21	302	0.3	0.5	0.6	1464	0	-	-	^	-	-	2
97	63.40	10.13	1.01	5.44	293	8.4	-7.6	11.3	1528	0	-	-	^	-	-	1
148	63.91	10.15	1.02	5.08	286	0.0	-0.3	0.3	1531	772	^	^	61	^	^	
153	64.25	10.16	1.02	5.08	286	0.0	0.5	0.5	1765	1286	^	^	70	^	^	

ACT 11 $\theta = 60$ L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
225	63.93	10.08	1.02	2.54	340	-1.0	-0.5	1.1	1268	0	-	-	34	-	-	4,8
223	64.25	10.21	1.02	2.54	340	^	^	^	1294	0	-	-	23	-	-	1
216	63.91	10.06	1.03	2.54	340	0.5	-0.5	0.7	1304	367	16.3	^	78	^	^	4,8
218	64.00	10.19	1.02	2.54	340	-0.5	-1.3	1.4	1307	0	-	-	41	-	-	4,8
222	64.07	10.36	1.02	2.54	340	-1.3	0.5	1.4	1309	0	-	-	50	-	-	3,8
221	64.37	10.20	1.02	2.54	340	-1.8	-2.0	2.7	1310	0	-	-	55	-	-	1
220	63.86	10.11	1.03	2.54	340	0.0	0.8	0.8	1323	581	18.7	^	98	^	^	8
217	64.28	10.32	1.02	2.54	340	1.0	-0.5	1.1	1329	^	^	^	73	^	^	2,8
183	63.90	10.15	1.02	2.54	340	-0.8	-0.8	1.1	1333	0	-	-	40	-	-	
177	64.01	10.16	1.02	2.54	340	-0.5	0.0	0.5	1339	0	-	-	42	-	-	4
185	64.30	10.15	1.02	2.54	340	1.5	0.3	1.5	1339	427	^	18.8	80	^	^	
224	64.00	10.18	1.03	2.54	340	0.8	-0.8	1.1	1352	586	^	^	98	^	^	7,8
184	64.20	10.16	1.02	2.54	340	-0.3	0.0	0.3	1358	^	^	^	58	^	^	
182	63.82	10.16	1.02	2.54	340	1.3	2.3	2.6	1361	151	^	15.6	76	^	^	1
180	63.68	10.16	1.02	2.54	340	-1.3	0.3	1.3	1361	212	^	7.8	65	^	^	
186	64.10	10.15	1.02	2.54	340	-2.8	-0.8	2.9	1365	0	-	-	^	-	-	1
178	63.82	10.26	1.01	2.54	340	-1.0	-0.5	1.1	1366	^	^	^	85	^	^	
181	64.16	10.16	1.02	2.54	340	-1.0	1.3	1.6	1370	171	^	12.0	155	^	^	
179	63.72	10.17	1.02	2.54	340	0.0	-1.8	1.8	1396	678	^	16.4	70	^	^	
226	63.99	10.15	1.02	2.54	340	0.3	-0.3	0.4	1504	907	^	12.8	111	^	^	8
234	63.47	10.17	1.02	2.54	364	^	^	^	1538	^	^	^	118	^	^	1

ACT 12 $\theta = 0$ L/D = 20

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
24	64.85	16.06	0.81	2.54	340	-0.8	0.5	0.9	990	0	-	-	28	-	-	
25	64.63	16.07	0.81	2.54	340	0.0	0.6	0.6	998	125	19.8	19.8	32	3.9	224	
23	64.84	16.06	0.81	2.54	340	0.0	1.0	1.0	1011	428	26.7	25.2	28	19.3	311	
22	64.67	16.06	0.81	2.54	340	-0.7	0.6	0.9	1090	776	^	37.2	40	2.6	49	
21	64.70	16.06	0.81	2.54	340	-2.0	-0.5	2.0	1154	886	^	40.4	58	8.6	206	6

ACT 13 $\theta = 0$ L/D = 20

#	M	L	D	T	H	α	β	δ	V_s	V_1	M_r'	M_r''	Δ	λ	ϕ	Remarks
38	64.81	16.20	0.81	3.81	321	-0.3	1.0	1.6	1130	0	-	-	38	-	-	3
40	64.64	16.20	0.81	3.81	321	-1.3	0.8	1.5	1148	0	-	-	^	-	-	4
39	64.67	16.19	0.81	3.81	321	-1.1	0.5	1.2	1160	338	16.3	16.5	20	8.5	226	
37	64.73	16.19	0.81	3.81	321	-0.8	0.5	0.9	1234	834	29.5	29.7	17	4.5	153	
36	64.82	16.19	0.81	3.81	321	1.0	0.9	1.3	1327	1025	34.2	34.6	42	4.9	9	

ACT 14 $\theta = 0$ L/D = 20

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
173	63.99	15.99	0.87	5.08	302	0.0	0.3	0.3	1270	0	-	-	^	-	-	
164	64.69	16.19	0.81	5.08	286	1.3	0.3	1.3	1296	0	-	-	^	-	-	3
162	64.76	16.19	0.81	5.08	286	0.3	0.8	0.8	1296	0	-	-	20	-	-	4,5
161	64.74	16.20	0.81	5.08	293	0.5	0.0	0.5	1297	499	^	13.4	40	^	^	
158	64.75	16.20	0.81	5.08	286	-0.3	0.0	0.3	1315	215	^	11.1	28	^	^	2
174	64.86	16.06	0.82	5.08	293	0.0	0.3	0.3	1316	^	^	^	60	^	^	
163	64.70	16.19	0.81	5.08	286	0.0	0.5	0.5	1318	383	^	13.3	10	^	^	
165	64.89	16.19	0.81	5.08	286	0.0	1.0	1.0	1322	^	^	^	23	^	^	
176	64.56	16.06	0.82	5.08	302	-0.5	0.0	0.5	1326	234	^	12.0	40	^	^	
156	64.67	16.20	0.81	5.08	293	0.5	1.0	1.1	1327	502	^	16.7	5	^	^	
175	64.63	16.06	0.81	5.08	293	-0.3	-1.0	1.0	1328	378	^	12.7	10	^	^	
160	64.50	16.19	0.81	5.08	293	0.3	0.3	0.4	1329	^	^	^	0	^	^	
166	64.86	16.19	0.81	5.08	286	0.0	0.3	0.3	1331	^	^	^	21	^	^	
167	64.69	16.19	0.81	5.08	286	0.0	0.8	0.8	1347	796	^	19.0	10	^	^	
159	64.75	16.20	0.81	5.08	286	0.0	0.3	0.3	1361	^	^	^	0	^	^	
157	64.80	16.19	0.81	5.08	293	0.0	-0.3	0.3	1364	842	21.0	^	50	^	^	
155	64.88	16.20	0.82	5.08	286	0.0	0.5	0.5	1400	948	^	23.7	43	^	^	
168	64.77	16.19	0.81	5.08	293	-0.5	-0.5	0.7	1500	^	^	^	30	^	^	
170	64.57	16.20	0.81	5.08	293	1.8	-0.5	1.8	1566	1183	^	23.5	^	^	^	

ACT 15 θ = 60 L/D = 20

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
208	64.20	15.75	0.81	2.54	340	0.5	0.3	0.6	1227	0	-	-	38	-	-	
211	64.63	16.05	0.81	2.54	340	-0.3	0.0	0.3	1234	0	-	-	26	-	-	
215	64.33	16.05	0.81	2.54	340	0.5	-0.3	0.6	1242	707	22.3	^	46	^	^	
213	64.40	16.04	0.81	2.54	340	0.8	-0.3	0.8	1260	735	21.3	^	48	^	^	
214	64.56	16.04	0.81	2.54	340	0.0	0.8	0.8	1261	0	-	-	32	-	-	
210	64.75	16.06	0.31	2.54	340	0.3	0.3	0.4	1263	564	^	^	69	^	^	
212	64.62	16.05	0.81	2.54	340	1.0	1.0	1.4	1271	725	18.8	^	61	^	^	

ACT 16 θ = 45 L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
240	64.37	10.25	1.02	2.55	364	-0.8	-0.1	0.8	1061	0	-	-	29	-	-	
239	64.00	10.25	1.02	2.55	364	-0.9	-0.4	1.0	1096	199	8.1	10.7	51	35.0	0	
238	64.11	10.25	1.02	2.55	364	-0.4	0.2	0.4	1138	536	11.8	14.2	0	21.6	356	
232	64.31	10.24	1.02	2.56	364	1.1	1.0	1.5	1187	744	16.7	19.1	94	32.1	353	
233	64.42	10.24	1.02	2.56	364	-0.9	0.0	0.9	1205	815	19.1	21.1	99	20.2	0	
231	64.33	10.24	1.02	2.54	364	-0.9	-0.5	1.0	1213	857	17.7	19.1	69	15.0	356	
235	64.31	10.24	1.02	2.56	364	0.5	0.5	0.7	1431	1166	30.3	30.2	120	6.0	354	
234	64.29	10.24	1.02	2.56	364	1.0	0.6	1.2	1433	1161	29.5	31.0	113	8.9	354	
237	64.40	10.25	1.02	2.55	364	-0.5	-2.1	2.1	1542	1280	30.0	32.4	129	5.7	43	
236	63.88	10.25	1.02	2.56	364	0.8	-0.2	0.8	1828	1575	32.2	32.7	206	1.0	262	

ACT 17 θ = 0 L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
246	63.82	10.22	1.02	3.84	321	-0.2	0.0	0.2	1196	0	-	-	53	-	-	
245	64.02	10.22	1.02	3.83	321	-0.2	0.0	0.2	1217	139	9.9	13.8	26	10.0	348	
241	64.22	10.24	1.02	3.85	340	-0.6	-0.3	0.6	1244	507	12.5	17.1	55	7.7	214	
242	64.15	10.23	1.02	3.83	321	0.2	0.8	0.8	1246	530	12.1	14.0	^	2.9	83	
243	64.30	10.23	1.02	3.81	340	-0.2	0.0	0.2	1469	1200	22.0	25.1	86	0.2	213	
244	64.09	10.24	1.02	3.83	340	-1.0	0.0	1.0	1809	1548	31.0	32.7	125	0.7	61	

ACT 18 θ = 0 L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	φ	Remarks
254	64.36	9.69	0.97	3.83	340	0.1	0.0	0.1	1095	0	-	-	^	-	-	
253	64.37	9.69	0.97	3.82	321	0.1	-0.1	0.2	1097	54	8.6	10.3	1	7.4	0	
252	64.73	9.69	0.97	3.81	340	0.2	-0.2	0.3	1097	^	8.1	^	9	^	^	
251	64.58	9.69	0.97	3.82	321	0.4	0.2	0.4	1125	478	11.6	10.7	17	4.3	299	
250	64.42	9.67	0.97	3.82	321	-0.4	0.2	0.5	1185	868	19.8	16.5	37	1.4	173	
249	64.44	9.69	0.97	3.83	332	0.6	-0.1	0.6	1257	1033	25.3	26.4	45	0.5	104	
247	64.00	9.68	0.97	3.84	321	-0.1	0.0	0.1	1258	1045	23.1	22.5	34	1.2	341	
248	64.40	9.67	0.97	3.83	321	-0.1	-0.3	0.4	1269	1047	26.6	30.5	54	0.7	28	
255	64.80	9.69	0.97	3.82	340	-0.5	0.3	0.6	1377	1194	29.2	29.0	70	0.7	249	
256	64.54	9.68	0.97	3.82	340	0.3	0.0	0.3	1627	1485	31.7	31.9	107	0.4	174	
257	64.28	9.68	0.97	3.83	340	-1.8	0.5	1.8	1789	1586	32.4	34.0	111	1.4	80	

ACT 19 $\theta = 60$ L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
264	64.30	10.25	1.02	2.54	364	-0.4	-0.4	0.5	1201	0	-	-	14	-	-	
263	64.43	10.26	1.02	2.53	364	0.0	0.1	0.1	1227	204	8.6	8.5	68	39.3	0	
262	64.29	10.26	1.02	2.56	351	0.0	0.6	0.6	1282	509	13.6	15.0	97	37.3	0	
261	64.06	10.25	1.02	2.53	364	0.4	0.7	0.8	1360	768	20.7	22.4	96	23.0	1	
265	64.04	10.22	1.02	2.54	364	0.1	-0.2	0.2	1471	997	18.5	20.2	98	16.1	2	
260	64.34	10.25	1.02	2.55	340	-0.5	0.4	0.7	1489	903	19.6	20.1	118	11.7	2	
259	64.20	10.26	1.02	2.54	351	-0.8	0.1	0.8	1647	1145	16.8	18.3	156	5.2	6	
258	64.35	10.25	1.02	2.53	364	^	^	1.5	1800	1285	13.6	^	171	^	^	

ACT 20 $\theta = 60$ L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
268	64.35	9.69	0.97	2.54	387	-0.8	0.5	0.9	1201	0	-	-	59	-	-	
266	64.46	9.70	0.97	2.53	364	-0.1	0.1	0.2	1331	898	21.4	22.6	91	16.1	1	
267	64.42	9.69	0.97	2.53	364	-1.1	0.5	1.2	1758	1399	22.9	24.0	176	2.6	350	

ACT 1.1 $\theta = 0$ L/D = 20

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
89	64.84	16.19	0.81	1.91	364	0.0	0.5	0.5	856	0	-	-	^	-	-	4
92	64.57	16.19	0.81	1.91	364	0.5	0.8	0.9	865	0	-	-	126	-	-	
91	64.68	16.19	0.81	1.91	364	-1.9	1.1	2.2	882	445	^	24.4	34	5.2	93	6
93	64.65	16.19	0.81	1.91	364	-0.8	0.6	1.0	886	555	^	33.7	^	4.1	177	

ACT 3.1 $\theta = 0$ L/D = 20

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
56	64.67	16.19	0.81	3.18	321	-0.5	0.0	0.5	1022	0	-	-	20	-	-	4
59	64.73	16.19	0.81	3.18	321	-0.8	0.8	1.1	1025	0	-	-	^	-	-	6
57	64.76	16.19	0.81	3.18	321	-0.3	0.5	0.6	1038	0	-	-	^	-	-	4
60	64.63	16.19	0.81	3.18	321	0.5	0.8	0.9	1045	0	-	-	^	-	-	
55	64.75	16.19	0.81	3.18	321	0.0	0.3	0.3	1061	503	25.0	^	^	^	^	
50	64.72	16.19	0.81	3.18	321	^	^	^	1081	^	24.0	^	35	^	^	1,2
53	64.77	16.19	0.81	3.18	321	-0.2	0.8	0.8	1087	597	^	28.7	^	3.2	14	

ACT 3.2 $\theta = 0$ L/D = 10

#	M	L	D	T	H	α	β	δ	V_s	V_r	M_r'	M_r''	Δ	λ	ϕ	Remarks
65	63.77	10.15	1.02	3.18	321	-0.6	0.8	1.0	1146	566	26.9	25.5	^	2.8	148	
63	63.90	10.16	1.02	3.18	321	1.2	3.6	3.8	1185	684	^	32.6	25	11.1	70	1
61	63.60	10.19	1.02	3.18	321	-1.0	5.6	5.7	1198	623	20.8	21.0	^	19.4	101	1
64	63.57	10.15	1.02	3.18	321	-0.7	3.7	3.8	1201	638	^	29.1	35	8.0	70	1
62	63.69	10.19	1.02	3.18	321	-0.6	4.2	4.3	1214	662	^	22.4	^	11.3	84	1

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APPENDIX B

DERIVED V_s, V_r CURVES

APPENDIX B: DERIVED V_s, V_r CURVES

This section is comprised of the V_s, V_r curves derived from the experimental data of Appendix A. The standard form used to represent dependence of residual velocity on striking velocity is

$$V_r = \begin{cases} 0, \text{ if } 0 \le V_s \le V_\ell \\ a(V_s{}^p - V_\ell{}^p)^{1/p}, \text{ if } V_s > V_\ell \end{cases}$$

with the constraints, $p > 1$ and $0 \le a \le 1$.

Values for the limit velocity, V_ℓ, and the other parameters, a and p, are derived via a non-linear least squares algorithm which extracts an optimal adaptation of the form to the data. For an elaboration on the above form and related methodology, see BRL Report 1852[2]. There is available at the Terminal Ballistics Division of the BRL a program in BASIC, called "Impact", which contains the algorithm and provides graphic capability; we have used this program to derive parameters for our various data sets and to generate the following figures. V_s, V_r data corresponding to rounds for which the total yaw of the penetrator at impact exceeded 2 1/2° was excluded from this analysis. In each figure "S" denotes the root mean square error associated with the fit of form to data.

[2]*Lambert, J. P. and Jonas, G. H., "Towards Standardization in Terminal Ballistic Testing: Velocity Representation", BRL Report 1852, January 1976 (AD A021389).*

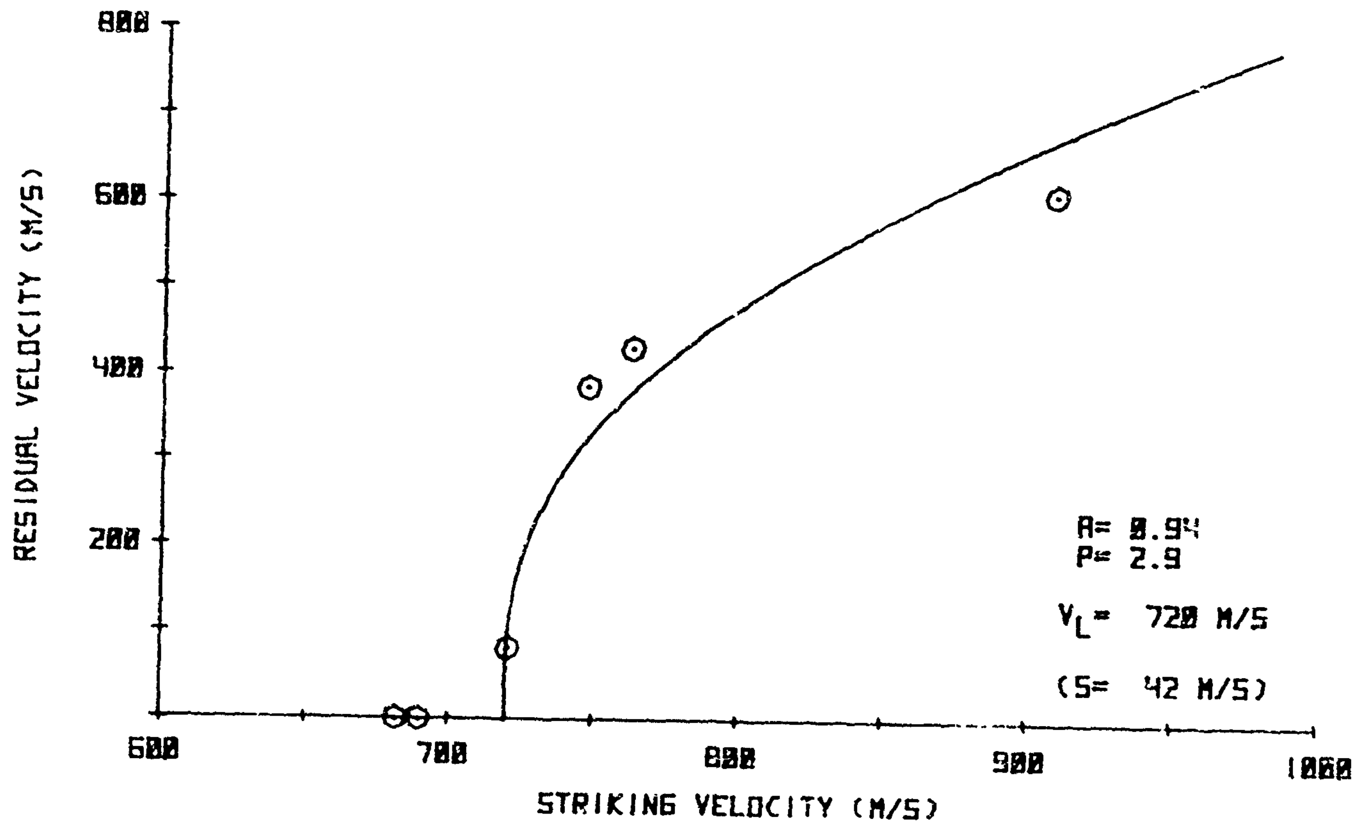

FIGURE B-1. V_S/V_R CURVE AND DATA FOR ACT 1

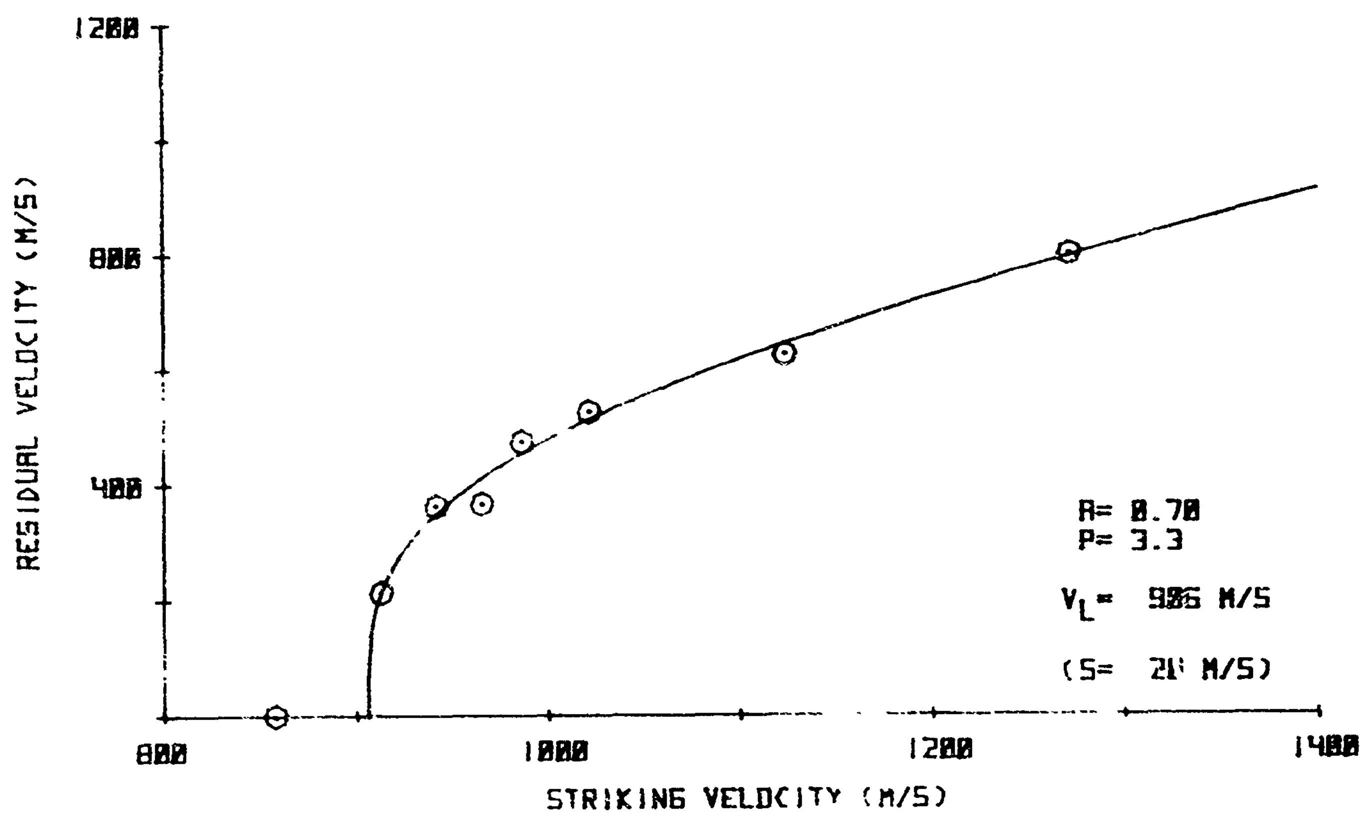

FIGURE B-2. V_S, V_R CURVE AND DATA FOR ACT 2

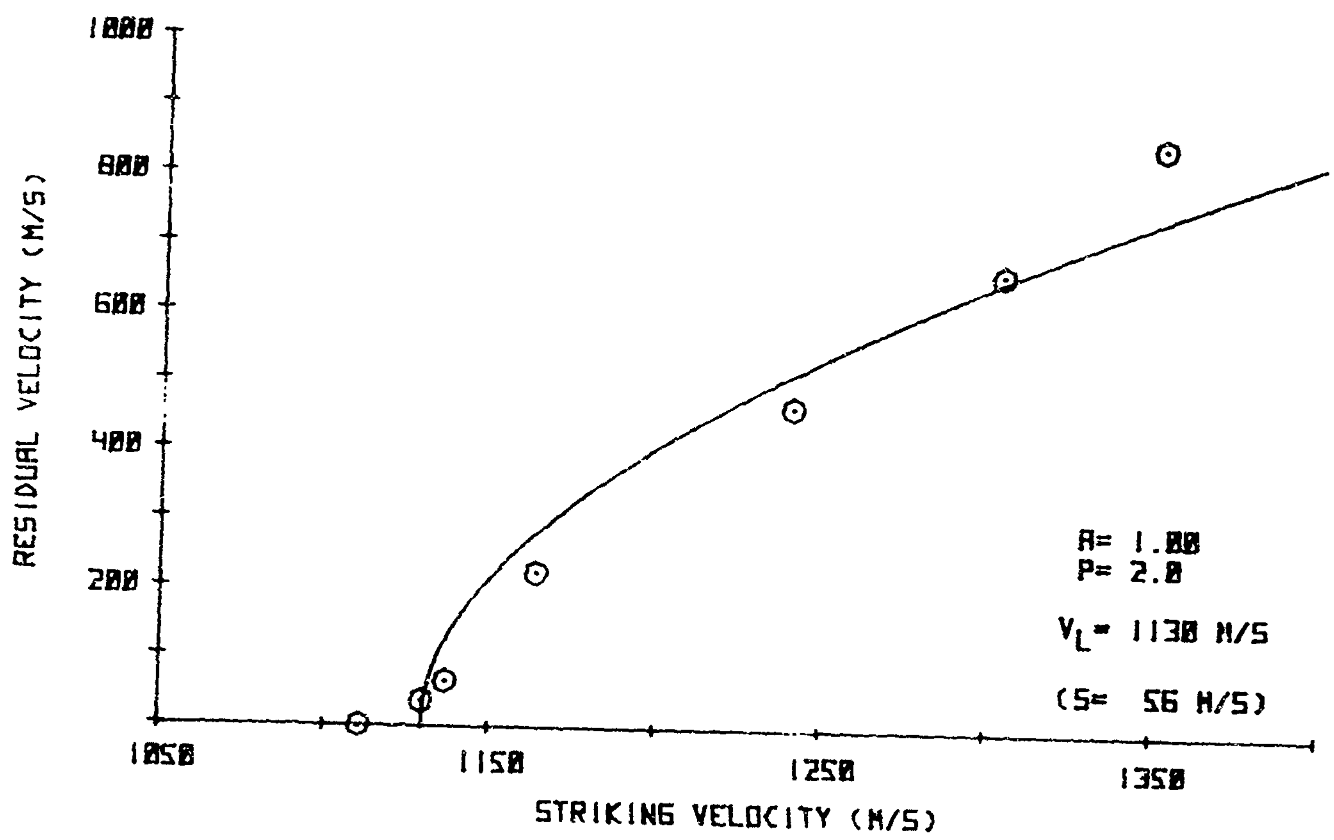

FIGURE B-3. V_S/V_R CURVE AND DATA FOR ACT 3

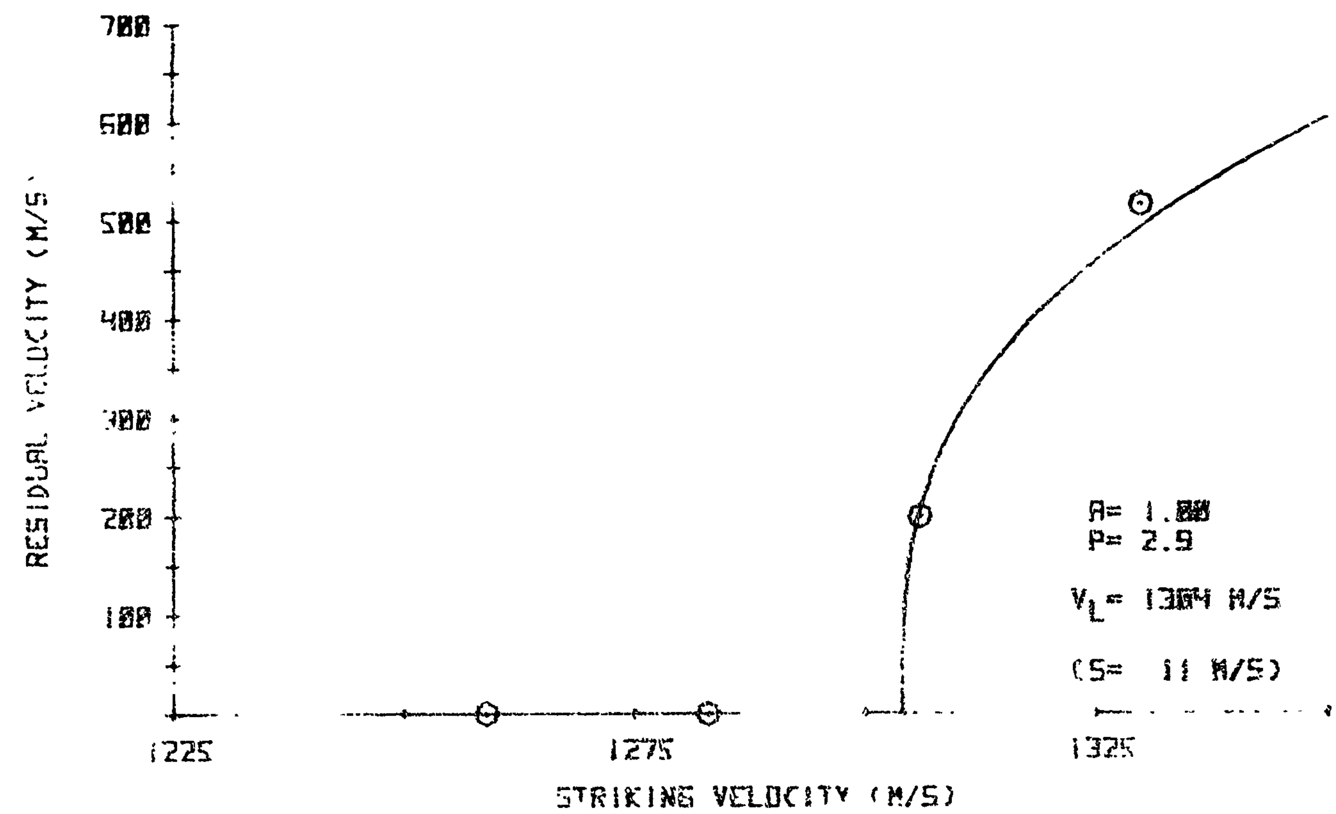

FIGURE B-4. V_S, V_R CURVE AND DATA FOR RCT 4

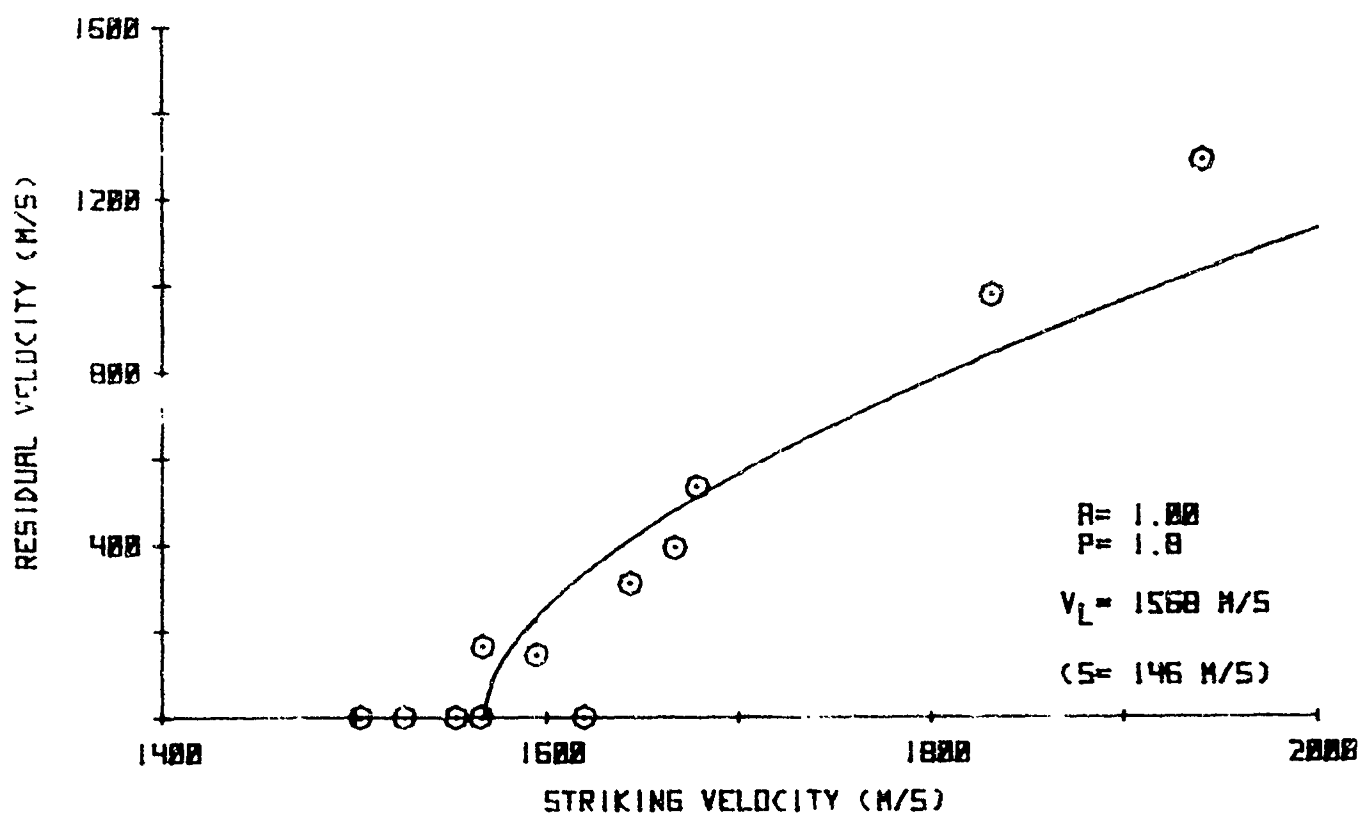

FIGURE B-5. V_S/V_R CURVE AND DATA FOR ACT 5

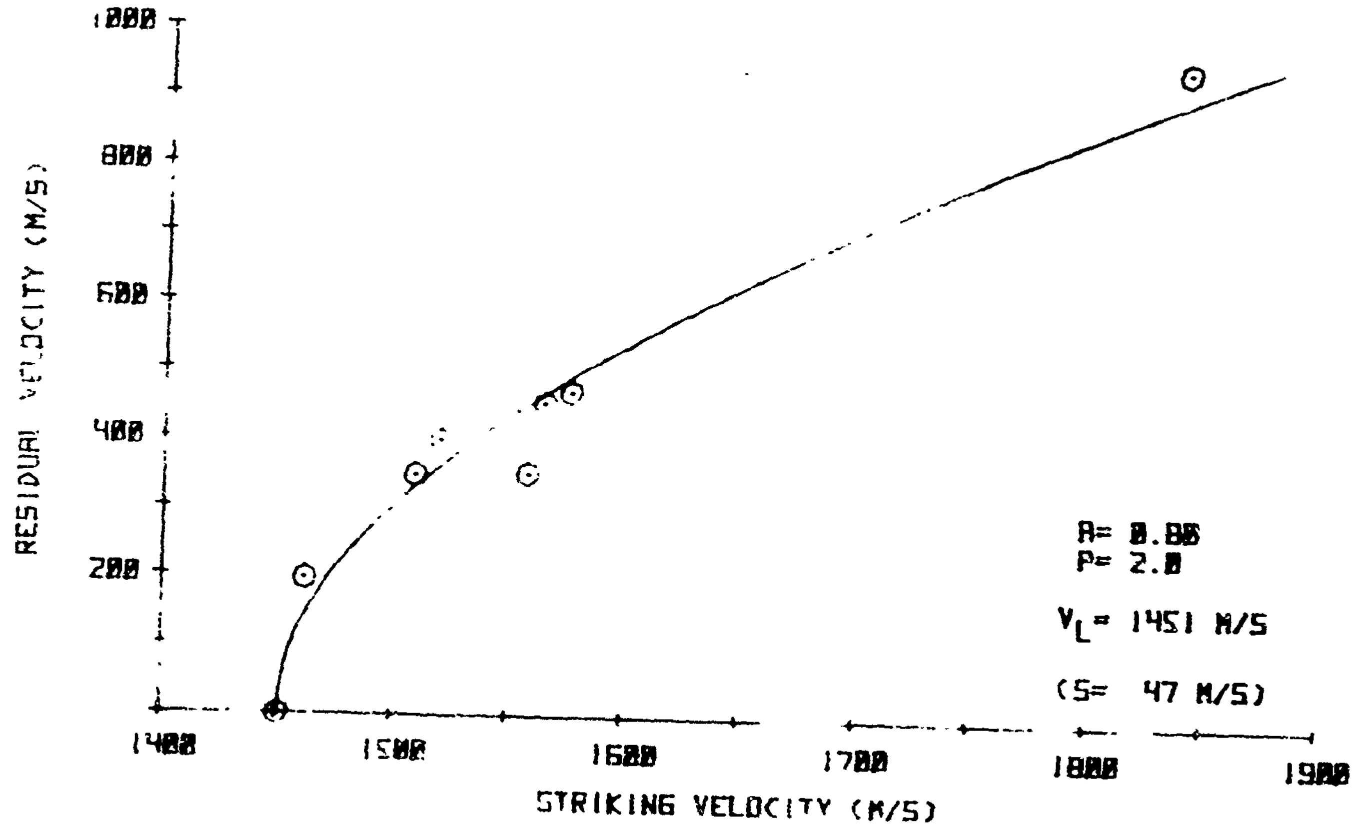

FIGURE B-6. V_S/V_R CURVE AND DATA FOR ACT 6

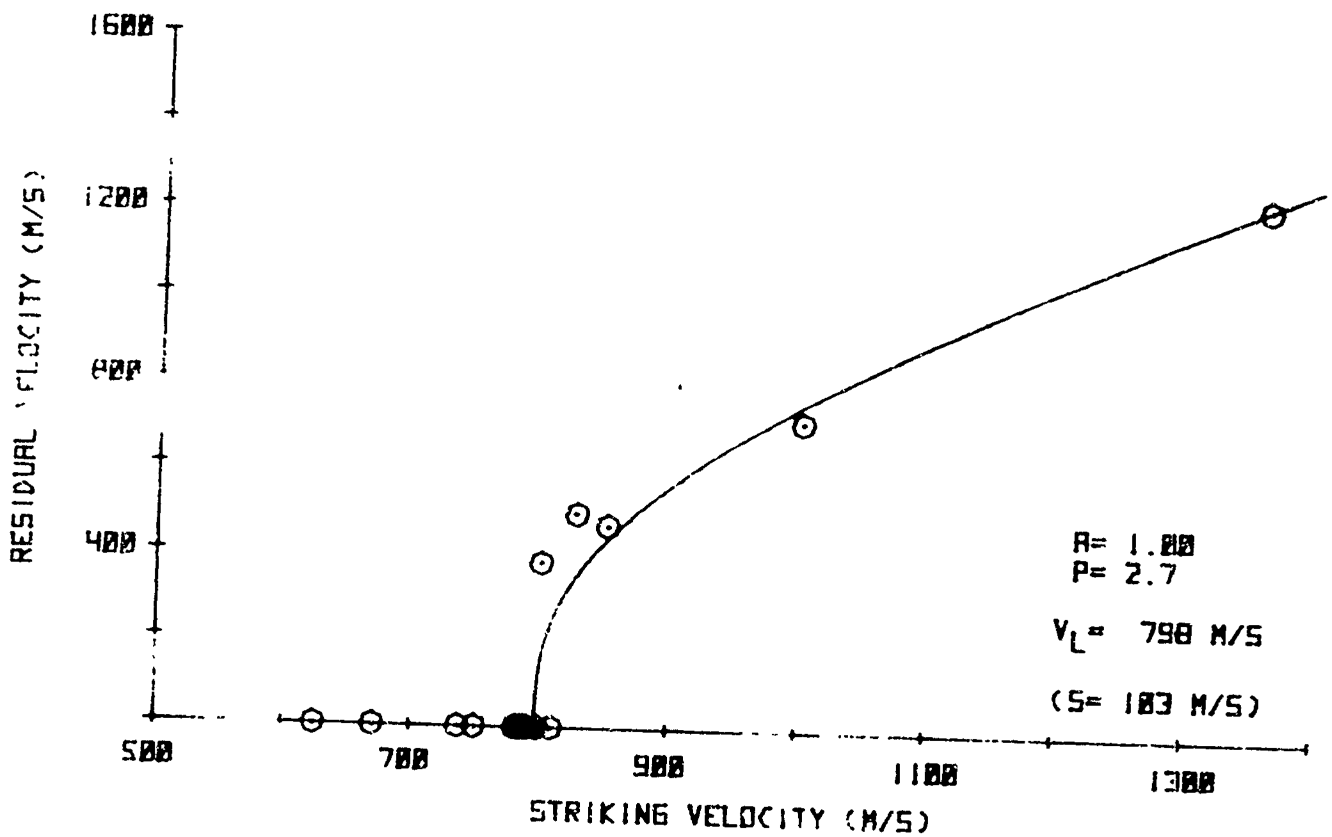

FIGURE B-7. V_S, V_R CURVE AND DATA FOR ACT 7

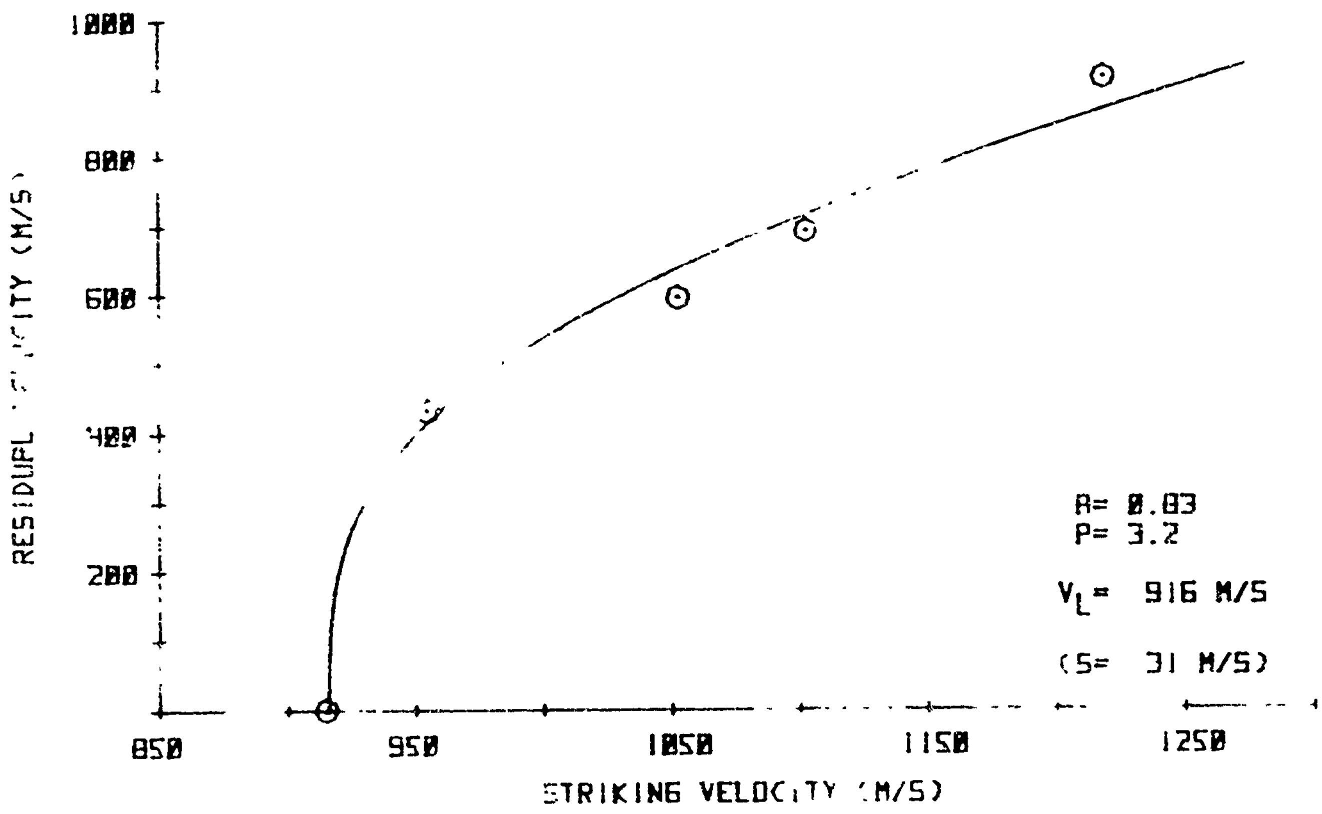

FIGURE B-8. V_S, V_R CURVE AND DATA FOR ACT B

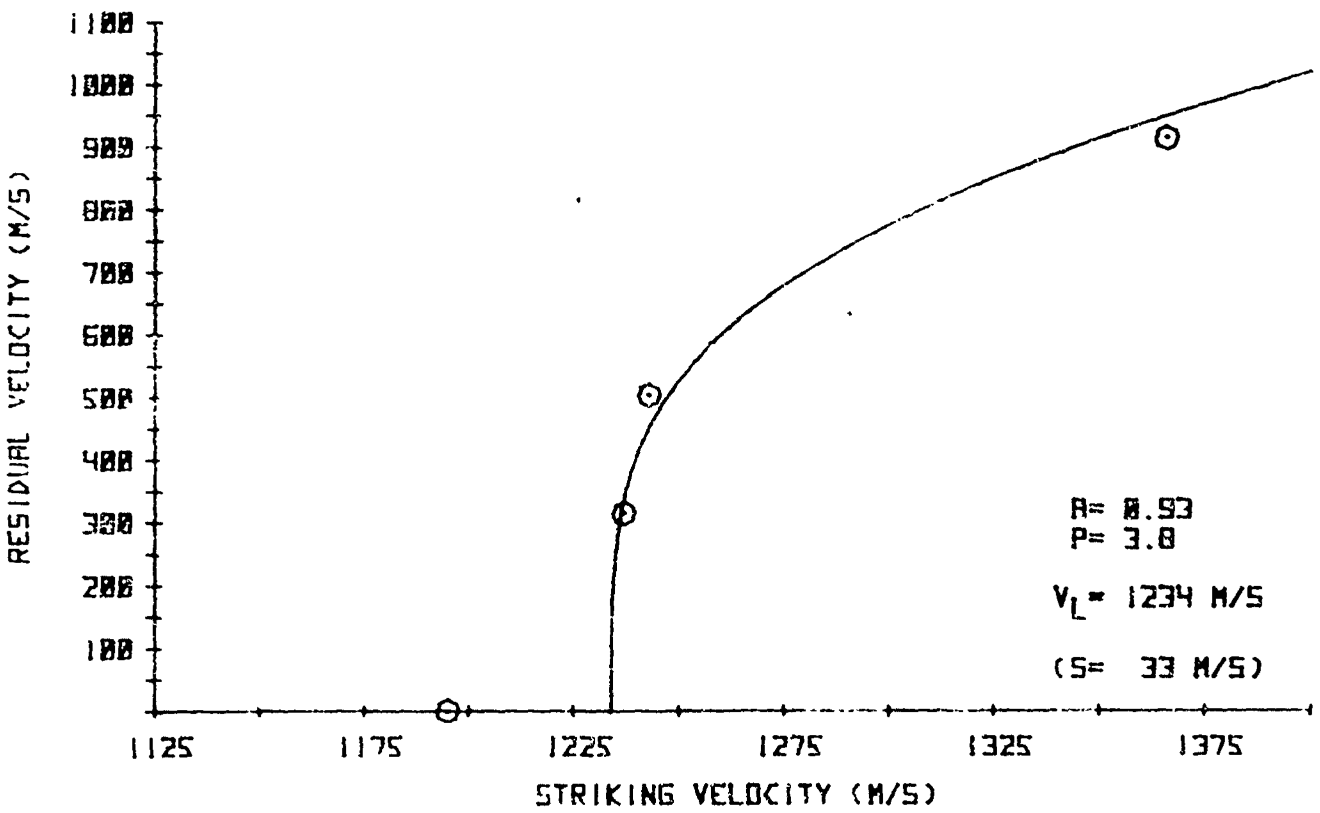

FIGURE B-9. V_S/V_R CURVE AND DATA FOR ACT 9

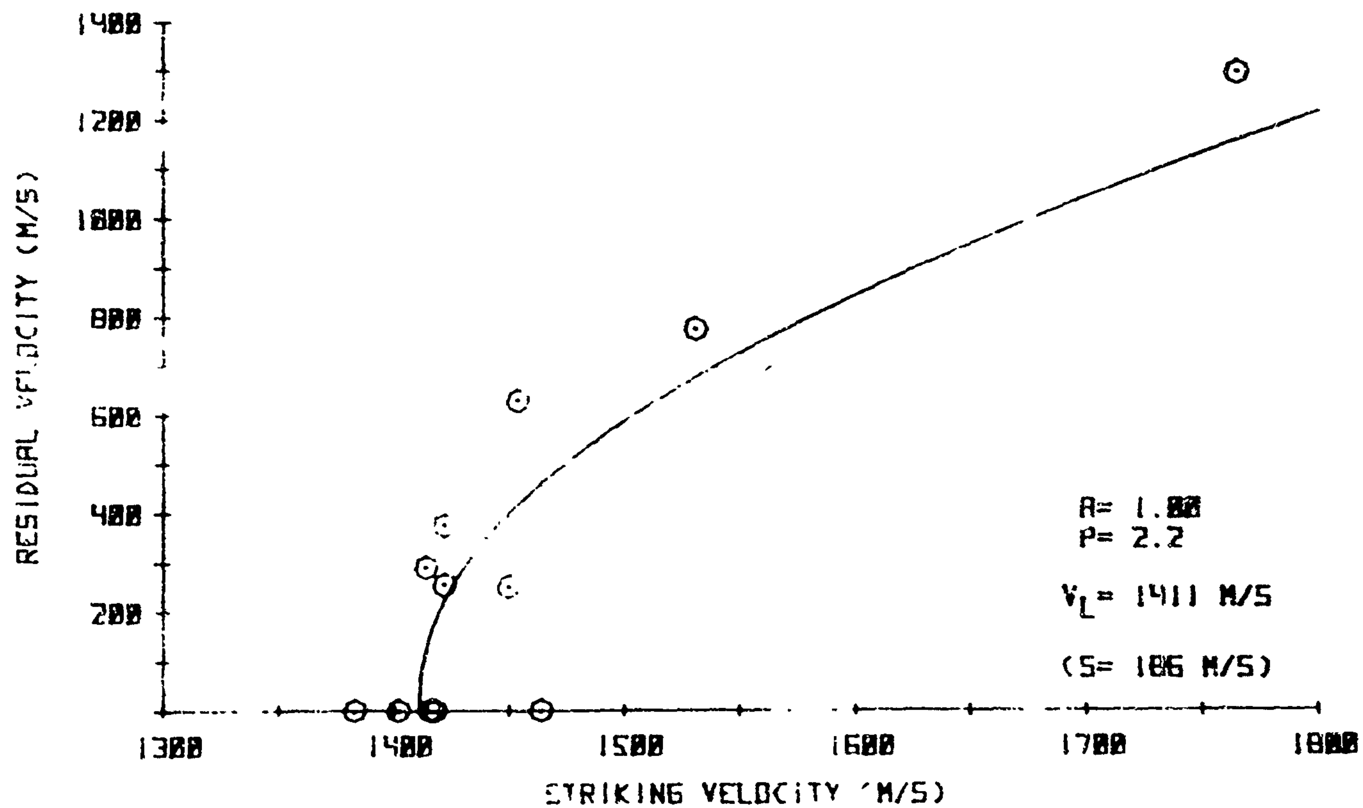

FIGURE B-10. V_S, V_R CURVE AND DATA FOR ACT 10

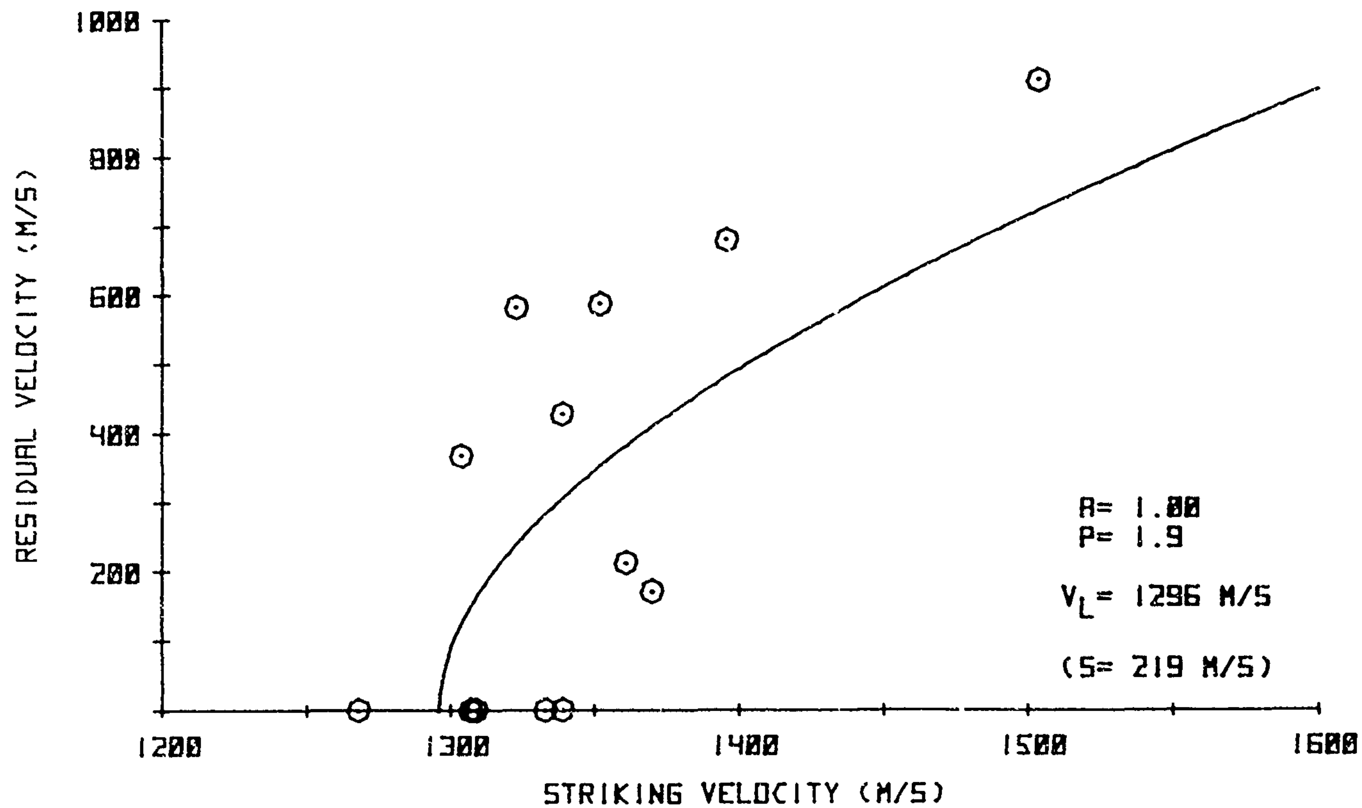

FIGURE B-11. V_S, V_R CURVE AND DATA FOR ACT II

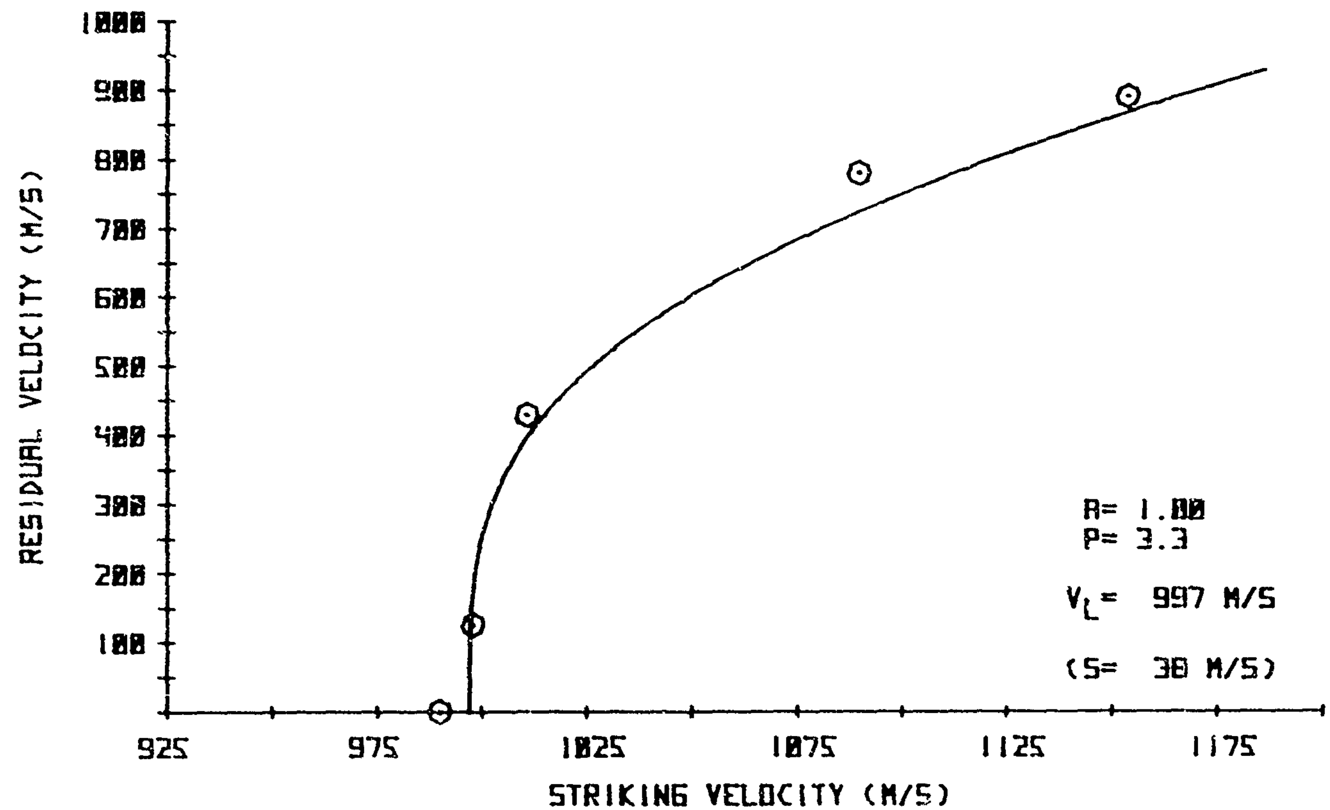

FIGURE B-12. V_S/V_R CURVE AND DATA FOR ACT 12

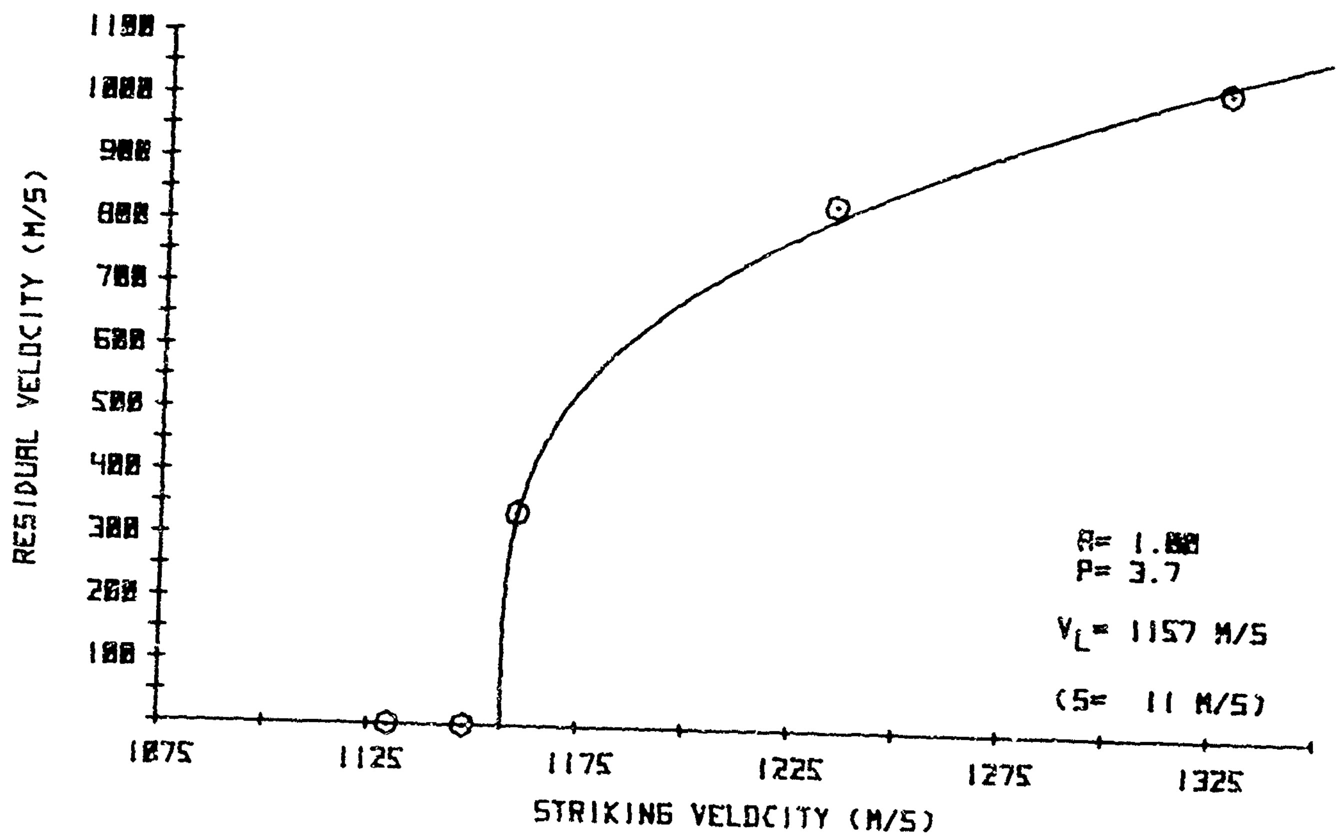

FIGURE B-13. V_S, V_R CURVE AND DATA FOR ACT 13

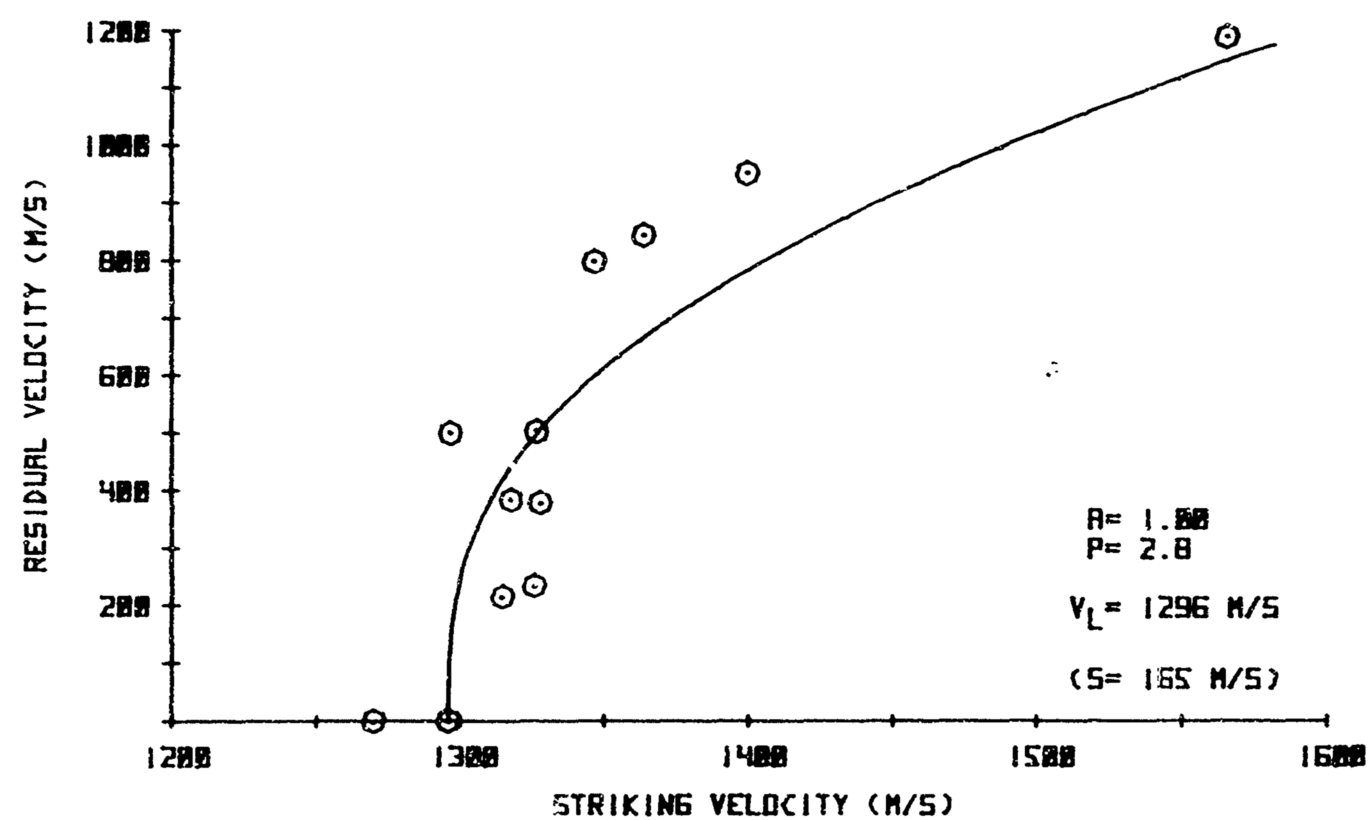

FIGURE B-14. V_S/V_R CURVE AND DATA FOR ACT 14

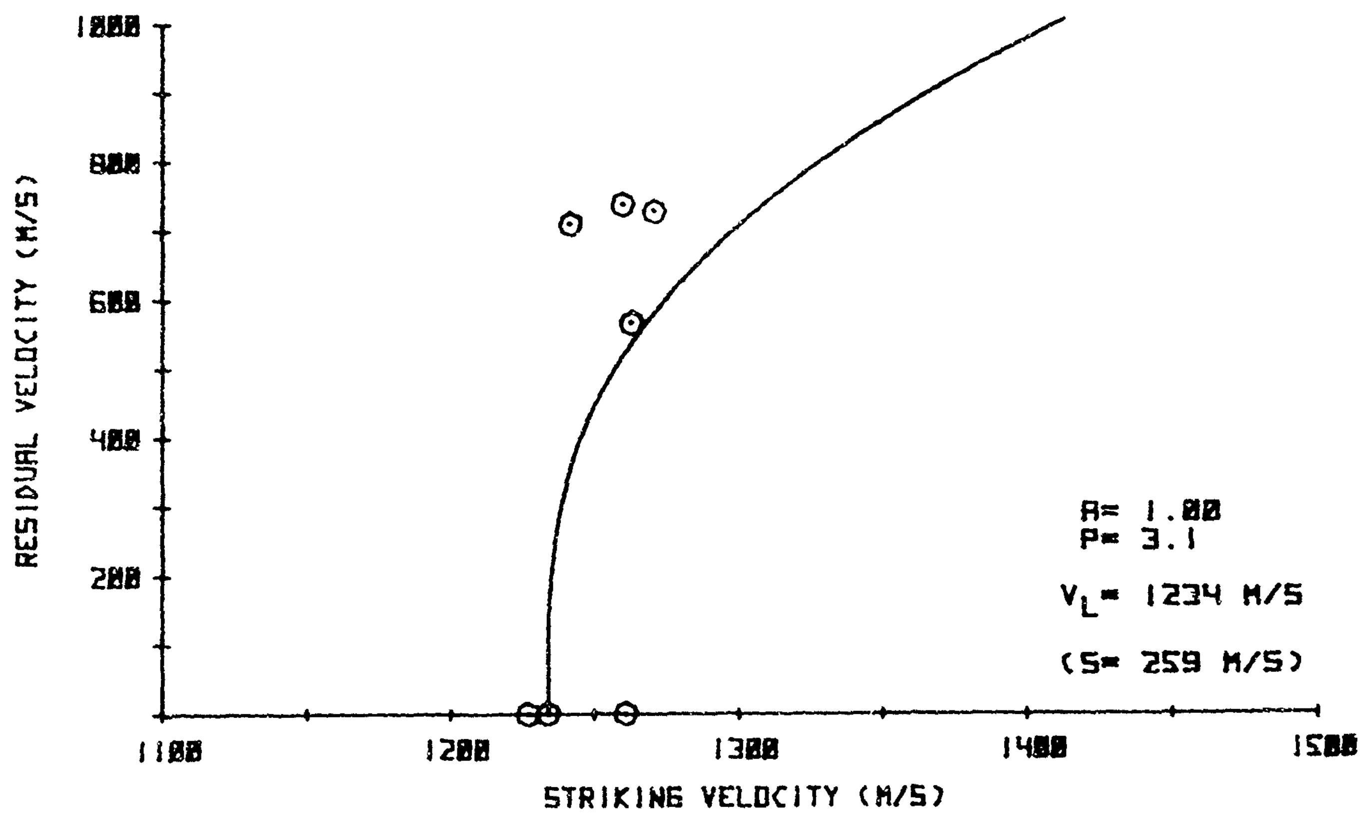

FIGURE B-15. V_S, V_R CURVE AND DATA FOR ACT 15

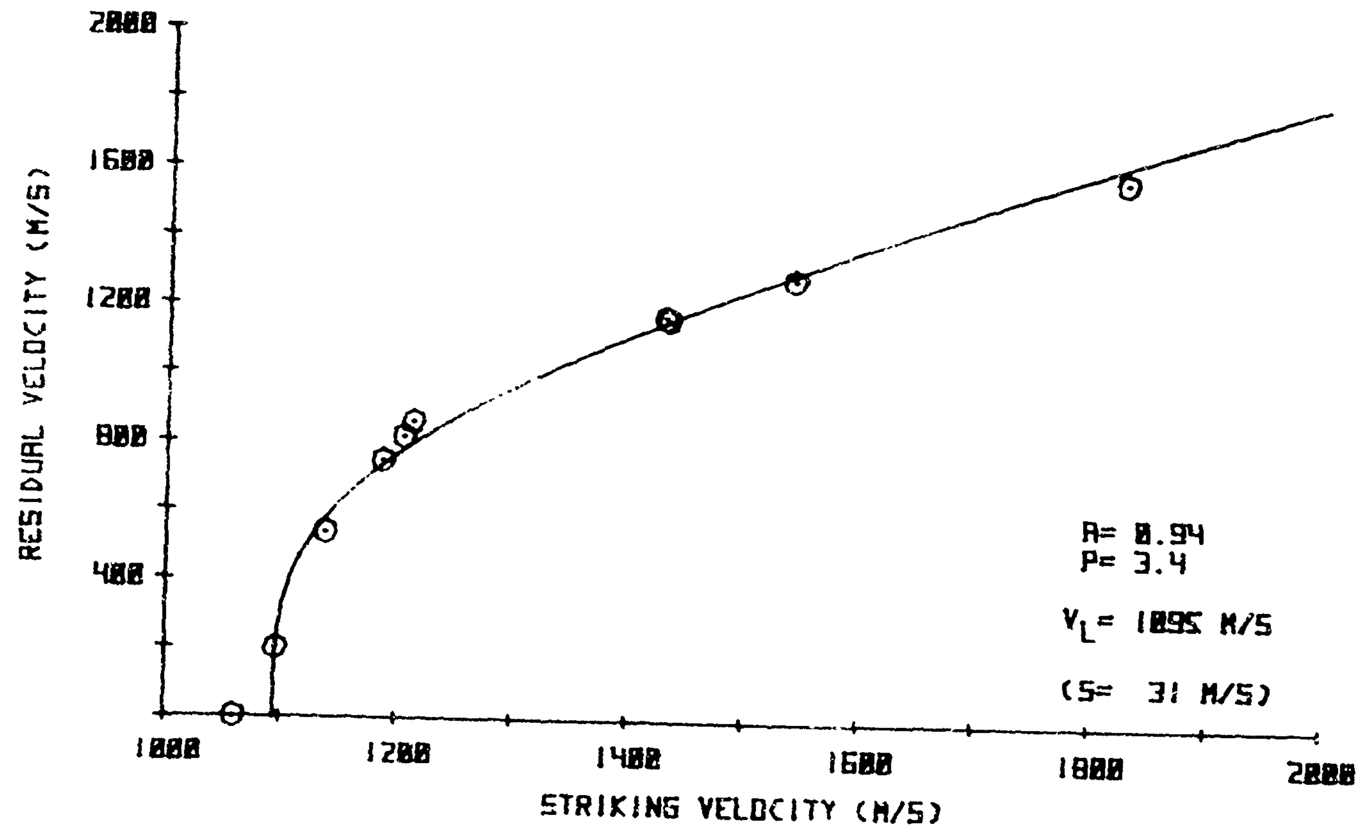

FIGURE B-16. V_S/V_R CURVE AND DATA FOR ACT 16

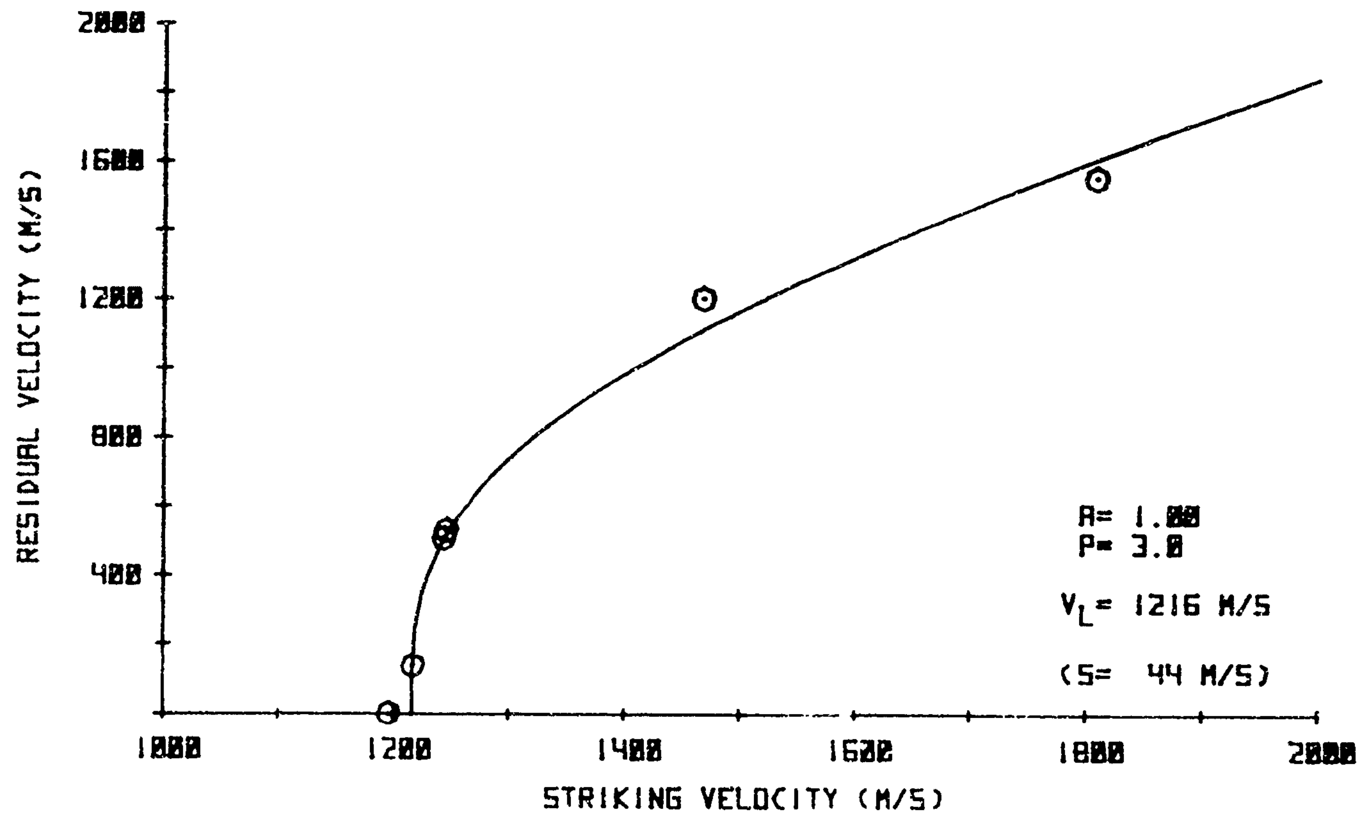

FIGURE B-17. V_S/V_R CURVE AND DATA FOR ACT 17

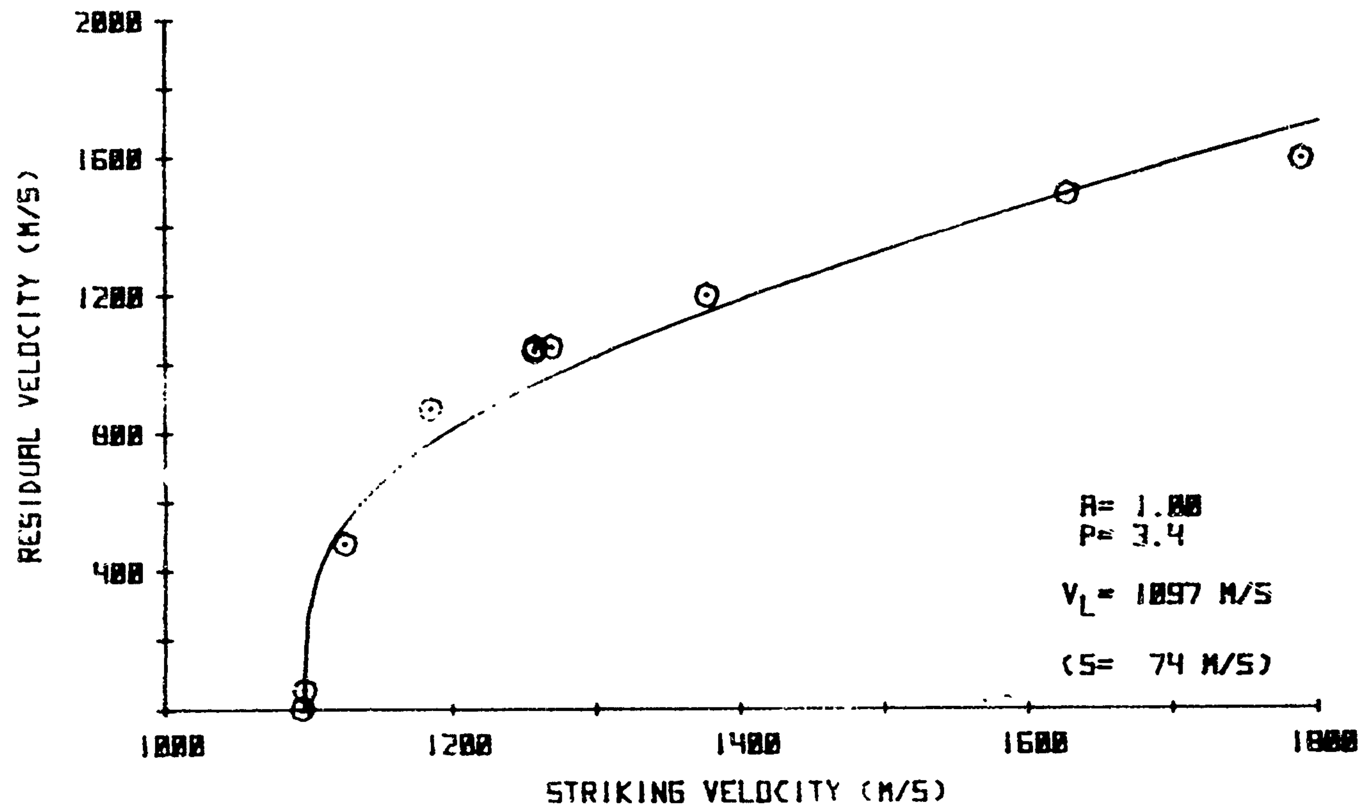

FIGURE B-18. V_S/V_R CURVE AND DATA FOR ACT 18

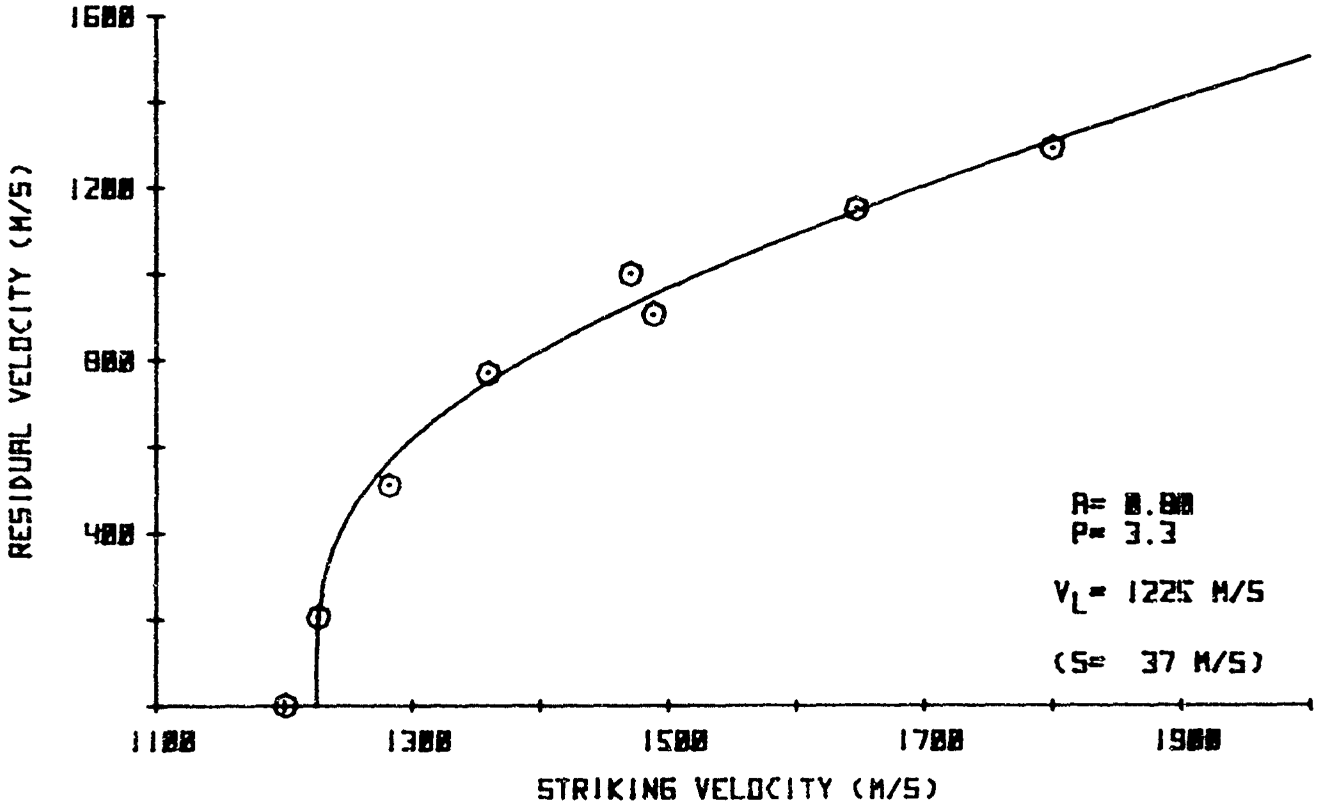

FIGURE B-19. V_S/V_R CURVE AND DATA FOR ACT 19

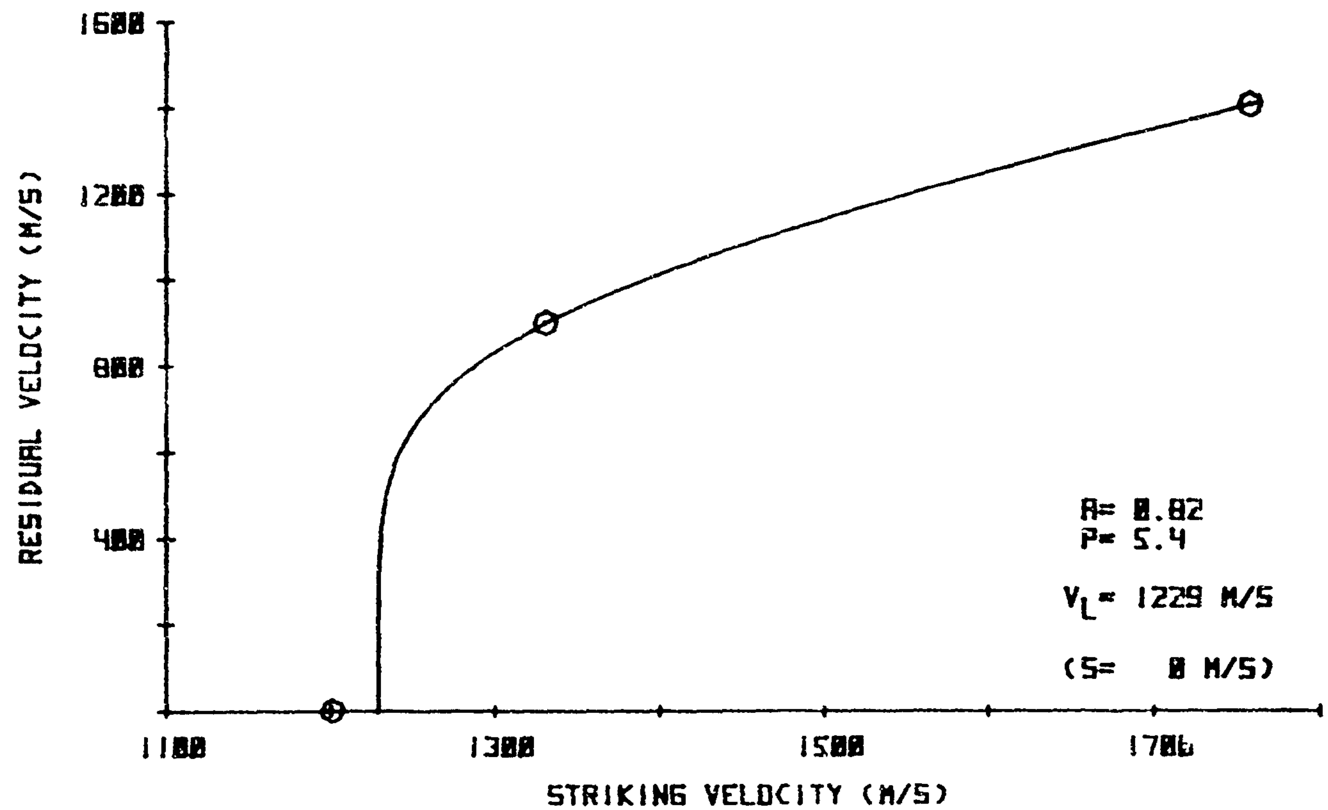

FIGURE B-20. V_S/V_R CURVE AND DATA FOR ACT 20

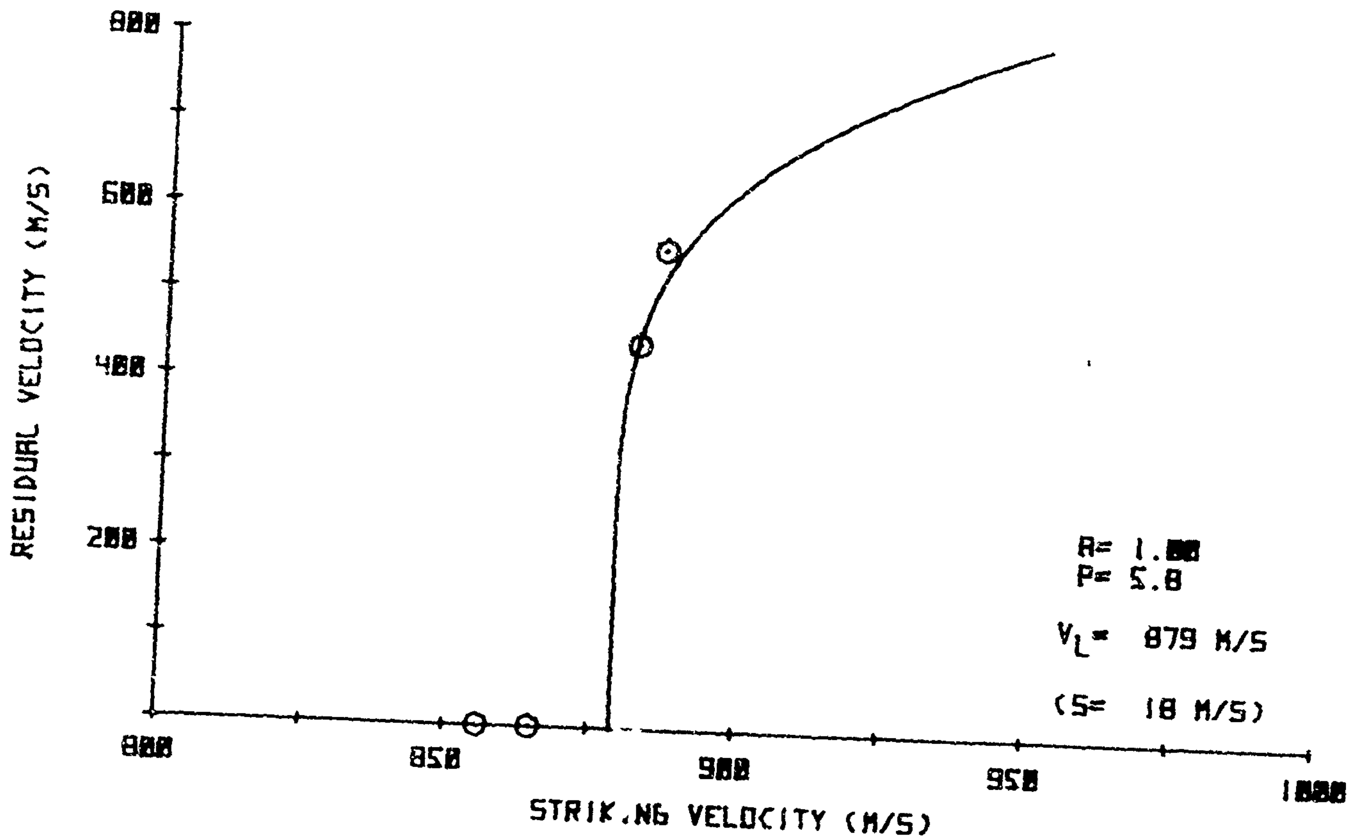

FIGURE B-21. V_S/V_R CURVE AND DATA FOR ACT 1.1

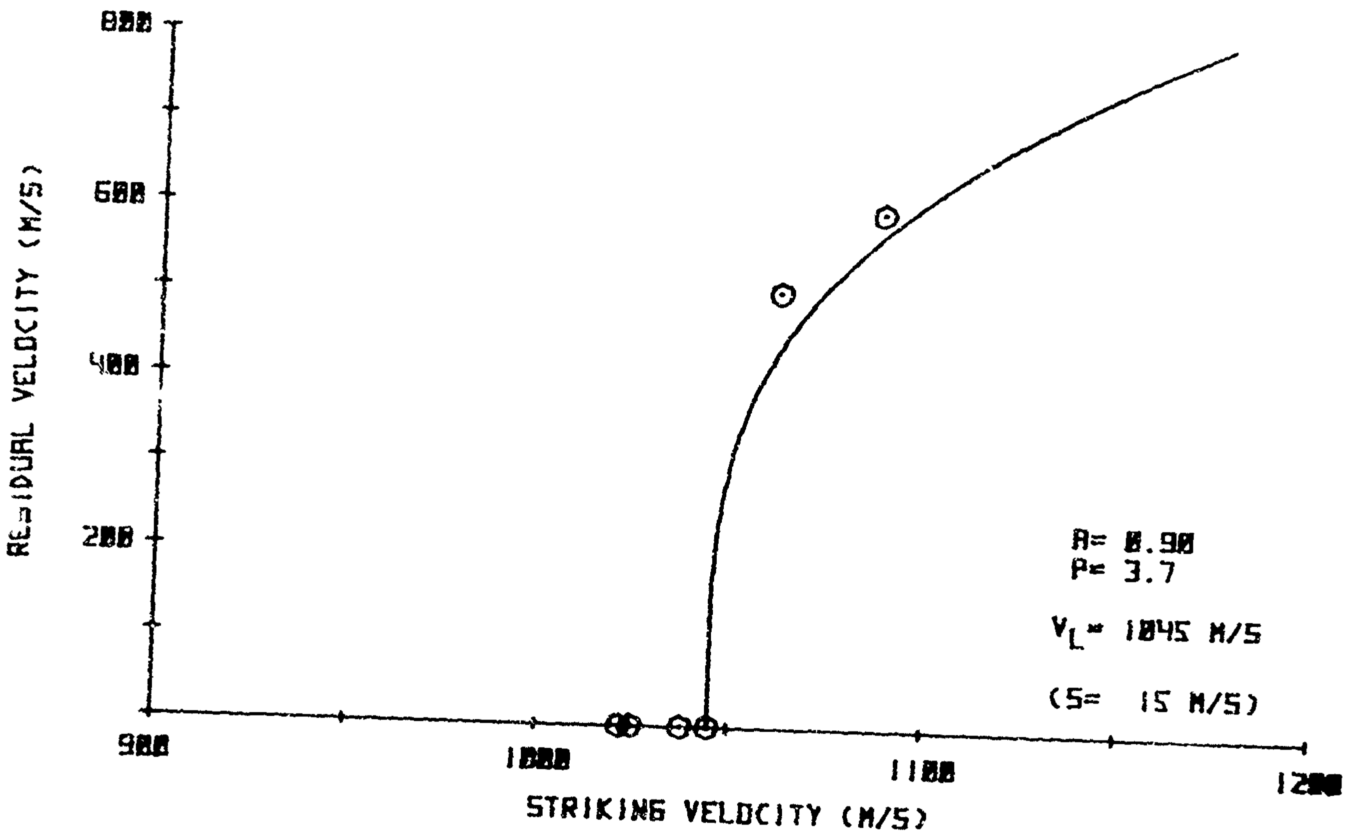

FIGURE B-22. V_S, V_R CURVE AND DATA FOR ACT 3.1

APPENDIX C

FRAGMENT DATA

APPENDIX C: FRAGMENT DATA

Summary of processed[3] behind-target fragmentation data for 29 selected rounds.

Notation

Type - P: penetrator fragment
- T: target fragment (spall particle)

Cone - Cone angle of fragment trajectory: the acute angle between the fragment path and the initial penetrator path. c.f., Figure C-1.

Phase - Phase angle of fragment trajectory: the angle, between 0 and 360 degrees and measured clockwise as perceived from the target hole, between the vertical upward direction and the projection of the fragment path on a plane behind the target orthogonal to the initial penetrator path. c.f., Figure C-1.

[3]*Arbuckle, A. L., Herr, E. L. and Ricchiazzi, A. J., "A Computerized Method of Obtaining Behind-the-Target Data from Orthogonal Flash Radiographs" BRL Memorandum Report 2264, January 1973 (AD 908362L).*

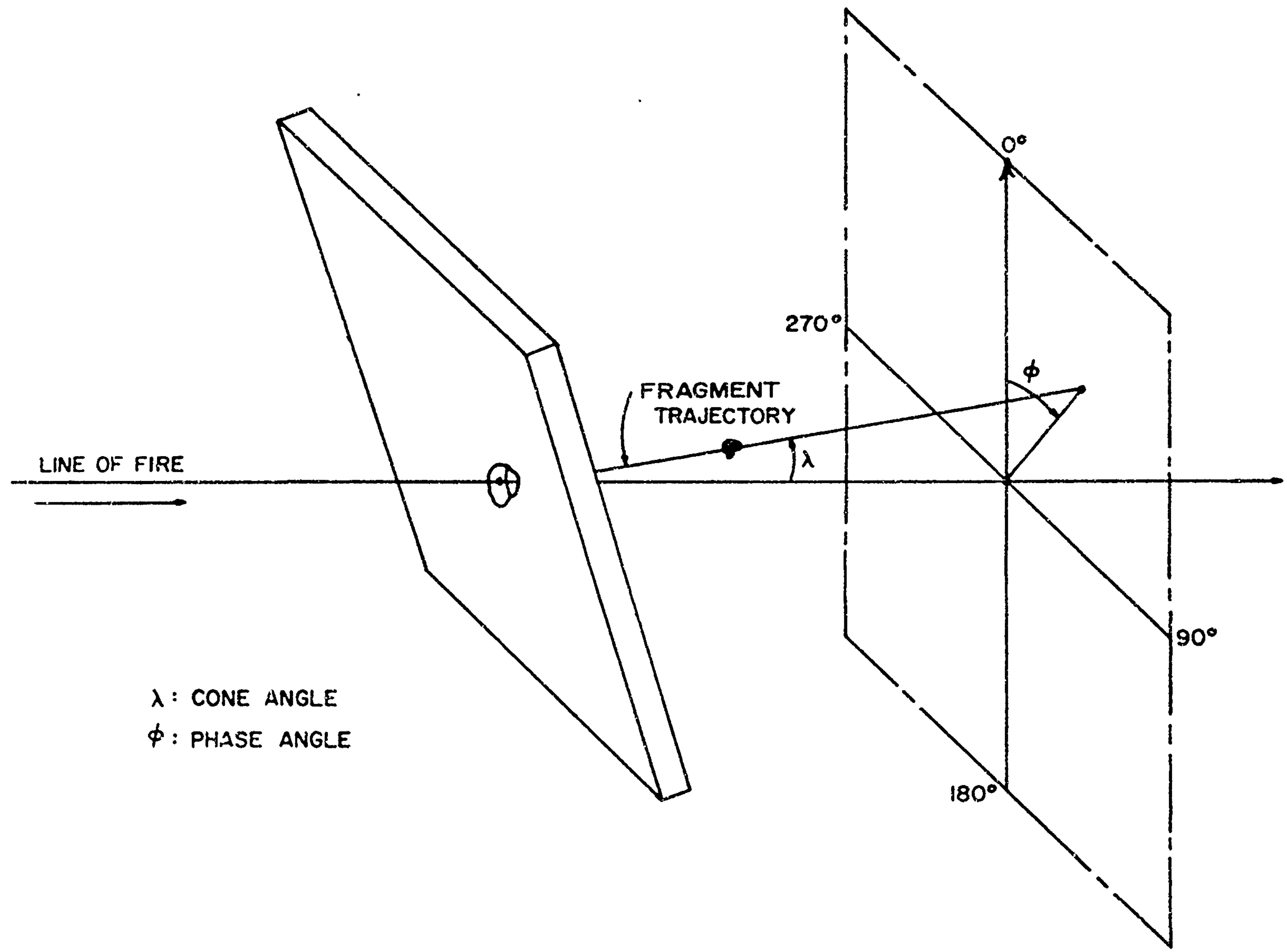

FIGURE C-1. COORDINATE SYSTEM DEPICTING ANGLES λ AND ϕ

ROUND 116 (ACT 5)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
P	189	11.4	20	203
T	379	0.2	71	14
T	371	0.3	62	14
T	511	0.3	71	39
T	482	0.4	76	86
T	402	0.5	61	27
T	466	0.6	70	34
T	443	1.0	69	31
R	406	1.5	65	33
T	269	3.2	24	134

ROUND 118 (ACT 5)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
P	430	7.7	9	270
T	482	0.3	14	87
T	539	0.4	3	39
T	529	1.6	12	63
T	401	1.9	7	349
T	504	2.2	16	90
T	502	7.6	8	70
R	518	9.5	5	46

ROUND 130 (ACT 5)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
P	389	19.8	1	188
T	430	0.1	11	36
T	311	0.1	7	187
T	311	0.1	7	176
T	328	0.1	11	130
T	363	0.1	14	304
T	325	0.1	10	289
T	407	0.2	8	18
T	418	0.2	10	39
T	372	0.2	15	38
T	328	0.2	6	241
T	336	0.2	5	37
T	437	0.2	10	46
T	407	0.4	12	13
T	310	0.4	6	175
T	250	0.4	9	317
T	241	0.5	7	11
T	348	0.5	5	23
T	322	0.5	4	140
T	281	0.5	7	248
T	331	0.6	8	41

ROUND 130 (CONTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	350	0.6	4	219
T	365	0.8	8	274
T	306	0.9	10	54
T	350	1.0	12	276
T	348	1.4	8	256
T	312	1.7	6	225
T	367	2.0	3	163
T	324	8.1	20	10
T	365	11.7	10	283

ROUND 132 (ACT 5)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
P	197	10.6	11	69
T	200	0.1	16	346
T	242	0.1	21	42
T	259	0.1	23	47
T	226	0.1	19	34
T	237	0.1	11	39
T	279	0.1	26	52
T	263	0.1	15	89
T	188	0.1	9	36

ROUND 132 (CONTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	171	0.1	10	43
T	178	0.1	11	46
T	227	0.1	22	34
T	242	0.2	12	[illegible]
T	298	0.2	28	47
T	207	0.2	1	254
T	263	0.2	21	[illegible]
T	211	0.2	3	96
T	207	0.2	15	87
T	250	0.2	13	[illegible]
T	171	0.2	15	27
T	236	0.2	22	25
T	237	0.2	24	31
T	211	0.3	28	47
T	241	0.3	24	47
T	166	0.3	7	30
T	182	0.3	17	39
T	262	0.4	13	178
T	211	0.4	6	76
T	250	0.4	15	84
T	194	0.4	18	21

ROUND 132 (CONTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	185	0.4	14	18
T	187	0.4	13	80
T	218	0.4	18	52
T	196	0.4	15	65
T	215	0.4	21	37
T	223	0.5	21	44
T	198	0.5	11	51
T	191	0.6	15	54
T	222	0.6	15	73
T	156	0.8	8	41
T	227	0.9	12	59
T	162	1.0	6	40
T	200	1.1	18	40
T	226	1.2	18	62
T	175	1.4	13	47
T	206	1.6	10	59
T	232	1.6	11	63
R	266	3.1	9	73
R	245	8.6	10	78
R	284	9.4	8	91
T	221	12.7	13	153

ROUND 133 (ACT 5)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
P	114	13.6	13	176
T	135	0.1	14	207
T	189	0.2	12	132
T	113	0.3	6	263
T	112	0.3	5	260
T	137	0.4	16	194
T	123	0.4	3	273
T	98	0.5	3	252
T	115	0.5	11	96
T	144	0.8	6	98
T	143	1.0	29	183
T	56	4.6	7	180
T	58	5.8	7	181

ROUND 135 (ACT 5)

TYPE	SPEED (M/S)	MAGS (GR)	CONE (DEG)	PHASE (DEG)
P	180	17.7	26	237
T	191	0.1	5	193
T	157	0.1	8	198
T	172	0.2	5	307
T	178	0.2	3	23
T	186	0.2	3	248
T	174	0.2	5	306
R	161	0.3	4	290
T	170	0.3	5	89
T	147	0.4	6	355
T	158	0.5	8	211
T	196	0.6	6	252
R	190	0.7	6	351
T	87	7.5	10	251

ROUND 137 (ACT 5)

TYPE	SPEED (M/S)	MAGS (GR)	CONE (DEG)	PHASE (DEG)
R	631	0.1	19	0
T	869	0.1	16	348
R	664	0.1	38	0
R	663	0.1	18	354
R	690	0.1	18	0
T	881	0.2	23	335
T	853	0.2	28	344
R	708	0.2	36	0
T	818	0.2	24	308
T	853	0.2	26	35
T	1080	0.3	28	42
T	1058	0.3	30	45
T	1373	0.3	9	298
T	865	0.3	20	351
T	1343	0.3	4	334
T	1877	0.3	12	234
T	1833	0.3	8	304
T	1838	0.3	8	198
T	1419	0.3	12	128
R	1368	0.3	14	305
R	1866	0.3	4	30

ROUND 137 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
R	788	0.4	28	28
T	813	0.4	17	385
T	786	0.4	16	334
T	834	0.5	18	320
T	1405	0.6	5	77
T	888	0.8	15	307
T	868	0.8	13	315
T	1392	0.8	7	193
T	837	0.8	11	309
T	1314	0.8	14	241
R	627	0.9	27	0
R	554	1.1	19	0
T	1144	1.2	16	230
R	586	1.3	14	0
T	1034	1.7	16	236
T	1135	1.7	25	108
R	1368	2.1	8	68
R	1387	2.9	6	112
R	1408	4.1	5	151
T	1023	4.5	19	83
R	1363	4.5	7	78

ROUND 138 (ACT 16)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	474	0.1	20	184
T	477	0.2	20	191
T	465	0.3	21	190
T	468	0.3	21	164
T	423	0.3	36	306
T	368	0.4	9	135
T	340	0.4	14	180
T	510	0.4	16	140
T	511	0.4	16	148
T	436	0.4	27	157
T	394	0.5	11	123
T	428	0.5	27	156
T	365	0.7	11	180
T	475	0.8	13	202
T	448	0.8	28	151
T	488	1.0	21	188
T	507	1.3	17	188
T	651	1.4	9	144
T	508	1.7	18	190
T	521	2.2	8	106
R	636	2.6	12	143

ROUND 138 (CMTS)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	550	2.8	20	54
T	440	3.7	10	71
T	483	6.7	9	259
T	367	7.2	8	348

ROUND 142 (ACT 10)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
P	321	5.2	5	138
T	214	0.1	17	10
T	213	0.2	17	352
T	285	0.3	18	21
T	308	0.3	13	244
T	160	0.4	20	337
T	153	0.4	19	342
T	142	0.5	19	358
T	265	0.5	10	346
T	143	0.5	19	364
T	272	0.5	11	86
T	270	0.6	3	188
T	280	0.7	9	53
T	181	0.8	13	344

ROUND 148 (CMTS)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	288	0.8	6	[illegible]
T	281	0.8	7	46
T	348	0.9	12	62
T	294	1.0	9	18
T	281	1.6	7	57
T	310	1.8	10	52
T	330	2.7	10	68
T	385	7.3	21	88

ROUND 144 (ACT 10)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	227	0.6	5	159
T	248	0.9	12	121
T	271	1.1	4	84
T	188	4.7	8	70
T	265	6.6	16	17
T	280	6.6	14	[illegible]

ROUND 153 (ACT 10)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	934	0.3	18	310
T	806	0.3	13	337
T	884	0.3	17	46
T	936	0.4	18	16
T	940	0.4	18	17
T	976	0.6	10	286
T	1104	0.6	11	173
T	982	0.6	6	188
T	980	0.6	13	160
T	819	0.7	13	223
T	818	0.7	13	137
T	875	0.7	16	127
T	971	0.7	20	119
T	791	0.8	18	300
T	864	0.8	13	51
T	846	0.8	26	34
T	1386	0.8	5	54
T	986	0.8	28	41
T	912	0.9	23	62
T	784	0.9	24	23
T	1041	1.0	14	318

ROUND 153 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	1201	1.0	5	238
T	1221	1.0	5	157
T	965	1.2	9	73
T	1078	1.2	13	230
T	1084	1.3	10	213
T	1067	1.3	9	170
T	873	1.5	17	63
T	1080	2.0	11	218
T	951	2.0	21	300
T	864	2.2	16	175
T	1014	2.4	23	45
T	880	2.4	28	323
T	509	2.5	25	0
T	536	2.5	26	17
T	932	2.5	18	286
T	1015	2.9	13	41
T	777	2.9	7	341
T	783	3.8	18	304
R	1308	5.1	8	8
R	1311	5.1	2	27

ROUND 155 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	489	0.2	19	8
T	880	0.5	5	356
T	485	0.8	38	353
T	587	1.3	10	280
T	504	1.5	16	85
T	648	1.6	12	325
T	764	2.0	14	309
T	805	2.2	7	348
T	380	2.6	20	35
T	464	2.6	10	303
T	786	4.2	9	114
R	913	4.4	1	180
T	531	6.1	2	84
T	272	6.7	26	0
T	272	11.3	26	4

ROUND 156 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	546	0.1	13	5
T	549	0.2	14	350
T	462	0.2	16	357

ROUND 156 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	461	0.2	16	0
T	486	0.2	17	15
T	502	2.7	6	237
T	490	2.8	4	141
T	308	3.4	21	0
T	403	3.6	15	0
T	412	3.7	16	82

ROUND 157 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	733	0.2	11	153
T	681	0.3	3	347
T	627	0.5	7	144
T	647	0.5	8	314
T	577	0.5	11	118
T	869	0.7	10	247
T	581	1.1	14	76
T	580	1.7	6	55
R	688	3.2	7	82
T	546	3.2	13	195
T	711	4.5	11	36

ROUND 158 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
P	314	8.3	20	60
T	240	0.1	11	285
T	288	0.1	8	189
T	256	0.1	9	65
T	215	0.1	14	182
T	284	0.1	15	207
T	245	0.1	10	309
T	246	0.1	18	151
T	246	0.1	6	243
T	321	0.1	5	0
T	249	0.2	4	52
T	231	0.3	7	190
T	189	0.3	13	186
T	275	0.3	9	270
T	258	0.3	8	32
T	204	0.3	7	53
T	190	0.4	13	161
T	331	0.4	6	30
T	310	0.4	2	37
T	306	0.4	4	55

ROUND 158 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	306	0.4	4	61
T	250	0.5	2	267
T	195	0.5	6	204
T	315	0.5	27	113
T	280	0.6	11	211
T	289	0.6	13	308
T	290	0.8	6	45
T	308	0.9	4	39
T	386	1.3	11	46
T	282	1.5	5	46
T	263	1.8	5	146

ROUND 161 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	414	0.1	10	117
T	474	0.2	6	58
T	330	0.2	4	132
T	507	0.3	5	280
T	482	0.4	9	314
T	336	0.4	8	184

ROUND 181 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	532	0.4	7	277
T	536	0.4	5	263
T	348	0.4	7	357
T	345	0.6	7	31
T	373	0.7	14	212
T	401	1.9	17	206
T	302	1.9	10	358
T	405	3.3	16	28
T	448	3.4	17	184
R	524	5.4	2	206
T	462	5.5	12	286

ROUND 183 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	378	0.1	6	247
T	360	0.2	10	65
T	344	0.4	10	62
T	341	0.4	9	60
T	430	1.0	8	86

ROUND 187 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	572	0.1	21	157
T	575	0.1	21	186
T	732	1.0	6	184
T	517	0.3	12	157
T	680	0.4	10	149
T	471	0.5	17	180
T	536	0.8	9	80
T	657	0.8	11	163
T	628	0.8	24	41
T	618	1.2	7	230
T	500	1.3	7	166
T	437	1.5	1	180
T	586	1.6	21	35
T	609	2.1	15	350
T	571	2.3	15	285
T	663	2.4	9	308
R	735	2.5	10	33
T	723	2.5	11	118
R	756	4.2	8	71
T	530	4.6	11	301
T	568	5.6	11	233

ROUND 170 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	1190	0.1	7	188
T	1182	0.1	8	185
T	878	0.1	11	51
R	1804	0.2	8	190
T	828	0.3	10	327
T	811	0.4	9	28
T	872	0.4	11	52
T	827	0.5	7	17
R	1121	0.5	11	222
T	853	0.5	9	46
T	1063	0.5	15	177
T	918	0.5	19	197
R	1139	5.0	9	151
T	881	0.6	2	0
T	912	0.6	3	0
T	830	0.7	10	35
T	865	0.7	6	30
T	1072	0.7	8	87
T	1113	0.8	14	224
T	1003	0.9	15	216
T	702	1.0	10	0
T	886	1.1	16	180

ROUND 170 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	853	1.1	9	46
T	772	1.2	10	19
T	862	1.2	4	312
T	813	1.2	12	38
T	1203	1.3	8	113
T	1006	1.4	6	182
T	815	1.9	11	344
T	803	1.9	5	0
T	808	1.9	11	9
T	781	2.0	5	188
T	850	2.1	7	12
T	880	2.1	2	352
T	888	2.1	2	0

ROUND 175 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	388	0.2	15	1
T	480	0.2	7	344
T	481	0.2	7	5
T	401	0.7	8	340
T	190	1.1	6	0

ROUND 176 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	415	8.2	17	300
R	386	3.1	14	331
T	168	4.7	31	0
T	373	4.9	16	140

ROUND 176 (ACT 14)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
P	277	6.7	20	241
T	238	0.1	2	21
T	330	0.1	22	58
T	291	0.1	17	57
T	303	0.1	17	59
T	240	0.1	11	84
T	226	0.2	6	0
T	219	0.2	7	0
T	237	0.2	12	15
T	321	0.3	6	136
T	254	0.3	18	344
T	407	0.3	16	283
T	265	0.3	8	3
T	285	0.5	5	0

ROUND 178 (ACT 11)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	515	0.1	51	15
T	580	0.1	40	347
T	577	0.1	33	338
T	584	0.1	41	345
T	368	0.1	56	0
T	428	0.1	46	353
T	427	0.1	48	353
T	578	0.1	41	2
T	586	0.1	57	12
T	444	0.2	49	6
T	518	0.2	37	10
T	461	0.2	49	9
T	521	0.2	38	347
T	503	0.2	37	355
R	585	0.2	13	340
T	482	0.2	43	356
T	565	0.2	23	340
T	485	0.2	54	12
T	707	0.2	43	17
T	486	0.2	35	360
T	580	0.2	47	5
T	588	0.2	46	348

ROUND 178 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	402	0.2	30	345
T	663	0.2	39	360
T	436	0.2	51	347
T	471	0.2	37	348
T	476	0.2	37	25
T	390	0.2	48	359
T	583	0.2	41	5
T	391	0.2	49	0
T	402	0.3	49	4
T	429	0.3	43	346
T	433	0.3	48	345
T	444	0.3	52	351
T	395	0.3	42	357
T	387	0.3	51	355
T	402	0.3	56	0
T	369	0.3	55	354
T	384	0.3	56	0
T	[illegible]	0.3	39	7
T	444	0.3	50	12
T	462	0.4	21	333
R	506	0.4	20	346
T	380	0.4	60	0

ROUND 178 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
R	562	0.4	22	24
T	531	0.4	46	338
T	606	0.4	55	344
R	637	0.4	34	350
T	689	0.5	28	355
T	690	0.5	36	6
T	386	0.5	43	356
T	425	0.5	35	6
T	383	0.6	43	358
T	337	0.6	11	325
T	385	0.6	28	15
T	356	0.7	13	314
T	401	0.8	30	3
T	655	0.8	31	359
T	387	0.8	38	0
T	387	0.8	54	354
T	386	0.9	54	356
T	420	0.9	36	353
T	383	0.9	55	0
T	384	0.9	55	1
T	465	0.9	35	4
T	674	1.1	31	4

ROUND 178 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	709	1.2	40	10
T	663	1.6	38	354
T	406	1.6	56	344
T	342	1.8	57	358
T	343	1.8	57	0
T	383	1.8	1	73
T	416	1.9	6	88
R	564	1.9	15	317
T	497	2.0	33	356
T	511	2.1	34	5
T	658	2.3	37	25
T	486	3.7	27	347
R	637	3.8	33	1
R	682	4.0	34	10
T	532	4.3	56	337
T	367	4.6	25	278
R	638	5.8	42	349
R	687	6.2	48	358
R	806	6.8	17	38
T	330	8.5	86	0
R	801	9.3	86	80

ROUND 181 (ACT 11)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	283	0.1	36	14
T	442	0.1	27	314
T	159	0.1	59	0
T	147	0.1	51	0
R	270	0.2	46	11
T	416	0.2	28	26
T	440	0.2	30	305
R	371	0.2	42	342
T	289	0.2	39	347
T	285	0.3	38	0
T	375	0.3	42	19
T	383	0.3	42	32
T	384	0.3	43	23
T	258	0.3	44	344
R	315	0.4	40	8
T	283	0.8	34	346
T	140	0.8	42	0
T	343	0.8	38	338
T	180	1.4	44	0
T	121	1.5	44	0
T	342	1.6	38	336

ROUND 181 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	167	1.7	51	358
T	281	2.1	39	338
R	293	2.8	35	336
T	263	4.3	39	342
T	329	10.7	40	0
T	264	11.4	45	0
T	215	12.2	61	0

ROUND 185 (ACT 11)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	384	0.1	34	4
T	437	0.1	40	6
T	320	0.2	29	7
T	347	0.2	41	16
T	378	0.2	50	358
T	311	0.4	71	0
T	440	0.4	53	346
T	365	0.5	44	15
T	460	0.8	57	10
T	396	0.9	54	5
T	534	1.0	55	341

ROUND 186 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	367	1.0	53	4
T	400	1.0	54	11
T	513	1.3	57	12
T	330	3.1	27	21
T	432	6.2	29	358

ROUND 190 (ACT 6)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	366	0.1	35	354
T	298	0.2	32	0
T	345	0.2	34	0
T	363	0.2	36	17
T	384	0.2	28	348
T	338	0.2	30	351
T	340	0.2	37	0
T	356	0.3	37	344
T	422	0.5	35	354
T	380	0.6	44	0
T	278	0.5	28	0
T	348	0.6	28	357
T	348	0.6	28	0

ROUND 190 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	351	0.6	33	0
T	356	0.7	34	10
T	361	0.7	34	13
T	299	0.7	33	0
T	378	0.7	54	0
T	268	0.8	26	0
T	341	0.8	50	0
T	362	1.0	51	0
T	273	1.0	29	23
T	346	1.8	43	358
T	345	1.8	44	0
T	345	5.0	35	0
R	228	6.7	49	0
T	364	7.5	75	0
T	167	16.5	69	0

ROUND 191 (ACT 6)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
P	278	6.6	77	27
T	323	0.1	55	8
T	430	0.3	56	9

ROUND 191 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	384	0.3	54	354
T	442	0.4	49	16
T	384	0.4	56	6
T	333	0.4	46	351
T	[illegible]	0.5	53	352
T	371	0.7	52	354
T	348	0.7	53	1
T	371	0.7	52	3
T	400	0.8	53	10
T	347	0.8	56	354
T	361	0.8	54	7
T	331	0.9	48	354
T	378	0.9	40	4
T	349	1.0	56	5
T	342	1.2	48	351
T	367	1.3	48	346
T	462	1.9	58	308
R	344	2.6	53	349
T	360	2.7	32	331
T	196	3.3	41	11
T	202	3.4	41	13

ROUND 199 (ACT 6)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	610	0.1	37	349
T	584	0.2	29	352
T	591	0.2	28	344
T	556	0.2	33	354
T	485	0.3	23	15
T	619	0.3	26	12
R	625	0.4	37	354
T	646	0.5	26	17
R	559	0.5	35	1
T	416	0.6	68	0
T	487	0.7	23	358
T	472	0.8	18	21
T	576	0.9	23	359
T	550	1.3	26	327
T	576	1.8	34	349
R	685	1.9	43	6
R	696	1.9	44	9
T	623	1.9	27	359
R	614	2.1	38	0
T	526	2.9	27	351

ROUND 206 (ACT 6)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	331	4.4	42	341
T	295	5.3	38	333
T	247	5.6	36	351
T	135	9.3	18	0
T	381	13.7	56	1
T	107	24.0	51	0

ROUND 213 (ACT 15)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	573	0.1	10	14
T	574	0.1	10	17
T	594	0.1	13	38
T	663	0.1	46	5
T	615	0.2	38	342
R	697	0.2	32	341
R	705	0.2	32	9
R	649	0.3	35	337
T	645	0.3	30	306
T	606	0.3	28	338

ROUND 213 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	706	0.3	37	350
R	630	0.3	36	343
T	641	0.3	27	4
R	737	0.3	24	1
T	734	0.4	33	3
R	729	0.4	35	355
R	735	0.4	36	1
T	668	0.4	37	357
T	722	0.4	34	351
T	634	0.6	43	358
T	498	0.7	39	342
T	628	0.7	37	336
R	506	0.7	38	14
T	727	0.7	32	2
T	475	0.7	39	356
T	722	0.7	34	0
R	691	0.7	22	15
T	709	0.7	26	352

ROUND 213 (CNTD)

TYPE	SPEED (M/S)	MASS (GR)	CONE (DEG)	PHASE (DEG)
T	690	0.8	32	340
T	461	0.9	38	6
T	680	1.4	30	332
T	657	1.5	29	341
R	698	1.8	40	5
R	696	1.8	11	336
T	643	1.9	25	32
R	689	2.2	14	358
R	539	2.3	45	6
T	577	2.6	30	27
T	615	2.7	48	2
R	685	2.7	19	347
R	731	2.8	43	338
R	566	2.9	38	5
R	693	3.1	42	356
T	592	3.1	58	348
R	690	5.0	35	353
R	539	5.4	14	57

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APPENDIX D

PENETRATION SKETCHES FOR ACT 19

APPENDIX D: PENETRATION SKETCHES FOR ACT 19

We attempt, in a sequence of rough sketches, to illustrate the pre-impact and residual penetrator (and/or "plug") and target plate section for rounds 258 through 265 (which constitute ACT 19). Figures are (roughly) 3/4 of actual size and the attempt is to convey approximate positioning and shape. In each sketch the initial penetrator position (with respect to the target plate) is representative of the situation 50 μsec before impact and (except for Round 264) the residual penetrator suggests the situation 50 μsec after perforation is complete (i.e., after the tail of the penetrator clears the rear target surface).

We recall that ACT 19 involves L/D of 10 monolithic steel penetrators impacting 1" RHA at 60° obliquity. M_r is used to denote recovered residual penetrator mass. Ordering of the sketches reflects an increasing sequence of striking velocities.

Following the sketches is a photograph of the sectioned target plates for these shots together with a representative original penetrator and recovered residual penetrators. In the photograph Δ is used to denote mass loss of the target plate. In a few cases there is a small discrepancy between the velocities given in the sketches and those on the photograph - those in the sketches are derived from a later, presumably more careful "reading" of the radiographs and are regarded as the official values. The sequence of rounds in the photograph is as follows:

top row, left to right - Rounds 264, 263, 262, 261

bottom row, left to right - Rounds 265, 260, 259, 258

Remarks: Each plate shows an indention on the upper front surface - these "lips" were formed by pusher plates impacting the targets and are not consequent to penetrator/target interaction.

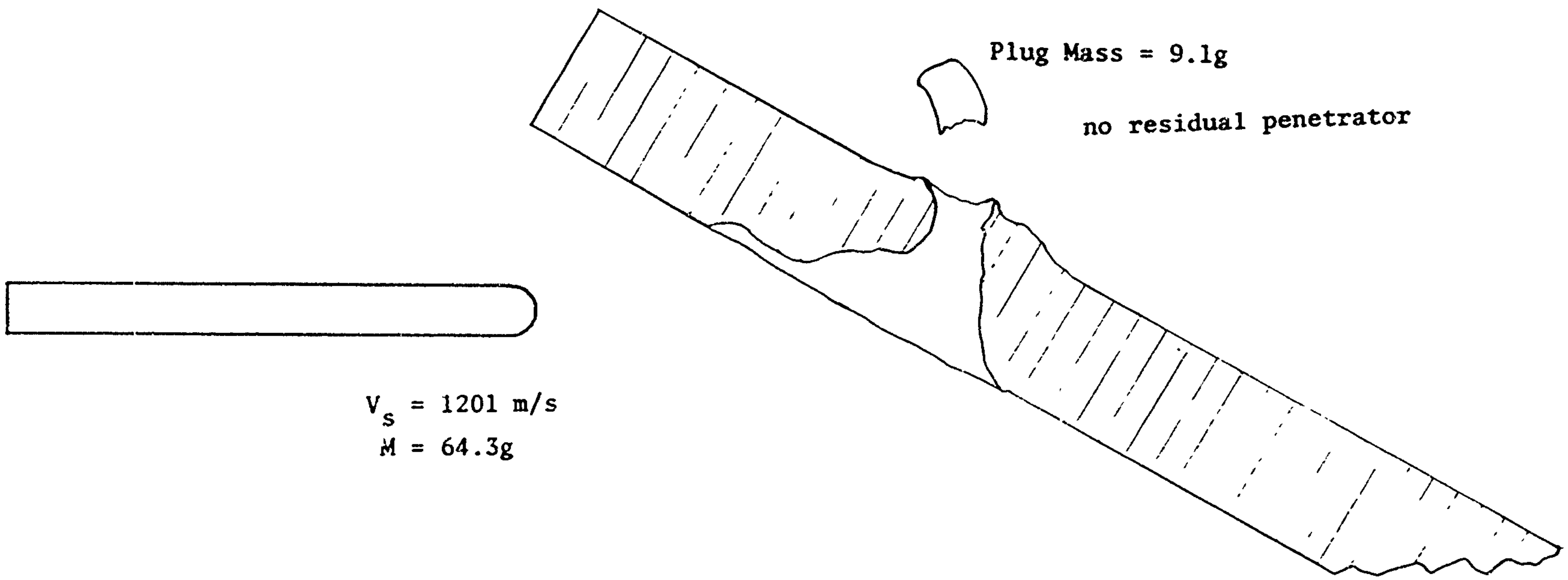

Figure D-1. Sketch for Round 264

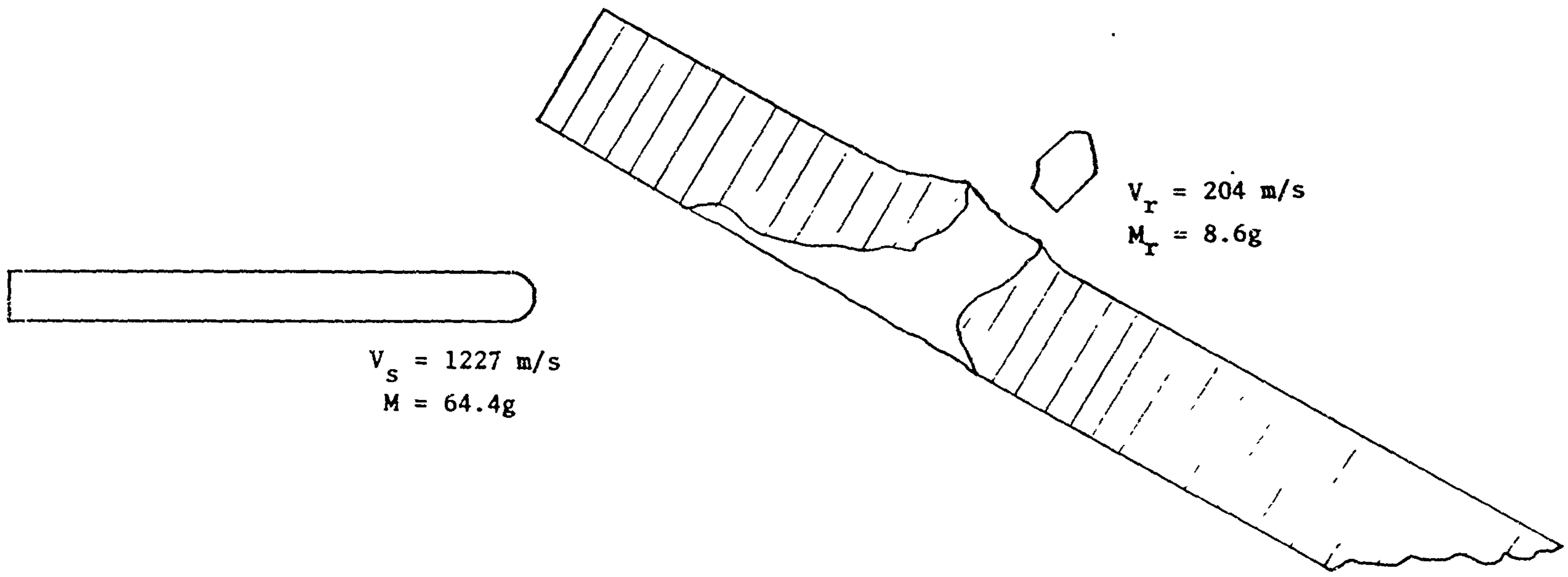

Figure D-2. Sketch for Round 263

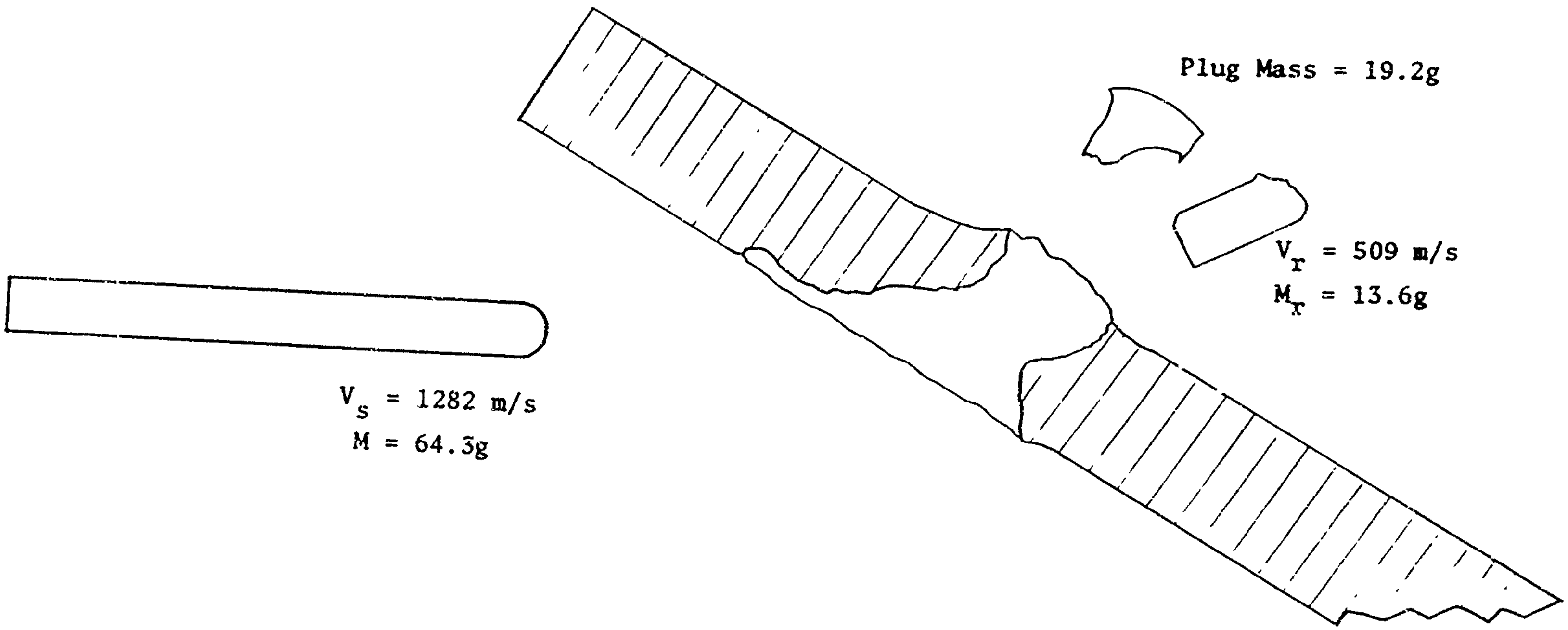

Figure D-3. Sketch for Round 262

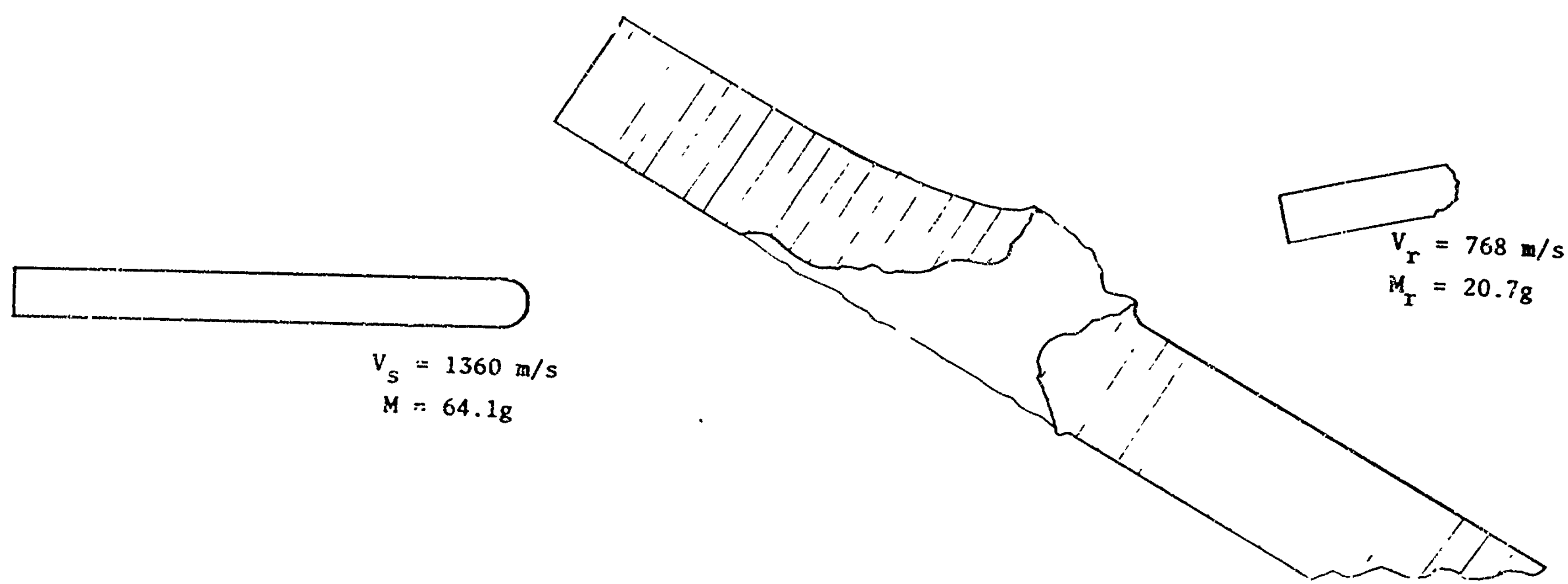

Figure D-4. Sketch for Round 261

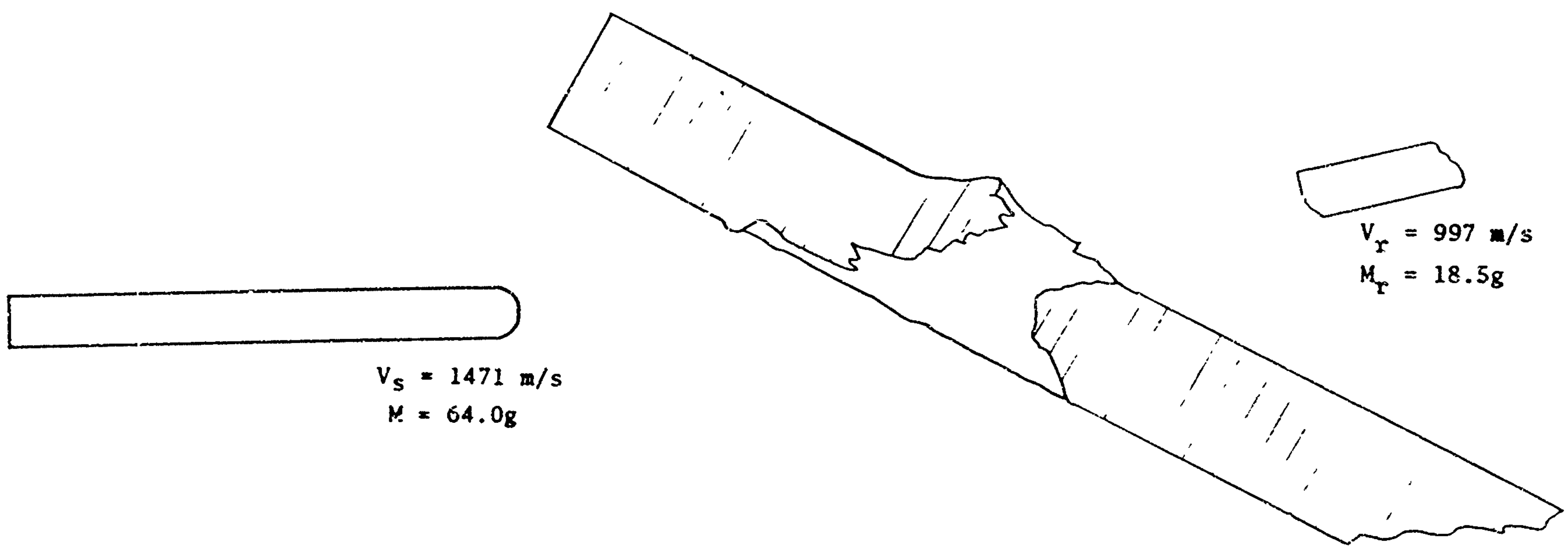

Figure D-5. Sketch for Round 265

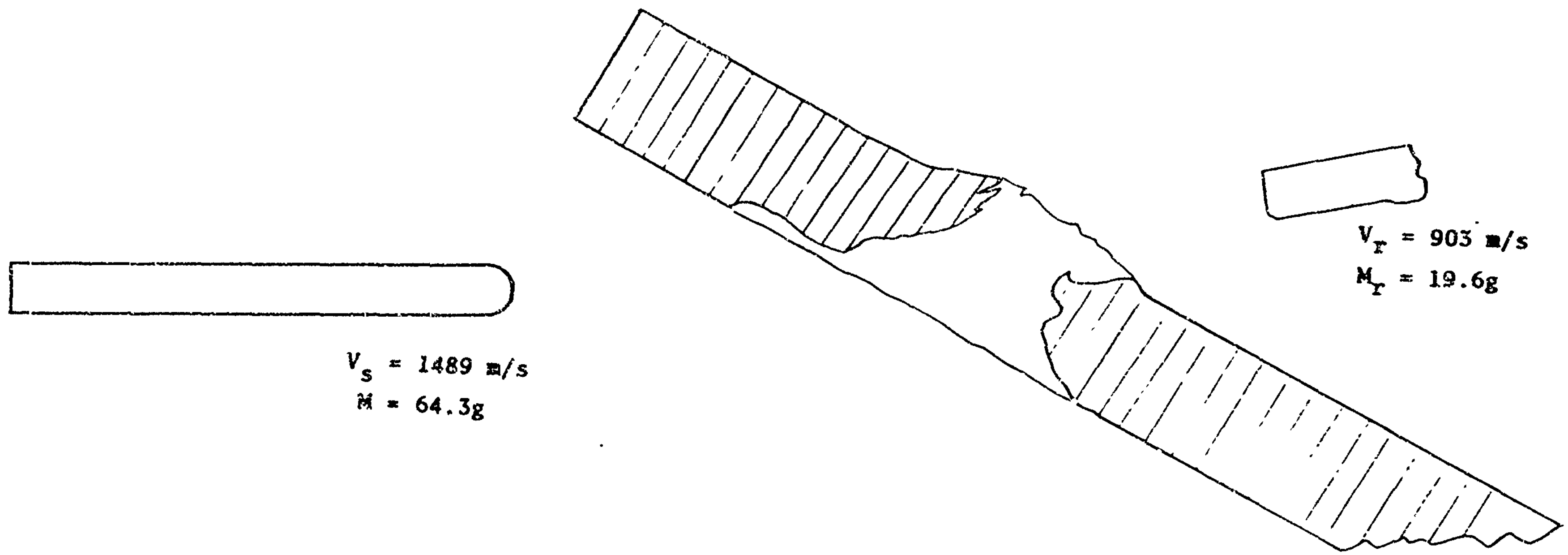

Figure D-6. Sketch for Round 260

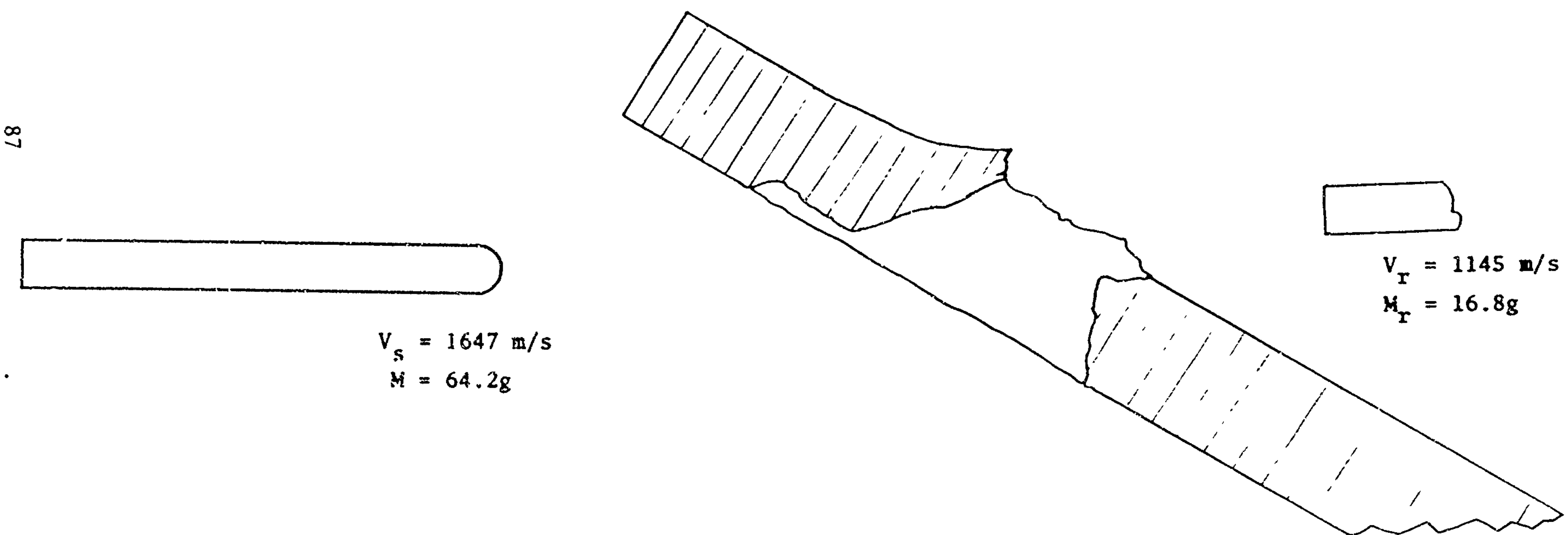

Figure D-7. Sketch for Round 259

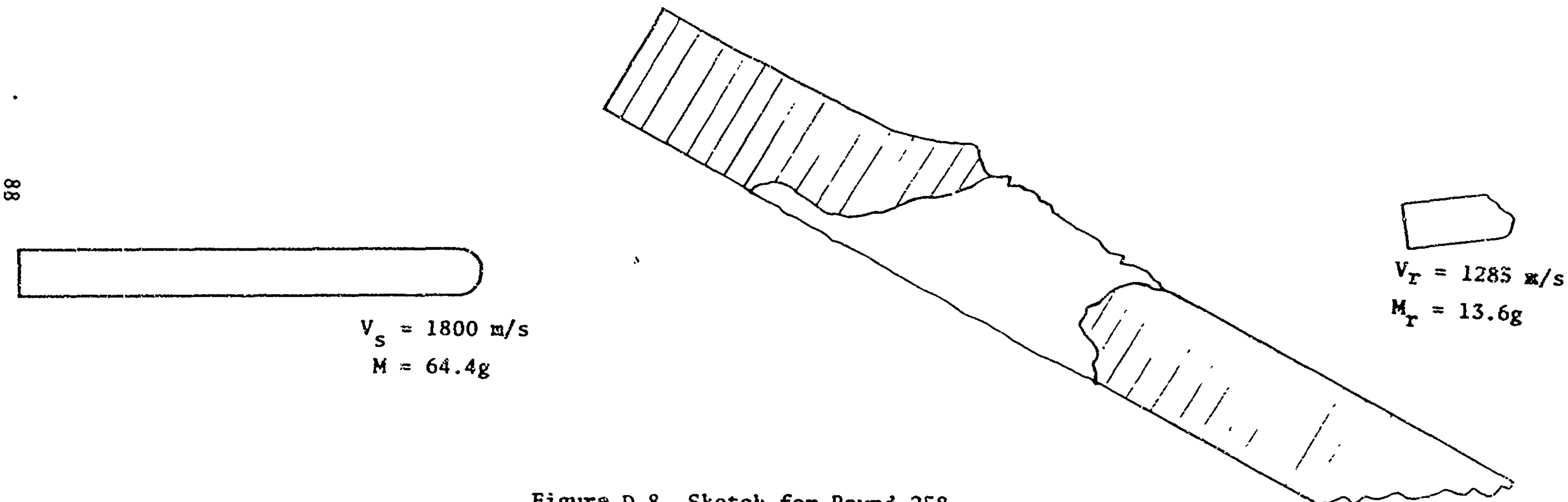

Figure D-8. Sketch for Round 258

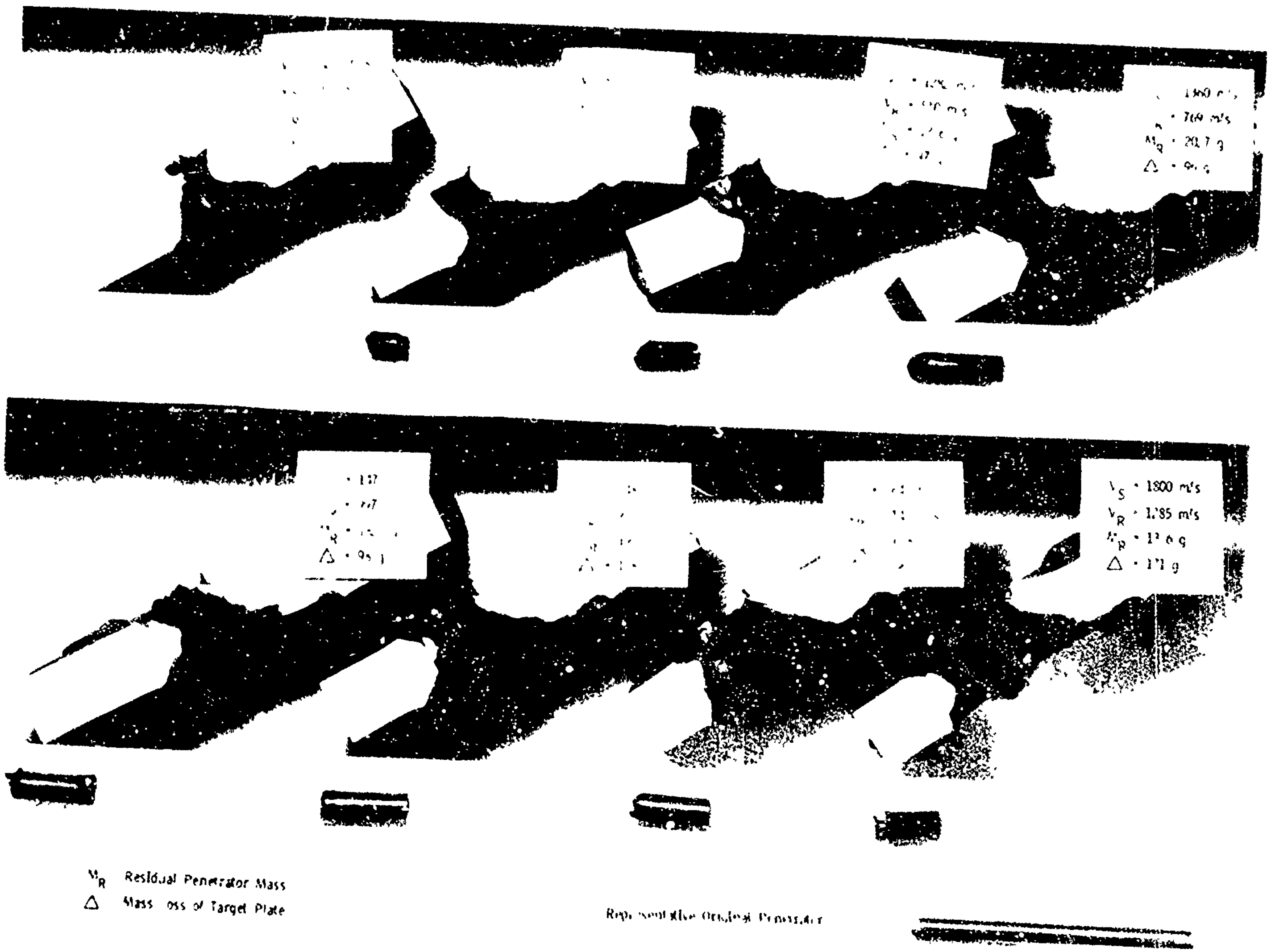

Figure D-9. Photograph of Sectioned Targets and Residual Penetrators for ACT 19

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APPENDIX E

PREDICTED CURVES

APPENDIX E: PREDICTED CURVES

A predictive scheme has been formulated for obtaining limit velocity and V_s, V_r curve estimates for situations involving long rod penetrators and single plate RHA targets[4]; pertinent equations are given below. For the final phase of this firing program, these equations were used to generate initial estimates of limit velocity (and of the full V_s, V_r relationship). Figures on the following pages provide for graphic comparison between the V_s, V_r curve predicted for the nominal situation and that derived from the experimental data for each of ACTS 16, 17, 18 and 19. In each case the data and predicted curve are graphed, and the derived curve, which also appears in Appendix B, is plotted as a dashed curve.

The predictive scheme is specified by:

$$V_r = \begin{cases} 0, \text{ if } 0 \le V_s \le V_\ell \\ a(V_s{}^p - V_\ell{}^p)^{1/p}, \text{ if } V_s > V_\ell \end{cases}$$

where

$$a = \frac{M}{M+M'/3}, \quad p = 2 + z/3,$$

$$\text{and } V_\ell = 4000 \left(\frac{L}{D}\right)^{1.5} \sqrt{f(z) \cdot \frac{D^3}{M}},$$

$$z = \frac{T}{D} \sec^{.75}\theta, \quad f(z) = z + e^{-z} - 1,$$

$$M' = \frac{\rho\pi}{4} D^3 \cdot z, \quad \rho = 7.8,$$

and where L, D, T are in centimeters, M in grams, V_ℓ in m/s.

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[4] *Lambert, J. P., "A Residual Velocity Predictive Model for Long Rod Penetrators", to appear.*

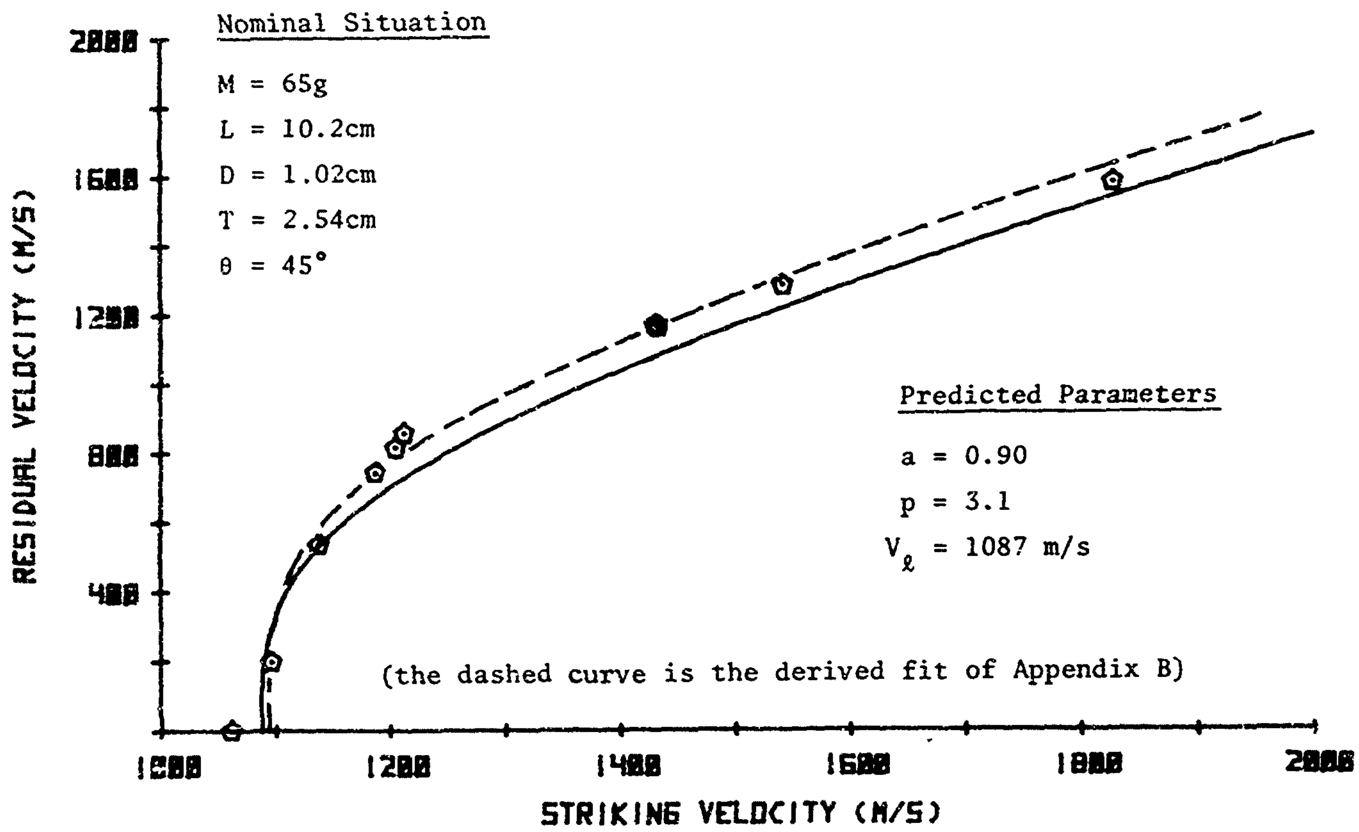

Figure E-1. Predicted V_s, V_r Curve for ACT 16

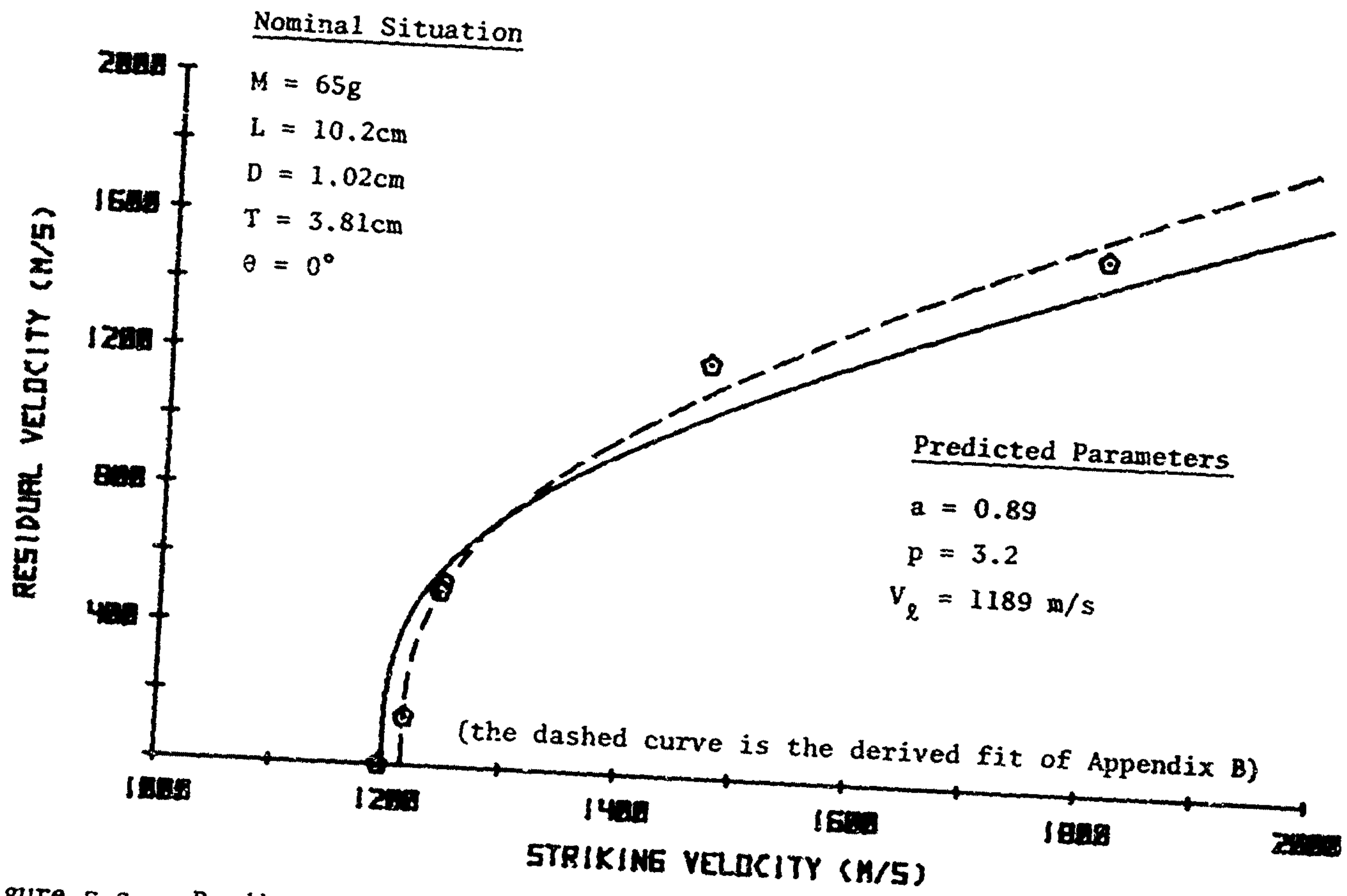

Figure E-2. Predicted V_s, V_r Curve for ACT 17

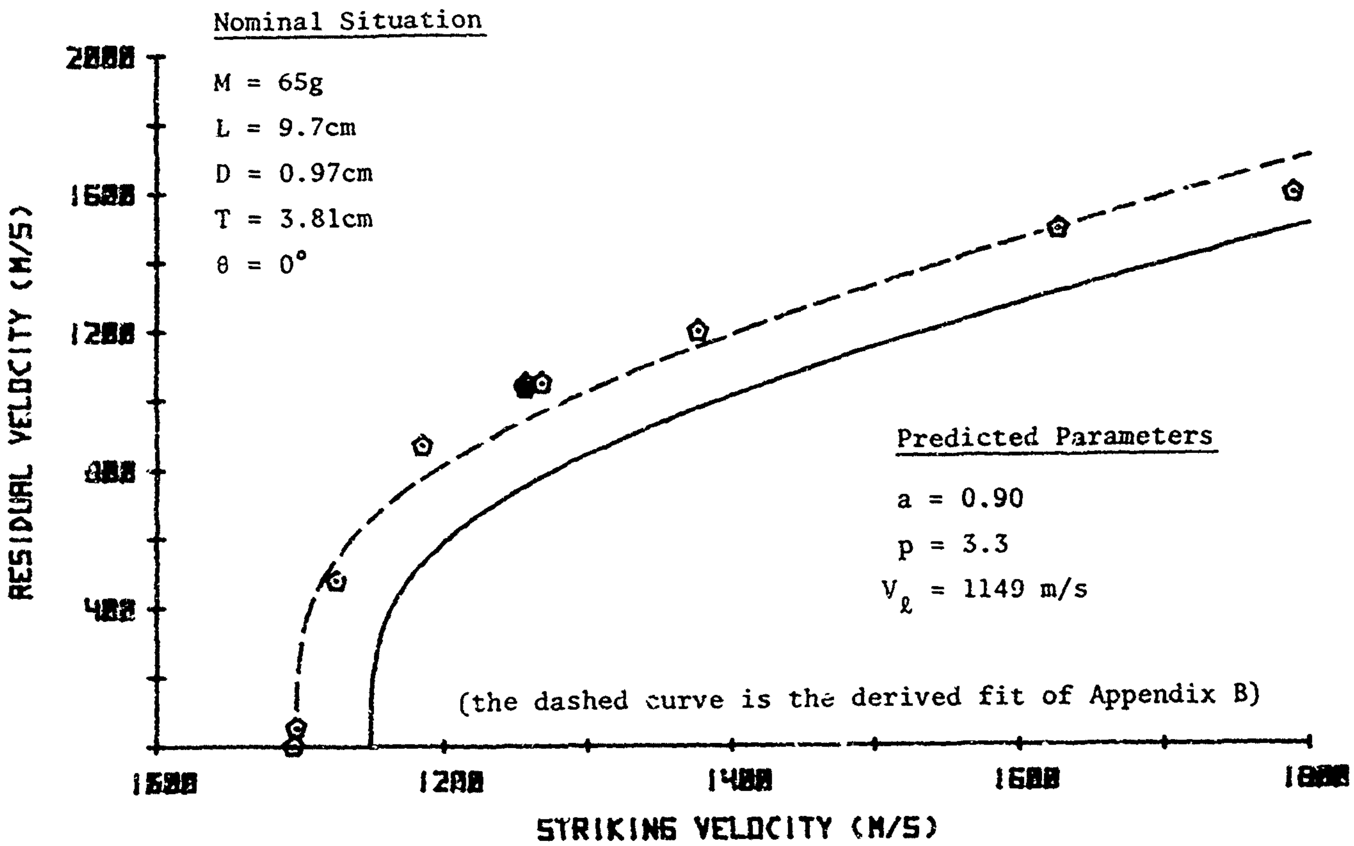

Figure E-3. Predicted V_s, V_r Curve for ACT 18

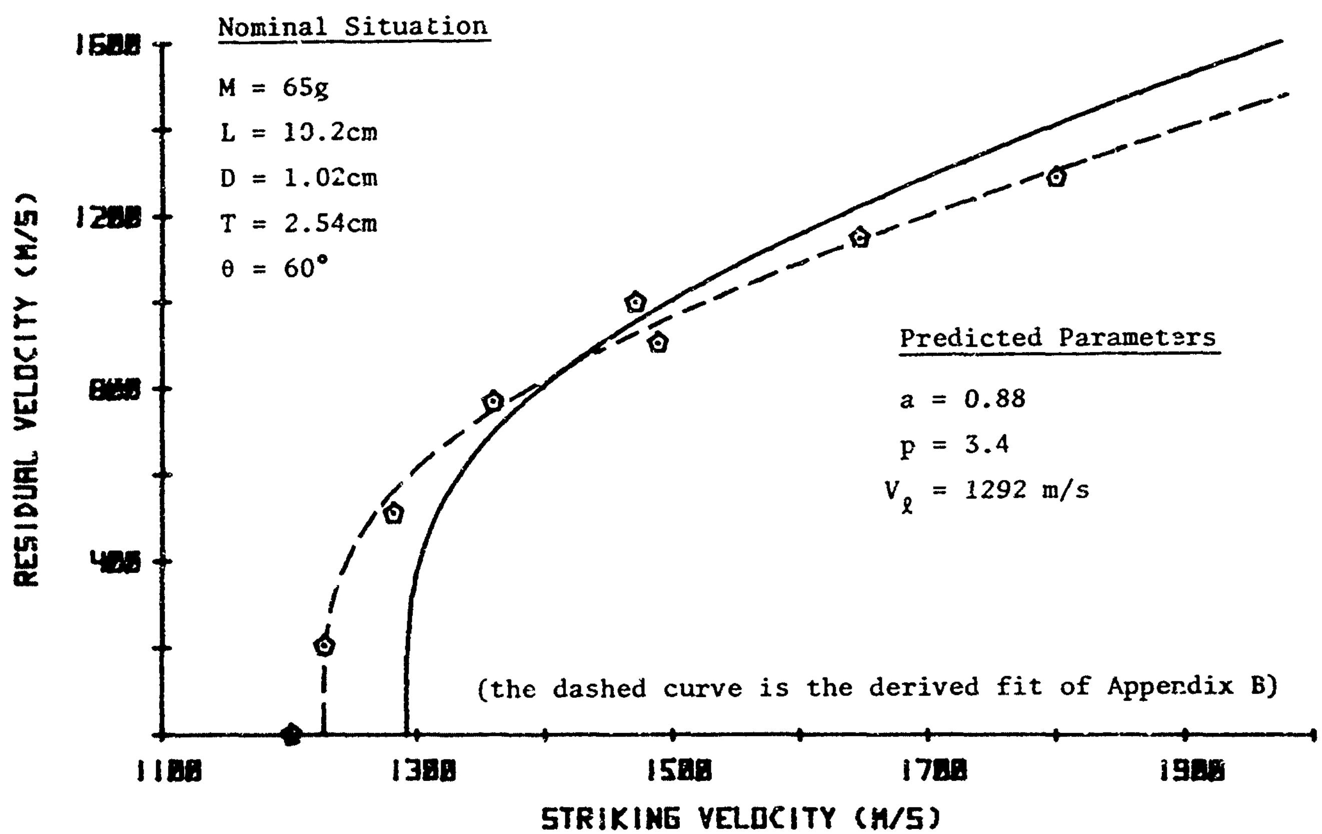

Figure E-4. Predicted V_s, V_r Curve for ACT 19

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