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## **MEMORANDUM REPORT NO. 2797**

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# AN ANALYTICAL MODEL OF KINETIC ENERGY PROJECTILE/FRAGMENT PENETRATION

John Zook

October 1977

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	BEFORE COMPLETING FORM
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BRL Memorandum Report No. 2797 AD-A086	346
4. TITLE (and Substite)	5. TYPE OF REPORT & PERIOD COVEREN
PROJECTILE/FRAGMENT PENETRATION	(9) Final reptos
	6. PERFORMING ORD. REPORT HUNDER
7. AUTHOR(3)	8. CONTRACT OR GRANT NUMBER(*)
1 )	10 45 11
John Zook	(2) 230
- PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK
USA Ballistic Research Laboratory	
Aberdeen Proving Ground, Maryland 21005	RDT&E 711.161192AH4 *
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
USArmy Materiel Development & Readiness Command	OCTOBER 1977
Alexandria, Virginia 22333	139
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	15. SECURITY CLASS. (of this report)
(11) $(1 + 11)$	UNCLASSIFIED
	15. DECLASSIFICATION/DOWNGRADING SCHEDULE
<b>16. DISTRIBUTION STATEMENT (of this Report)</b> Approved for public release; distribution unlimit	ed. () ] !! 7 ; / )
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#### TABLE OF CONTENTS

P	a	g	e
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	LIST OF ILLUSTRATIONS	5
	LIST OF TABLES	7
I.	INTRODUCTION	9
11.	THE RESISTIVE FORCE	6
III.	THE DEPTH OF PENETRATION EQUATION	7
IV.	THE TIME-PENETRATION EQUATION	9
ν.	DETERMINATION OF THE CONSTANTS $C_1$ , $C_2$ and $C_3$	0
VI.	COMPUTING RESIDUAL VELOCITY	9
VII.	VALIDATING THE MODEL	9
VIII.	ANALYZING THE PENETRATION PROCESS	8
IX.	SUMMARY AND FUTURE AREAS OF INVESTIGATION 4	5
	APPENDIX A - PROJECTILE-TARGET PENETRATION DATA 4	7
	APPENDIX B - GRAPHIC COMPARISON OF THOR AND Z/F EQUATIONS	3
	APPENDIX C - COMPUTER PROGRAM LISTINGS AND SAMPLE OUTPUTS	3
	LIST OF SYMBOLS	7
	DISTRIBUTION LIST	9



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#### LIST OF ILLUSTRATIONS

Figure														Page
1.	Outline of P	rocedure To	Find Re	esidu	ual V	/e100	cit	у	•	•	•	•	•	30
2a.	Generalized	Penetration	Curves	for	BHN	100	•	•	•	•	•	•	•	39
2Ъ.	Generalized	Penetration	Curves	for	BHN	200	•	•	•	•	•	•	•	40
3a.	Generalized	Penetration	Curves	for	Alun	ninu	m T	ar	get	s	•	•	•	41
3b.	Generalized	Penetration	Curves	for	Tita	niu	m T	ar	get	:5	•	•	•	42
3c.	Generalized	Penetration	Curves	for	Stee	91 Ta	arg	et	s,	•	•	•	•	43

#### е

.

#### LIST OF TABLES

4

.

Table		Page
Ι.	Postulated Empirical Equations	10
II.	The Thor Equation	15
IIIa.	Statements to Evaluate Partial Dorivatives for Non-Linear Least Squares Program	21
IIIb.	Non-Linear Least Squares Fit to Thor Data	24
IIIc.	Summary of Convergent Values for $C_1^{}$ , $C_2^{}$ and $C_3^{}$	26
IV.	Data Eliminated From Non-Linear Least Squares	28
۷.	Cross-Sectional Areas By Yaw Angle for Cylinder Rods	32
VIa.	Comparison of The Mean, Variance, Standard Deviation, Sum and Sum of Squares of The Plate Thickness Deviants	3;4
VIb.	Comparison of The Mean, Variance, Standard Deviation, Sum and Sum of Squares of The Plate Thickness Relative Error	35
VIc.	Comparison of The Mean, Variance, Standard Deviation, Sum and Sum of Squares of The Residual Velocity Deviants	36
VId.	Comparison of The Mean, Variance, Standard Deviation, Sum and Sum of Squares of The Residual Velocity Relative Error	37

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#### I. INTRODUCTION

Numerous empirical equations (see Table I, of which the major portion is a compilation made by Herrman and Jones<sup>1</sup>. The geometric values listed in the table have been converted to the metric system (cgs) system of units) are available for predicting depth of penetration and residual velocities for various projectile-target combinations. (Projectile and fragment may be used interchangeably through this report.) Unfortunately, since the equations are empirical, each equation is applicable only in the region of the data used to generate the empirical constants. Any extrapolation outside the range of the data is questionable.

Extended use has been made at the BRL of the equations developed under the code name "Project Thor"<sup>2</sup>. The equation for residual velocity for perpendicular impact (0° obliquity) is:

$$V_r = V_s - 10^a (X_t A)^b m_p^c V_s^d$$
 (1)

The values for the empirical exponents a, b, c and d determined by a least squares fit to experimental data are tabulated in Table II for various target materials along with the range of plate thickness  $X_t$ , striking velocity  $V_s$  and the area A and mass  $m_p$  of the projectile. Since the Thor equation is so widely used at the BRL, in order for any model predicting residual velocity to qualify as a replacement to this equation, it should be more accurate in its prediction or should exhibit other qualities which render it more useful - for example, allow extrapolation with greater confidence than a purely empirical model.

It is desirable to develop a theoretical model which can be used in general to predict terminal ballistics. Needless to say, projectiletarget interactions are complex. Although kinetic energy projectiles have been used for several centuries, no single predictive model has been found to be applicable for all test conditions.

The model to be discussed in this report is completely general in that its use does not require a data base to generate new empirical constants. The model is a modification of an analytic approach for predicting residual velocity of penetrators impacting targets at 0°

Herrman and Jones, "Correlation of Hypervelocity Impact Data," Proceedings of the Fifth Symposium on Hypervelocity Impact, Vol. 1, Part 2, April 1902.

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<sup>&</sup>lt;sup>2</sup>Project Thor, "The Resistance of Various Metallic Materials to Perforation By Steel Fragments; Empirical Relationships for Fragment Residual Velocity and Residual Weight," Technical Report #47, Ballistic Analysis Laboratory, Institute for Cooperative Research, The Johns Hopkins University, April 1961.

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	INVESTIGATOR					et. al.				7117	et. al.				1074	AND	E]CHELBERBER			•	3×3×1 1
	STRIKING Velocity				1. <sup>2</sup>						   0					3200 H/S					400 - 3500 H/S
	SIJE									0.518 CH N14.						•					8
3 TLL DEFICIA	Suap÷			5 V 1 F V F					SPHERE			CYLINDER			SHAPES	CHANGE	JFT				), Li
	141E2JAL	4641441A		LEAD	MAGNESLUN	STEEL	21 NC	ALUMI 4UM	62 A 55	LE≜D	MAGNESIUM	nagresium» Littur	LEAD			6 7 8					STEEL
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	56151-41174 F#UATIox			$\left  \mathbf{x}_{t-1} - \frac{1}{2\pi} \right  \mathbf{v}_{p} - \frac{2}{2} \left  \left  \frac{1}{c} \right  \right  = \frac{1}{c}$	$\frac{1}{2} = \frac{1}{2} + \frac{1}$					۲, <sup>1.4</sup>	$x_t = 2.5 \text{ D}$ $\overline{c_t}$	7						, ( <sup>n</sup> <sub>b</sub> v) <sup>1/3</sup> 1	$\left  \frac{x_{t}}{t} - \frac{x_{t}}{t} - \frac{x_{t}}{t} \right  = \frac{1}{t} \left  \frac{x_{t}}{t} \right $		

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	REF NR.		-1	**
	INVESTIGATOR	VAN FLEET et. al.	PARTRIDGE AND Çlay	ER
	STRIKING VELDCITY	<1800 M/S	$0.2 < \frac{v}{\tilde{c}_{t}} < 2.2$	2 2000 M/S
	512E	0.318 CM DIA. 0.476 CM D/A. 0.952 CM DIA.	0.450 CH DIA. 0.559 CH DIA. 0.638 CH LONG 0.965 CH LONG	r 1 8
PROJECTILE	SHAPE	SPHERE	SPRERE CVL:NDER	SРНЕАЕ
	MATERIAL	LEAD	₩AX (4°C)	HERCURY MATER ALUHINUM CUPPER IRON ZINC LEAD
	TARGET MATERIAL	LEAD	4X (23°C)	ALUMINUM 2024-0 COPPER LEAD STEEL ALUMINUM 2024-0 COPPER LEAD ALUMINM COPPER IRCH ZIMC LEAD LEAD
	PE LTRATICE EQUATION	$x_{t} = \frac{v_{p}(1 - e^{-k_{4}E})}{k_{1}k_{3}\sqrt{2}n_{p}E + k_{2}}$	$x_{t} \in W_{P}^{1/3} \frac{(v - v_{o})}{\tilde{c}_{t}} \frac{v_{0}}{\tilde{c}_{t}} < \frac{v}{\tilde{c}_{t}} < 2$	$X_{t^{*}} D \left[ \begin{array}{ccc} x_{1} & p_{1} & V \\ (c_{1} & p_{1} & c_{2} & p_{1}^{1/2} \\ (c_{1} & p_{1} & c_{2} & p_{1}^{3/2} \\ 1.5 & 0 \leq X_{t} \leq 5 & 0 \end{array} \right].$

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			PROJECTILE			
PE: FTPATION EQUATION	TARGEI Material	MATERIAL	SHAPE	SIZE	STRIKING Velocity	INVESTIGATOR
$x_{t} \in K D \left(\frac{v}{\overline{z}_{p}}\right)^{\overline{c}} t^{1}\overline{c}_{p}$	ALUMITAUM Fusper Lead Steel TIN	ALUMINUM COPPER Mallory 1000 Steel	FRAG"ENT		300 - 1800 M/S	AcKENZIE - et. al.
	COPPER LEAD	ALUMINUM COPPER LEAD MAGNESIUM- LITHIUM Steel IUNGSTEN	S F F F F F F F F F F F F F F F F F F F	0.452 CH DIA. D.302 CH DIA. 0.254 CH DIA. 0.554 CH DIA. U.318 CH DIA. U.318 CH DIA. 0.244 CH DIA.	< 3400 H/S	CHARTERS AND LDCKE
	ALUMINUM AGNESIUM ALUMINUM ALUMINUM STAINLESS- STAINLESS- STAINLESS-	STAINLESS-	MICRU- PARTICLE	LOD MICRONS And 150 MICRONS	700 - 4000 M/S	ANDERSON

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v<sup>2/3</sup>

 $\left[\frac{3}{4\pi^{2}}\frac{H}{H}\right]^{1/3}v^{2}$ 

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	RÉF NR.		-		-	-
	INVESTIGATOR		MĂIDEN		COLLINS And Kinarų	  0
	STRIKING Velocity		< 5400 M/S		€ 4000 M/S	1 1 1
	SIZE	0.508 CM DIA. AND	1.016 CH DIA.	0.508 CM DIA.	0.157 CH DIA. 0.559 CH DIA. 1.270 CH DIA. 0.555 CH DIA. 1.270 CH DIA.	t 1 1
PROJECTILE	SHAPE		SPHERE		SPHERE SPHERE CYLINDER (L/D=1)	1   
	MATERIAL	ALUHINUM HAGNESIUM	ALUMINUM	STEEL	ALUMINUM COPPER LEAU STEEL	1
	TARGET MATERIAL	ALU'IINUM STEEL STEEL	COPPER Lead	STEEL	ALIJMINUM COPPER LEAD STEEL	CADMIUM Copper Lead Zinc
	PE'iÉT4≟FL⊖N EQUATION.	$X_{t} = 1.9 D\left(\frac{v}{\overline{c}_{t}}\right) \left(\frac{\rho_{p}}{\rho_{t}}\right)$	$x_{t} = 2.6 p\left(\frac{v}{\overline{c}_{t}}\right)^{0.7} \left(\frac{\rho_{p}}{\rho_{t}}\right)^{0.6}$	$X_{t} = 2 D\left(\frac{v}{\overline{c}_{t}}\right)^{0.75}$	$x_{t} = \frac{k_{1}(p_{p} \vee t - k_{2})}{p_{p}^{K_{3}}(t_{t} + k_{4})^{K_{5}}}$	X <sub>τ</sub> = <u>K</u> M <sup>1/3</sup> y <sup>2/3</sup>

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	INVESTIGATOR	HERRAN	DKĂ	, JONES						THOR			97 \$ 30,4-404,-	agen a gand tindhe	De HARRE
	STRIKING VELJCITY		500 - 3600 M/S			690 - 3200 AVS	340 - 1800 H/S	550 - 2600 H/S	570 - 1605 M/S	300 - 1660 M/S	750 - 3000 H/S	350 - 3300 M/S.	700 - 2600 M/S	500 - 2800 M/S	
	SIZE	SETS	lles	FERIAL/					· • • • • • • • • • • • • • • • • • • •	2	1.745 CH DIA.				j I I
PROVECTLES	BORHS	700 DATIVH	N LAGORATOS	JECTILE MAT	BINATIONS.			CYLINDER	ONV	CURE-ON- CYLINDER	(1:/0≈1)				5 . 8 1
	KATERIAL	ICAL FIT TO I	ATED AT FIFTEE	ISING 52 PRO.	T MATERIAL COME					SIEEL	(SAE 1020)				L L I
	TARGET MATERIAL	E H P I P	GENER	СОНРВ	TARGE	MULSIUM	ALUMINUM	TITANIUM	CAST IRON	STEEL (Rolled Homogeneous	AND FACE-HARSENEU)	COPPER	LEAD	TUBALLOY	6 8 1
	PEVETPATI A COUATION	$\left(\frac{p_{1}}{p_{2}}\right)^{2/3} \left[ \frac{p_{2}}{p_{1}}\right]^{3} \left(\frac{p_{2}}{p_{1}}\right)^{1/3} \left(\frac{p_{2}}{p_{1}}\right)^{1/3} \right]$	$\chi = \kappa_1 0 \left( \frac{-\nu}{-\nu} \right) \chi_n  _1 + \sqrt{\kappa_1} \sqrt{-\kappa_1}  _1$		$K_1 \approx 0.6$ $K_2 \approx 4$ $D = \left(\frac{6}{77}\frac{h}{P_p}\right)^{1/3}$					/1 / X- Y_	X = ( + ) = 5 × 1 = 5	۲ ۵ ۱	E. F. G. AND H ARE EMPIRICAL CONSTANTS		$X_{t} = \begin{bmatrix} H & V^{2} \\ P & S \\ \hline K & D \end{bmatrix} \frac{1/N}{3-N}$

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<sup>5</sup>0gcrkiewicz, R. M., "Design and Development of righting Vehicles" Doubleday & Company, Inc., 1968.

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. Table II, The Thor Equation

)

$$V_{T} = V_{S} - 10^{a} (XA)^{b} M_{S}^{C} V_{S}^{d} \text{ or } X = \frac{1}{A} \left[ \frac{V_{S} - V_{T}}{10^{a} M_{S}^{C} V_{S}^{d}} \right]^{1/b}$$

$$= v_{S} + 10^{a} (XA)^{b} M_{S}^{C} V_{S}^{d} \text{ or } X = \frac{1}{A} \left[ \frac{V_{S} - V_{T}}{10^{a} M_{S}^{C} V_{S}^{d}} \right]^{1/b}$$

htare uniterness (Cm) < •  $V_{r}$  - residual velocity (cm/sec) where:

 $V_{s}$  - striking velocity (cm/sec) ,  $M_{s}$  - striking mass (grams) , A - projectile cross-sectional area (cm^2) ,

a, b, c and d are tabulated below.

	Empiri	cal Cons	stant Expo	onents		Applicable R	lange	
	8	Ą	υ	ų	X (cm)	V_S) (m/s)	M <sub>S</sub> (gm3)	Α (cm <sup>2</sup> )
Magnesium Alioy	5.801	1.092	-1.170	-0.087	0.30-7.62	690-3200	2-16	0.45-1.75
Aluminum Alioy	6.214	1.029	-1.072	-0.139	0.30-2.54	340-1800	2-16	0.45-1.75
Titanium Alloy	4.888	1.103	-ī.095	0.167	0.16-1.30	550-2600	2-8	0.45-1.26
Cast Iron	5.034	1.042	-1.051	0.523	0.45-1.50	570-1800	1-16	0.28-1.75
Rolled Steel (RHA)	5.690	0.889	-0.945	0*0€	0.05-1.27	300-1660	2-16	0.45-1.75
Face Hardened Steel	3.438	0.674	-0.791	0.434	0.30-1.27	750-3000	1-16	0.28-1.75
Copper	1.388	0.678	-0.730	0.802	0.15-2.54	350-3300	1-16	0.28-1.75
Lead	1.067	0.499	-0.502	0.818	0.30-2.54	700-2600	2-16	0.45-1.75
Tuballoy	1.368	0.583	-0.603	0.828	0.25-0.51	500-2800	2-30	0.45-2.39

obliquity proposed by Otto P. Fuchs.<sup>3</sup> The remainder of this report is a discussion of his model, the modification that has been made, and supportive arguments for use of the model.

#### II. THE RESISTIVE FORCE

The expression for the resistive force acting during the penetration process as proposed by Fuchs involves a sum of three components that are functions of the instantaneous velocity:

$$F = f_1 (V^0) + f_2 (V^1) + f_3 (V^2).$$
 (2)

The first component, a static force, is defined as the product of the projectile cross-sectional area and a stress factor. The stress factor is closely approximated by the target Brinell hardness when expressed in dynes/cm<sup>2</sup>. (The Brinell hardness number is multiplied by  $9.8 \times 10^7$  to obtain the value in dynes/cm<sup>2</sup>). The first component is:

$$f_1 (V^0) = A H_t.$$
 (2a)

The second component is a combination of the first and third components, hence, the third component will be presented next. Analogous to the aerodynamic resistive force, the third component is:

$$f_3 (V^2) = C A \rho_t V_x^2.$$
 (2b)

Conversions to be second component, it is defined to be:

$$f_{2}(V^{2}) = 2 \sqrt{f_{1}(V^{0}) f_{3}(V^{2})}$$

$$= 2A \sqrt{C H_{+} \rho_{+} V_{x}^{2}}.$$
(2c)

This component can be compared to Stoke's Equation' in which the resistive force is proportional to the velocity.

A more general form for the resistive force equation has been adopted since the equation proposed by Fuchs did not yield satisfactory results when applied to available data. The generalized equation is:

<sup>3</sup>Fuchs, Otto P., "Impact Phenomena," AIAA Journal, American Institute of Aeronautics and Astronautics, Vol. 1, Nr. 9, Sept. 1963.

<sup>4</sup>Ference, M., Lemon, H., and Stephenson, R., "Analybical Experimental Physics," University of Chicago Press, 1956.

$$F = A (C_1 H_t + C_2 \sqrt{H_t \rho_t} V_x + C_3 \rho_t V_x^2).$$
(3)

The coefficients  $C_1$ ,  $C_2$  and  $C_3$  will be determined in Section V. Equation (3) can be expressed more succinctly as:

$$F = A \left( K_{1} + K_{2} V_{x} + K_{3} V_{x}^{2} \right).$$
 (3a)

#### III. THE DEPTH OF PENETRATION EQUATION

Newton's second law of motion states:

$$F = \frac{d(mV)}{dt} = m\frac{dV}{dt} = ma$$
(4)

assuming that the mass is held constant. The work done in penetrating an increment "dx" is given by:

Work = F dx = - m dx 
$$\frac{dV}{dt}$$
 = - m  $\frac{dx}{dt}$  dV :: - m V dV (5)

where the minus sign is due to deceleration.

Substitution of Equation 3a for the force and arranging terms yields:

$$dx = \frac{-m_{p}}{A} \left[ \frac{VdV}{K_{1} + K_{2} V + K_{3} V^{2}} \right].$$
 (6)

For a specified striking velocity and residual velocity, Equation 6 is integrated to find the target plate thickness (or the maximum depth of penetration for zero residual velocity).

$$\int_{0}^{x_{\rm t}} dx = \frac{-m_{\rm p}}{A} \int_{V_{\rm s}}^{V_{\rm r}} \frac{V dV}{\kappa_1 + \kappa_2 V + \kappa_3 V^2} .$$
(7)

The projectile mass and cross-sectional area are assumed to be constant in Equation 7. In most cases, there is very little, if any, mass loss when penetrating a single target plate. When deformation of the projectile occurs, the cross-sectional area increases and should be accounted for. The effect of the cross-sectional area will be covered in Section VII and will be assumed constant in performing the integration of the equation.

In order to integrate Equation 7, it is necessary to determine the value of the discriminant q, where  $q = 4 K_1 K_3 - K_2^2$ .

If 
$$q > 0$$
, then:

$$X \Big|_{0}^{X_{t}} = -\frac{m_{p}}{A} \left( \frac{1}{2K_{3}} \right) \left[ \ln \left( K_{1} + K_{2}V + K_{3}V^{2} \right) - \frac{2K_{2}}{q^{1/2}} \left( \tan^{-1} \left( \frac{2K_{3}V + K_{2}}{q^{1/2}} \right) \right) \right] \Big|_{V_{s}}^{V_{r}}.$$
 (8)

Substituting the limits and taking into account the negative sign yields:

$$X_{t} = \frac{m_{p}}{A} \left( \frac{1}{2K_{3}} \right) \left[ \ln \left( \frac{K_{1} + K_{2}V_{s} + K_{3}V_{s}^{2}}{K_{1} + K_{2}V_{r} + K_{3}V_{r}} \right) + \frac{2K_{2}}{q^{1/2}} \left\{ \tan^{-1} \left( \frac{2K_{3}V_{r} + K_{2}}{q^{1/2}} \right) - \tan^{-1} \left( \frac{2K_{3}V_{s} + K_{2}}{q^{1/2}} \right) \right\} \right].$$
(8a)

When q = 0 (which is the condition for Fuchs' original equation), integration of Equation 7 yields:

$$X \Big|_{0}^{X_{t}} = -\frac{m_{p}}{A} \left(\frac{1}{K_{3}}\right) \left[ \ln \left(K_{1}^{1/2} + K_{3}^{1/2} V\right) + \frac{K_{1}^{1/2}}{K_{1}^{1/2} + K_{3}^{1/2} V} \right] \Big|_{V_{s}}^{V_{r}}.$$
 (9)

After substitution of the limits, Equation 9 becomes:

$$X_{t} = \frac{m_{p}}{A} \left(\frac{1}{K_{3}}\right) \left\{ \ln \left(\frac{\kappa_{1}^{1/2} + \kappa_{3}^{1/2} v_{s}}{\kappa_{1}^{1/2} + \kappa_{3}^{1/2} v_{r}}\right) + \left[\frac{\kappa_{1}^{1/2}}{\kappa_{1}^{1/2} + \kappa_{3}^{1/2} v_{s}}\right] - \left[\frac{\kappa_{1}^{1/2}}{\kappa_{1}^{1/2} + \kappa_{3}^{1/2} v_{r}}\right] \right\}$$
(9a)

Finally, if q < 0, Equation 7 is evaluated as:

$$X \Big|_{0}^{X_{t}} = \frac{m_{p}}{A} \left( \frac{1}{2K_{3}} \right) \left[ \ln \left( K_{1} + K_{2}V + K_{3}V^{2} \right) - \left( \frac{K_{2}}{\sqrt{-q}} \right) \ln \left( \frac{2K_{3}V + K_{2} - \sqrt{-q}}{2K_{3}V + K_{2} + \sqrt{-q}} \right) \right] \Big|_{V_{s}}^{V_{r}},$$
(10)

which is

$$X_{t} = \frac{m_{p}}{A} \left( \frac{1}{2K_{3}} \right) \left[ \ln \left( \frac{K_{1} + K_{2}V_{s} + K_{3}V_{s}^{2}}{K_{1} + K_{2}V_{r} + K_{3}V_{r}^{2}} \right) + \left( \frac{K_{2}}{\sqrt{-q}} \right) \ln \left( \frac{(2K_{3}V_{r} + K_{2} - \sqrt{-q})(2K_{3}V_{s} + K_{2} + \sqrt{-q})}{(2K_{3}V_{r} + K_{2} + \sqrt{-q})(2K_{3}V_{s} + K_{2} - \sqrt{-q})} \right) \right]. \quad (10a)$$

#### IV. THE TIME-PENETRATION EQUATION

The time to penetrate a target plate to a depth x can be found by again considering Newton's second law of motion.

$$F = -m \frac{dv}{dt} \quad . \tag{11}$$

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Substituting Equation 3a for the force, solving for the time, and integrating (assuming that the projectile mass and cross-sectional area are constant) yields:

$$\int_{0}^{T_{x}} dt = -\frac{m_{p}}{A} \int_{V_{s}}^{V_{r}} \frac{dV}{\kappa_{1} + \kappa_{2}V + \kappa_{3}V^{2}} , \qquad (12)$$

(the minus sign is due to deceleration).

Again letting  $q = 4K_1K_3 - K_2^2$ , three cases exist:

For q > 0:

$$T_{x} = \frac{m_{p}}{A} \left(\frac{2}{q^{1/2}}\right) \left[ \tan^{-1} \left(\frac{2K_{3}V_{s} + K_{2}}{q^{1/2}}\right) - \tan^{-1} \left(\frac{2K_{3}V_{r} + K_{2}}{q^{1/2}}\right) \right]; \quad (13)$$

For q = 0:

$$\Gamma_{x} = \frac{m_{p}}{A} \left( \frac{1}{\kappa_{3}^{1/2}} \right) \left[ \frac{1}{\kappa_{1}^{1/2} + \kappa_{3}^{1/2} v_{r}} - \frac{1}{\kappa_{1}^{1/2} + \kappa_{3}^{1/2} v_{s}} \right]; \qquad (14)$$

For q < 0:

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$$\Gamma_{x} = \frac{m_{p}}{A} \left( \frac{1}{\sqrt{-q}} \right) - \ln \left( \frac{(2K_{3}V_{s} + K_{2} - \sqrt{-q}) - (2K_{3}V_{r} + K_{2} + \sqrt{-q})}{(2K_{3}V_{s} + K_{2} + \sqrt{-q}) - (2K_{3}V_{r} + K_{2} - \sqrt{-q})} \right); \quad (15)$$

where  $T_x$  is the time (in seconds) required for the fragment to penetrate to a depth x (or, in other words, until the velocity drops to the value  $V_r$ ).

## V. DETERMINATION OF THE CONSTANTS $C_1$ , $C_2$ AND $C_3$

A non-linear least squares computer program was used to evaluate the constants  $C_1$ ,  $C_2$  and  $C_3$ . The experimental data are used in Equations 8a, 9a or 10a (depending on the value of the discriminant, q) to determine the best values for  $C_1$ ,  $C_2$  and  $C_3$ . To use the program, an initial guess is made for the values of the constants. The program computes new values for the constants based on values it computes for the partial derivatives of the plate thickness (the dependent variable) with respect to the constants. The statements to evaluate the partial derivatives are provided to the program in a subroutine and are tabulated in this report in Table IIIa. The computer program arrives at a convergent set of constants when the change in the value of each constant from one trial to the next becomes less than some predetermined tolerance value (0.01 was used in this case).

Listed in Table IIIb is a summary of the computational runs made. Shown are the initial guess values for the constants with the corresponding root-mean square error, then the general set of constants obtained when combining the data for all target materials, and finally, the convergent set of constants obtained for each target material. Also shown are the corresponding sigma and T-statistic test value for each constant of the convergent set. The data used are those tabulated in Appendix A with the exception of 20 out of the 277 datum sets.

a - a			Table IIIa. Statements To Evaluate Partial Derivatives For Non-Linear Least Squares Program
			A = PROJECTILE CROSS-SECTIONAL AREA (CM**2) (1 = EMPIRICAL CONSTANT TO BE EVALUATED (2 = EMPIRICAL CONSTANT TO BE EVALUATED (3 = EMPIRICAL CONSTANT TO BE EVALUATED HT = HARDNESS OF TARGET PLATE (DYNES/CM**2) MP = MASS OF PROJECTILE (GRAMS) P1 = FIRST DERIVATIVE OF XT WITH RESPECT TO C1 P2 = FIRST DERIVATIVE OF XT WITH RESPECT TO C2 P3 = FIRST DERIVATIVE OF XT WITH RESPECT TO C3 RHOT = DENSITY OF TARGET PLATE (GRAMS/CC) VR = RESIDUAL VELOCITY OF PROJECTILE (CM/SEC) XT = TARGET PLATE (FRICKNESS (CM)
	C.	(	S=SURT(RHDT+HT) B=S+VS U=RHDT+VS++2 D=S+VR L=RHDT+VR++2 H=2.0+S U=4.0+RHDT+HT H=S++2 R=2.0+RHDT+VR T=MP/(2.0+A+RHDT) U=2.0+RHDT+VS Q0=(4.0+C1+C3-C2++2)+RHDT+HT
	C C C C C		THE DISCRIMINANT Q IS GREATER THAN ZERD
· · · · · · · · · · · · · · · · · · ·	v	100	Q1=(1+HT+C2+B+C3+C Q2=(1+HT+C2+D+C3+E Q3=SQFT(Q0) D4=03**3 Q5=(3+R+C2+S Q7=ATAN(Q5/Q3) QR=ATAN(Q5/Q3) QR=ATAN(Q6/Q3) Q9=T/C3 Q10=C2/Q3 Q11=C3+F+G/Q4
			21

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#### Table IIIa. (Cont'd) Statements To Evaluate Partial Derivatives For Non-Linear Least Squares Program 112-1-0+(95/93)++2 313=1.0+(96/93)\*#2 414-05/04 . Q15=Q6/Q4 T1=02+011+(08-07)/2.0 T2=Q10+Q11+(Q6/Q13-Q5/012)/2.0 Ċ Ċ. P1=39+(HT/01-HT/02+T1+T2) Ċ. С T3=(F/Q3+C2##2#F#H/Q4)\*(Q7~Q8) T4=(5/Q3+C2≠H+Q14)/Q12 T5=(S/Q3+C2+H+Q15)/Q13 C, ( 02=09+(8/Q1-0/Q2+23+010+F\*(84-T5)) C. ( 16=AL0G(02/01)/03 T7=C2+F+(C1+G/(2.0+Q4)+1.0/(Q3+C3))\*(Q8+Q7) $T_{4=}(P/Q_{3}-C_{1}+G+Q_{1}+Q_{0})/Q_{1}2$ T9=(U/Q3-C1+G+Q15/2.0)/Q13 C C P3=49\*(C/Q1-E/Q2+T6+T7+Q10\*F\*(T8-T9)) ٢. ( XT=09+(ALDG(@1/02)+C2\*F/Q3+(27-Q8)) RETURN C C C C 1 THE DISCRIMINANT Q IS EQUAL TO ZERD ( С ι. Q3=SQRT(C1+HT) 200 Q1=Q3+SQRT(C3+RHOT)+VS 12=03+5QKT(C3+RHDT)\*VR 14=5₀5\*50RT(HT/01) \J5=: \_5+%QRT(RHOT/C3)#VS 06=0.5\*SQRT(RHOT/C3)\*VR Q7=:.0#T/C3 C C P1=07=04+(2.0/Q1-2.0/Q2+Q3/42\*+2-Q3/Q1\*+2) C С. 04=C2\*SQRT(HT/C3) 19=12+08/2 010 01-03 Q11=Q2-Q3 Q12=Q++Q10 413-09+011 Ĺ C p2=07+Q3+(2.0/Q12-2.0/Q13+Q9+(1.0/Q13\*+2+1.0/Q12\*\*2)) С Ü

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Table IIIa. (Cont'd) Statements To Evaluate Partial Derivatives For
                        Non-Linear Least Squares Program
      T1=03/01-Q6/02
      72=06/02**2-05/01**2
C
    Ċ
      P3=07*(Q3/Q1-Q3/Q2-ALQG(Q1/Q2)/C3+T1+Q3+T2)
    C
C
      XT=07*(ALOG(Q1/02)+Q3/Q1-Q3/Q2)
      RETURN
           THE DISCRIMINANT Q IS LESS THAN ZERD
Ĉ
C
    r
  300 Q7=5QRT(-Q0)
      Q1~ 1*HT+C2+B+C3+C
      Q2= 1+HT+C2+0+C3+E
      03×2.0×C3×R+C2×5-07
      04=03+2.0+07
      45=2.0+03+0+02+5+07
      46=05-2.0+07
      38×12×5/07
      47=T/C3
      Q10=ALDG(Q3+Q5/(Q4+Q6))
      UL1=C3+G/(2.0+Q7)
      012:02*4/07
      Q13=C1*G/(2.0*Q7)
      11=C3+6+Q10/(-Q0)+Q11/Q3+Q11/Q4-Q11/Q5-Q11/Q6
C
    ٤
      P1=J9*(H1/01-HT/02+Q8*T1)
Ĉ
    ſ
      72=5/47-02+4/(47++3)
      T3*(S-Q12)/Q3+(5+Q12)/Q5-(S+Q12)/Q4-(S-Q12)/Q6
C
    C
      P2=09+(B/Q1-D/Q2+T2#010+Q8+T3)
Ĉ
    ι,
      T4#98#Q10#(1.0/C3+C1#G/(2.0#ABS(QO)))
      15=(R+Q13)/Q3+(U=Q13)/Q5
      To=(R-Q13)/Q4+(U+0)3)/06
    ſ.
С
      P3=Q9*(C/Q1-E/Q2-ALDC(Q1/Q2)/C3-T4+Q8*(T5-T6))
C
    t
      XY=09*(ALDG(01/Q2)+Q8*Q10)
      RETURN
      END
```

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Target <u>Material</u>		Initial	General	Convergent	σ	T	Number of Datum Sets
Magnesium	С,	0.40	0.70	1.96	1.72	1.1	22
	່ ເຼົ	0,90	0.23	-1.17	1.84	-0.6	
	Cړ	0.50	0.50	0,83	0.42	2.0	
	ERMS	0.72	0.60	0.58	-	-	
Aluminum	с <sub>1</sub>	0.39	0.70	0.62	0.27	2.2	83
	с <sub>2</sub>	0.68	0.23	0.41	0.52	0.8	
	с <sub>3</sub>	0.41	0.50	0.40	0.21	1.9	
	ERMS	0.16	0.15	0.15	-		
Titanium	с <sub>1</sub>	0.40	0.70	4.06	2.92	1.4	18
	с <sub>2</sub>	0.80	0.23	-3.10	3.04	-1.0	
	C <sub>3</sub>	0.50	0.50	1.38	0.74	1.8	
	ERMS	0.12	0.17	0.11	-	-	
Cast Iron	C <sub>1</sub>	0.70	0.70	0.37	0.39	0.9	19
	$C_2$	0.23	0.23	0.13	0.58	0.2	
	C_3	0.50	0.50	0.53	0.18	0.3	
	ERMS	0.18	0.18	0.09	-	-	
Steel (RHA)	c1	0.40	0.70	0.53	0.93	0.6	17
	с <sub>2</sub>	0.40	0.23	0.31	1.32	0.2	
	C_3	0.30	0.50	0.34	0.44	0.8	
	ERMS	0.07	0.12	0.06	-	-	
Steel (FHA)	c,	0.00	0.70	$-3.4 \times 10^{-4}$	0.22	002	24
	$C_2$	0.20	0.23	1.18	0.30	3.9	
	C <sub>3</sub>	0.50	0.50	0.33	0.10	3.4	
	ERMS	0.47	0.14	0.08	-	*	
Copper	c,	0.10	0.70	0.48	0.98	0.5	27
	$c_2$	1.50	0.23	0.20	0.68	0.3	
	C_3	0.50	0.50	0.61	0.09	6.7	
	ERMS	0.16	0.18	0.09	-		

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Table IIIb. Non-Linear Least Squares Fit to Thor Data

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Table IIIb. (Cont'd) Non-Linear Least Squares Fit to Thor Data

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Target <u>Material</u>		<u>Initial</u>	<u>General</u>	Convergent	<u> </u>	<u> </u>	Number of Datum Sets
Lead	C,	-1.00	0.70	-7.70	1.84	-4.2	26
	c,	1.00	0.23	6.22	1.23	5.1	
	ເຼັ	0.50	0.50	0.19	0.11	1.8	
	ERMS	0.36	0.34	0.30	-	-	
Tuballoy	С,	-0.50	0.70	-0.34	0.59	-0.6	20
	c_	1.00	0.23	2.08	0.81	2.6	
	Cړ	0.25	0.50	0.30	0.22	1.4	
	ERMS	0.44	0.12	0.11	-	-	
Combined	с,	0.40	0.70	0.70	0.12	5.7	257
Data	$c_2$	0.90	0.23	0.23	0.13	1.8	
	Ċ,	0.50	0.50	0.50	0.03	18.6	
	ERMS	0.29	0.23	0.23	-	-	

Target		<u> </u>	с <sub>2</sub>	<sup>σ</sup> 2	с <sub>3</sub>	σ3	<u>Nr.</u>	Final ERMS
Magnesium	1.96	1.73	-1.17	1.84	0.83	0.42	22	0.58
Aluminum	0.62	0.27	0.41	0.52	0.40	0.21	83	0.15
Titanium	4.06	2.92	-3.10	3.04	1.38	0.74	18	0.11
Cast Iron	0.37	0.39	0.13	0.58	0.53	0.18	19	0.09
Steel (RHA)	0.53	0.93	0.31	1.32	0.34	0.44	17	0.12
Steel (FHA) -3	.4x10 <sup>-4</sup>	0.22	1.18	0.30	0.33	0.10	24	0.08
Copper	0.48	0.98	0.20	0.68	0.61	0.09	27	0.09
Lead	-7.70	1.84	6.22	1.23	0.19	0.11	26	0.30
Tuballoy	-0,34	0.59	2.08	0.81	0.30	0.22	20	0.13
Combined Data	0.70	0.12	0.23	0.13	0.50	0.03	257	0.23

## Table IIIc. Summary of Convergent Values For $C_1^{}$ , $C_2^{}$ and $C_3^{}$

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#### These 20 datum sets are tabulated in Table IV.

Two things should be noted concerning the values of Table IIIb. First, the values for the constants can vary considerably with little change in the root-mean square error. Secondly, the sigmas for the constants are large relative to the value of the constants for the individual target materials. This becomes more apparent in the summary Table IIIc. Therefore, the constants evaluated with the combined set of data seem to be relatively good estimates for a general set of constants. These values are:  $C_1 = 0.70$ ,  $C_2 = 0.23$  and  $C_3 = 0.50$ . (The values for Fuchs' original equation are 1.0, 1.414, and 0.50 when the shape factor is unity. However, Fuchs' equation corresponds to Equation 9a rather than 8a).

Substitution of the general set of constants into Equation 8a yields:

$$X_{t} = \frac{m_{p}}{A \rho_{t}} \left\{ 2n \left[ \frac{0.7 H_{t} + 0.23 \sqrt{H_{t} \rho_{t}} V_{s} + 0.5 \rho_{t} V_{s}^{2}}{0.7 H_{t} + 0.23 \sqrt{H_{t} \rho_{t}} V_{r} + 0.5 \rho_{t} V_{r}^{2}} \right] \right\}$$

+ 0.396 
$$\left[ \tan^{-1} \left( \frac{\rho_{t} V_{r} + 0.23 \sqrt{H_{t} \rho_{t}}}{1.16 \sqrt{H_{t} \rho_{t}}} \right)$$
(16)

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$$-\tan^{-1}\left(\frac{\rho_{t} V_{s} + 0.23 \sqrt{H_{t} \rho_{t}}}{1.16 \sqrt{H_{t} \rho_{t}}}\right)\right]$$

The penetration time equation becomes:

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$$\Gamma_{x} = \frac{2 m_{p}}{1.16 \text{ A } \sqrt{H_{t}} \rho_{t}} \left[ \tan^{-1} \left( \frac{\rho_{t} V_{s} + 0.23 \sqrt{H_{t}} \rho_{t}}{1.16 \sqrt{H_{t}} \rho_{t}} \right) - \tan^{-1} \left( \frac{\rho_{t} V_{r} + 0.23 \sqrt{H_{t}} \rho_{t}}{1.16 \sqrt{H_{t}} \rho_{t}} \right) \right].$$
(17)

Equation 8a along with the values for the constants  $C_1$ ,  $C_2$  and  $C_3$  or in the form of Equation 16 will be referred to as the Z/F equation.

Target Material	Datum Set Nr.	H <sub>t</sub>	X <sub>t</sub>	M	Dp	V <sub>s</sub>	V r
		(Kg/mm <sup>2</sup> )	<u>) (cm)</u>	<u>(gms)</u>	<u>(cm)</u>	<u>m/s</u>	<u> </u>
Magnesium	21	72.0	2.540	15.56	1.49	1417.0	537.7
Aluminum	78	120.0	2.540	15.56	1.49	975.4	0.0
Titanium	1	190.0	9.127	1.95	0.76	567.8	521.2
	10	190.0	0.318	3.89	1.01	620.3	500.8
Steel (FHA)	) 2	400.0	0.345	1,95	0.76	748.3	0.0
	4	400.0	0.345	1.95	0.76	1081.7	0.0
	9	400.0	0.635	3.89	1.01	1066,8	0.0
	14	400.0	1.270	3.89	1.01	1791.0	0.0
Copper	18	42.0	0.318	7.78	1.27	745.5	501.7
Lead	1	5.5	0.318	1.95	0.76	2401.2	1066.8
	2	5.5	0.318	1.95	0.76	2439.9	914.4
	4	5.5	0.348	1.95	0.76	957.7	457.2
	6	5.5	0.348	1.95	0.76	1721.5	762.0
	11	5.5	0.698	3.89	1.01	757.7	\$33.4
	14	5.5	0.318	7.78	1.27	1810.5	1101.8
	25	5.5	0.635	15.56	1.49	2608.8	1005.8
	32	5.5	2.54	15.56	1.49	1263.7	762.0
Tuballoy	8	240.0	0.254	3.89	1.01	1471.6	823.0
	15	240.0	0.508	7.78	1.27	1699.9	1219.2
	22	240.0	0.508	30.16	1.74	2171.4	640.1

## Table IV. Data Eliminated From Non-Linear Least Squares Fit to Thor Data

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Total number is 20 sets.

#### VI. COMPUTING RESIDUAL VELOCITY

An iterative procedure must be adopted to solve Equation 16 for residual velocity. One procedure is to determine the force acting over consecutive  $\Delta x$  increments and compute the corresponding speed reduction. From Equation 5,

$$dv = -F dx/(m v) = -(K_1 + K_2 v + K_3 v^2) dx/(m v).$$

The algorithm displayed in Figure 1 outlines the procedure.

This model was chosen for computing the residual velocity because it allows flexibility in defining the force equation. There is no need to check the value of the discriminant q ( $q = 4K_1K_3 - K_2$ ) since it does not appear explicitly in this approach. Admittedly, this model is an approximation to the integrated equation but little error is involved because of the imposed criterion of

$$\left| \frac{\Delta V' - \Delta V''}{1/2 (\Delta V' + \Delta V'')} \right| < 0.001.$$
 (18)

One problem that has been encountered occurs when the residual velocity approaches zero. The required  $\Delta x$  increment to cause the quantity of Equation 18 to be less than 0.001 becomes progressively smaller. Hence, a lower limiting value must be imposed on  $\Delta x$  or on the residual velocity in order to terminate the loop cycle. A tabulation of the computer program deck is given in Appendix C along with sample output.

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An alternative method is to use Equation 16 by progressively increasing or decreasing the residual velocity value until the computed plate thickness yields the correct plate thickness to some degree of accuracy. A tabulation of such a program is included in Appendix C along with sample output of the program.

Also in Appendix C are tabulacions of programs to find the plate thickness using Equation 82 and the Thor equation, and a program for finding residual velocity using the Thor equation. Sample output is included for each program.

#### VII. VALIDATING THE MODEL

One method for demonstrating the accuracy of a proposed model is to plot the predicted residual velocity or the predicted plate thickness against the experimental value. A perfect prediction will lie on the diagonal line. Plots are presented in Appendix B comparing the Thor equation with the Z/F equation for residual velocity and for plate thickness. The Thor data tabulated in Appendix A is used for making

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Figure 1. Outline of Procedure to Find Residual Velocity

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these comparisons. A study of the plots will show visually the accuracy and the similarity between the two models.

The Thor equation plots do not necessarily look like a least squares fit to the data because the exponents were obtained from a least squares fit to all the data for each target material reported in Reference 2. These data include oblique angle targets. What is plotted on the graphs of Appendix B is the data (tabulated in Appendix A) which involves normal impact only.

The similarity in the predictions made by the two equations and the poor showing for some of the data for each target material is likely due to inaccuracies in the data. The striking velocity and the residual velocity can be in error because of difficulties with the recording instrumentation. In some cases, the residual velocity was estimated from the depth of penetration into Celotex or similar material. Even in those cases where the residual velocity was determined from velocity screens and a chronograph, there can be doubt as to whether the same particle triggered both screens.

A second parameter which is possibly inaccurate is the crosssectional area of the projectile on impact. The yaw angle was not reported, resulting in uncertainty concerning the orientation of the projectile. Table V lists the values for the cylindrical rod crosssectional areas as a function of yaw angle. For example, the crosssectional area for the 1.95 gram cylinder at 0° yaw is 0.452 cm<sup>2</sup>. The maximum area occurs at about 40° yaw and is 0.611 cm<sup>2</sup>. At 90° yaw (sideways impact) the cross-sectional area is the minimum - 0.411 cm<sup>2</sup>. The uncertainty in the area can represent so such as a 26 percent error since the value which was used in both the Thor equation and the Z/F equation is the value at 0° yaw.

As indicated in Section III, the cross-sectional area was assumed to be constant when performing the integration. In reality, the projectile deforms and increases in cross-sectional area as it penetrates through the target plate. However, in using the non-linear least squares program to evaluate the three constants, the effect of the increase in projectile cross-sectional area was statistically taken into account. In other words, the particular values of the constants which were selected represent an average effect of the projectile penetrating the target plate.

The third parameter which is questionable is the target Brinell hardness. The values which were used are the nominal values reported in handbooks except an average value was used for cast iron and for the tace-hardened steel Experience has shown that the actual Brinell hardness for a particular plate can vary by at least 20% from the handbook value and seems to be a function of plate thickness, at least in the case of 2024T-3 aluminum and rolled homogeneous steel. 31

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Mass (gr	ns)	a	0.973	1.946	3.891	7.782	15.564	36.250
Radius	(cʰs)	=	0.296	0.380	0.506	9.633	0.746	0.372
Length	(cms)		0.457	0.541	0.617	0.795	1.143	1.661
Yaw Ang	l <b>e</b> (de	egs.	.)		Areas	(cm <sup>2</sup> )		
	0		0.275	0.452	0.804	1.259	1.748	2.389
	5		0.298	0.487	0.856	1.342	1.890	2.632
	10		0.318	0.517	0.901	1.414	2.018	2.856
	15		0.336	0.543	0.939	1.476	2.130	3.057
	20		0.351	0,566	0.969	1.527	2.226	3.236
	25		0.364	0.584	0.993	1.566	2.305	3.389
	30		0.374	0.597	1.009	1.593	2.367	3.517
	35		0.381	0.606	1.017	1.608	2.410	3.618
	40		0.385	0.611	1.018	1.611	2.435	3.692
	45		0.386	0.610	1.010	1.608	2.442	3.737
	50		0.384	0.605	0.995	1.580	2.430	3.755
	55		0.379	0.596	0.973	1.546	2.400	3.743
	60		0.372	0.582	0.943	1.501	2.351	3.703
	65		0.362	0.563	0.906	1.444	2.284	3.635
	70		0.348	0.541	0.862	1.376	2.200	3.539
	75		0.333	0.544	0.811	1.298	2.100	3.416
	80		0.314	0.483	0.755	1.210	1.983	3.267
	85		0.294	0.448	0.692	1.112	1.851	3.094
	90		0.271	0.411	0.624	1.006	1.705	2.897
Maximum	Erroz	r =	+29%	+26%	+21%	+22%	+28%	+36%
			- 1%	-10%	-29%	-25%	- 3%	- 0%

Table V. Cross-sectional Areas By Yaw Angel For Cylinder Rods

Area =  $\Pi r^2 \cos \alpha + 2rL \sin \alpha$ where: r - radius (cms), L - length (cms),

and  $\alpha$  - yaw angle (degrees).

Mathematical comparisons of the two equations are tabulated in Tables VIa, b, c and d. The definitions for the column headings are the following:

Number: number (n) of datum sets for the target material,

Mean: the arithmetic average  $\overline{X} = \Sigma X_{i}/n_{i}$ ,

Variance:  $(\Sigma(X_{i}^{2}) - n(\overline{X})^{2})/(n - 1)$ ,

Standard Deviation: = /Variance,

- D: the deviant (the difference between the predicted value and the experimental value),
- R. E.: the relative error (the deviant divided by the experimental value),

and  $\Sigma$  : denotes summation.

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Tables VIa and VIb are for plate thickness, and Tables VIc and VId are for residual velocity; the deviants and relative errors are presented respectively for both sets of tables. For some target materials, the Thor equation renders less error overall in its predicted values than the Z/F equation. For other target materials, the Z/F equation is better than the Thor equation. In all cases, the two equations do not yield grossly different results from each other.

The advantage of the Z/F equation is that it is more general in its application than the Thor equation. The Z/F equation may be used with some confidence for any case where the values of the parameters (target obliquity and Brinell hardness; projectile mass, cross-sectional area at impact, and striking velocity; and either plate thickness or projectile residual velocity) are known. By contrast, the Thor equation is limited to those projectile/target materials for which sufficient experimental data exists to evaluate the necessary empirical exponential constants. It is also limited to the range of values for each parameter for which data exists. As has been shown in Table II, the empirical constants vary from one target material to the next. The Thor equation is an expression involving parameters thought to be significant in the projectile-target interaction. On the other hand, the Z/F equation is based on an expression for the resistive force experienced by a projectile while penetrating a target. The three constants which appear in the equation were determined by fitting the depth-of-penetration equation to experimental data using a non-linear least squares procedure. While these constants have been evaluated empirically, the same values are used for all the target materials. As a result, one feels more confident in applying the Z/F equation to projectile/target materials in general.

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Target <u>Material</u>	Number	Mean	Variance	Standard Deviation	<u>ΣD</u>	ΣD <sup>2</sup>	
Magnesium	23	0.129	0.753	0.868	2,966	16.952	Thor
	23	0.021	0.517	0.719	0.474	11.378	Z/F
Altminum	84	-0.085	0.024	0.155	-7.127	2.606	Thor
	84	-0.066	0.016	0.129	-5.533	1.737	Z/F
Titanium	20	0.030	0.014	0.120	0.604	0.292	Thor
	20	0.033	0.024	0.155	0.665	0.480	Z/F
Cast Iron	19	0.015	0.010	0.102	0.284	0.190	Thor
	19	-0.144	0.006	0.077	-2.738	0.501	Z/F
Steel (RHA)	17	-0.094	0.002	0.048	-1.598	0.187	Thor
	17	-0.085	0.005	0.070	-1.442	0.201	Z/F
Steel (FHA)	29	0.012	0.015	0.124	0.363	0.436	Thor
	29	-0.090	0.014	0.119	-2.598	0.630	Z/F
Copper	28	0.022	0.011	0.107	0.627	0.324	Thor
	28	0.118	0.013	0.116	3.314	0.754	Z/F
Lead	34	0.180	0.337	0.581	6.127	12.232	Thor
	34	-0.061	0.209	0.457	-2.085	7.034	Z/F
Tuballoy	23	0.010	0.049	0.222	0.237	1.084	Thor
	23	0.029	0.042	0.205	0.673	0.941	Z/F
Combined	277	0.009	0.124	0.352	2.483	34.303	Thor
Data	277	-0.033	0.085	0.291	-9,270	23.656	Z/F

### Table VIa. Comparison of The Mean, Variance, Standard Deviation, Sum and Sum of Squares of The Plate Thickness Deviants

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Target Material	Number	Mean	Variance	Standard Deviation	<u>Σ R.E.</u>	<u>Σ (R.E.)<sup>2</sup></u>	
Magnesium	23	0.001	0.107	0.327	0.014	2.349	Thor
Magnesium	23	0.003	0.115	0.339	0.061	2.531	Z/F
Aluminum	84	-0.135	0.035	0.188	-11.323	4.470	Thor
	84	-0.113	0.026	0.160	-9.473	3.185	Z/F
Titanium	20	0.024	0.072	0.268	0.473	-0.530	Thor
	20	-0.027	0.086	0.293	-0.530	1.650	Ż/F
Cast Iron	19	0.020	0.013	0.115	0.371	0.244	Thor
Cast 110h	19	-0.215	0.017	0.131	-4.090	1.189	Z/F
Steel (RHA)	17	-0.353	0.041	0.202	-5.996	2.770	Thor
	17	-0.238	0.023	0.150	-4.053	1.327	Z/F
Steel (FHA)	29	0.024	0.048	0.220	0.684	1.366	Thor
00001 (111)	29	-0.083	0.019	0.138	-2.416	0.738	Z/F
Conner	28	0.017	0.033	0.182	0.483	0.900	Thor
copper	28	0.208	0.029	0.170	5.836	2,000	Z/F
Lead	34	0.307	0.599	0.774	10.428	22.964	Thor
Dead	34	0.100	0.218	0.467	3.393	7.549	Z/F
Tubaliov	23	0.034	0.217	0.466	0.790	4.798	Thor
10001109	23	0.074	0.186	0.431	1.693	4.212	Z/F
Combined	277	-0.015	0.149	0.386	-4.076	41.232	Tho
Data	277	-0.034	0.087	0.295	-9.579	24.381	Z/F

## Table VIb. Comparison of The Mean, Variance, Standard Deviation, Sum and Sum of Squares of The Plate Thickness Relative Error

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Target	No	N	Vantanaa	Standard	50	<sub>50</sub> 2	
Material	NUMBET	Mean	variance	Deviation	<u> </u>		
Magnesium	23	34.4	73596.7	271.3	790.8	1646313.1	Thor
-	23	14.6	38264.1	195.6	336.9	846745.9	Z/F
Aluminum	84	-51.9	4577.3	67.7	-4361.4	606365.9	Thor
	84	-39.1	5763.3	75.9	-3286.9	606962.7	Z/F
Titanium	20	42.8	20346.8	142.6	855.3	423167.2	Thor
	20	33.3	23154.6	152.2	665.7	462092.6	Z/F
Cast Iron	19	-0.4	8712.5	93.3	-7.3	156828.0	Thor
	19	-149.8	11266.8	106.1	-2846.8	629338.2	Z/F
Steel (RHA)	17	-119.9	4466.9	66.8	-2039.1	316062.1	Thor
	17	-100.1	5978.1	77.3	-1701.5	265952.4	Z/F
Steel (FHA)	29	-0.7	17081.4	130.7	-19.5	478292.9	Thor
	29	-94.3	37147.3	192.7	-2734.9	1298040.9	Z/F
Copper	28	18.2	12024.6	109.7	510.7	333979.7	Thor
	28	89.2	14203.1	119.2	2497.2	606139.8	Z/F
Lead	34	82.7	60913.1	246.8	2813.4	2224937.2	Thor
	34	34.8	66762.6	258.4	1184.0	2244396.9	Z/F
Tuballoy	23	-23.6	59978.1	244.9	-543.3	1332350.9	Thor
	23	12.7	72507.2	269.3	291.8	1598861.4	Z/F
Combined	277	-7.2	27187.9	164.9	-2000.4	7518297.0	Thor
Data	277	-20.2	30600.0	174.9	-5594.5	8558583.8	Z/F

## Table VIc. Comparison of The Mean, Variance, Standard Deviation, Sum and Sum of Squares of The Residual Velocity Deviants

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Target	·•• •		u	Standard		<b>F</b> ( <b>F F</b>	2
Material	Number	Mean	Variance	Deviation	<u>z R. E.</u>	<u>2 (R. E.</u>	2
Magnesium	23	0.048	0.383	0.619	1.111	8.482	Thor
	23	0.062	0.259	0.508	1.431	5.778	Z/F
Aluminum	83*	-0.113	0.043	0.207	-9.370	4.577	Thor
	83*	-0.085	0.073	0.270	-7.062	6.596	Z/F
Titanium	20	0.063	0.066	0.258	1.261	1.341	Thor
	20	0.059	0.103	0.321	1.173	2.032	Z/F
Cast Iron	19	-0.003	0.044	0.210	-0.049	0.795	Thor
	19	-0.352	0.041	0.376	-6.698	4.901	Z/F
Steel (RHA)	17	-0.189	0.015	0.121	-3.214	0.844	Thor
	17	-0.139	0.011	0.103	-2.366	0.500	Z/F
Steel (FHA)	26*	-0.049	0.022	0.149	-1.286	0,615	Thor
	28*	-0.237	0.139	0.373	-6.641	5.239	Z/F
Copper	28	0.025	0.021	0.144	0,696	0.576	Thor
••	28	0.171	0.031	0.175	4.789	1.646	Z/F
Lead	34	0.166	0.150	0.387	5.664	5.880	Thor
	34	-0.001	0.126	0.355	-0.023	4.156	Z/F
Tuballoy	23	0.023	0.100	0.316	0.530	2.215	Thor
	23	0.025	0.173	0.416	0.578	3.286	Z/F
Combined	273*	-0.017	0.093	0.305	-4.657	25.325	Thor
Data	275*	0.054	0.124	0.352	-14.809	34.764	Z/F

#### Table VId. Comparison of The Mean, Variance, Standard Deviation, Sum and Sum of Squares of The Residual Velocity Relative Error

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Does not include data where the residual velocity was zero unless the predicted residual velocity was also zero.

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### VIII. ANALYZING THE PENETRATION PROCESS

Although the force Equation 3 may not represent reality, it does involve relevant physical parameters. When applied to Newton's equation of metion, the resulting integrated equation does a fair job of predicting plate thickness (or residual velocity as the case may be) over a wide range of target materials. It would be fair to say that the force equation represents an average effect of the resistance to penetration encountered by a projectile. Therefore, it should be possible to learn something about the penetration process.

The equations of Section III can be reduced to the following form:

$$\frac{X_t A}{M_p} = f(\rho_t, H_t, V_s, V_r) .$$

The parameters associated with the projectile (the cross-sectional area, A, and the projectile mass  $M_p$ ) appear on one side of the equation along with the target plate thickness  $X_t$ . This allows generalized curves to be drawn, plotting the values for  $X_tA/M_p$  as a function of velocity for particular values of target plate hardness  $H_t$  and target density  $\rho_t$ .

A family of curves is shown in Figure 2a. The target plate hardness is held constant at BHN 100. Each curve represents a different target plate density. Along the abscissa (the x-axis) is the parameter  $\chi_t A/M_p$ and along the ordinant (the y-axis) is the projectile velocity. The plot can be used in two ways.

First, an estimate of the residual velocity for a given striking velocity can be made by finding the point on the curve corresponding to the striking velocity, then following the curve for a distance in the x direction corresponding to the computed value for  $X_tA/M_p$  and then reading the residual velocity off of the y-axis. For example:

Given:  $X_t = 1.5 \text{ cm}$ .  $H_T = BHN \ 100 = 9.8 \times 10^9 \text{ dynes/cm}^2$   $A = 2.5 \text{ cm}^2$   $V_s = 2500 \text{ m/s} = 250000 \text{ cm/sec}$   $\rho_t = 2.77 \text{ g/cc} \text{ (aluminum)}$  $M_p = 2.2 \text{ grams}.$  (1.5)(2)

Find the residual velocity where  $X_tA/M_p = \frac{(1.5)(2.5)}{2.2} = 1.70$  by referring to Figure 3a.

Proceeding over 1.70 units in the x-direction along the curve for





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aluminum (BHN 100) beginning at the point for 2500 m/s yields a value for velocity which is less than zero. That is, the projectile would not be able to penetrate 1.5 cm. Changing  $X_t$  to 0.5 cm yields a new value of 0.568. Using this value results in an approximate residual velocity of  $V_T = 780$  m/s.

The second way these curves can be utilized is to estimate the limit velocity, i.e., the striking velocity required for the projectile to travel completely through the target with zero residual velocity. For the second case in the example above, where  $X_t A/M_p = 0.568$ , the limit velocity is found by going to the left 0.568 units along the x-axis from where the curve for aluminum meets the axis and finding the corresponding x-point on the curve and then reading the velocity value on the y-axis. In this example, the limit velocity is approximately 1630 m/s. Greater precision (mathematically) can be obtained by substituting the appropriate values into Equation 16.

It should be noted in Figure 2a, Figure 2b (which is similar to 2a except the hardness is held constant at BHN 200) and in Figures 3a, b and c that the slope of each curve becomes more negative as the velocity decreases and changes dramatically as the velocity approaches zero. The latter is caused by the static component of the force equation dominating the other two terms. This explains why it is not possible to linearly extrapolate limit velocities from residual velocity data.

It should also be noted that the variation of penetration with respect to target plate density is non-linear. There is greater variation for a change in less dense materials than a corresponding change in the more dense materials. For example, a velocity change from 2500 m/s to 2000 m/s yields the following:

Density	X <sub>t</sub> A/M <sub>p</sub>	<sup>ρ</sup> t <sup>X</sup> t <sup>A/M</sup> p
1 g/cc	0.300	0.300
2 g/cc	0.175	0.350
4 g/cc	0.095	0.380
8 g/cc	0.052	0.416.

If the variation were linear, the values in the third column would be identical. A non-linear effect can also be seen in Figures 3a, b and c with respect to target plate hardness for a given plate density. Hence, the homogeneity of the target with respect to hardness and density determines to a great extent the replicability of a given set of experimental conditions.

The single most important geometric variable of the projectile parameters is the projected cross-sectional area of the projectile at impact. The yaw angle is difficult to control and to determine with the exception of spheres and spin stabilized projectiles. Any change

in the yaw angle results in a new cross-sectional area since it is the projected area of the projectile onto the surface of the target plate that is required.

When considering the ability of the projectile, as a whole, to penetrate a target, the important parameter is the ratio of the projectile mass to its area. Shaped charges are capable of deep penetrations because they have a large mass per unit area ratio.

### IX. SUMMARY AND FUTURE AREAS OF INVESTIGATION

An analytic model of kinetic energy round penetration has been presented. This model compares favorably with the Thor equation in predicting residual velocity for a projectile-target interaction. It is more general in its application than the Thor equation and can be used to study the penetration process.

An extension will be made to include oblique attack angles. A preliminary approach will be to adopt the same method as the Thor approach, i.e., multiplying by the secant of the angle raised to some power (sec  $\theta$ )<sup>f</sup>. Something more complex may be required to adequately predict the effect of oblique angles.

Arother area of investigation is predicting projectile breakup and predicting residual masses. This information can then be used to predict penetration of a secondary target plate.

#### ACKNOWLEDGMENT

The author acknowledges the assistance of Dr. Charles Anderson in the preparation of this report and to Mr. Thomas Jeter, Mr. John Kineke and Mr. John Polk, all in the Fragmentation Branch of Warhead Mechanics Division, for reviewing the report for comprehensiveness and accuracy.

## APPENDIX A

## PROJECTILE-TARGET PENETRATION DATA

All values reported in Reference 2 appearing in this appendix have been converted from the British system of units to the metric system with the exception of the Brinell hardness numbers which were already in the metric system.

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	Mass (Grams)	15.564	7.782	3.891	1.946	0.973	15.564	7.782	3.891	. 1.946	0.973	30.804	
Type II		1.052	0.897	0.716	0.536	0.424			-				eel .
	<b>O</b> .	0.899	0.556	0.437	0.424	0.348		1	- <b>•</b>				SAE 1020 St
←- ▼+ ↓ ℃	<b>U</b>	0.572	0.432	0.333	0.292	0.236	• · ·						ents made of
	, <b>m</b>	1.471	0.988	0.770	0.716	0.584	1.143	0.795	0.617	0.541	0.457	1.661	cms. Fragm
Type I	<b>X</b>	1.491	1.267	1.013	0.759	0.592	1.491	1.267	1.013	0.759	0.592	1.745	tions are in
	Type	I	I	I	I	н	II	II	II	II	H	II	All dimens

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Target Materials

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	BHN	- 72	120	190	150-220	(Front) 480-550 (Rear) 331-375	~ 150 ~ 380	42	5.5	. 235-245
	Density (g/cc)	1.76, 1.83	2.77	4.42, 4.55	7.21	7.78	7.78	8.91	11.01	18.71
	Identification	FS-1 (Dow Chemical), AZ92	2024T-3 and 2024T-4	Ti 6Al 4V; Ti 7 Mn	Ductile Nodular Graphitic (60-45-18) ASTM-A339-51T			Elec. Tough Pitch; QQC-502	Comm. Pure (No Sb) B-29-40-I	Depleted Uranium or U238
	Name	Magnesium Alloys	Aluminum Alloys	Titanium Alloys	Cast Iron	- Face-Hardened Steel	Homogeneous Steel (a) Mild (b) Hard	Copper	Lead	Tuballoy

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HOLE	AREA (CH <sup>2</sup> )	***	***	***	**	***	***		*	**		#	ŧ	***	**		**	#	:	*	***			
RESIDUAL	HASS (GRAMS)	1.650	1.640	1.650	1.640	1.500	.660	. 590	3.630	3.580	3.550	3.750	7.720	***	5.050	6.780	7.000	#		13.110	14,320	13.920	12.860	***
	REŠIOUAL (M/S)	487.1	632.5	763.9	603.2	419.1	6*666	1164.9	680.9	842.2	660.5	447a4	738.5	945.5	10.79.0	820.8	[ 6°661	237.7	1239.0	1201.5	980.9	537.7	572.7	1275.9
SPE	STRIKING (M/S)	695.5	£°616	1488.6	1373.4	1328.5	2497.5	2390.7	359.8	1206.1	1211.3	1244.8	877,2	1149.7	1382.6	1485.0	1478 <b>.</b> 0	2218.9	1439.3	1530.4	1410.3	1417.0	1438.1	3179.8
	AREA (CM <sup>2</sup> )	.452	.452	. 452	. +52	452	. 452	. 452	306	806	. 806	. 306	1.261	1,261	1,251	[ I.261	1.261	1.261	1.746	I.746	1.746	1.746	1.746	1.746
PROJECTILE	DIAHETER (Sm)	.759	.759	.755	.759	.759	.759	.759	1.613	1.013	1.013	1.613	1.267	1.2 <i>6</i> 7	1.267	1.267	1.267	1.267	16431	164.1	1.491	1.491	1.491	164-1
	MASS (SRAMS)	1.950	1.950	1.950	1.950	1.950	1.950	1.950	3_890	3.890	3.890	3.890	7.780	7.780	7.780	7.780	7.780	7.780	15.560	15.560	15.560	15.560	15.560	15.500
	08619011Y (DEG)	c.	0	c.	0	0	•	ē.	c		•	c.	0	0	•	<b>G•</b>	0	•	C		· ·	0.	0.	0.
	THICKNESS (CM)	BIE.	.765	1.273	2.540	2.540	2.540	2.540	.765	1.270	1.270	2.540	.765	1.270	1.905	2.540	5.080	5.080	672-1	1.905	2.540	2,540	5.090	7.620
Pur Indi	HAKPIESS (KG/: 42)	72.0	72.0	72.0	12°D	72.0	72,5	72.0	77 . 0	72.5	72.0	72.0	72.5	72.7	72.0	72.0	72.0	72.0	72.0	22.0	72.0	72.0	72.0	72.0
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HOLE	AREA	(CH <sup>Z</sup> )	***	***	**	**	#	#			#							#		#	#	#			*	:	=	#		<b>.</b>						
RESIDIAL	HASS	(GRAMS)	***	***	***	***	**	***		***		# :							#	*					ŧ	***	##	##	##		#	#	**	#	**	
c	RESIDUAL	(S/N)	260.3	396.9	723.0	952.2	312.1	576.1	629.1	620.3	920-8	1357.9	1385.9	202.2	19962	1 2 7 7	1.011	653.8	1013.4	1029.0	1052.5	330.1	346.0	691*0	627,0	377.9	+58.1	565.1	581.2	911.7	1196.3	282.9	# * + 0 +	132.6	869.0	360.5
SPEI	STRIKING	(H/S)	338.0	545.9	912.0	1115.9	545,9	572.3	380.6	381.6	1182.6	1616.0	E•24c1	1.190		6 4101	2001c1	1367.4	1425.6	1432,9	1446.9	1154.0	1160.7	L442.3	1394.8	633.4	727.9	581.2	1167.1	1229.3	1481,3	935.9	1287.5	1479.2	1493.5	1476.8
	AREA	(CH2)	452	.452	.452	.452	.452	.452	.452	452	.452	<b>55</b> 2	-52	265	264.	764	764	. 52	. 452	452	. 452	.452	.452	452	•52	806 -	. 836	. 506	. 806	. 836	909.	\$36	. 806	606	. 806	<b>806</b>
FRAJECTILE	CIAVETER	(CH)	.759	. 759	.759	. 759	.759	.759	. 759	. 759	.759	.759	. 759	. 759	46) ·	1 (2).	. (34	651	. 759	.759	.759	.755	. 759	.759	• 759	1.613	1.013	1.013	1.0.3	1.013	I.013	1.013	E10.1	1.013	I.013	1,013
	HASS	(GRAMS)	1.950	1.950	1.950	1.950	I.950	1.950	1.950	L-950-	1.950	I.950	I.950	1.950	1.950 I	1.950	005.T	1.950	1.950	1.950	1.950	1.550	1.950	1.950	4.950	068.E	3.890	3.690	3.690	3.890	3.990	3.890	3.89C	3.890	3.890	3.690
	DBLIQUITY	(053)	0		0	6.	0	0	C.	.0.	د.	с,	ç	ų į	0						¢.	e.	0	0.	Ċ.	c				0	5	0	ç.	6.		
	The TCK"ESS	(CR)	316.	8.0	3.8	.316	814.	.478	.478	478	.473	e7a.	B74.	.635	635	- C - C - C - C - C - C - C - C - C - C	160.		569.	.635	.635	1.270	1.273	1.270	1.270	, 635	635	635	.635	.635	.635	1.270	1.279	1.270	1.27u	I. 935
אחרין ין אווא	HAPLESS	(KG/P32)	120.9	120.0	125.0	120.0	120.0	125.7	120.0	120.0	120.0	120.0	120.0	120°C	120.0	120.0	120.0	0.021	120.0	120.0	120.0	120.0	120.0	120.0	126.0	0.001	120.5	120.1	120.0	120.0	120-0	120.1	120.0	120.0	120.0	120.5
		44	-		- m	4	5	•	2	æ	6	1.5	11	12	<b>E</b>	4	5	0 1		0	20	21	22	23	54	 5 7	) %	26	- au	5	0.5		12			1

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HOLE	AREA CH <sup>2</sup> )	#	ŧ	***	#	##	÷.	#	Ŧ	*	#				Ĩ	##	0 4 4 4	ŧ.				ŧ	#	***	***		#	**								*
RESIDUAL	(GRANS)	Ŧ	**	#	##	Ħ	#	Ħ	ŧ	**					1	#	###	#	#	#	***	#	ŧ	#	#		#		#	# 1						
53	RESIDUAL (M/S)	1,652	448.4	821.1	1054.9	445.0	111.4	E.E01	379.5	405.7	712.9	774.5	5 222 1 5 222 1	5-84C1	537.7	544.1	583,3	C*E56	201.5	158.5	925.1	665 <b>.</b> 6	1584.7	1574=9	[6[0.3	513.6	530.1	9*616	946.4	1295.7	1017 e e	353.6	0.005	24421		41:350
SPEI	STRIKI4G (4/5)	1483.2	557.2	917.8	1200.6	580.3	924.8	1197.9	5+2*2	552.5	942.4	237.2	1 1721	1 1 2 2 2 3 1	1350.3	1069.5	1503.3	1524.3	1006.5	1351.3	1536.3	1521.0	2°5EL1	1776.4	1791.3	602°6	634.9	1395.5	1119.2	1488.6	1-20°C	630 <b>.</b> 6	1933.7	+ 500 T		1 0"cs+1
	AREA (CHZ)	603s	1.261	L.261	1,261	1.261	I.261	1.261	1.261	I.261	1.261	1.261	132*1	1921	1.261	1.261	1.261	1.261	L.261	1.261	1.261	I•26I	1.745	L.745	Le 745	1,746	L.746	I. 746	I.746	1.746	1.1	1.740	I. 745			L • /40
RGJECTILE	DEASETER (CK)	1.C13	1.267	1.267	1.267	1.267	I.267	1,267	1.267	1.257	1.267	1.267		7.25-1	1,267	I.267	1,267	1.267	1.267	1.267	1.267	1.257	1441	164°I	1.491	164.1	I-491	1.491	1.491	1.491	1.471	169.1	164•1	164.1	1,2.1	1.4°2
1	MASS (GRAMS)	3.853	7.780	7.763	7.735	7.780	7.786	7.750	7.780	7.760	7.760	7.780		7.750	7, 780	7.789	7.760	7.760	7.780	7,780	7.50	7.780	15.560	15.560	15.560	15.550	L5.560	15.560	15.560 [	15-560	L3•560	15.560	15.550	[ 2000 - C]	2000	10.000.01
	CBLIQUITY [	с <b>.</b>	0	0.	<b>.</b>	0	ų.	¢.	e,	ę	ç	ç	2			0	ç.	ę	ç	<b>c</b> ,	c <u>;</u>	<u>с</u>	ů.	¢.	č.	с. •	•	е <b>.</b>	ດຸ	c,	C. 1	ę	ç	<b>•</b>	ņ,	
	THICKNESS (CH)	1.905	.316	.318	91e.	.476	.476	.476	.635	.635	.635	-635 	200	625	1.270	1.270	1.270	1.270	1.905	1.905	1.905	1.905	.478	67.4.	.478	\$69.	.635	•635	\$69.	.635	- CE0-	1.270	1.270	I.270	0/2-1	1 0/2-1
ריזר ויזר	HAPHILESS (KG/F#2)	C.021	12 <b>J</b> .r	120-0	120.0	120.5	120.9	120°C	120.0	120.0	5.021	120.0		2027	120.0	120.0	120°C	120-J	120-0	120.0	120.0	120,0	120.0	120.0	120.0	129.5	120.0	120.5	120.0	120.0	120.0	120.0	120.2	120-0	- CZ1	120.0
	aN	36	37	36	39	9	14	42	<b>1</b>	\$	\$	4 1 4 4	- 4	u 0 € 1	ŝ	15	52	53	5	52	26	5	29 29	35	90	19	62	63	<del>6</del> 4	65	66	67	96	6.9	01	71

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TARGET= ALUPINON 2924T3

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HOLE	AREA (CH <sup>2</sup> )	***	***	###	**	**	***	***	***		***	##	*	**
ARIMARY RESIDUAL	HASS [GRAMS]	***	#	***	###	***	***	###	**	***	***	***	***	***
ĒD	RESIDJAL (H/S)	1136.7	532.5	493.2	533.4	950.7	9*0*6		229.8	245.7	150.3	215.2	666.6	673,3
S₽E	STRIKENG (M/S)	1496.0	1343.0	1365.8	1.181.1	1496.9	L505.7	975.4	9°19CI	1067.4	1069.2	1393.0	1508.5	1517 <b>°9</b>
	AREA (C4 <sup>2</sup> )	1,746	L.746	L.746	L.745	1.746	I.746	I.746	1.746	I.746	1.746	L.746	1.746	L.745
PRIJECTILE	DIAHETER (CH)	164.1	164.1	164.1	164.1	164.1	167*1			E. 4.7	1.491	1.491	1.491	164°I
	RAHS)	15-560	15.560	15.560	15.560	15.560	15.560	15,560	15.550	15-560	15-560	15-560	15.560	15.560
	06LIQUITY (DEG)	U.	0	5				0	C.	C				<i>.</i> .
	THICKNESS (CM)	1.270	1.995	1.935	1.935	1*905	I.935	2.540	2.540	2.540	2.540	2.540	2-540	2.543
1441-04	EXENCESS (XG/MM2)	120.5	120.0	120.2	120.0	120.0	129-9	120-0	120.0	0.001	0.021	120.0	126.0	123.6
	NR NR	22	13	74	75	76	1	4.4	10	C			1 (1	3

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1.680	.910	***	1.630	1.730	.560	***	3.830	1.720	3.620	3.610	2,430	3.240	**	.120	.570	7.720	7.720	7.720	**
521.2	1294.2	590.4	1063.6	683.4	1127.1	361.6	672.7	957.7	500.9	582.8	1251.8	774.5	6.979.3	1367.3	1165.9	561.4	874.8	785.5	6**66
567.8	1461.8	880,3	1355.5	1491.1	1986.4	2371.7	798.9	1032.7	620.3	173.3	1499.0	1505.7	1,526.1	2455.2	2551.8	641.0	959.2	976.0	1484.4
452	. 452	.452	. 452	. 452	. 452	.452	. 806	. 806	. 506	. 806	. 806	. 806	. 506	. 806	. 305	1.261	1.261	1.261	1,261
.759	.759	.759	. 759	.759	. 759	• 759	1,013	1.013	1.013	E10.1	1.013	1.013	1.013	1.013	E10.1	1.267	1.267	1.267	1.267
1.950	1.950	1.950	1.950	1.950	1.950	1.950	3.890	3 890	3.690	3.890	3.890	3.890	3.890	3.890	3.890	7.780	7.780	7.780	7.780
•	•	•	0.	0.	0.	υ.	0.	0	0	0.	°.	•	0.	•	с <b>.</b>	0	C.	0	0
.127	.127	.316	•316 ·	.635	.635	1.270	.127	.127	.318	.318	916.	.635	.635	.635	1.270	.127	.127	.318	635
190.1	190.0	2-06I	190.0	150°0	190.0	196.0	0°061	1 0.021	190°0	0.001	190.0	150.0	190.0	0*061	190.0	190-0	190.0	150.0	190.0
-	2	m.	4	Ś	<u>ب</u>	r-	u	0	10	11	12	Ľ,	14	15	1¢	17	-	61	50
	1 190.0 .127 .0 1.950 .759 .452 567.8 521.2 1.000 ***	1 190.0 .127 .0 1.950 .759 .452 567.8 521.2 1.000 ***   2 190.0 .127 .0 1.950 .759 .452 1461.6 1294.2 .910 ***	1 190.0 .127 .0 1.950 .759 .452 567.8 521.2 1.080 ***   2 190.0 .127 .0 1.950 .759 .452 1461.6 1294.2 .910 ***   3 190.0 .318 .0 1.950 .759 .452 880.3 590.4 ***	1 190.0 .127 .0 1.950 .759 .452 567.8 521.2 1.000 ***   2 190.0 .127 .0 1.950 .759 .452 1461.8 1294.2 .910 ***   3 190.0 .318 .0 1.950 .759 .452 1461.8 1294.2 .910 ***   3 190.0 .318 .0 1.950 .759 .452 1350.3 1963.4 .910   4 190.0 .759 .452 1350.3 1963.4 1.630	1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   199.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     3   190.0   .127   .0   1.950   .759   .452   160.6   .010      3   190.0   .127   .0   1.950   .759   .452   1860.8 </td <td>1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   199.0   .127   .0   1.950   .759   .452   1461.6   1294.2   .910     3   199.0   .318   .0   1.950   .759   .452   1461.6   1294.2   .910     3   190.0   .318   .0   1.950   .759   .452   1860.3   590.4   .910     4   190.0   .759   .452   1365.3   1063.4   1.630      5   190.0   .759   .452   1355.0   1.759       5   190.0   .759   .759   .452   1355.4   1.730      5   190.0   .759   .759   .452   1986.4   1.730      5   190.0   .759   .452   1986.4   1.730   </td> <td>1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1461.8   521.2   1.000     3   190.0   .127   .0   1.950   .759   .452   1461.8   1294.2   .910     4   190.0   .318   .0   1.950   .759   .452   180.3   590.4   .910     5   .019   .0   1.950   .759   .452   1355.5   1903.6   1.730     5   .001   .0590   .759   .452   1355.5   1903.6   1.730     5   .001   .0590   .759   .452   1355.5   1963.6   1.730     5   .0020   .759   .452   1396.6   1.730       6   .001   .0590   .759   .452   1966.6   1.730      7   .0020   .759   .452   .0196.6        7   .190.0   .</td> <td>1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     2   197.0   .127   .0   1.950   .759   .452   1461.6   1294.2   1.000     2   190.0   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     4   190.0   .318   .0   1.950   .759   .452   1860.3   590.4   .010     5   190.0   .759   .452   1491.1   1083.4   1.730   .010   .010     5   190.0   .759   .452   1355.5   1083.4   1.730   .010   .010     5   190.0   .759   .452   1355.5   1986.4   1.730   .010<td>1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1567.6   521.2   1.000     3   190.0   .127   .0   1.950   .759   .452   1661.6   1296.2   .010     4   190.0   .318   .0   1.950   .759   .452   1860.3   990.4   .010     5   190.0   .759   .452   1355.9   1083.6   1.790   .010     5   190.0   .759   .452   1355.9   1083.6   1.790   .010     5   190.0   .0   1.950   .759   .452   1395.9   1.790   .010     7   190.0   .759   .452   1986.4   11271   .900   .1790   .010     7   190.0   .759   .452   1986.4   11271   .900   .1790   .011   .010   .011   .010   .010   .010   .010   .010   .010   .010   .010</td><td>1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1661.6   1294.2   1.000     3   190.0   .318   .0   1.950   .759   .452   1661.6   1294.2   .010     5   190.0   .759   .452   1461.6   1294.2   .010   .010     5   190.0   .759   .452   1491.1   1294.2   .010     5   190.0   .759   .452   1955.9   .1996.4   11.790      7   190.0   .759   .452   1955.9   .1996.4   11.790      7   190.0   .759   .452   1986.4   11271         7   190.0   .759   .452   1986.4   11271         790.0   .799   .452   2371.7   301.6         &lt;</td><td>1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.900     2   190.0   .127   .0   1.950   .759   .452   1661.6   1.950     3   190.0   .127   .0   1.950   .759   .452   1661.6   1.990     4   190.0   .318   .0   1.950   .759   .452   1860.3   990.4     5   190.0   .759   .759   .452   1860.4   1.790     5   190.0   .759   .759   .452   1990.4   1.790     5   190.0   1.950   .759   .452   1991.1   1.790     6   190.0   1.950   .759   .452   1996.4   1.790     7   190.0   1.986.4   11271   .996.4   1.790   .996.4     190.0   1.270   1.996.4   1.996.4   1.796.4   .996.4   .996.4     190.0   1.986.4   1.916.1   .996.4   .996.4   .996.4   .996.4     190.0   .127.7</td><td>1   190.7   .127   .0   1.950   .759   .452   567.8   521.2   1.900     2   190.7   .127   .0   1.950   .779   .452   1401.4   1294.2   1.900     4   190.7   .318   .0   1.950   .7759   .452   1491.4   1294.2   1.910     5   190.7   .318   .0   1.950   .7759   .452   1880.3   590.4   .910     5   190.7   .318   .0   1.950   .7759   .452   1880.3   590.4   1.910     6   190.7   .190.0   1.950   .7759   .452   1355.5   1093.4   1.730     6   190.0   1.270   .759   .452   1355.5   1980.4   1.730     9   190.0   1.950   .759   .452   1980.5   1.730     9   190.0   1.950   .759   .452   1980.5   1.730     9   190.0   1.950   .759   .452   1980.5   1.730     9   190.0   .9</td><td>1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1591.2   1.000     4   190.0   .318   .0   1127   .0   1.950   .759   .452   1860.3   5994.2   1.000     5   190.0   .318   .0   1.9950   .759   .452   1860.3   5994.2   1.000     5   190.0   .759   .452   1860.3   5994.2   1.770   1.770     5   190.0   .759   .452   1995.4   1.1271   1.770   1.770     6   190.0   .759   .452   1995.4   11271   1.770   1.770     1   190.0   .759   .452   1995.4   1.1271   1.770   1.770     1   190.0   .1.013   .800   1.013   .800   1.773   1.770     1   199.4   .1013   .800   1.013   .800   1.773   1.770   1.773     1</td><td>1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1461.8   1294.2   1.000     5   190.0   .127   .0   1.950   .759   .452   1461.8   521.2   1.000     5   190.0   .127   .0   1.950   .759   .452   1800.3   590.4   .010     5   190.0   .190.0   .1950   .759   .452   1800.3   590.4   .010</td><td>1   190.7   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.5   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     4   190.5   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     5   190.5   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     5   190.5   .318   .0   1.950   .759   .452   190.3   1000.6   1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910   1.910    1.910   1.910    1.910   1.910   1.910   1.910   1.910   1.910   1.910   1.910   1.910   1.</td><td>1   190.0   -   127   -0   1.950   -759   -452   567.8   521.2   1.900     1   197.0   -   127   -0   1.950   -759   -452   1461.8   1294.2   1.910     1   197.0   -   197.0   -   1990.0   -759   -452   1461.8   1294.2   1.910     1   1970.0   -   035   -0   1.950   -759   -452   1491.4   1.710     1   1970.0   -   035   -0   1.950   -759   -452   1491.4   1.710     1   1970.0   -   0   1.950   -759   -452   1491.4   1.710     1   1970.0   -   1.950   -759   -452   1990.4   1.710     1   1970.0   -   1.013   .000   1.910.7   1.710   1.710     1   1970.0   -   3490   1.013   .000   1.910.7   1.710   1.710     1   1970.0   -   34890   1.013   .000   &lt;</td><td>1   190   <td< td=""><td>1   190.0   127   .0   1.950   .759   .452   567.8   521.2   1.000     1   190.0   .127   .0   1.950   .779   .452   1461.8   1206.2     1   190.0   .127   .0   1.950   .779   .452   1461.8   1206.2     1   190.0   .1270   .779   .452   1880.3   1900.4   1.000     1   190.0   .1290   .779   .452   1890.3   1900.4   1.000     1   190.0   .035   .0   1.990   .779   .452   1890.4   1.000     1   190.0   .035   .0   1.990   .779   .452   1990.4   1.000   1.000     1   190.0   .127   .0   1.990   .759   .452   1990.4   1.1790   1.1790     1   190.0   .1270   .0   1.990   1.013   .000   1.1270   1.1790   1.1790     1   190.0   .121   .000   1.013   .000   1.013   1.1790   1.17</td><td>1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     190.0   .127   .0   1.950   .779   .452   1800.3   1294.2   .100     190.0   .127   .0   1.950   .779   .452   1800.3   1990.4   1.000     190.0   .1270   .095   .759   .452   1990.5   1990.4   1.000   1.990   .779   .452   1990.4   1.000   1.990   .000   .000</td></td<></td></td>	1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   199.0   .127   .0   1.950   .759   .452   1461.6   1294.2   .910     3   199.0   .318   .0   1.950   .759   .452   1461.6   1294.2   .910     3   190.0   .318   .0   1.950   .759   .452   1860.3   590.4   .910     4   190.0   .759   .452   1365.3   1063.4   1.630      5   190.0   .759   .452   1355.0   1.759       5   190.0   .759   .759   .452   1355.4   1.730      5   190.0   .759   .759   .452   1986.4   1.730      5   190.0   .759   .452   1986.4   1.730	1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1461.8   521.2   1.000     3   190.0   .127   .0   1.950   .759   .452   1461.8   1294.2   .910     4   190.0   .318   .0   1.950   .759   .452   180.3   590.4   .910     5   .019   .0   1.950   .759   .452   1355.5   1903.6   1.730     5   .001   .0590   .759   .452   1355.5   1903.6   1.730     5   .001   .0590   .759   .452   1355.5   1963.6   1.730     5   .0020   .759   .452   1396.6   1.730       6   .001   .0590   .759   .452   1966.6   1.730      7   .0020   .759   .452   .0196.6        7   .190.0   .	1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     2   197.0   .127   .0   1.950   .759   .452   1461.6   1294.2   1.000     2   190.0   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     4   190.0   .318   .0   1.950   .759   .452   1860.3   590.4   .010     5   190.0   .759   .452   1491.1   1083.4   1.730   .010   .010     5   190.0   .759   .452   1355.5   1083.4   1.730   .010   .010     5   190.0   .759   .452   1355.5   1986.4   1.730   .010 <td>1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1567.6   521.2   1.000     3   190.0   .127   .0   1.950   .759   .452   1661.6   1296.2   .010     4   190.0   .318   .0   1.950   .759   .452   1860.3   990.4   .010     5   190.0   .759   .452   1355.9   1083.6   1.790   .010     5   190.0   .759   .452   1355.9   1083.6   1.790   .010     5   190.0   .0   1.950   .759   .452   1395.9   1.790   .010     7   190.0   .759   .452   1986.4   11271   .900   .1790   .010     7   190.0   .759   .452   1986.4   11271   .900   .1790   .011   .010   .011   .010   .010   .010   .010   .010   .010   .010   .010</td> <td>1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1661.6   1294.2   1.000     3   190.0   .318   .0   1.950   .759   .452   1661.6   1294.2   .010     5   190.0   .759   .452   1461.6   1294.2   .010   .010     5   190.0   .759   .452   1491.1   1294.2   .010     5   190.0   .759   .452   1955.9   .1996.4   11.790      7   190.0   .759   .452   1955.9   .1996.4   11.790      7   190.0   .759   .452   1986.4   11271         7   190.0   .759   .452   1986.4   11271         790.0   .799   .452   2371.7   301.6         &lt;</td> <td>1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.900     2   190.0   .127   .0   1.950   .759   .452   1661.6   1.950     3   190.0   .127   .0   1.950   .759   .452   1661.6   1.990     4   190.0   .318   .0   1.950   .759   .452   1860.3   990.4     5   190.0   .759   .759   .452   1860.4   1.790     5   190.0   .759   .759   .452   1990.4   1.790     5   190.0   1.950   .759   .452   1991.1   1.790     6   190.0   1.950   .759   .452   1996.4   1.790     7   190.0   1.986.4   11271   .996.4   1.790   .996.4     190.0   1.270   1.996.4   1.996.4   1.796.4   .996.4   .996.4     190.0   1.986.4   1.916.1   .996.4   .996.4   .996.4   .996.4     190.0   .127.7</td> <td>1   190.7   .127   .0   1.950   .759   .452   567.8   521.2   1.900     2   190.7   .127   .0   1.950   .779   .452   1401.4   1294.2   1.900     4   190.7   .318   .0   1.950   .7759   .452   1491.4   1294.2   1.910     5   190.7   .318   .0   1.950   .7759   .452   1880.3   590.4   .910     5   190.7   .318   .0   1.950   .7759   .452   1880.3   590.4   1.910     6   190.7   .190.0   1.950   .7759   .452   1355.5   1093.4   1.730     6   190.0   1.270   .759   .452   1355.5   1980.4   1.730     9   190.0   1.950   .759   .452   1980.5   1.730     9   190.0   1.950   .759   .452   1980.5   1.730     9   190.0   1.950   .759   .452   1980.5   1.730     9   190.0   .9</td> <td>1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1591.2   1.000     4   190.0   .318   .0   1127   .0   1.950   .759   .452   1860.3   5994.2   1.000     5   190.0   .318   .0   1.9950   .759   .452   1860.3   5994.2   1.000     5   190.0   .759   .452   1860.3   5994.2   1.770   1.770     5   190.0   .759   .452   1995.4   1.1271   1.770   1.770     6   190.0   .759   .452   1995.4   11271   1.770   1.770     1   190.0   .759   .452   1995.4   1.1271   1.770   1.770     1   190.0   .1.013   .800   1.013   .800   1.773   1.770     1   199.4   .1013   .800   1.013   .800   1.773   1.770   1.773     1</td> <td>1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1461.8   1294.2   1.000     5   190.0   .127   .0   1.950   .759   .452   1461.8   521.2   1.000     5   190.0   .127   .0   1.950   .759   .452   1800.3   590.4   .010     5   190.0   .190.0   .1950   .759   .452   1800.3   590.4   .010</td> <td>1   190.7   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.5   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     4   190.5   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     5   190.5   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     5   190.5   .318   .0   1.950   .759   .452   190.3   1000.6   1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910   1.910    1.910   1.910    1.910   1.910   1.910   1.910   1.910   1.910   1.910   1.910   1.910   1.</td> <td>1   190.0   -   127   -0   1.950   -759   -452   567.8   521.2   1.900     1   197.0   -   127   -0   1.950   -759   -452   1461.8   1294.2   1.910     1   197.0   -   197.0   -   1990.0   -759   -452   1461.8   1294.2   1.910     1   1970.0   -   035   -0   1.950   -759   -452   1491.4   1.710     1   1970.0   -   035   -0   1.950   -759   -452   1491.4   1.710     1   1970.0   -   0   1.950   -759   -452   1491.4   1.710     1   1970.0   -   1.950   -759   -452   1990.4   1.710     1   1970.0   -   1.013   .000   1.910.7   1.710   1.710     1   1970.0   -   3490   1.013   .000   1.910.7   1.710   1.710     1   1970.0   -   34890   1.013   .000   &lt;</td> <td>1   190   <td< td=""><td>1   190.0   127   .0   1.950   .759   .452   567.8   521.2   1.000     1   190.0   .127   .0   1.950   .779   .452   1461.8   1206.2     1   190.0   .127   .0   1.950   .779   .452   1461.8   1206.2     1   190.0   .1270   .779   .452   1880.3   1900.4   1.000     1   190.0   .1290   .779   .452   1890.3   1900.4   1.000     1   190.0   .035   .0   1.990   .779   .452   1890.4   1.000     1   190.0   .035   .0   1.990   .779   .452   1990.4   1.000   1.000     1   190.0   .127   .0   1.990   .759   .452   1990.4   1.1790   1.1790     1   190.0   .1270   .0   1.990   1.013   .000   1.1270   1.1790   1.1790     1   190.0   .121   .000   1.013   .000   1.013   1.1790   1.17</td><td>1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     190.0   .127   .0   1.950   .779   .452   1800.3   1294.2   .100     190.0   .127   .0   1.950   .779   .452   1800.3   1990.4   1.000     190.0   .1270   .095   .759   .452   1990.5   1990.4   1.000   1.990   .779   .452   1990.4   1.000   1.990   .000   .000</td></td<></td>	1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1567.6   521.2   1.000     3   190.0   .127   .0   1.950   .759   .452   1661.6   1296.2   .010     4   190.0   .318   .0   1.950   .759   .452   1860.3   990.4   .010     5   190.0   .759   .452   1355.9   1083.6   1.790   .010     5   190.0   .759   .452   1355.9   1083.6   1.790   .010     5   190.0   .0   1.950   .759   .452   1395.9   1.790   .010     7   190.0   .759   .452   1986.4   11271   .900   .1790   .010     7   190.0   .759   .452   1986.4   11271   .900   .1790   .011   .010   .011   .010   .010   .010   .010   .010   .010   .010   .010	1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1661.6   1294.2   1.000     3   190.0   .318   .0   1.950   .759   .452   1661.6   1294.2   .010     5   190.0   .759   .452   1461.6   1294.2   .010   .010     5   190.0   .759   .452   1491.1   1294.2   .010     5   190.0   .759   .452   1955.9   .1996.4   11.790      7   190.0   .759   .452   1955.9   .1996.4   11.790      7   190.0   .759   .452   1986.4   11271         7   190.0   .759   .452   1986.4   11271         790.0   .799   .452   2371.7   301.6         <	1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.900     2   190.0   .127   .0   1.950   .759   .452   1661.6   1.950     3   190.0   .127   .0   1.950   .759   .452   1661.6   1.990     4   190.0   .318   .0   1.950   .759   .452   1860.3   990.4     5   190.0   .759   .759   .452   1860.4   1.790     5   190.0   .759   .759   .452   1990.4   1.790     5   190.0   1.950   .759   .452   1991.1   1.790     6   190.0   1.950   .759   .452   1996.4   1.790     7   190.0   1.986.4   11271   .996.4   1.790   .996.4     190.0   1.270   1.996.4   1.996.4   1.796.4   .996.4   .996.4     190.0   1.986.4   1.916.1   .996.4   .996.4   .996.4   .996.4     190.0   .127.7	1   190.7   .127   .0   1.950   .759   .452   567.8   521.2   1.900     2   190.7   .127   .0   1.950   .779   .452   1401.4   1294.2   1.900     4   190.7   .318   .0   1.950   .7759   .452   1491.4   1294.2   1.910     5   190.7   .318   .0   1.950   .7759   .452   1880.3   590.4   .910     5   190.7   .318   .0   1.950   .7759   .452   1880.3   590.4   1.910     6   190.7   .190.0   1.950   .7759   .452   1355.5   1093.4   1.730     6   190.0   1.270   .759   .452   1355.5   1980.4   1.730     9   190.0   1.950   .759   .452   1980.5   1.730     9   190.0   1.950   .759   .452   1980.5   1.730     9   190.0   1.950   .759   .452   1980.5   1.730     9   190.0   .9	1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1591.2   1.000     4   190.0   .318   .0   1127   .0   1.950   .759   .452   1860.3   5994.2   1.000     5   190.0   .318   .0   1.9950   .759   .452   1860.3   5994.2   1.000     5   190.0   .759   .452   1860.3   5994.2   1.770   1.770     5   190.0   .759   .452   1995.4   1.1271   1.770   1.770     6   190.0   .759   .452   1995.4   11271   1.770   1.770     1   190.0   .759   .452   1995.4   1.1271   1.770   1.770     1   190.0   .1.013   .800   1.013   .800   1.773   1.770     1   199.4   .1013   .800   1.013   .800   1.773   1.770   1.773     1	1   190.0   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.0   .127   .0   1.950   .759   .452   1461.8   1294.2   1.000     5   190.0   .127   .0   1.950   .759   .452   1461.8   521.2   1.000     5   190.0   .127   .0   1.950   .759   .452   1800.3   590.4   .010     5   190.0   .190.0   .1950   .759   .452   1800.3   590.4   .010	1   190.7   .127   .0   1.950   .759   .452   567.8   521.2   1.000     2   190.5   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     4   190.5   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     5   190.5   .318   .0   1.950   .759   .452   1461.6   1294.2   1.000     5   190.5   .318   .0   1.950   .759   .452   190.3   1000.6   1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910    1.910   1.910    1.910   1.910    1.910   1.910   1.910   1.910   1.910   1.910   1.910   1.910   1.910   1.	1   190.0   -   127   -0   1.950   -759   -452   567.8   521.2   1.900     1   197.0   -   127   -0   1.950   -759   -452   1461.8   1294.2   1.910     1   197.0   -   197.0   -   1990.0   -759   -452   1461.8   1294.2   1.910     1   1970.0   -   035   -0   1.950   -759   -452   1491.4   1.710     1   1970.0   -   035   -0   1.950   -759   -452   1491.4   1.710     1   1970.0   -   0   1.950   -759   -452   1491.4   1.710     1   1970.0   -   1.950   -759   -452   1990.4   1.710     1   1970.0   -   1.013   .000   1.910.7   1.710   1.710     1   1970.0   -   3490   1.013   .000   1.910.7   1.710   1.710     1   1970.0   -   34890   1.013   .000   <	1   190 <td< td=""><td>1   190.0   127   .0   1.950   .759   .452   567.8   521.2   1.000     1   190.0   .127   .0   1.950   .779   .452   1461.8   1206.2     1   190.0   .127   .0   1.950   .779   .452   1461.8   1206.2     1   190.0   .1270   .779   .452   1880.3   1900.4   1.000     1   190.0   .1290   .779   .452   1890.3   1900.4   1.000     1   190.0   .035   .0   1.990   .779   .452   1890.4   1.000     1   190.0   .035   .0   1.990   .779   .452   1990.4   1.000   1.000     1   190.0   .127   .0   1.990   .759   .452   1990.4   1.1790   1.1790     1   190.0   .1270   .0   1.990   1.013   .000   1.1270   1.1790   1.1790     1   190.0   .121   .000   1.013   .000   1.013   1.1790   1.17</td><td>1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     190.0   .127   .0   1.950   .779   .452   1800.3   1294.2   .100     190.0   .127   .0   1.950   .779   .452   1800.3   1990.4   1.000     190.0   .1270   .095   .759   .452   1990.5   1990.4   1.000   1.990   .779   .452   1990.4   1.000   1.990   .000   .000</td></td<>	1   190.0   127   .0   1.950   .759   .452   567.8   521.2   1.000     1   190.0   .127   .0   1.950   .779   .452   1461.8   1206.2     1   190.0   .127   .0   1.950   .779   .452   1461.8   1206.2     1   190.0   .1270   .779   .452   1880.3   1900.4   1.000     1   190.0   .1290   .779   .452   1890.3   1900.4   1.000     1   190.0   .035   .0   1.990   .779   .452   1890.4   1.000     1   190.0   .035   .0   1.990   .779   .452   1990.4   1.000   1.000     1   190.0   .127   .0   1.990   .759   .452   1990.4   1.1790   1.1790     1   190.0   .1270   .0   1.990   1.013   .000   1.1270   1.1790   1.1790     1   190.0   .121   .000   1.013   .000   1.013   1.1790   1.17	1   190.0   .127   .0   1.950   .759   .452   567.6   521.2   1.000     190.0   .127   .0   1.950   .779   .452   1800.3   1294.2   .100     190.0   .127   .0   1.950   .779   .452   1800.3   1990.4   1.000     190.0   .1270   .095   .759   .452   1990.5   1990.4   1.000   1.990   .779   .452   1990.4   1.000   1.990   .000   .000

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PENETRATION CATA

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HOLE MREA (CH2) IIII IIIII \*\*\* PRIMARY RESIDUAL MASS (GRAMS) .700 1.910 1.510 .890 1.580 1.580 3.830 3.250 2.370 2.720 2.720 2.090 1.570 15.290 13.940 11.870 11.870 12.600 11.083 11.850 7.840 193.2 667.8 667.8 1149.1 148.1 552.0 378.9 894.3 1304.9 357.2 755.0 755.0 424.3 851.9 1307.9 1702.3 1079.6 486.2 809.9 570.6 RESIDUAL (M/S) 7.21 5/00 STRIKING R (M/S) 573.0 1183.2 1735.2 1154.8 1154.8 624.8 1295.4 1862.0 1249.4 1775.8 1775.8 1315.5 607.8 1063.1 1592.3 1185.7 1862.0 1236.6 1236.6 1815.7 ENSITY= ARCA (CM2) •275 - 806 - 806 - 806 - 806 - 806 - 806 - 806 L.746 L.746 L.746 L.746 L.746 L.746 L.746 L.746 452 452 452 PROJECTILE CLAMETER (CM) .592 1.013 1.013 1.013 1.013 1.013 1.013 ACTUAL HARDNESS VARIES FROM 15- TO 220 PHN. .759 .759 .759 .759 1.491 1.491 1.491 1.491 1.491 1.491 1.491 1.491 PASS [GRAMS] 1.950 1.950 1.950 1.950 3.893 3.893 3.890 3.890 3.890 3.890 .5.560 15.560 15.560 15.560 15.560 15.560 15.560 15.560 16. TARGET= CAST IPCK (DEG) CBLICUTY 00000 000000 0000000 THICKNESS (CV) .478 .478 .478 .478 .953 .953 .427 1.427 .478 478 478 478 953 953 1.427 .478 .478 .953 .953 195.C\* HARDNESS HARDNESS IXG/WHZ] 185.C 185.C 185.C 185.C 185.C 185.C 185.C 185.C 185.C # 38 -CV TH W TH V - 8 6 2 H R 56

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FE IETRATION DATA

TARGFT= RLLLED HOMOGENEGUS STEEL

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<u>.</u>

. . . DENSITY= 7.73 G/CC

HOLE	AREA (CM <sup>2</sup> )	***	#	**		*		***	***	#		Ī	*		*					***	:
PRIMARY Residual	MASS (GRANS)	***	#	***	***		-	***	***	***	**	***			***					***	**
ÊD	RESIDUAL (M/S)	648.9	1015.0	1196,3	460.3	367.9		277.4	256.0	542.5	583.7	1164.3	687,3	_	690°4		1944	1179.0	1037.8	1109.5	759.6
SPE	STRIKING (M/S)	366.5	1211.6	1521.3	1394.5	509 <b>.9</b>		302.1	393.5	383.6	379.6	1466.1	1466.1		909.5		910.5	1425.0	1432.6	1556.0	1660.5
	AREA (CM2)	.452	.452	.452	. 452	. 4,52		.806	.806	. 806	. 806	. 506	.806		1,261	1	1.746	1.746	1.746	1.746	1.748
PROJECTILE	DIAFETER (CM)	.759	.759	.759	. 759	.759		1.013	1.013	1.013	1.013	1.013	1.013		1,267		1.491	1.491	1.491	1.491	1.491
	HASS (GRAMS)	1.950	1.950	1.950	1.950	1.950		3.890	3.890	3.890	3.890	3.890	3.690		7.780		15.560	15.560	15.560	15.560	15.560
	DBLIQUITY (DES)	•	c.	•	•	c.		c.	•	c.	ç	°.	•		ç		•	0	•	0	0
	THICK4ESS (CM)	.046	.152	,318	\$E9.	.152		.046	.152	.318	.31b	.318	\$63.		.316		.316	.31ë	.635	.635	1.270
1041 FON	HARDESS [KG/MH2]	135.0	135.0	300.0	305.0	353.0		135.0	135.0	135.0	300.0	300.0	300.0		300 ° U		300.0	300.0	300.0	305.0	332.0
	NR	-	2	'n	4	<b>1</b> 0		\$	~	8	٥	10	11		12		E1	14	15	9	1

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FELETRATION DATA

TARGET= FACE HARDENED STELL

DENSITY= 7.78 G/CC

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HOLE	AREA (CH <sup>2</sup> )	***	**	.593	.710	***	***	1,606	1,606				1.951	1,551		2+396	1.961				6°3%6	5.083	***	3.091	3,323	3,878	1 1 1				***	***
RESIDUAL	KASS (GRAMS)	061.	***	1.650	1.570		.430	.090	.220	000.	1 046 T	. 340	690	016.	000	1•120	061.		0.430	04E • 1	. 600	.220	6.560	- 730	1.000	. 400	0			12+310	7.480	0.64.
	RESIDUAL (M/S)	566.5	0.	372.2	•	551.1	716.6	1115.9	1263.4		331,0	767.2	901,3	1514.6		304.8	1.669			610°2	960.1	2043.4	369.1	525.5	765.7	978.4	6 00Y		105401	269.0	710.2	1351.5
\$PEI	STRIKI46 (M/S)	2207.7	748.3	1017.4	1381.7	1765.1	1319.7	2381.6	2336.1	1266.5	1163.7	1785.5	2151.3	2799.3	1791.0	2275.6	2693.8		6°0011	1766.0	1397.4	2985.2	1902,0	2086.4	2225.0	2381.3	4 0011		1 40651	1200.3	1839.8	2753.0
	AHEA (CH2)	.275	452	452	. 452	.452	.452	.452	. 452	 809	. 500	806	909	908.	. 806	. 606	• <b>8</b> 09		1.201	1,261	1,261	1,261	1.261	1.261	1.261	1.261	776			1.746	1.746	1.745
PROJECTILE	DIAMETER (CM)	.592	. 759	. 759	.759	.759	. 759	.759	.754	 1.013	1.013	1.013	1.013	1.013	E10.1	1.013	1.013		1.207	1.267	1.267	1.267	1.267	1.267	1.267	1.267	101		1.441	1.491	169.1	1,491
	HASS (GRAHS)	£76.	1.950	1.950	1.950	1.950	1.950	1.950	1.950	3.890	3.890	3.890	3.890	3.390	3.890	3.890	3.890	1	7.780	7.780	7.780	7.780	7.760	7.790	7.780	7.780			12+509	15.560	15.560	15.560
	DBLIQUITY (DEG)	0.	C,	0	0.	Ċ.	c.	0.	с <b>.</b>	 Ċ,	¢,	•	ç	ç	0	•	•		•	ç	c.	•	•	c,	ç	c.			• •	<b>•</b>	0.	5.
	THICK'IESS (CM)	.635	.345	.345	.345	ςεş.	.635	.635	·635	 .635	.635	.635	.635	.635	1.270	1.270	1.270		.635	.635	.635	.035	1.270	1.270	1.270	1.270	u T		CE0.	1.270	1.270	1.279
ITNI-DA	HARULESS (KG/HMZ)	*c•03*	2°00 <b>%</b>	400.0	400.0	40.0	400.0	40.0	400.0	400.0	400.0	400.0	400.0	400.0	0.004	0.074	400.0		400.0	0.034	400-0	400.0	400.0	40.0	400	0.004		• Do •	400.0	400.0	400.0	400°U
	NR	1	~		4	5	•	2	æ	σ	2	11	12	13	14	5	16		11	<b>8</b> 1	19	50	21	22	53	24		23	56	27	28	56

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ACTUAL HARDNESS FRONT SURFACE 480 - 550 MHN, REAR SURFACE 331 - 375 944

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FENETRATION L TA

TARGET= CUPPER

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DENSITY= 8.01 G/CC

HOLE	AREA	(CK4)	**	***	***	***	***	•	. *	***	***	***	***	***	***	# 1	::			***	***	*	* <b>*</b>	***	***	#	***	*	**
RESIDUAL	HASS	(GRANS)	***	.910	***	Ci6.	.650	***	1.780	1.880	***	.210	.040	3.630	3,520	3.520		7.720	7.480	7.720	.350	***	15,500	#0#	12.750	15.500	***	***	***
	RESIDUAL	(H/S)	239.6	611.1	1107.0	410.6	906.5	962.9	440.1	666.0	1325,3	385.9	467.0	265.2	622,7	804.7	199.6	261.2	501.7	392.6	377.0	861.1	331,3	325,5	705.6	607 e	559°0	224.3	226.5
SPE	STRIKING	(5/6)	413.6	362.0	1446.0	349.2	1438.7	3227.5	175.1	1179.4	3480.2	2674.9	3209.2	368,6	790.4	1131.7	3312.0	 349.3	745.5	912.3	1524,3	2635.0	401.7	403.9	2.0201	1403.3	1,5631	1565.2	1575.5
	AREA		.275	.275	.275	.275	.275	.275	.452	. 452	. 452	. 452	.452	. 806	. 606	908.	. 806	 1.261	1.261	1,261	1,261	1,261	1.746	1.746	1.746	1,745	1.746	1,746	1.746
PRIJECTILE	DIAFETER	( ( ( )	.592	.592	.592	.592	.592	.592	.759	.759	. 759	.759	.759	£10.1	1.013	1.013	1.015	1.267	1.267	1.267	1.257	1.257	1.491	164.1	1.491	1.491	1.491	164.1	164.1
	HASS	(GRAMS)	.970	.970	.970	.970	.970	.970	1.950	1.950	1.950	1.950	1.950	3,890	3.690	3.890	3.690	 7.780	7.780	7.780	7.780	7.780	15.560	15.560	15.560	15.560	15.560	15.560	15.560
	DBLIQUITY	(DEG)	0	ç.	•	<u> </u>	<u>.</u>	0	°.	•	•	•	0	0	0.	0	•••	 0.	•	<u>°</u>	•	¢.	0	•	•	•	ç	c.	0
	THICKNESS	( CH )	.152	.152	.152	.316	.318	.635	.318	. 635	.635	1.270	1.270	.152	.152	BIE.	1.270	 .152	.316	.635	1.270	1.270	.152	.318	669.	1.270	1.270	2.540	2.540
NUWINAL	HARDNESS	(KG/FMC)	42.1	42.0	42.0	÷2•0	42 ° Ū	42 0	C.21	42.0	42.0	C-24	42.0	6-24	42.0	42°0	0.04	42.5	42.0	42°J	42.0	42.0	42.3	42.0	42.0	42.0	42.9	42.0	42.0
		ž		2	Ē	4		•	~	80	o	10	11	12	13	4	19	 17	18	67	20	21	22	23	24	25	26	27	28

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	HOLE	AREA (CH <sup>2</sup> )	5.72J	5,704	***	Zete2	24013	34676			- 720				344		15.518		ŧ								:	26,320	**	***	12,366	25,652	***	104.11	0 ##	*	*
	PRIMARY Residual	HASS (GRAHS)	100	.080	1.400	1.780	.670	• 210			~~~		1.780		***		.840	***		6.360		1.300			7747		13.260	046.	7,260	7,130	15.370	1.430	11.220	<b>9 • 3</b> 00	11.090	6.420	3.100
3/00	03	RESTOUAL (M/S)	1066.6	914.4	868.7	457.2	000°0	162.0	260.3	29600	764 3		4 . EES	211.5	174.6	<b>,</b>	1101.5	367.0	373.1	640.1	701.0	2.442	5°1°6	530°2	34616	4-121	1305.6	1005.8	370,6	377.3	385,9	609.6	196.5	169.2	762.0	201.9	336.6
Y= 11,01	SPEL	5 TRIKI 46 (H/S)	2401.2	2439.9	1235,3	7.76	1343.6	1/21.2	1961.7	A.0602	1440	700 0	757.7	574.2	984.2	•	1910.5	719.9	7.367	1217.7	1236,3	5.156	0,1121	1221-0	0 007T	1.0011	1199.1	2603.8	8-263	597.3	942.4	1739.0	937.6	972.9	1263.7	1480.7	1,197.1
DENSIT		AREA (CM2)	.452	• + 52	. +52	259.	269	204	264	764.			806	806	606		1.261	1.261	1,261	1.251	1.261	1.201	1.261	19291	107.1	102.1	1.745	1.746	1.746	1.746	1.746	1.746	1.746	1.746	L.746	1.746	1.746
	PRJJECTILE	DIAHETER (CH)	.759	. 759	-159	• 759 222	• 759	6C7.	. 759	6C/ •	610 1	610°1	1.011	1.013	1.013	)   	1.267	1.267	1.267	1.267	1.267	1.267	1.207	1.207	102*1	1.02.1	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	164.1	164*1	164.1
		MASS (GRAHS)	1.950	1.950	1.950	1,950	1.950	1.950	1.950	066.1			068.6	3.890	3.890		7.780	7.780	7.780	7.780	7.780	7.780	7.780	7.780	001.1	02/ 1	15.560	15.560	15.560	15.560	15.560	15.560	15.560	15.560	15.560	15.560	15.560
T= L£גה		08412UTY (066)	0.	¢.	ç	C,	0	C;	<b>o</b>		(	<b>,</b> (					C,	•	0	<b>.</b>	ç	ç	0	0,0		<b>c</b>	c		C.	с <b>.</b>	•	0.	¢,	°.	•	Ċ.	e •
TARGE		THICKNESS (CM)	.318	.316	.330	946	10 V M	. 348	1.270	040-2	50.3	160.		1.270	1.270		314	049.	.660	. 660	. 660	1.270	1.270	1.270	1.2.1	0+c+2	056.	3E¢.	1.279	1.270	1.270	1.270	2.540	2.540	2.540	2.540	2.540
	HOMINAL	HARDWESS (KG/MM2)	5.5	5.5	5.5	in -	5°1	5.5	2 2 2	<b>.</b>	4	n 4	r: 40 • 0				5.5		5.5	5.5	5.5	5.5	5.5				یں ب نو			5.5	5.0	5.5	5.5	5.5	5.5	5.5	5.5
		٩R	-	2	<b>m</b>	•	<b>K</b> 1 (	0	~ '	¢	•	× (	3:	: -			*	1	16	17	81	61	0	22	22	53	40	5	26	27	0	0 N	9	31	32	33	34

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PÉ IETRATION DATA

CENSITY= 18.71 6/CC

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TARGET= TLRALLEY

HOLE	AREA (CH )	896.	***	***	#	###	***	1.606	***		**	***		3,045	- 132	**		#	2,394				ž		.8.548	2.130
PRIMARY RESIDUAL MASS (GRAMS)		1.490	1.040	• 0 6 0	.230	.320	-040	016.	.320	.520	.130	•100		045*1	5.510	1.0	.060	.060	14.270	24.590	.260	. 780	.060		1.360	5,420
SPEED	RESTDUAL (H/S)	6,262	548.6	1371.6	487.7	457.2	762.0	320.9	E23.0	414.5	609.6	792,5		174.4	366.8	914.4	1219.2	962,3	442.6	762.0	792.5	731.5	1219.2		540.1	807.7
	STRIKI46 (M/S)	1090.6	1446.6	2867.6	1734.9	1518.8	2340.4	925 <b>.</b> 7	1471.5	1484.7	1716.5	2535.3	•	495 <b>.</b> 3	585,8	1394.5	1699.9	1843.4	731.5	1418.2	1785.0	1779.1	1859.3		2171.4	1560.6
	AREA (Cm )	.452	. 452	. 452	.452	.452	• + 52	. 506	.836	. 606	. 806	. 806		1,261	1.261	1.261	1.261	1.261	1.746	1.746	1.746	1.746	1.745		2,392	2,392
PACIECTILE	DIAPETER (CH)	.759	.759	.759	.759	.759	.755	 1.013	1.013	1.013	1.013	1.013		1.267	1.267	1.257	1.267	1.267	 1.451	1.491	1.491	164-1	I.491		1.745	1.745
	HASS (GRAMS)	1.950	1.950	1.950	1.950	1.950	I.950	3.895	3.890	3-690	3.890	3.990		7.780	7.790	7.780	7.780	7.780	 15.560	15.560	15.500	15.560	15.560		30.160	30.350
	0aL1Qu1TY (7EG)	0.	0	ç	•	0	•	ç	0.	•	e.	Ģ		0.	•	•	0.	°.	 0.	¢.	•	¢.	•		0	•
	THICKNESS (CM)	.254	.254	.254	.316	.391	.508	•254	.254	186.	.508	.508		.254	.254	.381	.508	• 50è	.254	.316	185.	.50è	.5ně		.506	.508
NG-LINAL	KG/MM )	240.0	240.2	240-0	240.0	240-0	240+0	 240.0	240.0	240.0	240.0	240.0		240-0	240.7	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0		240-0	240.0
	AN	-	~	m	•	en.	9	•	æ	6	10	11		12	1	+1	51	16	 17	9	0	0	12	6		53

APPENDIX B

GRAPHIC COMPARISON OF THE THOR AND Z/F EQUATIONS

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## APPENDIX C

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## COMPUTER PROGRAM TABULATIONS AND SAMPLE OUTPUTS

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с				
C				2
č				3
ç			Z/F FORCE PENETRATION MODEL	4
C C				6
č	,		GLOSSARY	7
C C	***	r	DENTIFIES DEGUIDED INDUT DATA	8 9
č	***	i	DENTIFIES INPUT DATA WHICH IS NOT REQUIRED	10
C				11
C C				13
č		A	- FIRST TERM OF THE FORCE EQUATION (K1)	14
C	ىقى بەر بەر	Δ <b>Δ</b>	- STATIC FORCE COMPONENT (DYNES)	12
C C	***	ANG	- IMPACI ANGLE (DEGREES) - Constant based on least square fit to data	17
č		8	- CREFFICIENT OF SECOND TERM OF THE FORCE EQUATION (K2)	18
Ċ		8MF	- CONSTANT BASED ON LEAST SQUARE FIT TO DATA	19
C		C	- CDEFFICIENT OF THIRD TERM OF THE FORCE EQUATION (K3)	20
C			- CONSTANT BASED UN LEAST SQUARE FIT TU DATA - DRITA TIME INCOEMENT	21
c			A DELTA SPEED DECREMENT	23
č		DELV	- COMPUTED DRUP IN SPEED BASED ON VR1 AND F1	24
Ċ		DELVP	- COMPUTED DRUP IN SPEED BASED ON VR2 AND F2	25
C		C ELX	- X INCREMENTAL VALUE	20
C r		VEVANI	DESTRUAL VELOCITY ( THE DEVIANT )	28
č		+1	- FORCE ACTING AT START OF X INCREMENT	29
Ċ		12	- FORCE ACTING AT END OF X INCREMENT	30
C		FURCE	- TOTAL FORCE	31
C		+V1	- COMPUNENT OF FORCE PROPURTIONAL TO SPEED - COMPONENT OF FORCE PROPURTIONAL TO SPEED SOUARED	32
С. С	*	· DIA	- HOLF DIAMETER (CM)	34
č		TCNT	- INDEX COUNTER	35
٤	*	4 <b>R</b> -	- SHOT IDEN IFICATION NUMBER	36
ç	ىلەر باد باد	PCA	→ PROJECTILE CROSS→SECTIONAL AREA (SQ CM) DROJECTILE DIAMETER (CM)	37
C C	*** ***	PUIA	- PROJECTILE DIAMETER (UN)	39
č		PRESU	STATIC PRESSURE ACTING UN PROJECTILE (MEGA-PASCALS)	40
C		RATIO	- THE COMPUTED RELATIVE ERROR	41
C	7,4	RMASS	- PRIMARY RESIDUAL FRAGMENT MASS (GRAMS) - TOTAL (KOULSE TO DEPTH X (DVNE-SEAS)	42
C C	***	30000 1860	- TARGET PLATE BRINELL HARDNESS NUMBER (KG/MM##2)	45
Ċ		FEST	- VALUE TO BE TESTED	45
ι.	***	THICK	- TARGET PLATE THICKNESS (CM)	46



	*** * ***	T IME TRHO VR VR1 VR2 VRE VRP VS VSP X XPRT XPRTI	- PENETRATION TIME (MICRU SECONDS) - TARGET PLATE DENSITY (G/CC) - RESIDUAL SPEED (CM/SEC) - RESIDUAL SPEED AT START OF X INCREMENT - RESIDUAL SPEED AT END OF X INCREMENT - EXPERIMENTAL RESIDUAL SPEND (M/S) - RESIDUAL SPEED (M/S) - STRIKING SPEED (M/S) - STRIKING SPEED (M/S) - DEPTH OF PENETRATION (CM) - DETERMINES WHEN TO PRINT OUTPUT - THE PRINT INCREMENTAL VALUE	47 48 50 52 53 54 55 57 59 50
c c				61
Č	υ4	ATA P1/3	3.141592654/	62
	Δŀ	1F=0,70		63
	BN	4F=0.23		04 65
	C N	4F≠0.50 	40)	66
	- <u>40</u> 6/	SIIE(020 1014/12/12	HI / 1HO - 20X ANHSAMPLE DUTPUT FUR Z/F FORCE PENETRATION >	67
	1 1	45H MD	DDEL PREDICTING RESIDUAL VELOCITY /)	68
	່າວົວເ	INTINUE		69
С		READ	CARD WHICH IDENTIFIES TARGET MATERIAL	70
	R	EAU (5,95	5)TGT1,TGT2,TGT3	71
	W	KIIE(6)9	95)TGT1,TG12,1GT3	73
	11	()K()A ( <b>)A</b> ()NT=A	20 }	74
	100 01			75
c	1.7.	A BLA	ANK CARD SEPARATES TARGET MATERIAL GROUPS	76
ċ		END P	PUNGHED IN COLUMNS 1 TO 3 WILL TERMINATE THE PROGRAM	77
	R	EAP(5,11	10)NR, TRHO, TBHN, THICK, ANG, PMASS, PUIA, VSP, VRE, RMASS, HOIA	70
	110 F	ORMAT(A6	16,2,5,6,1,5,5,1,5,0,1,5,0,2,5,0,2,2,5,0,1,2,5,7,6,1,2,5,7,6,1	80
,	1		LE.O.DJGLIU 900 DT ETDIVING EDEED IN CHISEC	81
C	v	5500000 1100000		82
с	•	OMPUT	TE CRUSS-SECTIONAL AREA	83
•	р	CA=PI#(P	PDIA/2.0)**2	84
C		COMPUT	JTE K1, K2 AND K3 (= A, B, C)	82
	Â.	29.8E7*1		64 67
	р р	*20K1(A#	14   KMU] 76M2	88
	С. л	> i KnU≠∪r ⇒∆#∆MF	1917 1	89
	А	∆≡PC∆ <b>≭</b> Δ		90
	v	R=VS		91
٢	x	DE TER PRII=THI	ERMINE PRINT FREQUENCY AND INITIAL DELTA X INCREMENT HICK/10.0	92 93

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DELX=THICK/10.0
      IF(DELX .GT. 0.01) DELX=0.01
C
         INITIALIZE VARIABLES
      X=0,0
      XPRT=0.0
      TIME=0.0
      SUMFT=0.0
      ICNT=ICNT+1
      WRITE(6,115)ICNT ,NR
  115 FORMAT(1H0/1H0/50X/13HDATUM SET NR., 15/10X/12HIDENTIFIER =/2X/A6/)
      WRITE(6,150)
  150 FORMAT(1H0,9X,1HX,8X,2HVR,10X,5HF(V0),10X,5HF(V1),10X,5HF(V2),10X,
         5HFORCE, 8X, 4HTIME, 4X, 8HPRESSURE, 5X, 7HIMPULSE )
     1
      WRITE(6,151)
  151 FORMAT(1H = 6X=4H(CM)=5X=5H(M/S)=8X=7H(DYNES)=8X=7H(DYNES)=8X=
         7H(DYNES)=8X=7H(DYNES)=4X=8H(MU-SEC)=6X=18H(M PA) (DYNE-SEC)/)
     1
         COMPUTE FORCE AND STATIC PRESSURE ACTING AT X=0 BASED ON VR=VS
С
      FV1=PCA+B+VS
      FV2=PCA+C+VS++2
      FORCE=AA+FV1+FV2
      PRESUR=FORCE/PCA+1+E=7
      WRITE(6,251)X,VSP,AA,FV1,FV2,FORCE,TIME,PRESUR,SUMFT
  200 CUNTINUE
      IF(X .GE. THICK) GOTO 300
      1F(VR.LT.13.0)GDTD 290
          THE POLLOWING STATEMENT INSURES THAT THE PLATE THICKNESS
С
C.
          WILL NOT BE EXCEEDED
      IF((X+DELX) .GT. THICK) DELX=THICK=X
      IF(UELX .LE. 0.0) GOTO 300
С
         COMPUTE FORCE ACTING AT X1 BASED ON VI
      VR1=VR
      F1=PCA+(A+8+VR1+C+VR1++2)
  220 CUNTINUE
         COMPUTE DELTA V' BASED ON F1
С
      DFLV=F1*DELX/(PMASS+VR1)
      VR2=VR-DELV
      IF(VR2.LT.0.0)GDT0 290
         COMPUTE FORCE F2 ACTING AT X2 BASED ON V2=V1-DELV'
C
      F2=PCA+(A+B+VR2+C+VR2++2)
         COMPUTE DELTA VII BASED ON F2
С
      UELVP=F2+DELX/(PMASS+VR2)
C
         MAKE TEST
      TEST=(DELV=DELVP)/ ((DELV+DELVP)/2.0)
      IF(\BS(TEST).LT.0.001)GDTD 250
      IF([ELX.LT.1.E=5)GUT0 250
C
         FAILS TEST - REDUCE DELX BY HALF (MINIMUM IS 0.00001 CM. )
      DELX=DELX/2.0
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		GUTE 220	141
	250		142
	251	CΠΡΜΑΤ/1μ .ΕΙΔ.3.ΕΙΔ.1.104ΕΙΚ.Κ.Δ0ΕΙ3.3.2ΕΙ3.Ι)	143
c	· · · · ·	METCY TECT.	144
			144
c			142
C		COMPOSE ANAVIOLETA A	140
~		ETHE THE AVENACE FORMER ACTING OVER THE INTERVAL	147
L		- FIND THE AVERAGE FURCE ACTING OVER THE SNIERVAL	140
~		FURNES/FIFE//2.0	147
C		OPDATE THE DEPTH OF PENETRATION A	150
~		ARATUCIA Dealer auf deustration the in Miser seconds	191
Ç		OPUALE THE PENETRATION TIME IN MICKU-SECUNDS	152
		THE FAMASSAUCLIAV/FURGE+1.60	153
		ILME # ILME # DELT	154
C		OPDATE THE TOTAL IMPULSE EXPERIENCED BY THE PROJECTILE	155
		SUMFT*SUMFT+FORCE#DELT #1.E-6	156
C		CHECK FOR PRINTING INFORMATION	157
		IF(X.GE.XPRT)GUTU 460	158
		60TD 200	159
	260	CONTINUE	160
С		RESOLVE THE VARIABLE COMPONENTS OF THE FORCE	161
		FV1=PCA#B#(VR+DELTAV/2.0)	162
		FV2=PCA+C+(VR+DELTAV/2.0)++2	163
C		COMPUTE THE STATIC PRESSURE	164
		PRESUR=FORCE/PCA+1.E=7	165
		VRP = VR/100.0	166
		WRITE(6,251)X, VRP, AA, FV1, FV2, FORCE, TIME, PRESUR, SUMFT	167
		XPRT=XPRT+XPRTI	168
С		CONTINUE CYCLING UNTIL TARGET PLATE IS COMPLETELY PENETRATED	169
С		OR UNTIL THE RESIDUAL SPEED IS LESS THAN 10 CM/SEC.	170
		GDTU 200	171
	240	CONTINUE	172
С		DEFAULT - SINCE THE RESIDUAL SPEED IS LESS THAN 10 CH/SEC	173
		VR=0.0	174
		DELTAY=0.0	175
	360	CONTINUE	176
C		COMPUTE AND PRINT FINAL VALUES	177
-		FV1=PCA+B+(VR+DFLTAV/2.0)	178
		FV2=PCA+C+(VR+DF1TAV/2,0)++2	179
		SUMFYESUMFT+FORCE#DEIT #1.E=6	180
		PRESUR=FORCE/PCA+1.5.7	1.91
		VRP VR/100.0	182
		WRILE(6,251)X, VRP, AA, EV1, EV2, EDRCE, TIME, PRESUR, SUMET	101
	3(5	CONTINUE	105
c		ONPUTE AND PRINT THE DIFFERENCE RETWEEN THE PREDICTED VALUE	104
č		AND THE EXPERIMENTAL VALUE ( DEVIANT FROME) AND THE EFLATIVE	144
ř		ARTE TOTAL TREAT A DETINATE TREAT AND THE RELATIVE	100
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1.0	7.78	135.0	. 746	.0	1,95	.759	888,49	848.87	-10.00
2.0	7.78	135.0	.152	.0	1.95	•759	1211,58	1014.98	-10.00
3.0	7.78	300.0	318	.0	1,95	759	1521,26	1196.34	-10.00
4.0	7.78	305.0	.635	.0	1.95	•759	1394.46	460.25	=10.00
5.0	7.78	393.0	.152	.0	1,95	•759	609.90	367.89	-10.00
6.0	7.78	135.0	.046	.0	3,89	1.013	302.06	277.37	-10,00
7.0.	7.78	135.0	.172	.0	3,89	1.013	393,50	256.03	-10,00
8.0	7,78	135.0	.318	.0	3.89	1.013	883.62	542.54	-10.00
9.0	7.78	300.0	.318	.0	3.89	1.013	879.65	583.69	-10.00
10.0	7.78	300.0	.318	•0	3.89	1.013	1460.09	1164.34	-10.00
11.0	7.78	300.0	.635	•0	3 . 89	1.013	1466.09	687.32	-10,00
15.0	7.78	300.0	.318	. ၁	7.78	1.267	909.52	690.37	-10.00
13.0	7.78	300.0	.318	•0	15,56	1+491	916.53	754.38	-10.00
14.0	7.78	300.0	.310	•0	15.56	1.491	1425.55	1179,58	-10.00
15.0	7.78	300.0	.635	• • •	15,56	1.491	1432.56	1037.84	=10.00
16.0	7.78	305.0	.635	.0	15,56	1.491	1556.00	1109.47	-10.00
17,0	7.78	332.0	1.270	•0	15,56	1.491	1660,55	759.50	-10,00

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	(DANE-SEC)	0.	2440-4	5055.5	7486.0		1.7221	5-5651 2-5651	20059.6	22624.4	25272.4	-1139	TAHD	4.48		1 MPULSE 1 DYNE-SEC 1		•		5.070.2	8676.8	11362.0	1-0000	19344.6	7,19915	24407.1	27534.3	.022	TRHD 4.48	
1.0	PRESSURE (A PA)	2402.9	2400.9	2323.1	2284.9	1.1422	8.4022	2123-6	2097.5	2061.7	2025.2	ED ERROR IS	HD1A	• 000	210	PRESSURE (M PA)		7061.2	1.1507	6821.9	4754.3	0.55.0	0.6044	6376.6	6285.6	6145.5	6108.5	ED ERROR 15	401A .000	
itifier =	TIME (MU-SEC)	000"	- 022 - 245	644	. 706		1.1.1		1.977	2.250	2,534	RELATIVE SPE	A104	654."	itifiër «	TIME MITCEL		000"	101	190	278	.367	456	169.	.730	, 623	616"	RELATIVE SPE	PD[A .759	
IDEN	FDRCE (DY-1ES)	1.087196 10	1.08630E 10	1.05111E 10	1.03382E 10	1,01673E 10	9,998256 09 0 41116 00	9.831115 09 9 452445 09	9.48999E 09	9.32821E 09	9.16327E 09	-82.8	RE RHASS	2 1.580	ICEN	FORC C		3.194855 10	3,19028E 10	3.10017E 10	3.05601E 10	3.012456 10	2,96947E 10 2 837045 10	2. 88521F 10	2.84392E 10	2.80319E 10	2.763796 10	5 28.6	K4455	
LUI SET NR. I	F(V2) (DYNES)	3.267945 09	3.26087E 39	2.96317E 09	2.64772E 09	2,71450E 09	Z.583495 09	2.45467E 09 2 11846F 69	2.19427E 09	2.C7197E 09	1.94823E 05	SPEED DEVIANT IS	VSP VR	567.8 521.	ru4 SET NR. 2	F(V2)	(CAMED)	2.16575E 10	Z*161615 10	2. CT988E 10	2.C3986E 10	2.COC46E 10	1.96160E 19 1.01310E 10	1.54543F 10	1.64831E 10	1.61162E 10	1.77618E 10	SPEED DEVLANT IS	VSP VF 14c1.5 1294,	
C A 1	F(VI) (DYNES)	1.73670E C9	1.70435E C9 1 447446 09	1.63064E C9	1.59319E C9	1.5554SE C9	1.51748E 09	1.47916E C9	1 30840F 09	1.358975 09	1.31777E C9	VALUES	SS ANG	• 0	CAT	F(VI)	(DTNES)	4.39364E 09	4.38943E 09	4 20545F 00	4.26405E C9	4.22264E 09	4,18142E 09	A. 190555 07	4.05888E C9	4.01640E 09	3,97839E r9	VALUES	50 ANG 50 40	
	F(V)) (DYVES)	5 <b>.</b> 89727£ )5	5.89727E GC	5. 69727F 35	54 312194-3	5. B4727F 35	5,85727F JC	5.857275 J9	5.247375 35	5. 27275 35	5.29727E 09	= EXPERIMENTAL	THICK DYA	.127 1.9		E(V3)	(CAMES)	5.89727E 39	5.89727E 39	5.997275 70 5.997375 70	5.69727E 05	5.372763.5	5.69727c 39	5.54727F 44	5.89727E JP	5.63727E 09	5. 27275 .35	= Experive:17AL	THICK PHA	
	44 (3/2)	567.2	566.5	5-1-5	529.5	51è,9	524-3		2 - 0 - C	451.5	4.11.4	521+2	A HR	193.5		VR	(5/2)	1461.8	1434.0		1417.3	1403.0	1349.E	1376.2	1.0461	1335.6	3-2261	1274.2	792.0	~ • • • •
	( LC L )	ວະມວ"	100.		<b>₽</b> €0.	<b>•</b> 051	.064	.076	100 <b>.</b>	911 ·	127	.127		SI TUANI		×	( 10)	-050	-0C3	c10.	070	053	.065	• 07E		5112	.127	.127	/wo:17 15	51 . OLE

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SAMPLE RETAIL FOR ZIE FIRCE PERETIATIEN MOMEL PREDICTING RESIDUAL VELOCITY

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SAMPLE LITS, T FL. Z/F FIRCE PENETATIUN MODEL PREDICTING RESIDUAL VELOCITY

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	(DYNE-SEC)	0. 031.0 032.7	12064.0	24075.6 29617.9 36095.0	41665.7	53370.6 59252.1	<b>620</b>	TRH0 4.48		(DYNE+SEC)	•0 527•1 6816•4	13556.5 20223.2	20314.0 32848.6 39318.2	45726.6 51590.6 57890.9 63852.9
3,0	PRESSURE (M PA)	3623,6 3612,8 3483,2	3357.6	3096.7 2985.0 2854.7	2442.8	2534.6 2432.9	ED ERROR IS	401A .000	0.4	PRESSURE (H PA)	6319.2 6310.1 6995.3	5870.2	5255.7 5259.4	4869.8 4700.7 4523.4 4357.4
TJFIER =	TIME (MU-SEC)	000	1.202	1,591 1,995 2,467	2.928	3.910 4.426	RELATIVE SPE	PD[A , 759	itifier =	TIME (MU-SEC)	000 018 243	492 748	991 1,261 1,539	2.095 2.396 2.398 2.398
IDEN	FJRCE (JYNES)	1.63961E 10 1.63464E 10 1.57596F 10	1.45510E 10	1.402316 10 1.350566 10 1.292506 10	1.19575E 10	1.14678E 10 1.10077E 10	-13.5	E RMASS 4 -10.000	IDEN	FORCE (DYNES)	2,85916E 10 2,85534E 10 2,75783E 10	2.65630E 10 2.55766E 10	2.46989E 10 2.37794E 10 2.26913E 10	2.203385 10 2.126826 10 2.046626 10 1.971506 10
rum set 58. 3	F(V2) (DYNES)	7.55314E 39 7.El060E 39 7.31004E 30	6,62748E 39 6,28651E 39	5.41191E 09 5.41191E 09 4.93118F 39	4.53566E 39 4.13939E 39	3.74374E 39 3.37582E 99	SPEED DEVIANT IS	VSP VR 880.3 590.	ru4 set nr. 4	F(V2) (DYNES)	1,66204E 10 1,65833E 10 1,77682E 10	1.67938E 10 1.59132E 10	1.51294E 10 1.43106E 10 1.35233E 10	1.27636E 10 1.20885E 10 1.13836E 10 1.07258E 10
[.A.]	F(V1) (19446)	2.64570E n9 2.63853E 09 - 663661 00	2,456395 09 2,456395 09 2,357145 09	2.23174E C9 2.19632E C9 3 09650E 09	2.01066E 09 1.92082E 09	1.82672E 09 1.73454E 09	VALUES	55 Å''6 50 <b>,</b> 0	DAT	(S3NAG) (TA) <del>J</del>	4.07393E 09 4.06937E 09 3.97289E 09	3,86896E 09 3,76616E 09	3.67223E 09 3.57148E 09 3.47173F 09	3,272926 09 3,282506 09 3,185366 09 3,091966 09
	F(VJ) (34:ES)	5.89727E 09 5.89727E 09 5.883727E 09	5.89727E 09 5.89727E 09 5.89727E 09	5.897276 39 5.897275 39 6.807376 00	5.897275 39 5.697275 39	5.89727E 39 5.69727E 30	= ExpeR₂HEHTAL	THICK PKA .318 1.9		F(V3) (DY-ES)	5.89727F 29 5.89727E 39 5.89727E 39	5.89727E 19	5.69727E 09 5.59727E 09 5.69727E 09	5.697276 09 5.697276 09 5.697276 09 5.697276 09
	(575) 84	5 4 4 4 5 4 4 4 6 4 4 6 4 4 6 4 4 6 4 4 6 4 6	N 48 N 0 10 10 1 11 11 1 11 11 11 1 11 11 11 1 11 11 11 1 11 11 11 11 11 11 11 11 11 11 11 11 1	1 1 00 10 10 10 10 10 10 10 11 11 11 11	1 0 0 0 1 0 0 1 0 0 1 0 1 0 1 0 1 0 1 0	500.6 576.9	4*064	o • oe E		VR ( * / S )	1355.5 1352.7	1255.9	1220.5 1127.0 1551.5	1121.0 1121.0 1056.9 1056.5 1326.5
	۲ ۲	000	500 190 190	• 130 140 140	225	255	.318	SI TUGNI		( C~ )	000 000 000 000	290°	80 C C C C C C C C C C C C C C C C C C C	2255 255 318 318

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-55.1 RELATIVE SPEED ERROR IS

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INPUT IS

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SPEED DEVIANT IS

= EXPERIME FAL WILDES

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TITANIUM ALLOY

5°0	PRESSURE (M PA)	7274 7263.4 6761.9 6761.9 6292.7 5627.7 5627.7 5627.6 56293.9 5623.9 7565.7 8451.6 8451.6 8451.6
ittfler =	TIME (MU-SEC)	1415647440 6464676644440 64646766464440 64646766766464440 646467667667664440 646467667667667676 746667667767676 74666776776767676
5 IDEN	FDRCE (DYNES)	3.291216 10 3.295516 10 3.0595516 10 2.854516 10 2.6540946 10 2.555816 10 2.555816 10 2.51555696 10 2.51555696 10 1.8955956 10 1.561695 10 1.561695 10 1.561695 10
JUM SET NR.	F(VZ) (DYNES)	2,25332E 10 2,25332E 10 2,642995E 10 1,65120E 10 1,66588E 10 1,366588E 10 1,34652E 10 1,169803E 10 1,169803E 10 1,169803E 10 1,168362E 09 9,379622E 09 9,379622E 09 7,18336E 09
<b>f</b>	(JANEC)	4,481585 09 4,477338 09 4,267338 09 4,062368 09 3,656368 09 3,656368 09 3,656368 09 3,656368 09 3,656368 09 3,656368 09 3,656368 09 3,267795 09 3,267795 09 2,710512 09 2,531245 09
	F(VO) (RMES)	5.897275 00 5.897275 00
	78 12/1-1	1 1 1 1 1 1 1 1 1 1 1 1 1 1
	(CE)	00001110 0000110 000000000000000000000

(DYNE-SEC)

551.6 27481.6 27481.6 53752.7

	(DYNE-SEC)	326.2	1641141	32372,2	47903°E	63024-1	77469.3	91836.3	105652.2	119537.5	132913.0	146000.1	
••0	PRESSURE (M PA) (	.11461.3 11453.3	10679.8	9942.4	<b>7</b> 253,7	<b>6</b> 610.5	6021.3	7459.6	<b>6935</b> ,1	6445.3	5967.9	5569.0	ED ERADR 15
VTIFIER =	TIME (MU-SEC)	000 •	,328	.671	1,029	1.403	1.786	2.199	2,630	3.062	3,559	4.050	RELATIVE SPE
1901	FORCE (DYNES)	5.18570E 10 5.18238E 10	4.83211E 10	4.49648E 10	4.18687E 10	3.89586E 10	3,62924E 10	3.37511E 10	3.13760E 10	2.91619E 10	2.70926E 10	2.51969E 10	111.8
TUM SET NR. 6	F(V2) (DYNES)	3,99395E 10 3,99558E 10	3,67041E 10	3,36135E 10	3.07372E 10	2.80602E 10	2.56165E 10	2.32970E 10	2.11399E 10	1.91348E 10	1.72717E 10	1.55738E 10	SPEED DEVIANT IS
CA	F(V1) (DYNES)	5,97625E 09 5,96773E 09	5.71975E 09	5,47367E 09	5,234225 09	5,00110E C9	4.77839E 09	4.55639E 09	4,34091E 09	4_12983E 09	3.92352E 09	3,725765 09	VALUES
	FEVG)	5.89727E 39 5.89727E 39	5.89727E 09	5.89727E 09	5.89727E 09	5.89727E 39	5.89727E 39	5.29727E 79	5.89727E 39	5.85727F 39	5.59727F 29	5.83727E 34	= EXPERIMENTAL
	re Suj	1986.4 1984.7	1902.2	1620.4	1740.7	1663.2	1589.1	1515.4	2.6441	1273.4	1304.8	1239.0	1127.1
	K (HO)	.000 .000	- 064	.128	10 T	-255	315	351	1949	505	173	.635	·635

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7AHD 4.4

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PD1A .759

RHASS .560

VRE 1127.1

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PMAST 1.950

Tulck .035

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SPEED DEVIANT IS

- EXPERIMENTAL VALUES

633.4

•635

66542.62 78992.65 91048.5 103403.7 115139.1 127231.4

. 231

157.6 RELATIVE SPEED ERROR IS

4.4

410H

PD1A

RHASS 1.730

VRE 683.4

45P 1491.1

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PHASS 1,950

THICK .635

**TB**HN 196+0

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SA THLE JOTTON FOR ZVE FORCE PERETATION MODEL PREDICTING RESIDUAL VELOCITY

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SAPPLE UPTS I FOR INF FIRCE PERETRATION MODEL PREDICTING RESIDUAL VELOCITY

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TITANIUM ALLEY

CATUS SET NR. 7 IDENTIFIER =

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	169.0 36559.5 26559.5	6*904412 6*904412 8*902461 8*902461 8*902461 8*902461 8*902461	227632.4 227632.4 227632.4 227632.4 227632.4 2022.1	TRH0 4.48
(H HA)	1547842 1546746 1346947	11070-94 6-571-94 7603-95 7671-25 7671-25 7670-25 7670-25	4245 4206.0 3610.7 EED ERRDR 1	A10H
(MU-SEC)	000 960 960	L - 100 L - 100 2.550 2.500 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.133 2.1355 2.13555 2.13555 2.13555 2.13555 2.13555	6.235 7.437 8.784 8.784 Relative SP	P01A .759
(BANES)	7.033186 10 6.998346 10 6.085376 10	2.555555 10 3.970655 10 3.940425 10 3.940425 10 2.973145 10 2.555655 10 2.565655 10	2.21352E 10 1.90328E 10 1.63367E 10 1.63367E 10 495.8	E RMASS 6 -10.000
F(YZ) (DYNES)	5.70063E 10 5.c9608E 10 4.63891E 10	4,08095E 10 3,44076E 10 2,67473E 10 2,58922E 10 1,96492E 10 1,59849E 10 1,59849E 10	1.28541E 10 1.61306E 10 7.80227E 09 SPEED DEVIANT IS	VSP VR 2371.7 351.
F(VI) (JYNES)	7.12821E 09 7.12537E 09 6.55739E 09	6.03558E 09 5.53757E 09 5.5081974E 09 4.18496E 09 3.77463E 09	3.38435E C9 3.00495E 09 2.63712E C9 V&LUES	ASS AnG
(D44ES)	5.E9727E	5.99727F 39 5.99727F 39 5.89727F 39 5.89727F 39 5.89727F 39 5.89727F 39	5.89727E 39 5.89727F 39 5.59727F 39 * ExpERIME <sup>4</sup> TAL	THICK PV1 1.270 1.5
VR (~/S)	2371.7 2369.5 2184.2	2011 2012 2013 2014 2014 2014 2014 2014 2014 2014 2014	1125.4 999.2 877.4 391.6	1844 196•0
(C>)	000° 1903 128	N	1.016 1.144 1.270 1.270	SI TURNI

17110 4.4	410H 400°	P01A 1.013	E RMASS	V5P VF 798.9 572,	155 A1.5 190 , 0	TuICK BN	7644 19040	INPUT IS
. 0	ED ERROR IS	RELATIVE SPE	1.8.7	SPEED DEVIANT 15	VALUES	= EXPERIMENTAL	£72.7	÷127
06144	2844.6	1.707	2.29262E 10	6.70380E 39	3.717425 09	1.C5045E LC	<b>**</b> 169	.127
2054E	2672.0	1.606	2.31467E 10	8 EE554E 09	3.75613E C9	1.050455 17	697.3	.120
30206	2904.4	1 . 464	2.34052E 10	9.10160E 29	3,80142E n9	1.050615 10	3-20%	.110
21942	2970.2	1.184	2.39383E 10	3 <sub>5</sub> 54105E 09	3.89211E C9	1.05049F 1C	7-22-7	C60°
+269Z	3003.5	1.046	2.42070E 10	9.76449E 09	3,93742E 09	I.C5043E 10	7-1-7	.050
23033	3037.2	• <b>1</b> 0	2.44753£ 10	9.59044E 09	3.98272E 09	1.05045E IC	7.2ET	.070
29792	3071.2	.176	2.47520E 10	1,C2159E 10	4.023335 C9	I.CSO44E IN	745.1	. 360
291£1	3140.0	°215	2.53072E 10	I.CSE3SE IC	4.11855E C9	1.C5045E IP	765.0	0+0
	3175.0	.382	2.55887E 10	I,09196E 10	4,16393E C9	1.05045E 10	2.54	090
2120	3210.2	.253	2.58728E 10	I.11536E LO	4.20912E C9	1.05043E Ir	752.9	- 220
2476	3245.8	,126	2.61595E 10	1.14001E 10	4.25442E 09	1.05043E 10	4.061	610
	3263.7	000"	2.63036E 10	1.152186 10	4,27738E 09	1.55045E 1r	6°86	G00*
INPUL:	PRESSURE (H PA)	TIME (MU=SEC)	FORCE (OYNES)	F (V2) (DYNES)	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	(67)7 (67)	уя (3/У)	K CH3

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SAMPLE JUTTING RESIGNATION MODEL PREDICTING RESIGNAL VELOCITY

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TRHD	AD I.A	PDIA	RE RHASS	VSP	ASS ANG	THICK PH	19HST	
037	ED ERRUR IS	RELATIVE SPEI	15 -35.2	SPEED DEVIANT	YALUES	= EXPERIMENTAL	1-72	
-0-554	3820.3	106.1	3.03354E 10	1.52904E 10	4.94324E C9	1.05043E 10	922.4	
36861.	3877.ªL	1.171	3.12477E 10	1.57433E 10	4.99950E C9	1+020488 10	932.8	
34073+	3929.6	1,038	3,16703E 10	1.61083E 10	5.05722£ 09	1+05049E 1r	543.5	
30481°	3982.6	* <b>90</b> 6	3.20980E 10	1.04782E 10	5.1149åE 09	1+C5043E IV	954.3	~
26277	4036 a	. 776	3.25308E 10	1.68532E 10	5.17283E C9	1.C5043E IC	965.1	an
22065	4040*1	647	3.296875 10	1.72331E 10	5.23031E 09	1.C5043E 1C	615.9	5
	4145.7	,520	3.34119E 10	1.76182E 10	5.28893E 09	1+C5044E 1C	9-5-3	m
13611.	4201,3	<b>*</b> 39 <b>+</b>	3.38604E 10	1.80085E In	5.34719E 09	1+02045E 10	7 <b>•</b> 792	Ų
- 6966 -	4257.6	•269	3.431436 10	1.84040E IO	5.40559E 09	L+C504*2 1C	1008.6	μQ
2117	4314.6	.146	3.477375 10	1.58048E 10	5.46413E C9	1.05043F LC	5"61uI	wh,
	4372.3	•20	3.52385E 10	1.92109E 10	5,52292E 09	1.05043F 1C	1030.5	m
•	4378.1	000*	3.52853E 10	1,925186 10	5,52870E 09	1.C5043F Ir	1032.7	ø
(DYNE-SEC	(M PA)	(HU-SEC)	(DAMES)	(SANES)	(SANES)	(DYNES)	(3/2)	~
SINGHI	PRESSURE	TIME	FIJRCE	F(V2)	F(VI)	E(1)3	a v	×

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T2HD 4.48	НD1. .000.	PCIA 1.013	E RHASS 5.BLO	VSP V2 773.3 582	9:4 SS4 SS4	THICK Pr.	190-0 190-0	INPUT IS
₹.146	EED ERROR 15	RELATIVE SPI	-54.2	SPEED DEVIANT 13	VALUES	EXPERIMENTAL	572+3	• 318
107031.7	2192.1	5,067	1.76674E 10	4.49200E 09	2.67059E 09	L.C554+E L	495.6	• ale
95710.8	2278.0	844.4	1,83596E 10	5.02908E 39	2.62573E c9	Lecsrees lt	527.2	•286
84917.2	2363c7	3.570	1.90596E 10	5.571598 09	2.97425E 09	1+05045E In	555,00	<b>*</b> 255
74686.1	2450.0	3,342	1.97457E 10	5.12296E 09	3.11794E c9	1+050445 10	591.43	.225
33717,6	2544.0	2° 796	2.05036E 1C	5°156622°5	3.268545 09	して いたすいたしょう	609.1	E6I°
52842.7	2644.6	2,275	2.13140E 10	7,33491E 39	3.42421E 59	1-05043E 10	637.4	.163
42867.7	2736.5	1.613	2.20550E 10	7.498669E C9	3,561435 09	1+C5043F LC	553.1	130
32937.7	2839.0	1.370	2.28810E 10	3.66638E 09	3,70942E C9	1-05045E IC	6°5,6	·103
23039.0	2936.3	.942	2.366516 10	9.31439E 29	3,84560E 09	01 3640MU*1	714.1	.070
13159.9	3036.3	529	2.44712E 10	9°984248 00	3,98154E n9	I.CS^44F lr	2.9rT	су <b>.</b>
3289,8	3139 J	.130	2+52999E 10	I.06775E In	4.11738E 09	1-02044E IV	754 5	010*
0.	3156.5	000	2.54430E 10	1,C7952E 10	4"14032E ~9	1.0504FC [r	773.3	622.
(DANE-SEC)	(H PA)	(HU-SEC)	(DANES)	(SANES)	(SERAC)	(3Y-ES)	1-15]	(1)
IMPULSE	PRESSURE	TIME	FJRCE	F(V2)	F(VI)	(CV)?	VŔ	×

25544 97810.0 97810.0 1418.9 73512.0 25455.5 96434.5 108188.7 (DYNE-SEC) 985.2 12741.7 119300.2 -,047 RELATIVE SPEED EREDR IS PRESSURE (M 24) 5284.1 TIME (SEC) FORCE (DYVES) -59.0 5.536396 1 5.35545E 1 5.19292E 1 5.02234E 4.85640E 4.69535E 5.90213E 5.72438E 4.55203E 5.909666 4.25869E SPEED DEVIANT IS +.05663E IJ 4.06978E IJ 3.618793E IJ 3.718794E IJ 3.7381E IJ 3.45596E IJ 3.25297E IJ 3.10392E IJ 3.10392E IJ 2.69507E IJ 2.69507E IJ 2.69507E IJ 2.6550E IJ (SVNES) (TV1ES) **6** 6 800 P 6.01856E 7.954105 7.354105 8.02546E 7AL JES EXPERIMENTAL F(V0) 507-ES) \*\*\*\* 54 44 1.05045E 1r 1.050435 1.050455 1.059455 L.C5043E L+C5343E -C5-48E 3=9050\* 334051-1 384050\*1 H 1433.5 8.1C41 1372.5 1341.1 1316.0 1279.3 XY (5/2) 1499±0 1251.1 5.2911 [456.3 5\*15ċI K (MC) .255 316 . 31¢

TRHG 4.48

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CATUM SET NR. 12

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TITARIUM ALLEY

	(DYNE-SEC)	-0 967.4	25400.9	101244 114111	96639.0	119190.0	14223461	164032.6	186367 <b>,8</b>	207561.2	229354.4	.186	TRHO	4,48		1 MAULSE	(DYNE-SEC)	°,	8.066	25575.1		74159.3	2016214		165025.0	187461.4	206739.0	230605.2
13.0	PRESSURE (M PA)	7382+1 7372-7	6916°6	1.1840	9696.9	5328.9	4978.7	4661.9	4352.0	4071.5	3407.3	ED ERROR IS	AIGH	.006	14.0	PRESSURE	(M PA)	7534.3	7.452	1059.8	0.622.0	6193.6	2.00.5			4445.5	4159.6	3690.3
TIFIER =	TIME (MU-SEC)	000°			100°°1	2,362	2,916	3.480	4.096	¢.722	5,343	RELATIVE SPE	PDIA	1.013	fifier •	JHIT .	(NU-SEC)	000	\$10.	.435	E18.	1,348	124-1	275"2	3.429	4.035	4.650	5,299
IDEN	FORCE SDYNES)	.94959E 10 .94201E 10	S7445E 10	-225295 10	58333E 10	29495E 10	.01261E 10	1.75730E 10	1.50747E 10	*28154E 10	.06847E 10	143.5	RHASS	3,240	IDEN	FORCE -	(CANES)	.07229E 10	.06457E 10	.68935E 10	.33700E 10	- 69177E 10	.67932E 10			1.58282E 10	1.35243E 10	1.13535E 10
UM SET NR. 13	F(72) (DYNES)	4.092986 10 5 4.086086 10 5	3,75214E 10 5	3 438906 IO 5	2.65910E 10 4	2.601666 10 4	2.35115E 10 4	2,125555 10 3	1.90675E 10 3	1.70992E 10 3	1.52580E 10 3	SPEED DEVIANT IS	VSP VRE	1505.7 774.5	UM SET NR. 14	F(V2)	(DANES)	4.20475E 10 6	4.19771E 10 6	3.85637E 10 5	3.53712E 10 5	3.225656 10 4	Z-94922E IC 4	2,68237E 10 6	2,19646610 10 1	1.97269E 10 3	1.77160E 10 3	1.5834EE 10 3
C.A.T	(S3FYC) (TV1)	6,001336 09 8.95456 09	7.716395 69	7.38919E 09	(,023/05 UV 6.73755E A9	6.42736E 09	6,109306 09	5.80969E 09	5.50221E 09	5,21045E 09	4,921935 09	VALUES	SS ANG	0° 05	DAT	F(V1)	(SANES)	8.17056E 09	8,16331E 09	7.82536E 09	7.49397E 09	7.15642E C9	6.83826E 09	6.52558E 05	0.207045 07 5 005305 09	5.59651E C3	5,303596 24	5.01410E 09
	E (VC) (DY::ES)	1-359488 10 1-150488 10	1.0504 E 10	1.05045E 10	1+03043F LC	1.050435 10	1.C5045E 10	1.C5948E IC	1.C5043E 1C	1.C5043E IC	1.05043E IC	e Experisental	THECK PYA	•635 ž•8		F(V3)	(DYNES)	1.03049E 10	1.C5043E 1C	1+C5043E 1r	I.CSO44F LC	1.c5n43E l0	1.C5043E IC	L.C5543F LC	1-030435 10 1.657445 10		· 1.05045£ 10	1.05049E 10
	VR (3/k)	1505.7	1440=4	1378°9	1257.2	1199.2	1+0+11	1634.0	1026.5	972.1	916.3	774.5	T B T S	190.0		R N	(5/~)	1526.1	1523.6	1450=4	1393.5	1335.5	1276.1	1217-6	2.9611	1044.7	5-526	935.5
	(H)	000°	690	.128	- 145 - 145	315	263	.445	.510	573	.635	÷635		INPUT IS		×	(43)	000*	.003	.065	.128	<b>E</b> 61 <b>3</b>	.255	.315	585°	110	525	.635

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RELATIVE SPEED ERROR IS

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Z/F FIRCE PENETRATION MEDEL PREDICTING RESIDUAL VELOCITY

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CATPLE DUTY FOR TYPE FRETANTICN WATEL PREDICTING RESIDUAL VELOCITY

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TTAP TON ALLEY

	(DYNE-SEC)	0.114	6410 77042	6647.1	99194.2	130564 .C	160544.4	190363.2	219442.0	247609 4	275493.7	302523.2	.228	TRHD	4.48		INPULSE	(DYNE-SEC)	0				254814.8	310434.5	363987.8	415135.5			5,548666	-,036	TRHD	4.48
15.0	PRESSURE (H PA)	16436.6	15445	14503.3	13616.6	12722.2	12012-0	11272.4	10576.5	9921.8	9305,8	6737.4	ED ERROR IS	ADIA	• 000	16.0	PRESSURE	(¥ ¥ ¥)	17584.6	17573.6	02661		10628.7	9363.8	6232•5	7231.3	C*E5E0		E=1184	ED ERROR IS	AD LA	000
ttffler =	TIME (HU+SEC)	000		530			1.419	1.737	2.067	2.411	2,762	3,130	RELATIVE SPE	PIIA	1.013	a Titler a	TTHE	(MU-SEC)	000*	002	916	1.075	2.316	3,006	3,766	4.589	5.417	A C 4 - 0	7,529	RELATIVE SPE	PDIA	1,013
IDE	FJRCE (DYVES)	1.324715 11	1+3637UC 41		1,03743E 11	.0301#F 1	9.66111E 10	9.085325 10	8.52417E 10	7.99650E 10	7.50036E 10	7.04190E 10	311.	RHAS :	120	10E	FURCE	(DY4ES)	1.41723E 11	1.41636E 11	1.25055E 11	1,102/9t 11 5 774605 10	8.56621E 10	7.54675E 10	6+63497E 10	5.32806E 10	5,12063E 10	4.4:50t 10	3.93058E 10	-42.3	E RYASS	9 .570
J'4 SET NR. 15	F(V2) (DYNES)	L.C6822E 11	11 364,8341	9.41575F 10	8.74545F 10	A TATATA	7.536736 10	6.93177E 10	6.46088E IO	5.97225E LO	5.513926 10	5,092256 12	SPEED GEVIANT IS	VSP VRI	2455.2 1367.	UM SET MR. 16	F(V2)	( DANES )	1.17557E 11	I. 17474E 11	I. DIR66E II	5.79564E 10	6.69986F 10	5.55697E 10	4.71891E 10	3.98242E 10	3,34175E 10	2.77294E 10	2.2788RE 10	SPEED DEVIANT IS	VSP VR	255128 1155.
1 <b>14</b> 1	F(V1) (SYVES)	1.31445E 10	1.313495 LU	1 223486 10	01 3753771 I	1 125165 10	1 1012011	1.052355 10	1.012326 10	9. 737705 09	9.35658E 09	6.99170F 09	VALUES	55 Å'sG	0* 06	CAT	F(V1)	(SANES)	1,366195 10	1.36571E 10	1.27175E 10	1.18174E 10	1.07/LIC 10	9.293346 29	8.65591E 09	7.95171E 09	7,29476E 99	6.63645E 39	6.01517E 09	VALUES	SS ≜∿6	o" 55
	(23540) (24482)	1.053635 10	1.55554=1 10 . 25 2201 10	Lecydar tr						1.5344E 1C	1.r5343E Ir	1.05043E 10	= EXPERIMENTAL	THICK P-1	•635 3•E		F [ V J ]	(DYLES)	1.C5044F 10	1+05044E 10	1.5545210	1.050455 RC	1. PEREPE LC		1.05043E IC	1.05044E 1C	1+C504#E 1r	1.05045E LC	1*62044E 1C	= EXPERIMENTAL	THICK PIST	1.270 3.5
	1R (~/S)	2455.2	2453.4	C.002	100000		2463.6			1.513.1	1747.0	1678.5	1367.3	N1181	190.0		хх Х	(5/1)	2551.6	2550.0	2374.5	2206.5	2048.4	1753.8	Icita.1	1+8+1	1359.5	L229.3	1123.5	1165.9	TB-tv	130.5
	x (::)	300	100	• •	101	1.14					573	.635	<b>.</b> 635		INPUT IS		×	(HD)	660	100*	÷12f	• 255	1961 1962		E67.	.690	1.016	1=1+4	L.279	1.270		INPUT IS

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	(DYNE-SEC)	Q	2606.8	7226.5	15672.6	20915-4	27483.5	24046			0 0.000	2.64665		68112.9	<b>#</b> ,012	TRHD 4.48	•		IMPULSE	(DAXE=2EC)	0.	2629.0						47075.7	54876-1	60070 al	67334+0	100	TRHU 4.46
	PRESSURE (7 PA)	2640.5	2643.6	2420.1	2565.0	2561.9	2.920.2	1054	11222		0.0442	241142	<b>5390.4</b>	2363.7	EED ERROR IS	A10H 000,		18.0	PRESSURE	( 4 4)	4001.6	21666	6°0565	5-0145		1.9284 1.9041		3717.4	3670.5	3639.6	3594.1	EED ERROR IS	401A .000
•	TINE (NU-SEC)	000	078	.236	476	.637			1000			1.092	1,912	2,127	RELATIVE SPI	P01A		itteter =	THE	(MU-SEC)	000	°032	197					040	1.137	1.250	1.387	RELATIVE SPI	P01A 1.267
	FORCE (DYNES)	3.34053F 10	3,3333366 10	3.30337E 10	3.25919E 10	3.23000E 10	3.19017E 10	2.15429F 10	341/4675 tO	31110/20 10	3,06345E 10	3.04847E 10	3,01379E 10	2.98037E 10	÷9•	LE RHASS		106)	FORCE	(DAYES)	5.04516E 10	5.03460E 10	4.99254E 10	4.93004E 10	4.88876E 10	4.827915 10 4 764895 10	4.100075 10 4 736675 10	4.64666 10	4.62777E 10	4.56872E 10	4.53646E 10	3	LE RMASS .6 7.720
	F(V2) (DVNES)	1.14C36F 10	I. 5430E IU	1-13021E 10	L.09448E 10	1.07093E 10	I.CREAPE I.D			J FALODUE UV	9.53437E 29	9.25063E 09	5,98156E N9	5,71503E 09	SPEED DEVIANT IS	VSP VSP VR 641-0 561-		U4 SET HR. 18	F(V2)	( DANES )	2,59647E 10	2,58933E 10	2.55293E 10	CT 306964*2	2,46326E 10	2.41035E 10 3 375/85 10	01 3546/642 01 3546/642	2 366485 10	2.23874F 10	2.20531E 10	2.16059E 10	SPEED DEVIANT IS	VSP VR 959.2 874.
	(SHAC)	5 36648F 09	5.354456 09	5.298286 09	5.213856 09	5.57446 09	5.07946F 69		2 03377E 00		4 80044E 09	4.79491E 09	4.72313E 09	4.65252E 09	VALUES	SS ANG 80 .0		DA1	F(V1)	( JANES )	B.03366E 09	6.01951E 09	7.96294E 09	7.87823E 09	7.82185E 09	7.737395 09	7 50511/5 09		7 45640F 06	7.40097E 09	7.325555 09	VALUES	SS ANG 80 .0
	F ( V ) ( CY4ES )	1.662335 1C	1.64332F 10	L.64337F IC	1 2266991	1.643375 20				1.000000000000000000000000000000000000	1.64332E LC	1-643325 1C	1.64332E 10	1.643325 In	· EXPERIME ITAL	THICK PHA			(CA)3	(DY1,ES)	1.64332E 1C	1.64332E 1C	1.64332E 10	1.64332E 10	1.64332E LC	1.64332E 10	1.64332F 10	1 1222231 10	1 - 4433325 45	1.6623375 15	1.64332E 1C	= EXPERIMENTAL	THICK PM4 .127 7.7
	VR (14/21)	0-122	637.5	630.9	620.8	614.1	605.7	5.07	7719C	736.1	280*2	571 °7	563.1	554.8	561.4	1944 190.0	none T		AV	(5/2)	959.2	555 eB	3*6*6	93 <b>9</b> °0	2*2:5	922,2	4.016		070e~		874.0	874.8	784% 190.0
	X ( می	-005	5.15	.015	030	040	.053	2.40			C60 3	.103	.115	.127	e 127	Madef 14			×	(Cr)	000°	.005	•015	• 030	-040	.055		080,	5		127	.127	INPUT IS

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SAMPLE JUTP IT FOR Z/F FURCE PENETRATION MODEL PREDICTING RESIDUAL VELOCITY

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TITARIUM ALLEY

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	005.4 2637.9 1076.8 2637.9 1975.7 18427.2 1876.7 34155.1	7.04.0 52433.4 969.8 8263.4 1977.5 83613.4 1972.5 101727.5 1324.6 117219.5 1200.7 150710.6 1200.7 150710.6 1200.7 150710.6 121.4 160665.0	1411 1411 1411 1411 1411 1411 1411 141	ESSURE IMPULSE IM PA) (DYNE-SEC)	7225.0 7217.8 6655.9 7645.6 7695.6 7695.6 76965.7 76966.7 76966.7 76965.1 7697.6 719525.1 7697.6 71956.5 7697.6 71956.5 7697.6 7	REDR IS .025 14 TRHD 30 4.48
TIME PRE (MU-SEC) (		1.002 1.002 1.006 1.0096 1.0096 2.1497 2.505 3.0140 3.014000000000000000000000000000	P01A H01 1.267 .00	TIME PRE (MU-SEC) (		RELATIVE SPEED E <sup>0</sup> Pdia Hdi 1.267 .00
FJRCE (DYVES)	5.15079E 10 5.14034E 10 5.01248E 10 4.88773E 10	4.74566E 10 4.62679E 10 4.51033E 10 4.25727E 10 4.15886E 10 4.03536F 10 3.93536F 10 3.93536F 10	13 - 4147 VRE R4ASS 15.5 7.720 10E	FORCE (DY4ES)	9.10926E 10 9.10017E 10 8.65646E 10 8.53307E 10 7.61332E 10 7.451857E 10 7.451857E 10 7.65144E 10 6.03330E 10 6.03330E 10 5.72973E 10 5.44031E 10	IS 24.9 Vre RmASS 24.9 -10.000
F (V2) (DVNES)	2.69074E 10 2.68074E 10 2.55018E 10 2.46237E 10 2.46237E 10	2.3399FE 10 2.23792E 10 2.125492E 10 2.525492E 10 2.525492E 10 1.531354 10 1.533595E 10 1.535495 10 1.535495 10 1.65158E 10 1.65158E 10	57.550 UC41441 VSP 976.0 71 11U4 SET AR. 2	F(V2) (DYNES)	6,222746 13 5,214476 13 5,811656 13 5,65656 13 5,65656 13 5,65656 13 4,754316 10 4,754356 13 4,754356 10 4,375436 10 4,375436 10 4,251356 10 3,452346 10 3,452346 10 3,452346 10	SPEEJ DEVLANT VSP 1464.4 99
(13) J	8,17473E C9 8,15933E C9 7,98990E 09 7,82243E 09	7.62351E 59 7.65350E 59 7.282337E 59 7.282337E 59 6.9262437E 59 6.475951E 59 6.4756E 59 6.4756E 59	A50 A1.6	F(VI) (DY4ES)	1.24321E 10 1.224339E 10 1.22145E 10 1.10145E 10 1.11996E 10 1.042034E 10 1.04204E 10004E 10004E 1000000000000000000000	. VALUES ∗455 A∿G •730 •0
F [ Y'] ) ( DY'ES )	1.000000000000000000000000000000000000	1.443327 [7 1.443327 [7]] [7]] [7]] [7]] [7]] [7]] [7]] [7		F(47) (011 ES)	1 - - - - - - - - - - - - -	<ul> <li>Experime ital</li> <li>T+15K</li> <li>P+</li> <li>T-25</li> <li>T-25</li> </ul>
45 (21-)	972.6 972.6 932.3	0 0 0 0 0 0 0 0 0 0 0 0 0 0	190.0 190.0	46 ( 11 5 )	4444 444 444 444 444 446 446 446 446 44	994.9 1841 130.5
() X		11000000000000000000000000000000000000	INPUT IS	X X (40)	00000000000000000000000000000000000000	.635 INPUT IS

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SAPPLE LETS THEN PLACE PERFERATION MOREL PREDICTING RESIDUAL VELOCITY

TITARIUM ALLEY

,	(DAME-SEC)	0	P. 272.	2173.6	3255.5	+ 334 + +	5410.3				10745.0	10745.0	-,018	TRHD	7,76		(	0.			12783.0	16835.2	20843 4	0*202*2	23035e0	1.44740	40427,3	= ,011	FRHU 7.78
1.0	PRESSURE (M PA)	4 <b>6</b> 52+5	20/000	0"6254	4531.1	4+ <b>8</b> 0.6		0*10**		0.767	4247.7	4242.8	ED ERROR 15	MDIA	000.	5.0	PRESSURE (M PA)	7530.4	201261		6889.2	0.094	6496*3			3759.3	2294.0	EED ERROR IS	HD [ A 000 .
NTIFIER =	71ME (MU-SEC)	000		104	151	.210	.263	116.			545	565'	RELATIVE SPI	PDIA	. 759	NTIFIER =	11ME (MU-SEC)	000			. 393	525	620	961.		1.235	1,379	RELATIVE SPI	P01A .759
106	FORCE (DYNES)	2.10506E 10	2.102045 10 2 088105 10	2.06937E 10	2.05012E 10	2.03132E 10	2.012695 10	1.59422E 10	1.973906 10	1. 939745 10	1.921896 10	1.919676 10	S <b>-15,5</b>	RE RMASS	-10.000	106	FORCE (DYNES)	3.40713E 10	3.432794 10	3,30300E 10	3.11704E 10	3.02692E 10	2,93929E 10	2.65437c 10	2.764395 10 2 483005 10	2.63531E 10	2.531036 10	s -10.8	RE RMASS 1.0 -10.030
rut set wr. 1	F (V2) (DYNES)	1.38940E 10	1 374176 10	L.35691E 10	1.33981E 10	1.32284E 10	1,30607E 10	1.28943E 10	1.27293E 10	1 37007E 10	1.22440E 10	1.22241E 10	SPEED DEVIANT I	VSP V	388°5 848	'UM SET NR. 2	F(V2) (DYMES)	2.58361E 10	2.57977E 10	2.486962 LU	2.31511E 10	2.231946 10	2.15117E 10	2.C7274E 10	1,99034E 10	1.844976 10	I.77658E 10	SPEED DEVIANT I	VSP V 1211-6 1015
C A T	F(VI) (DYNES)	2.96636E 09	2.90403E 09	2.93147E 09	2,91293E 09	2.89445E C9	2.87603E 09	2.85765E 09	2.839335 09	Z.6Z175E 09	2.78466F 09	2.78239E 09	VALUES	SS ANG	••	CAT	F(VI) (DYNES)	4.04504E 09	4.04203E 09	3.970255 09	3.877285 UV	3.759686 09	3.69102E 09	3.62311E 09	3,55036E 09	3.403400 UT	3,35430E 05	VALUES	50 ANG 50 ANG
	( CV ) ( DY4ES )	4*13017£ 09	4.19017E 09	4-19017F C9	4.19017E 09	4.19017F 09	4.19017F 09	4.19017E 39	4*19017E 39	4.19017F 99 4 10017F 00	4.19017E 09	4.19017E 09	* EXPERIMENTAL	THICK PEA	-046 1.9		F(V3) (DY:E5)	4.19017£ 09	4.19017E 35	4.13017F U9	4.190176 30 4.190176 30	4"19017F 05	4.19017E 35	4.19017F 39	4.19017E 19	4.190175 09	4.19717F 09	= EXPERIMENTAL	ТНІСК РЧА •152 I.9
	VR (3/M)	633.5	637] 527.0	577.3	671.8	856.3	560.7	655 <b>.</b> 2	8 + <b>6</b> + 8	044°.		833.4	843°S	TSHN	135.0		VR (1/5)	1211.6	1299.8	1188.3	0.1411	1125.2	1104.7	1074.4	1052.6	1.52401	1004.2	1015.0	ТВ <sup>Н</sup> 3 135+0
	K {CM]	• 630	106.		10	.518	• 023	.025	ZED	150.		940	• 0 + 6		SI INPUT IS		х (Сн)	000	100*	.016	160.	190-	.076	169"	10E	513 511	.152	.152	ENPUT IS

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SAMPLE CATA IT FOR ZVE FORCE PERSTATION MODEL PREDICTING RESIDUAL VELOCITY

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SAMPLE GUTHIT FOR ZVF FORCE PENETATILA MODEL PREDICTING RESIDUAL VELOCITY

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FATUR SET MR. 3 ROENTIFIER # 3.0

TAHO 7,78	000°	4104 422.	R4455 -10,000	VRE 1196.3	450 1521.3	919 • 0	P: 455 1 + 950	THICK . JIG	TB#5 303+0	15	tk₽u†
161"	ERROR 15	RELATIVE SPEED	+235.4	VIANT IS	SPEED DE	ES	TAL VALU	∗ Expealue.	1196.3	60 e-1 7%	
	010714	C3043	01 356060	F 10 7	L.62071	6474E 09	.d 4°1	9.31145F	391.0	9∃€.	
		30407 304			1,50576	4538E 09	jc 2°0	1. 1.4116°5	1012.7	.245	
		500.52	40410L 10		62766.1	0247E 79	5.3	9-311446	3-94-4	. 255	
		14/10	040785 40	5 [] ]	2,19728	6344E 09	5°2	3-311446	1116.9	.224	
	0.03.0		93796E E0		2.42257	3940E C9	14 S.B	2 334[[2"6	1172.2	161.	
	1.0724	1,1,1	19428E 10	E 10 4.	2.65213	09495 09	15 6.1	3*911E*6	1226.5	.153	
2.07207	9859.3	915	47718E 10	E 10 +	2,92646	9566E C9	6°9	9.311495	1293.9	128	
	+ EE60T.	414.	76587E 10	E 10 4.	3.16709	7627E 09	6°9	2 369116"6	1340.3	<b>96</b> 0.	
***2052	0*16211		054505 10		3.455951	74-385 09	6°3 51	3:4112°6	1+22+1	. 764	
8+11771 5-121	E-05611	912.	40956E 10		3.75286	6652E 29	G 7.2	3:411E*6	1459.5	660.	
2424	1-11/21	5003	75432E 10	E 13 5.	4.066651	6522E 39	5° 1°2	" Jetlle"6	1518.8	100.	
0, 0, 0,	12733.7	000"	761425 10	E 10 5.	4°C7315	7120E C9	نک 2 <b>°£</b>	9.9114°F	[52].3	0-0-	
(DYNE-SEC)	PRESSURE (M PA)	71ME (MU-SEC)	FJRCE (DYVES)	(V2) 4533	4 (7 (	F(V1) (974ES)		ELVS LOT ES	74 (21)	×)	

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EATUM SET NR. 4 IDENTIFIER #

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-SEC1 (M PA) (DYNE-SEC 009 11203-1 454 474 8575-7 22708 1.574 9698-1 454 2.209 7627-3 65862 1.574 9686-1 454 2.209 5695-0 105774 3.699 5125-0 125774 5.678 3355.0 125774 5.659 3355.0 125774 5.650 100000000000000000000000000000000000	: Яния 7 - 7 - 8	HDIA COO	PDIA PDIA 759	R4A55 	SPEEU ULVIA-: 1. V5P V1 1344+5 469	ALUES S AtG	A SA	<pre>Experients # Thick p. 45 .015 1.72</pre>
-SEC1 (K PA) (DYNE-SE 000 11203.1 455 000 11203.1 455 1.574 9875.7 22708 1.574 98875.7 44558 1.574 76271.3 65662 2.999 5869.0 123774 2.999 5869.0 123774 5.678 3355.5 185193 5.678 3355.5 185274 5.678 3355.5 186214 5.678 3355.5 186214	- 3C	EED ERROR 15	RELATIVE SP	5 <b>-138-5</b>	VIANT IS	SPEED DE	VALUES SPEED DE	EXPERIMENTAL VALUES SPEED DE
-SEC1 (M PA) (DVME-SEC 0009 11203-1 454 474 8475-7 22708 1.574 7627-3 65662 2.209 5666.1 056662 2.209 5666.1 05576 5.676 3665.2 105776 5.676 3865.2 105776 5.676 3865.2 105776 5.676 3865.2 105776	20%171.4	2852, 0	8*622	I.29039E 10	60 39	1.5224	1.61431E 09 1.6224	5.456675 75 1.61431E 29 1.6224
-SEC1 (M PA) (DVNE-SEC 009 11293-1 454 478 9675-7 22708 1.574 9696-1 4559 1.574 9696-1 4559 2.209 5669-0 105774 2.209 5669-0 105774 5.670 3669-0 105774	186010.0	3338.5	6,959	1.51050E 10	76.09	3,4246	2.213515 29 3.4246	6.464477 JC 2.21351E 39 3.4246
-SEC1 (H PA) (DYNE-SEC -000 11203.1 454 -474 9675.7 22708 1.000 8684.8 454 1.209 8684.8 6566 2.209 5669.0 105774 2.509 5125.0 105774 4.610 4.62.1 145195	+*++*****	3269.5	5.678	1.75075E 10	2E 39	5.2897	2.75112E 09 5.2897	3.464676 C 2.75112E 09 5.2897
-SEC1 (H PA) (DVNE-SEC 009 11189-2 454 678 9675-7 22708 1.574 7627-3 6566 1.574 7627-3 6566 2.509 5669-1 005774 2.509 5125-0 105774	24641641	1.2444	4.610	2.018996 10	15E 29	7.4559	3.256216 09 7.4559	9.48667c Jc 3.25621E 05 7.4559
-SEC1 (M PA) (DVNE-SEC 009 11293-1 454 474 9675-7 22709 1.000 8984-8 4556 1.574 7627-9 65862 2.209 5869.1 86169 2.209 5869.0 103774	1°002c21	0°531c	3,699	2,31891E 10	56 <b>E 7</b> 9	9.946	3,772886 19 9,948	3 450675 75 3,772885 79 9,948
-SEC1 (M PA) (DVNE-SEC 000 11203.1 454 474 8575.7 22708 1.000 8484.8 44598 1.574 7627.3 6566.2	105774.3	5865.0	2.902	2.655446 10	105 10	1.2857	4.25071E 09 1.28C1	9.466675 19 4.25071£ 09 1.2801
-SEC1 (M PA) (DVNE-SEC 000 11203-1 454 478 9675-7 22708 1.000 8694-8 44598 1.574 7627-3 65862		0688.1	2,209	3.92605E 10	01 30	1,6309	4.73587E 09 1.6308	9.46657 JS 4.73587E 09 1.6308
-SEC1 (H PA) (DVHE-SEC .000 [1203.1 454 .009 [1169.2 454 .478 9675.7 22708 1.000 Bas4.8 44559	05662 eB	7427.3	1.574	3.45099E 10	1E 10	0219.1	5.31371E 29 1.9730	9.466575 25 5.31371E 39 1.9730
-SEC1 (H PA) (DVHE-SEC .000 [1203.1 454 .009 [1189.2 454 .478 9675.7 22708	44558.1	8484.8	1,000	3,929456 10	3E 10	2,3971	5.85650E C9 2,3971	9.494675 39 5.85650E 09 2,3971
-SEC1 (M PA) (DVNE-SEC ,000 [1203.1 ,009 [1189.2 454	22709.3	1.2739	814.	4.468296 10	25 10	2.6797	6.419.0E 09 2.6797	9.466575 30 6.41900E 09 2.6797
-SEC] (H PA) (DYNE-SEC .000 [1203.1	454,2	11169.2	600°	5,06258E 10	25 10	3.4167	6.99193E 39 3.4167	3.45667F 30 6.99193E 39 3.4167
-SEC] (H PA) (DYHE-SEC	0	11203.1	000"	5,066986 10	JE 10	3.4224	6.99778E 09 3.4224	3.46697F ]c 6.99778E 09 3.4224
	(DVNE-SEC)	(# 44)	(NU-SEC)	(STYLES)	YVES)	()	(344ES) (3	

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DANE-SEC)	6.611 6.624 6.611 6.611 6.611 6.6266 6.62666 6.6266 6.6266 6.6266 6.62666 6.62666 6.62666 6.62666 6.626666 6.6266666 6.6266666666	жн0 •78	Castang Briefse		днс • 78
PRESSURE (H PA) (	4410,8 4741.2 4741.2 4741.2 4741.2 4740.4 4740.4 4105.4 8891.4 8916.8 8312.4	EED ERKUR 15 4014 7 000 7 6.0	PRESSURE (M PA) (	1903.9 1903.9 1999.0 1999.0 1999.0 1991.0 1990.9 1390.9 1391.0 1391.9 1391.9 1391.9 1391.9 1391.9 1391.9 1391.9 1391.9 1391.0 1001.0 1001.0 1001.0 1001.0 1001.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.0 1000.000.	4000 -
(MU-SEC)	444480848489800 444880 444880 440848480 800848480 800848480 80080 8000000	RELATIVE SP PDIA .739 NTIFIER =	114E ( 114EC )	R 200 200 200 200 200 200 200 200 200 20	PD1A 1.013
FORCE (DYNES)	216762 10 216762 10 145176 10 071786 10 0000386 10 957776 10 857776 10 857726 10 722846 10 722846 10 556556 10 555556 10	*32,5 *4455 *10,000	FORCE (DY4ES)	2120861 .2120861 .2113461 .2113461 .1213461 .165916 .165916 .165916 .19146	R4455 -10.000
F(V2) (DYNES)	6,554697E 09 5,94344E 09 5,94344E 09 5,37256E 09 4,82131E 09 2,725991E 09 3,725991E 09 1,86144E 09 1,86144E 09 1,43437E 09 1,43437E 09 1,43437E 09	PEED DEVIANT IS VSP VE 609.9 367.9	F(V2) (DYNES)	2,66052E 09 2,85490E 09 2,85490E 09 2,60627E 09 2,51335E 09 2,51335E 09 2,51335E 09 2,17172E 09 2,17172E 09 2,17172E 09 2,00729E 09 2,00729E 09 2,00729E 09 2,00729E 09 2,00729E 09 2,00729E 09	VSP VRE 302.1 277.4
(SAVES)	3.47423E 09 3.46738E 09 3.31023E 09 2.98141E 09 2.98141E 09 2.60032E 09 2.45033E 09 2.65035E 09 2.65035E 09 1.85252E 09 1.62618E 09	VALUES S SS ANG 50 .0 DATU	F(V1) (DYNES)	1,796396 09 1,796396 09 1,794626 09 1,749365 09 1,712386 09 1,683366 09 1,683366 09 1,683366 09 1,654576 09 1,555376 09 1,555536 09 1,555536 09 1,555376 09 1,555376 09 1,555376 09 1,555376 09 1,555376 09 1,555376 09 1,555376 09 1,5555376 09 1,555536 09 1,555556 09 1,5555556 09 1,5555556 09 1,555556 09 1,555556 09 1,555556 09 1,5555556 09 1,555556 09 1,555556 09 1,555556 09 1,5555556 09 1,5555556 09 1,55555556 09 1,5555556 09 1,5555556 09 1,555556 09 1,5555556 09 1,555555555555555555555555555555555555	55 AVG
(DYVES)	1.219835E 15 1.219835E 15 1.219855E 15 1.2198555E 15 1.2198555E 15 1.2198555E 15 1.2198555E 15 1.21985555E 15 1.2198555555555555555555555555555555555555	<ul> <li>EXPERIMENTAL</li> <li>THICK</li> <li>PMA</li> <li>152</li> <li>1.9</li> </ul>	F(V0) (DYNES)	7.463916 39 7.4633916 39 7.4663916 39	THICK PMA .045 3.8
(3/2)	600 600 600 600 600 600 600 600	967.9 1812 193.0	VR (4/5)	200 200 200 200 200 200 200 200 200 200	T8HN 135.0
( M )	000 000 0040 0040 0040 0040 0040 0040	.152 INPUT IS	(HC)	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	INPUT IS

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SAMPLE OUT FOR Z/F FURCE PENETRATION MODEL PREDICTING RESIDUAL VELOCITY

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SAMPLE ONTROT FOR 2/F FJRCE PENETAATION TOBEL PREDICTING RESIDUAL VELOCITY

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(DANE-SEC)	0. 465.8 4.4703	11732.7	232245	25050.9	540000 5413614	47577,3	59964 . 3 60473 - 4	-072	TRH0 7.78		(DANE-SEC) 35"NDN" SE	•	526.0	13559.2	26374.4	70704	2°6315		70007.3	4.2004			18618237
PRESSURE (H PA)	1818.8 196.5 1762.6	1709.9	1606.9	1537.5	1507.2	1412.8	1367.1	ED ERROR IS	410H	0**	PRESSURE (M PA)	4615 4	4610.2	4339.6	4121.8	3007.2	3673.2	3462.3	9269.9	1.0806	0.1042		7+7827
TIME (MU-SEC)	000,000,000		1.667	2.147	2,029	3,696	4 260 4 88:	RELATIVE SPE	PD1# 1.013	TIFIER =	714E ( 01-SEC )	000*	•10	.375	.751	1,156	1.566	2°008	2.434	2,939	124°E		
FORCE (DYNES)	1.46536E 10 1.46403E 10 .22056E 10		1.3303/E 10 1.29538E 10	1.25529E 10	1.17651F 10	1,13864E 10	1.10179E 10		E RMASS 0 -10.000	1 DER	FORCE (DY-JES)	3.71977E 10	3.71562E 10	3.513666 10	3,32194E 10	3,13256E 10	2.96045E 10	2.79041E 10	2.635355.10	2.48240E 10	2.34290E 10	2,210425 JU	2.08117E 10
F(V2) (DYNES)	4.85454E 09 4.83978E 09 4.40107E 00	4.15274E 09	3.624585 29 3.49992E 09	3,19152E 09	2.692745 09 7 501475 30	2.308646 59	2.03780E 09	SPEED DEVIANT IS	VSP VR 393.5 256.	UM SET NR. 8	F(V2) (DYNES)	2.447285 10	2.44413E 10	2.26210E 10	2,08998E 10	1.92095E 10	1.76752E 10	1.61693E 10	1.48031E 10	1.34629E ID	1,224795 10	Telleler 10	9.99058E 04
F(V) (DYVES)	2.34019E 09 2.33663E 09	2.16444E 09	2.07715E 09 1.98771E 09	1.89747E 09	1.5064/E 09	1,61382E 09	1.51620E 09	VALUES	55 ANG 90 .0	DAT	F(V1) (DY465)	5.25499E 09	5.25097E 09	5,C5165E 09	4.85566E 09	4.65517E 09	4.46539E 09	4.27093E 09	4,08652E 09	3.89715E 09	3.71714E 09	3,536346 04	3.35716E 0Y
F(VJ) (04. ES)	7.46391E 39 7.46391E 39 7.45391E 39	7.463915 09	7.463915 39 7.463915 39	7.46391E 39	7.46391E 49	7.46391E 05	7.40391E 39	<pre>************************************</pre>	THICK <b>P</b> MA .152 <b>3.</b> 8		F (V0) (DYh,E5)	7.46391F 09	7.46391F 09	7.46391E 09	7.46391E 39	7.40391E 0C	7.46391E 09	7.46391E 09	7.46391E 09	7.46391E 09	7.46391E 99	7.46391E 09	7.46391E 09
۲R ۲۳/۱۳	393.5 392.3	353.9	348.7 333.8	318.7	303.44	271.2	254.8	256.0	твну 135•0		VR (M/S)	483-6	882.3	848.6	815.8	782.1	750.2	717.5	686.5	654.7	624.4	594.5	554.3
( 23)	000 1000 1000	160.	• 0 4 6 • 0 6 1	076	160.	.122	.137	.152 251.	INPUT 15		X (69)	000	100	660.	.064	.096	.128	.160	161.	.224	. 255	.286	.318

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SPEED DEVIANT

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(DANS-SEC) 21287.6 21287.6 41373.4 61373.4 61383.4 61383.4 101066.2 1138990.9 1138990.9 151190.6 151170.6 151170.6 153194.2 (DANE-SEC) 1342.1 53421.6 69765.9 87510.0 105364.9 122723.8 140376.2 140376.2 158460.0 177815.8 -.167 • -,275 7.16 10 15 SI 12018.7 12018.7 11371.8 10757.8 10152.2 9600.0 9655.5 8558.9 7622.7 7198.8 6785.3 5030.1 4179.8 3921.6 PRESSURE (M PA) PRESSURE (M PA) 3680.3 **5**069.2 4436.4 3222.5 691.7 6035.6 5352.1 6021.<u>5</u> ERROR ERROR 4104 1000, 0.6 10.0 RELATIVE SPEED SPEED 1.203 1.754 1.754 2.962 2.9653 2.9633 2.9633 2.9633 TINE (NU-SEC) TIME (MU-SEC) PD1A 1.013 RELATIVE IDENTIFIER = 8 **IDENTIFIER** R4ASS -10.000 (DYNES) FORCE (DYVES) -160.4 2222 2 8.18217E 7.73715E 7.29827E 6.89839E 6,143525 5,80184E 5,46850E 6.50341E 4.054356 3.5916316 3.591638 3.368696 3.160656 2.966176 2.778446 9,16512E 8.67023E 9.69715E 9.686455 4.58721E 4.86443E 2.5971BE 4.31357 4.85307 VRE 583.7 S 2 • SPEED DEVIANT F (VZ) 0000000000 222 F(V2) 0100 01000006 6.6 DATUM SET NR. 3,54249E 3,24171E 5.80522E 5.36391E 5.72899E 1.95496E 1.73575E 2.5499RE DATUM SET NR. 1.54525E 1.35101E 1.00105E 7.00681E 5.62885E 6.73875E 4.96307E 4 56934E 4.21186E 3, e6094E 2,41614E 2,18794E ..16874E 2.42593E VSP 879.6 F(V1) (DYNES) 9 0 0 • • F(V1) (DYNES) 1.20637E 1.15951E 1.11544E 1.07028E 1.02756E 9.83824E 9.42379E 9.01484E 8.59965E 1.29891E 1.25216E 5.00954E 4.19113E 3.75648E 1.29975E 7.79848E .40639E .000505 6,59651E 6.22402E 5.81959E .41290E .78273 VALUES PrASS 3,890 EXPERIMENTAL (CV) P(C) 1.65865F 1c د **م** (CV)F (DYNES) ŝ <u>...</u> 5 4 1.659055 1 1.653055 1 1.653055 1 1.65865F 1.65965E 1.65465E .65965F L+65965F •65965F 1.659655 I.¢58655 I.65865F 1.658635 L.65865F 1.65865F 1.63865F L.658655 1.65965F . 65865F .65345F .65965F 1.65895F TH1CK .316 1454.0 1411.4 1359.7 1357.0 1158.1 1062.1 876.1 833.6 787.9 742.3 700.3 654.7 564.2 518.8 472.3 423.3 TBHN 370.0 VR (1/5) VR (1/5) **9**•61 6.8.6 583.7 236.3 466.1 100 .316 × (<u>``</u>) (<sup>1</sup>, <sup>2</sup>) 600 15 INPUT 105

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VRE 1164.3

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SPEED DEVIANT

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SAMPLE DUTOUT FOR Z/F FURCE PENETRATIUL MUDEL PREDICTING RESIDUAL VELOCITY

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DATU-1 SET 11R. 11 IDENTIFIER = 11.0

TAH0 7.78	HD1A ,000	PD1A 1.013	RMASS -10.000	VRE 687.3	VSP 1466.1	S ANG 0 .0	98.89 3.89	THICK .635	7848 300.0	INPUT IS
++2*÷	EED ERROR IS	RELATIVE SP	-167.4	NT IS	SPEED DEVIA	ALUES	ENTAL V	■ EXPERIM	687.3	<b>635</b>
368791.	3685.9	7,054	97068E 10	9 2.	8.50323E 0	4.61753E C9	10	1.658055	519.9	.635
333060 .I	4180.7	5.946	369465 10		1.16937E 1	5.41436E C9	C.1	1.65865F	609.8	<b>5</b> 73
294168.	4737.2	4.971	81791E 10		1.53827E 1	6.20994E 09	(. =1	1.658655	699.6	<b>5</b> 06
265417.	5353.3	611ª4	31452E 10	••	1.95567E 1	7.00195E 09	1C	1.65865E	785.9	
228406,	6°36°6	3,348	86549E 10	•	2.42684E 1	7.79995E C9	۲ <b>1</b>	1.65305F	878.9	.381
192630.4	6796.2	2.658	47744E 10	0 <b>5</b>	2,9577CE 1	8,61089E C9	ن 1 ن	1.458655	970.4	.al8
157170.	7622.7	2,042	14352E 10	••	3.54249E 1	9.42379E C9	C	1.65365E	1062.1	.255
119803.	. 6536.9	1.467	89879E 10	0 6	4,21183E 1	1.02756E 10	.10	1.558055	1158.1	191.
61257.	9600.0	6E6 <b>°</b>	73715E 10	0 7.	4.96307E 1	1.11544E 10	-1-	1.653655	1257.2	•128
41373,	10757.6	<b>452</b>	67023E 10	0 8.	5, 80522E 1	1.20637E 10	c1	1.658655	1359.7	• 064
626.	12018.7	600°	68645E 10	• <b>6</b>	6.72899E 1	1.29831E 10	د 1	1.65865F	1464.0	100*
	12031.9	000	69715E 10	0 <b>9.</b>	6.73875E 1	1.29975E 10	Ű	1.653655	1466.1	000
(DYNE-SEC	PRESSURE (M PA)	TIME (MU-SEC)	FJRCE (DYNES)		F (V2 (DYNES	F(VI) (DYVES)	V0) ES)	р 1.У.С.)	VR ( M / S )	(HD)

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(DANE-SEC) L174. -. 191 246604 218549 246604 137376 10178 10966 1°.78 RELATIVE SPEED ERAGE IS PRESSURE (M PA) 6276.4 6265.0 5996.3 4083.6 5448 .7 5230 .8 4963.3 4725.7 294.9 5716. 1644 4014 .000 12.0 TIME (MU-SEC) 000 3.667 4.417 .95 20 Ŧ PD1A 1.267 EDENTIFIER = FORCE R4ASS -10,030 -132.0 50 7.91320E 10 5.14856E 4.90010E .56013E 5.67040E .20770E 6.86966 6.56984 6.25768 5,95807 .89881 5.41495 785 490,44 SPEED DEVIANT IS 12 F(V2) (DYNES) 10 2 101 DATUM SET NR. 1.53062E 4.C5711E 2.644575 2.394335 2.156135 1.9465135 1.946525 1.730136 4 . C4466 .44983 3.16146 2.90733 424 96.945 F(VI) ANG 0.4 60 **6 6** 60 6.23715E 7.74768E u 1.261385 w .11348E .06779E .01839E .690155 ,73710E .21306 .16315 .19551 .2592 VALUES PHASS 7.780 EXPERIMENTAL F(V0) (DYNES) 2 Ü ŝ w 2.59471E 2.59471E 2.59471 2.59471 2.59471 TH1CK .318 2.59471 2,5947 2.5947 2.5947 2.5947 2.5947 2.5947 1844 ۲۳) (۱۳/۶) 909.5 **9\*0**59 CH) .318 INPUT IS

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語言の別

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Z/F FJRCE PENETRATIDY MGUEL PREDICTING RESIDUAL VELOCITY SAMPLE JUTSIN FOR

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IDENTIFIER

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FORCE (DYNES)	1.10590E 11 1.10312E 11 1.07020E 11 1.03816E 11 1.00184E 11	9,716916 10 9,421526 10 9,421526 10 8,538766 10 8,538766 10 8,538766 10 7,983996 10 7,983996 10 7,983996 10 7,983996 10	VRE RMASS 4.4 -10.000 4 IDEN	FORCE (DYNES)	2,01337E 11 2,01336E 11 1,95384E 11 1,89368E 11 1,89368E 11 1,89368E 11 1,77526E 11 1,57526E 11 1,575206 11 1,575206 11 1,575206 11 1,575206 11 1,575206 11 1,575206 11
F(V2) (DYNES)	5.70543E 10 5.68133E 10 5.39675E 10 5.12067E 10 6.80904E 10	<pre>% &gt;&gt;&gt;004 IG % &gt;&gt;&gt;005E IG % &gt;005E IO 3.78295E IO 3.29960E IO 3.09435E IO 3.09435E IO 3.09435E IO 3.09435E IO</pre>	VSP 916.5 75 71 75	F(V2) (DYNES)	1.35026E 11 1.37806E 11 1.37806E 11 1.27157E 11 1.21367E 11 1.21367E 11 1.21366 11 1.67325E 11 1.67325E 11 1.67325E 10 9.40638E 10 3.99314E 10
F(VI) (37465)	1.76029E 10 1.775656E 10 1.71201E 10 1.66764E 10 1.66764E 10	<pre>1.5/208E 10 1.52618E 10 1.52618E 10 1.43336E 10 1.338965E 10 1.33866E 10 1.29635E 10 VALUES</pre>	455 ANG 560 .0	(SANYO) F(VI)	2.73791E 10 2.73573E 10 2.68370E 10 2.65790E 10 2.57266E 10 2.57266E 10 2.57266E 10 2.41429E 10 2.41429E 10 2.41429E 10 2.36111E 10 2.36111E 10 2.31247E 10 2.31247E 10 2.31247E 10
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VR ( M/S )	916.5 912.7 8895.5 8866.4	4 4 4 4 4 4 4 4 4 4 4 4 4 4	0.00 800 800	VR (3/5)	1425,6 1425,6 1362,3 1364,2 1364,2 1312,1 1256,0 10
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SPEED DEVIANT

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SAMPLE ("ITPUT FOR Z/F FORCE PENETRATIC : MOUGL PREDICTING RESIDUAL VELOCITY

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IDENTIFIER = 15 DATUM SET NR.

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15.0	PRESSURE		11617.0	11603.1	10928.7	10287.4	9659.	6.6906	8551.3	8022 ° 5	7542.4	7070.5	6642 · B	62 <b>38.1</b>	EED ERROR IS	401A • 000
NTIFIER =		( 135-06)	000*	.017	E94°	<b>928</b>	1.431	1.937	2ª465	3,040	3.620	4.253	4,493	5,566	RELATIVE SPI	P014 1.491
196	FORCE	( Carto)	2.02833E 11	2.02590E 11	1.90780E 11	1.79618E 11	1.65659E 11	1.58710E 11	1.49306E 11	1.40073E 11	1.31690E 11	1.23458E 11	1,15984E 11	1.08917E 11	-134.0	E R4ASS 5 -10,000
UM SET NR. 15	F(V2)	(DANES)	1.39386E 11	L.39165E 11	1.28437E-11	1.183355 11	L.C8456E 11	9.95276E 10	9.11269E 10	8.2919CE 10	7.550716 10	6.E2702E 10	6.17398E 10	5.56060E 10	SPEED DEVIANT IS	VSP VX 1432.6 1037.
DAT	F(V1)	(SANES)	2.75137E 10	2.74919E 10	2.64109E 10	2.53510E 10	2.42698E 10	2.32493E 10	2,22465E 10	2,12210E 10	2.02534E 10	1,92555E 10	1.83114E 10	1,73780E 10	VALUES	155 ANG 160 .0
	F(V0)	(DANES)	3.59323E Ir	3.59329F 10	3.5932BE LC	3.59328E 10	3,59328E Lr	3.59328E IC	3.59329E 10	3.59325E 10	3.59328E In	3.59325E 10	3.59328F 10	3,59329E 1C	= EXPERIMENTAL	THICK PHA .635 15.3
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SAMPLE UNTY IT FOR Z/F FORCE PENETATION MODEL PREDICTING RESIDUAL VELOCITY

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C C C				1 2 3
0 0 0	ми	PROGRAM	USING Z/F EQUATION TO PREDICT RESIDUAL VELOCITY	4 5
C C C		ULUSSAR	Y DF VARIABLES	7
c c	***	ID	PENTIFIES REQUIRED INPUT DATA	9 10
č c	*	1 D	DENTIFIES INPUT DATA WHICH IS NOT REQUIRED	11
C C	***	ANG	- THE ANGLE OF THE TARGET PLATE WITH RESPECT TO	13
C C		REA	LINE OF FLIGHT - OBLIQUITY (DEGREES) - THE PRUJECTED CROSS-SECTIONAL AREA OF PROJECTILE	12
C C		C 1	DN IMPACT - CONSTANT BASED DN LEAST SQUARE FIT TO THOR DATA	18
C C		· 2 · 3	- CONSTANT BASED ON LEAST SQUARE FIT TO THOR DATA - CONSTANT BASED ON LEAST SQUARE FIT TO THOR DATA	20
: ¢		) DBAR	- THE DEVIANT - COMPUTED VALUE MINUS EXPERIMENTAL VALUE - THE AVERAGE (MEAN) VALUE OF THE DEVIANTS	21
С С		DELV	- ALLOWED TOLERANCE ON THE PLATE THICKNESS (CM) - The increment on the residual velocity	23
C C		DSD DTUR	- THE STANDARD DEVIATION OF THE DEVIANTS - Conversion factor - Degrees to radians	20
с С		OVAR 但BAR	- THE VARIANCE OF THE DEVIANTS - THE AVERAGE (MEAN) VALUE OF THE RELATIVE ERROR	28
с С		ESD EVAR	- THE STANDARD DEVIATION OF THE RELATIVE ERROR - THE VARIANCE OF THE RELATIVE ERROR	30
С С	*	401A 1CT	- THE DIAMETER OF THE HOLE MADE IN THE TARGET (CM) - INDEX TO COUNT NUMBER OF DATA CARDS FOR ONE TARGET	32
с С		ICTO ICIE	- INDEX COUNTER ON NUMBER OF POINTS FOR DEVIANTS - INDEX COUNTER ON NUMBER OF POINTS FOR RELATIVE ERROR	34
C C	*	IDN 1FLGM	- AN IDENTIFICATION NUMBER OR STABULADESIGNATES SHOT ARE - FLAG TO INDICATE RELATIONSHIP ON THICKNESS FOR THIS VR	36
С С		I FL GP FRFP	- FLAG TO INDICATE RELATIONSHIP ON THICKNESS FOR THIS VE - NUMBER OF ITERATIONS COUNTER INDEX	38
С С	***	PDIA PMASS	- DIAMETER OF THE PROJECTICE (CM) - MASS OF PROJECTILE (GRAMS)	40
C		RALIO	- USED TO DEFERMINE A FIRST ESTIMATE OF RESTOLAT VELOCITY The article frame of computer velocitiental	42
с С	¥	RELERR RM4SS	- THE RECOVERED PROJECTILE MASS (GRAMS)	44
C C C		501050 501050 51086	- THE SUM OF THE DEVIANTS - THE SUM OF THE DEVIANT SQUARED - THE SUM OF THE RELATIVE ERROR	46

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С		SUMRES	-	THE	SUM	DF	TH	ER	EL/	TI	VE	ERR	OR	5	QU/	R	D												48
Ċ.	***	TBHN	-	THE	TAR	GET	BR	INE	ĒÈ	HÅ	RDN	ÉSS	N	UM	BEP	l	()	G,	/5		MM	)							49
C	***	THICK	-	THE	THI	CKN	ESS	OF	Ťŀ	4E	TAR	ĜE1	' P	LA	TE	(	CN	1)											50
č	***	TRHO	-	THE	DEN	STT	Y D	FT	HE	TA	RGE	ŤF	LA	TE	(	(G)	icc	:)											51
č		VR	-	PRE	DICT	ED	RES	IDÚ	AL.	VE	LOC	İTY	1	(Ā	15			•											52
č	*	VRF	-	THE	EXP	ĒRI	MEN	TAL	RI	EŠĨ	DUA	ĹΫ	EL.	DC	ĪŤĬ	1		١Ż:	5)										53
č	***	VSP	_	THE	FXP	FOI	MEN	TAL	SI	TR 1	KIN	ā v	EL	00	TTY	1		1/	ŝj										54
č		XT		PREI	DTCT	FD	VAL	UE	nĒ.	PL	ATE	TH	ΠĒ	KN	ÊŚŚ	s I	Ö	ï	Éùl	RR	E N	T	v		UE				55
č				nF.	e F S	Tou		VÊL	nc :	ιΫŸ			•••										• •						56
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	100 00	116(6.1)	023																										67
	103 60	PMATIN	1)																										Å
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c	1	PEAD				i t n 1	NC	THE	<b>′т</b> /	A D G	ĒΤ	MA1		1 4	i i														72
U.	D.F.	AD (5.12	) 76		1672		112		••			1.11-1			-														73
		17616.13	7 1 U 7 1 T	CT1.	. TCI	2.1	1 2 1 C T 1																						74
		176(6.1)	101			611	513																						-75
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	VR=0.0	95
		96
	THILKP = THICK + DEL TAX	97
	THICKMATHICK-OBLIAX	6.
C	COMPUTE CREEFICIENTS AND OTHER QUANTITIES	69
ĉ	(NOTE : O AET CONVERTS THE BRINELL HARDNESS NUMBER	100
ĉ		100
<b>C</b>	CARD RETAINED.	101
	CR-2,027-70,227-70	102
		103
		104
		109
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	144 - Jahn I. 187 A I C. A. C. 284 V A. C. 284 V	107
		109
		107
	03-1003(ANG+040K)/47144(00)	110
	97-98-77664779983787687 976-89478186787977833786687	111
	X10'4'T(ALUG(UI/C4)T2'0'CC/Q0T(ATAN(C0/Q0)ATAN((USTC0//Q0)))	114
c	ALGUARDED AND A THICK THEN DENERDATION IS SNEDNULETE SPACIA	113
C I	WICH ATC CHICK THEN FENERALIGN IS INCOMPLETE VR-9.0	114
c	ANDITE A CLOCK CETWARE COD THE DESTAILS VELOCITY	112
L.	DATIDEARS//YTAFUT/V/YTUT/V/	110
		117
		110
		114
		120
		121
1		122
λ.		123
		124
r	(THURTE THE NOTATES TAGET DIATE THINNESS	123
L	- OPPOIE INE PREVICIED IARGEL PEATE INIGRNESS	120
	NAND (NETEND	121
		129
c	AT A A T A LOUGHT AZT Z. AT LO AUA AT ANGLE TADACT	127
C	VIVUONI FUR UBLIQUE ANGLE INPACI	130
	АЛ-АЛ-МА ПСЛУТ СТ ТЫТСИВХСОТО 196	131
	17 (A1+01+111CRF)0110 170	136
~	TELEVISION FOR THE ADDREETE STATEMENTS MEANE THAT TO REVISE	193
c	TH THE DIALG TRADUCT IN ADDRESS OF ADDRESS MEANS THAT THERE AND ADDRESS WALLS	134
r	AND THE REATE INAURIESS HAS DEEN HET WITH THE CORRENT VALUE	132
C C	COT ONE RESIDUAL VELOCITY	130
۱		13/
r	TO REPORTULET	130
C I	TELOPET HEARS (HAT THE VALUE FOR VE TO TUD LUW	1 1 4
		140
		741

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175 VR=VR-DELV
                                                                                  142
C
         IFLGH=1 MEANS THAT THE VALUE FOR VR IS TOD HIGH
                                                                                  143
                                                                                  144
      IFLGM=1
      GOTU 160
                                                                                  145
  180 DELV=DELV/2.0
                                                                                  146
         THE VALUE FOR VR HAS OVERSHOT THE TOLERANCE LEVEL FOR
С
                                                                                  147
С
         THICKNESS MEANING THAT THE VALUE FOR DELV IS TOO LARGE
                                                                                  148
      IFLGP=0
                                                                                  149
      IFLGM=0
                                                                                  150
      IF(DELV.LT.0.1)G070 910
                                                                                  151
      GOTO 160
                                                                                  152
185
      VR = VR / 100 • 0
                                                                                  153
         COMPUTE DEVIANT AND RELATIVE FARDE AND CORRESPONDING SUMMATION
C
                                                                                  154
      D=VR-VRE
                                                                                  155
      ICTD=ICTD+1
                                                                                  156
      SUMD=SUMD+D
                                                                                  157
      SUMDSQ=SUMDSQ+D++2
                                                                                  155
      RELERR=1000.0
                                                                                  159
                                                                                  160
      IF(VRE.LE.0.0)G0T0 186
      RELERR=D/VRE
                                                                                  161
      GOTU 187
                                                                                  162
  186 IF(VR.LE.0.0)RELERR=0.0
                                                                                  163
  187 IF(RELERR.GE.500.0)GDTD 189
                                                                                  164
      ICTE=ICTE+1
                                                                                  165
  189 CONTINUE
                                                                                  166
      SUMRE=SUMRE+RELERR
                                                                                  167
      SUMRES=SUMRES+RELERR=#2
                                                                                  168
      WRITE(6,195)IDN, TRHO, TBHN, THICK, ANG, PMASS, PDIA, VSP, RMASS, HDIA,
                                                                                  169
     1 VRE, VR, D, SUMD, SUMDSO, RELERR, SUMRE, SUMRES
                                                                                  170
  195 FORMAT(1H >A6;F6.2;F6.1;F8.3;F5.1;F6.2;F6.3;F8.1;F7.2;
                                                                                  171
     1 F7.3,4F8.1,F10.1,3F8.3 )
                                                                                  172
      ICT=1CT+1
                                                                                  173
                                                                                  174
      GOTO 150
  200 CONTINUE
                                                                                  175
        FIND THE MEAN, VARIANCE AND STANDARD DEVIATION OF
С
                                                                                  176
        ADEVIANTS AND RELATIVE ERROR
С
                                                                                  177
      CT=ICTD
                                                                                  178
      CT1=ICTD-1
                                                                                  179
      DBAR=SUMD/CT
                                                                                  180
      DVAR=(SUMDSQ-DBAR+=2+CT)/CT1
                                                                                  181
      USD=SQRT(DVAR)
                                                                                  182
      CT = 1CTE
                                                                                  183
      CT1=ICTE-1
                                                                                  184
      FBAR=SUMRE/CT
                                                                                  185
      EVAR=(SUMRES-EBAR++2+CT)/CT1
                                                                                  186
      ESD-SQRT(EVAR)
                                                                                  187
      WRITE(6,220)ICTD
                                                                                  188
```

<pre>WRITE(6,220)1CTE WRITE(6,215)EBAR,EVAR,ESD 210 FDRMAT(1H0)10x37HEAN,VARIANCE AND STANDARD DEVIATION,2X, 1 14HOF DEVIANTS = , 3F10.1 ) 215 FORMAT(1H0,10X37HEAN,VARIANCE AND STANDARD DEVIATION,2X, 1 17HOF RELATIVE ERROR, 3F10.5) C PRINT NUMBER OF POINTS WRITE(6,220)1CT 220 FURMAT(1H0,10X318HNUMBER OF POINTS = , 15) IF(10N.EG. 6HEND 1GUT0 900 GUT0 100 900 WRITE(6,905) 905 FORMAT(1H0,10X318HNUMBER OF POINTS = , 15) IF(10N.EG. 6HEND 1G FRUN ) STOP 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,TOELV 910 U 150 FND * DATA 70.0 4.48 190.0 .127 .0 1.95 .759 160.184 521.21 1.88 2.0 4.48 190.0 .318 .0 1.95 .759 180.26 590.40 -10.07 4.0 4.48 190.0 .318 .0 1.95 .759 180.36 1127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 798.86 672.69 3.83 9.0 4.46 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .127 .0 3.89 1.013 1526.13 979.32 -10.05 7.50 4.48 190.0 .127 .0 3.89 1.013 1526.13 979.32 -10.05 7.50 4.48 190.0 .127 .0 3.89 1.013 1526.13 979.32 -10.05 7.50 4.48 190.0 .127 .0 7.78 1.267 959.21 874.77 7.72 10.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.77 7.72 10.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.77 7.72 10.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.77 7.72 10.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.77 7.72 10.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.77 7.72 10.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.77 7.72 10.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.77 7.72 10.0 7.76 135.0 .152 .0 1.95 .759 888.49 \$\$48.87 -10.07 7.70 7.76 135.0 .152 .0 1.95</pre>					W	<b>R</b> 1	[T]	E	(6	•	2	10	))	D	BA	R	<b>)</b> (	١V	A		DS	D																								
<pre>WRITE(0,215)EBAR,EVAR,ESD 210 FORMAT(1H0,10x,37HMEAN, VARIANCE AND STANDARD DEVIATION ,2X, 1 14HOF DEVIANTS = , 3F10.1 ) 215 FORMAT(1H0,10x,37HMEAN, VARIANCE AND STANDARD DEVIATION ,2X, 1 17HOF RELATIVE ERROR , 3F10.5) C PRINT NUMBER OF PDINTS WRITE(6,220)1CT 220 FORMAT(1H0,10x,10HNUMBER OF PDINTS = , 15) IF(10N,EC. 6HEND )GUTD 900 GUTD 100 900 WRITE(6,905) 905 FORMAT(1H0,30x,10HEND DF RUN ) STDP 910 WRITE(6,915) 1DN,TREP,DELV 915 FURMAT(1H0,10x,2X,10HEND DF CONVERGE IN , 15,2X, 1 10HITERATIONS,5X,6HDELV = , F10.5 ) GUTU 150 FND * DATA 11AN1DM ALLOY 1.0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.46 190.0 .318 .0 1.95 .759 180.26 590.40 -10.00 '*.0 4.48 190.0 .635 .0 1.95 .759 1980.36 1127.15 .56 7.0 4.48 190.0 .635 .0 1.95 .759 1980.36 1127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 1092.66 957.58 1.73 9.0 4.46 190.0 .127 .0 3.89 1.013 1092.66 957.58 1.72 10.0 4.46 190.0 .127 .0 3.89 1.013 1092.66 957.58 1.72 10.0 4.46 190.0 .127 .0 3.89 1.013 1502.71 74.03 .24 14.0 4.46 190.0 .318 .0 3.89 1.013 1502.71 74.03 .24 14.0 4.46 190.0 .318 .0 3.89 1.013 1502.71 74.03 .24 14.0 4.46 190.0 .635 .0 3.89 1.013 1502.71 74.03 .24 14.0 4.46 190.0 .635 .0 3.89 1.013 1502.71 74.03 .24 14.0 4.46 190.0 .635 .0 3.89 1.013 1505.71 74.03 .24 14.0 4.46 190.0 .635 .0 3.89 1.013 1505.71 74.03 .24 14.0 4.46 190.0 .635 .0 3.89 1.013 1255.13 979.32 -10.07 15.0 4.48 190.0 1.27 .0 7.78 1.267 952.21 874.78 7.72 19.0 4.46 190.0 .635 .0 3.89 1.013 1255.13 77 125.81 .24 17.0 4.48 190.0 1.27 .0 7.78 1.267 952.21 874.78 7.72 20.0 4.46 190.0 .635 .0 7.78 1.267 952.21 874.78 7.72 20.0 4.46 190.0 .635 .0 7.78 1.267 1484.38 994.87 -10.00 7.0 7.76 135.0 .122 .0 1.95 .759 888.49 848.87 -10.07 7.0 7.76 135.0 .152 .0 1.95 .759 888.49 848.87 -10.07 7.0 7.76 135.0 .152 .0</pre>					W	R 1	l T	E	( 6	•	2	26	5)	1	ĪT	E				• -																										
<pre>210 FORMAT(100,10X,37HMEAN, VARIANCE AND STANDARD DEVIATION ,2X, 1 14HOF DEVIANTS = , 3F10.1 ) 215 FORMAT(140,10X,37HMEAN, VARIANCE AND STANDARD DEVIATION ,2X, 1 17HOF RELATIVE ERROR , 3F10.5) C PRINT NUMBER OF POINTS WRITE(6,220)1CT 220 FURMAT(140,10X,18HNUMBER OF POINTS = , 15) IF(TON.EC. 6HEND )GUTD 900 GUTD 100 900 WRITE(6,905) 905 FURMAT(140,30X,10HEND DF RUN ) STOP 910 WRITE(6,905) 906 GUTD 150 FND * 0ATA ***********************************</pre>					W	RI	T	Ē	1		2	1	5)	Ē	A A	R	. F	٠v	۸g		FS	:0																								
<pre>1 14HOF DEVIANTS = / 3F10.1 ) 215 FURMAI(1H0,10X,37HMEAM, VARIANCE AND STANDARD DEVIATION ,2X, 1, 17HOF RELATIVE ERROR, 3F10.5) C PRINT NUMBER OF POINTS WRITE(6,220)1CT 220 FURMAI(1H0,10X,18HNUMBER OF POINTS = , 15) IF(10N.EQ. 6HEND )GUTU 900 GUTU 100 900 WRITE(6,905) 905 FURMAI(1H0,30X,10HEND DF RUN ) STOP 910 WRITE(6,915) IDN,TREP,DELV 915 FURMAI(1H0,10X,46,2X,19HDID NOT CUNVERGE IN , 15,2X, 1 10HITERATIONS,5X,6HOELV = , F10.5 ) GUTU 150 FND * DATA TIFAMIUM &amp;LUOY 1.0 4.4&amp; 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.4&amp; 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.4&amp; 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.4&amp; 190.0 .318 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.4&amp; 190.0 .635 .0 1.95 .759 1491.08 683.36 1.73 0.0 4.4&amp; 190.0 .635 .0 1.95 .759 1241.63 683.36 1.73 0.0 4.4&amp; 190.0 .635 .0 1.95 .759 1241.63 683.36 1.73 0.0 4.4&amp; 190.0 .635 .0 1.95 .759 1241.63 683.36 1.73 0.0 4.4&amp; 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 1.0 4.4&amp; 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 1.0 4.4&amp; 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 1.0 4.4&amp; 190.0 .318 .0 3.89 1.013 1255.11 12.14 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 1252.61 397.32 .100 3.4 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 1.21.15 3.172 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 1.21.15 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 1.21.15 3.1 1.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 397.32 .100 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 397.32 .100 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 397.32 .100 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 397.32 .100 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 397.32 .100 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 397.32 .100 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 397.32 .100 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 397.32 .100 3.2 4.4&amp; 190.0 .318 .0 3.89 1.013 152.61 367.33 .12 3.2 4.4&amp; 190.0 .635 .0 3.89 1.013 152.61 874.78 7.72 3.0 4.4&amp; 190.0 .635 .0 3.89 1.013 2551.61 3.64 7.72 3.0 4.4&amp; 190.0 .635 .0 3.89 1.013 2551.61 3.64 7.72 3.0 4.4&amp; 190.0 .635 .0 3.89 1.013 2551.61 367.33 .12 3.2 4.4&amp; 190.0 .635 .0 3.89 1.013 2551.61</pre>		2	ł	0	F	O F	2 M	Ā	τi	1	H	ο.	1	0	K .	2	7 F	iM	FI	Ň		v	ΔF	2 t	۸	NC	F	4	١N	מו	S	Ŧ	Δŀ	JD	٨R	ſ.	n	×۷	17	۵τ	10	N	. :	×		
<pre>215 FURMAI(1H0,10X,37HMEAN, VARIANCE AND STANDARD DEVIATION ,2X, 1. 17H0F RELATIVE ERROR , 3F10.5) C PRINT NUMBER OF POINTS WRITE(6,220)ICT 20 FURMAI(1H0,10X,18HNUMBER OF POINTS = , 15) IF(10N.EC. 6HEND )GUTD 900 GOTD 100 900 WRITE(6,905) 905 FURMAI(1H0,30X,10HEND OF RUN ) STOP 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,OELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,DELV 910 WRITE(6,915) IDN,TREP,TEV 1. 0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.48 190.0 .635 .0 1.95 .759 1355.45 1083.56 1.63 5.0 4.44 190.0 .635 .0 1.95 .759 1355.45 1083.56 1.63 5.0 4.44 190.0 .635 .0 1.95 .759 1366.38 1127.15 .56 7.0 4.48 190.0 .635 .0 1.95 .759 12371.65 361.61 =10.0' 8.0 4.46 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 125.181 2.43 3.10 4.48 190.0 .318 .0 3.89 1.013 125.13 12.43 3.11 C 4.48 190.0 .318 .0 3.89 1.013 125.13 12.43 3.2 4.46 190.0 .318 .0 3.89 1.013 125.13 12.43 3.3 C 4.46 190.0 .318 .0 3.89 1.013 125.13 0.24 1.40 4.48 190.0 .318 .0 3.89 1.013 125.13 12.43 3.12 4.48 190.0 .318 .0 3.89 1.013 125.13 12.43 3.14 C 4.48 190.0 .318 .0 3.89 1.013 125.13 0.74.50 3.24 1.40 4.48 190.0 .127 .0 7.78 1.267 959.21 874.78 7.72 1.60 4.48 190.0 .127 .0 7.78 1.267 959.21 874.78 7.72 1.70 4.46 190.0 .318 .0 7.18 1.267 959.21 874.78 7.72 1.60 4.48 190.0 .318 .0 7.78 1.267 959.21 874.78 7.72 1.60 4.48 190.0 .318 .0 7.78 1.267 959.21 874.78 7.72 1.60 4.48 190.0 .318 .0 7.78 1.267 959.21 874.78 7.72 1.60 4.48 190.0 .318 .0 7.78 1.267 1484.38 994.87 -10.00 7.0 7.76 135.0 .952 .0 1.95 .759 888.49 848.87 -10.</pre>		•	Î	ົາ	'		1	2	Hr	่าคื		Di	÷v	ī	۵N	Ť	ć		-		í .	IF	10	5.	7		-						~'	•		-			• 7	• •	• -			- ^ .		
1. 17HOF RELATIVE ERROR, 3F10.5) C PRINT NUMBER OF POINTS WRITE(6,20)ICT 220 FURMAT(1H0,10X,18HNUMBER OF POINTS = , 15) IF(10N.EQ. 6HEND )GOTO 900 GOTO 100 900 WRITE(6,905) 905 FURMAT(1H0,30X,10HEND OF RUN ) STOP 910 WRITE(6,915) IDN,1REP,DELV 915 FURMAT(1H0,10X,66,2X,19HDID NOT CONVERGE IN , I5,2X, 1 IOHITERATIONS/5X,6HDELV = , F10.5 ) GOTO 150 FND * DATA TITANIUM (LLOY 1.0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.48 190.0 .318 .0 1.95 .759 186.26 590.40 -10.07 4.48 190.0 .318 .0 1.95 .759 185.45 1083.56 1.63 5.0 4.48 190.0 .635 .0 1.95 .759 1241.08 683.36 1.73 6.0 4.48 190.0 .635 .0 1.95 .759 1286.38 1127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 9.0 4.46 190.0 .127 .0 3.89 1.013 202.66 957.68 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 202.66 97.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 122.66 97.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 122.66 97.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 122.66 97.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 122.66 97.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 12.0 4.46 190.0 .318 .0 3.89 1.013 1251.79 1.612 .44 13.0 4.46 190.0 .318 .0 3.89 1.013 1251.79 1.65 .61.61 -10.07 7.0 4.48 190.0 .318 .0 3.89 1.013 125.78 3.31 12.0 4.46 190.0 .318 .0 3.89 1.013 125.78 1.77 10.0 4.48 190.0 .635 .0 3.89 1.013 125.79 1.65.86 .57 17.0 4.48 190.0 .635 .0 3.89 1.013 125.79 1.65.86 .57 17.0 4.48 190.0 .635 .0 3.89 1.013 255.79 1.65.86 .57 17.0 4.48 190.0 .127 .0 7.78 1.267 940.99 51.47 7.77 20.2 4.46 190.0 .318 .0 7.78 1.267 94.99 .61.47 7.77 18.0 4.48 190.0 .127 .0 7.78 1.267 94.99 .61.47 7.77 20.2 4.46 190.0 .318 .0 7.78 1.267 94.99 .61.47 7.77 20.2 4.46 190.0 .635 .0 3.89 1.013 255.79 1165.86 .57 17.0 4.48 190.0 .127 .0 7.78 1.267 94.99 .61.47 7.77 18.0 4.48 190.0 .127 .0 7.78 1.267 94.99 .61.47 7.77 18.0 4.48 190.0 .127 .0 7.78 1.267 94.88 .994.87 -10.07 7.0 7.76 135.0 .045 .0 1.95 .759 888.49 848.87 -10.07 20.7 7.76 135.0 .045 .0 1.95 .759		2	1	5	F	ns	й	A	11	1	ц	<u>.</u>		Ô,	2.	2	3 7⊾	ıM	Ē.,	เพิ่				11	*	Nŕ	c	1	4.14	n	5	. 7	٨	٥n	A 12	n	D/	8 V	• /	A 7	п	M		×		
<ul> <li>PRINT NUMBER OF POINTS</li> <li>WRITE(6,220)1CT</li> <li>220 FURMAT(1H0,10X)18HNUMBER OF POINTS = , 15) IF(TON.EC. 6HEND 16UTD 900 GOTU 100 900 WRITE(6,905) 905 FDRMAT(1H0,30X)10HEND DF RUN ) STOP 910 WRITE(6,915) 1DN,1REP,DELV 915 FURMAT(1H0,10X)A6,2X,19HDID NDT CUNVERGE IN , 15,2X, 1 UNITERATIONS/SX/6HDELV = , F10.5 ) GOTU 150 END * DATA 11AN1UM <lloy 1.0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 166.38 127.41 8.91 3.0 4.42 190.0 .318 .0 1.95 .759 166.38 1127.15 .56 7.0 4.48 190.0 .635 .0 1.95 .759 186.38 1127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 9.0 4.48 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 1.0 4.46 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .127 .0 3.89 1.013 1505.71 774.50 3.24 1.0 4.48 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 1.0 4.48 190.0 .127 .0 3.89 1.013 1505.71 774.50 3.24 1.0 4.48 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 1.0 4.48 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 1.0 4.48 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 1.0 4.48 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 1.0 4.48 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 1.0 4.48 190.0 .127 .0 7.78 1.267 40.99 561.44 7.72 1.0 4.48 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 1.0 4.48 190.0 .127 .0 7.78 1.267 40.99 561.44 7.72 1.0 4.48 190.0 .127 .0 7.78 1.267 40.99 561.44 7.72 1.0 0.448 190.0 .127 .0 7.78 1.267 1464.38 994.87 -10.90 1.0 7.78 135.0 .127 .0 7.78 1.267 1484.38 994.87 -10.90 2.0 7.78 1.35.0 .152 .0 1.95 .759 121.58 1014.98 -10.90 2.0 7.78 135.0 .152 .0 1.95 .759 121.58 1014.98 -10.90 7.0 7.78 135.0 .152 .0 1.95 .759 121.58 1014.98 -10.90 2.0 7.78 135.0 .152 .0 1.95 .759 121.58 10.14.98 -10.90 2.0 7.78 135.0 .152 .0 1.95 .759 121.58 1014.98 -10.90 2.0 7.78 135.0 .152 .0 1.95 .759 121.58 10.14.98 -10.90 2.0 7.78 135.0 .152 .0 1.95 .759 121.58 10.14.98 -10.90 2.0 7.78 135.0 .152 .0 1.95 .759 121.58 10.14.98 -10.90 2.0 7.78 135.0 .152 .0 1.95 .759 121.58 10.14.98 -10.90 2.0 7.78 130.</lloy </li></ul>		C		ĺ,	1	Ur		7	ur ur	או		• J • d	/ # 51	٥ <i>۲</i>	77	2	( r C	Ē	54	11	<b>,</b>	Y	мг -	10	~			、"		μ		• •	~	10	# N	0	0	C V	4.		14				,	
C TERMIN NUMBER OF PDINTS WRITE(6,220)ICT 220 FURMAT(1H0,10X,18HNUMBER OF PDINTS = , 15) IF(TDN.EQ. 6HEND )GUTD 900 GGTD 100 900 WRITE(6,905) 905 FDRMAT(1H0,30X,10HEND DF RUN ) STDP 910 WRITE(6,915) IDN,IREP,DELV 915 FURMAT(1H0,10X,A6,2X,19HDID NOT CDNVERGE IN , 15,2X, 1 10HITERATIONS,5X,6HDELV = , F10.5 ) GGTU 150 END * DATA TITANIUM (LLOY 1.0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 1661.82 1294.18 .91 3.0 4.42 190.0 .318 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.42 190.0 .318 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.48 190.0 .635 .0 1.95 .759 1986.36 1127.15 .56 7.0 4.48 190.0 .635 .0 1.95 .759 1986.36 1127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 798.88 67.69 3.83 9.0 4.48 190.0 .127 .0 3.89 1.013 1032.66 957.68 1.72 10.0 4.46 190.0 .127 .0 3.89 1.013 1032.66 957.68 1.72 10.0 4.46 190.0 .127 .0 3.89 1.013 1032.66 957.68 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.68 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.68 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.68 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1092.61 97.93 .83 9.0 4.48 190.0 .318 .0 3.89 1.013 1092.66 957.68 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1092.61 97.93 .83 11.0 4.48 190.0 .318 .0 3.89 1.013 1502.77 93.83 11.0 4.48 190.0 .318 .0 3.89 1.013 1502.77 93.2 -10.00 15.0 4.48 190.0 .635 .0 3.89 1.013 1526.13 97.82 -10.00 15.0 4.48 190.0 .27 0.778 1.267 95.21 61.367.33 .12 16.0 4.48 190.0 1.27 0.778 1.267 95.21 61.367.33 .12 17.0 4.48 190.0 1.27 0.778 1.267 1484.38 994.87 -10.90 17.0 4.44 190.0 .127 0.778 1.267 1484.38 994.87 -10.90 18.0 4.43 190.0 .127 0.778 1.267 1484.38 994.87 -10.90 17.0 4.44 190.0 .635 .0 3.89 1.013 2551.79 1165.86 .57 17.0 4.44 190.0 .635 .0 7.778 1.267 1484.38 994.87 -10.90 20.7 778 1.35.0 .152 .0 1.95 .759 888.49 848.87 -10.90 20.7 778 1.35.0 .152 .0 1.95 .759 1211.58 1014.98 -00.20 10.7 778 135.0 .152 .0 1.95 .759 1211.58 1014.98 -00.20 10.0 778 300.0 318 .0 7.78 1.267 1484.38 994.87 -10.90 20.0 778 78 000 0 318 .0 1.95 .759	c			1	•		ו ח		1.5	ur u¶r			5 kg 7 s.a	н Б 1	14	v				(U	R.				Τ,	••	7	'																		
<pre>NNTE(0,220)(C1 220 FURMAT(1)(0,10X,18HNUMBER OF PUINTS = &gt; 15) IF(1DN.EG. 6HEND )GUTO 900 GDTU 100 900 WRITE(6,905) 905 FURMAT(1)(0,30X,10HEND DF RUN ) STOP 910 WRITE(6,915) 1DN,TREP,DELV 915 FURMAT(1)(0,10X,Ac,2X,19HDID NOT CUNVERGE IN , I5,2X, 1 10HITERATIONS/5X,6HDELV = , F10.5 ) GOTU 150 FND * DATA 11TAMUM 4LLOY 1.0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.47 190.0 .318 .0 1.95 .759 1860.26 590.40 -10.01 4.0 4.48 190.0 .318 .0 1.95 .759 1860.36 1127.15 .56 5.0 4.48 190.0 .635 .0 1.95 .759 191.08 683.36 1.73 0.0 4.48 190.0 .635 .0 1.95 .759 1986.38 1127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 798.86 672.69 3.83 9.0 4.46 190.0 .127 .0 3.89 1.013 798.86 672.69 3.83 9.0 4.46 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 129.01 1251.81 2.43 13.0 4.48 190.0 .318 .0 3.89 1.013 129.01 1251.81 2.43 13.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.78 7.72 14.0 4.48 190.0 1.270 .0 3.89 1.013 2551.79 1165.86 .57 17.0 4.48 190.0 1.27 .0 7.78 1.267 1464.38 994.87 -10.90 17.0 4.48 190.0 .127 .0 7.78 1.267 1484.38 994.87 -10.90 20.7 4.46 190.0 .635 .0 3.89 1.013 2551.79 1165.86 .57 18.0 4.48 190.0 .127 .0 7.78 1.267 1484.38 994.87 -10.90 20.7 7.76 135.0 .152 .0 1.95 .759 888.49 848.87 -10.90 20.7 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.90 20.0 7.78 100.0 .318 .0 7.78 1.267 1484.38 994.87 -10.90 20.0 7.78 0.90 0.0 318 .0 1.95 .759 121.558 1014.98 -00.20 20.0 100 7.78 100.0 2.150 0.100.0 100.20 0.00 0.00 0.00 0.00 0.0</pre>	L.				ы		r i T	R F	10	4.1	-		14			i	Ur	•	۲	11	NI	3																								
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1+(10).EG. 6HEND       )GUTD 900         GOTU 100         900 WRITE(6,905)         905 FORMAT(1H0,30X,10HEND DF RUN )         STOP         910 WRITE(6,915) IDN,TREP,DELV         915 FURMAT(1H0,10X,46,2X,19HDID NOT CUNVERGE IN , I5,2X, 1         10HITERATIONS,5X,6HOELV = , F10,5 )         GOTU 150         FND         *         0ATA         TITANIUM &LLOY         1.0       4.48 190.0         .127 .0       1.95 .759 1461.82 1294.18         91.0       4.48 190.0         .10       .127 .0         .1.95 .759 1355.45 1083.56 1.63         5.0       4.48 190.0         .30       .441 190.0         .318 .0       1.95 .759 1355.45 1083.56 1.63         5.0       4.48 190.0         .270 .0       .195 .759 1365.45 1083.56 1.63         5.0       4.48 190.0         .270 .0       .195 .759 1241.08 683.36 1.73         6.0       4.48 190.0         .270 .0       .195 .759 2371.65 361.61 -10.0°         7.0       .48 190.0       .127 .0       3.89 1.013 794.88 672.69 3.83         7.0       .448 190.0       .127 .0       3.89 1.013 774.28 582.76 3.31         7.0       .448 190.0		2	4	0	1		(M	<u>A</u>		1	HI	1	ļ	07	K.)	1	8⊧	111	U۴	10	EP	l	U		P	nt	N	12	>	2	ر		1:	))												
GUTU 100 900 WRITE(6,905) 905 FÜRMAT(1H0,30X,10HEND DF RUN ) STOP 910 WRITE(6,915) IDN,IREP,DELV 915 FÜRMAT(1H0,10X,A6,2X,19HDID NOT CÜNVERGE IN , I5,2X, 1 IOHITERATIONS/5X/6HOELV = , F10.5 ) GUTU 150 END * DATA 717AHUM 4LLOY 1.0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.42 190.0 .318 .0 1.95 .759 1862.6 590.40 -10.00 4.0 4.48 190.0 .635 .0 1.95 .759 1355.45 1083.56 1.63 5.0 4.48 190.0 .635 .0 1.95 .759 1363.45 1083.56 1.63 5.0 4.48 190.0 .635 .0 1.95 .759 1986.38 1127.15 .56 7.0 4.48 190.0 .635 .0 1.95 .759 1986.38 1127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 9.0 4.46 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1525.178 1.24 1.0 4.48 190.0 .318 .0 3.89 1.013 1525.178 3.31 1.2 4.44 190.0 .318 .0 3.89 1.013 1525.179 1.65 36.57 1.4.6 4.48 190.0 .318 .0 3.89 1.013 1525.179 1.65 3.24 14.0 4.48 190.0 .635 .0 3.89 1.013 1525.179 1165.86 .57 17.0 4.48 190.0 .635 .0 3.89 1.013 1525.179 1165.86 .57 17.0 4.48 190.0 .127 .0 7.78 1.267 640.99 561.44 7.72 14.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.78 7.72 17.0 4.48 190.0 .127 .0 7.78 1.267 1486.38 94.87 -10.00 5.0 4.49 190.0 .127 .0 7.78 1.267 1486.38 94.87 -10.00 5.0 4.49 190.0 .127 .0 7.78 1.267 1486.38 94.87 -10.00 3.0 7.78 1.267 1486.38 94.87 -10.00 2.0 7.76 135.0 .122 .0 1.95 .759 121.58 1014.98 -10.00 2.0 7.76 135.0 .122 .0 1.95 .759 121.58 1014.98 -10.00 2.0 7.76 135.0 .122 .0 1.95 .759 121.58 1014.98 -10.00 3.0 7.78 1.267 1486.48 94.87 -10.00 3.0 0 0 1.95 .759 121.58 1014.98 -10.00 3.0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0					1	F (	1	D	N	Ē	Q	•	0	ы	EN	D			) (	ju	T C	]	9(	0																						
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905 FORMAT(1H0,30X,10HEND OF RUN ) STOP 910 WRITE(6,915) IDN,TREP,DELV 915 FURMAT(1H0,10X,A6,2X,19HDID NOT CUNVERGE IN , 15,2X, 1 IOHITERATIONS,5X,6HDELV = , F10,5 ) GUTU 150 FND * DATA TITAMIUM (LLOY 1.0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.48 190.0 .318 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.48 190.0 .318 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.48 190.0 .318 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.48 190.0 .318 .0 1.95 .759 1491.08 683.36 1.63 5.0 4.48 190.0 .635 .0 1.95 .759 1491.08 683.36 1.73 6.0 4.48 190.0 .635 .0 1.95 .759 1986.38 1127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 6.0 4.46 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .127 .0 3.89 1.013 602.7 500.79 3.83 11.0 4.46 190.0 .318 .0 3.89 1.013 602.7 500.79 3.83 11.0 4.46 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 12.0 4.48 190.0 .635 .0 3.89 1.013 1505.17 774.50 3.24 14.0 4.48 190.0 .635 .0 3.89 1.013 1505.71 774.50 3.24 14.0 4.48 190.0 .635 .0 3.89 1.013 1505.71 774.50 3.24 14.0 4.48 190.0 .635 .0 3.89 1.013 1505.77 774.50 3.24 14.0 4.48 190.0 .635 .0 3.89 1.013 1505.77 774.50 3.24 14.0 4.48 190.0 .635 .0 3.89 1.013 1505.77 774.50 3.24 14.0 4.48 190.0 .127 .0 7.78 1.267 640.99 561.44 7.72 18.0 4.48 190.0 .127 .0 7.78 1.267 745.71 745.72 19.0 4.48 190.0 .127 .0 7.78 1.267 745.71 745.77 20.0 4.48 190.0 .127 .0 7.78 1.267 1484.38 994.87 -10.07 7.77 7.77 135.0 .127 .0 7.78 1.267 1484.38 994.87 -10.07 7.77 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.07 7.9 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.07 7.9 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.07 7.9 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.07 7.9 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.07 1.0 7.78 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.07 1.0 7.78 135.0 .152 .0 1.95 .759		9	0	0	W	R 1	T	Ε	(6	) »	9(	0,	5)					-																												
STOP 910 WRITE(6,915) IDN, IREP, DELV 915 FURMAT(1H0, 10X) A6, 2X, 19HDID NOT CONVERGE IN , 15, 2X, 1 10HITERATIONS, 5X, 6HOELV = , F10, 5 ) GUTU 150 FND * DATA TITANIUM (LLOY 1.0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.47 190.0 .318 .0 1.95 .759 1860.26 590.40 -10.00 4.0 4.48 190.0 .318 .0 1.95 .759 1855.45 1083.56 1.63 5.0 4.48 190.0 .635 .0 1.95 .759 1986.38 1127.15 .56 7.0 4.48 190.0 .635 .0 1.95 .759 1986.38 1127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 9.0 4.48 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 9.0 4.48 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 9.0 4.48 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .635 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .635 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .217 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.48 190.0 .127 .0 3.89 1.013 1505.71 774.50 3.24 14.0 4.48 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 14.0 4.48 190.0 .635 .0 3.89 1.013 255.16 1367.33 .12 16.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.78 7.72 20.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.78 7.72 20.0 4.48 190.0 .127 .0 7.78 1.267 959.21 874.78 7.72 20.0 4.46 190.0 .635 .0 3.89 1.013 255.16 1367.87 .72 20.0 4.46 190.0 .635 .0 7.78 1.267 959.21 874.78 7.72 20.0 4.46 190.0 .635 .0 7.78 1.267 959.21 874.78 7.72 20.0 4.46 190.0 .635 .0 7.78 1.267 1484.38 994.87 -10.00 RHA 10 7.78 135.0 .127 .0 7.78 1.267 1484.38 994.87 -10.00 RHA		9	C	5	F	ÛF	۱M	Δ.	Т (	1	H	0,	3	0)	K,	1	01	1E	NC	)	QF		RL	JN		)																				
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915 FURMAT(1H0,10X,46,2X,19HDID NOT CONVERGE IN , I5,2X, 1 IOHITERATIONS/5X,6HDELV = , F10.5 ) GOTU 150 FND * DATA TITAMIUM (LLOY 1.0 4.48 190.0 .127 .0 1.95 .759 567.84 521.21 1.88 2.0 4.48 190.0 .127 .0 1.95 .759 1461.82 1294.18 .91 3.0 4.42 190.0 .318 .0 1.95 .759 880.26 590.40 -10.00 4.0 4.48 190.0 .318 .0 1.95 .759 1355.45 1083.56 1.63 5.0 4.48 190.0 .635 .0 1.95 .759 1355.45 1083.56 1.63 5.0 4.48 190.0 .635 .0 1.95 .759 1368.81 127.15 .56 7.0 4.48 190.0 .635 .0 1.95 .759 1368.81 127.15 .56 7.0 4.48 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 G.O 4.46 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 G.O 4.46 190.0 .127 .0 3.89 1.013 798.88 672.69 3.83 G.O 4.46 190.0 .127 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 1032.66 957.58 1.72 10.0 4.46 190.0 .318 .0 3.89 1.013 1505.71 774.50 3.24 14.0 4.46 190.0 .635 .0 3.89 1.013 1505.11 774.50 3.24 14.0 4.46 190.0 .635 .0 3.89 1.013 1526.13 979.32 -10.00 15.0 4.48 190.0 1.270 .0 3.89 1.013 1525.179 1165.86 .57 17.0 4.48 190.0 1.270 .778 1.267 959.21 874.78 7.72 19.0 4.44 190.0 .635 .0 3.89 1.013 2551.79 1165.86 .57 17.0 4.44 190.0 .127 .0 7.78 1.267 959.21 874.78 7.72 19.0 4.44 190.0 .635 .0 3.89 1.013 2551.79 1165.86 .57 17.0 4.44 190.0 .127 .0 7.78 1.267 1484.38 994.87 -10.00 RHA 1.0 7.78 135.0 .046 .0 1.95 .759 888.49 848.87 -10.00 RHA 1.0 7.78 135.0 .046 .0 1.95 .759 1211.58 1014.98 -10.00 RHA		9	1	0	W	R I	T I	E	(6	,,	9	1 :	5)		1 D	N,	, 1	R	Ep	,	DE	Ľ	V																							
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END         *       DATA         T1TANIUM ALLOY         1.0       4.48       190.0       .127       0       1.95       .759       567.84       521.21       1.88         2.0       4.48       190.0       .127       0       1.95       .759       1661.82       1294.18       .91         3.0       4.42       190.0       .318       0       1.95       .759       180.26       590.40       -10.07         4.0       4.48       190.0       .318       0       1.95       .759       1355.45       1083.56       1.63         5.0       4.48       190.0       .635       0       1.95       .759       1986.38       127.15       .56         7.0       4.48       190.0       .270       0       1.95       .759       108.38       672.69       3.83         9.0       4.46       190.0       .127       0       3.89       1.013       1032.66       957.58       1.72         10.0       4.48       190.0       .318       0       3.89       1.013       1032.66       957.58       1.72         10.0       4.48       190.0       .318       0       3.8					G	<b>n</b> 1	1)		15	0																																				
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17.0       4.48       190.0 $127$ 0       7.78       1.267       640.99       561.44       7.72         18.0       4.43       190.0 $127$ 0       7.78       1.267       959.21       874.78       7.72         19.0       4.48       190.0       .318       0       7.78       1.267       959.21       874.78       7.72         20.0       4.48       190.0       .318       0       7.78       1.267       975.97       785.47       7.72         20.0       4.48       190.0       .635       0       7.78       1.267       1484.38       994.87       -10.00         RHA       1.0       7.78       135.0       .046       0       1.95       .759       888.49       848.87       -10.00         C       7.77       135.0       .152       .0       1.95       .759       1211.58       1014.98       -10.00         L       0       7.78       .059       .579       1211.58       1014.98       -10.00		l	Ĵ.	• ()		4	• •	48	Η	1	90	2.	Ō			1	• 2	1	0		٠	Q		3	•	88		1.	0	1	3	2	51	1	• 7	9	11	6	5.	. 8	6			, 5	/	
18.0       4.43       190.0       .127       .0       7.78       1.267       959.21       874.78       7.72         19.0       4.48       190.0       .318       .0       7.78       1.267       975.97       785.47       7.72         20.0       4.46       190.0       .635       .0       7.78       1.267       1484.38       994.87       -10.00         RHA       1.0       7.78       1.35.0       .046       .0       1.95       .759       888.49       848.87       -10.00         .0       7.78       1.35.0       .046       .0       1.95       .759       888.49       848.87       -10.00         .0       7.78       135.0       .046       .0       1.95       .759       888.49       848.87       -10.00		1	Ĩ	• .		4	• •	4 i	ri -	1	90	3.	0				<b>.</b> l	2	7		•	0		7	•	78		1.	2	6	7		64	0	.9	9		56	1.	• 4	4		7.	<b>, 7</b> 1	,	
19.0       4.4P       190.0       .318       .0       7.78       1.267       175.97       785.47       7.72         20.0       4.46       190.0       .635       .0       7.78       1.267       1484.38       994.87       -10.00         RHA       1.0       7.78       1.35.0       .046       .0       1.95       .759       888.49       848.87       -10.00         .0       7.76       135.0       .046       .0       1.95       .759       888.49       848.87       -10.00         .0       7.76       135.0       .046       .0       1.95       .759       1211.58       1014.98       -10.00         .0       7.77       .135.0       .152       .0       1.95       .759       1211.58       1014.98       -10.00		I	8	• ^		4	• •	4	3	1	90	).	0				• 1	2	7		•	0		7	•	78		1.	2	6	7		95	19	• 2	1	6	7	4,	, 7	8		7.	,7,	2	
20.0       4.46       190.0       .635       .0       7.78       1.267       1484.38       994.87       -10.00         RHA       1.0       7.78       135.0       .046       .0       1.95       .759       888.49       848.87       -10.00         2.0       7.78       135.0       .046       .0       1.95       .759       888.49       848.87       -10.00         2.0       7.78       135.0       .152       .0       1.95       .759       1211.58       1014.98       -10.00         3.0       7.78       135.0       .152       .0       1.95       .759       1211.58       1014.98       -10.00		1	9	• 0		4	•	41	n	1	9(	Э.	0				. 3	1	8			0		7	•	78	;	1.	2	6	7		47	15	• 9	7	1	78	5,	.4	7		7.	,7,	,	
RHA 3.0 7.78 135.0 .046 .0 1.95 .759 888.49 848.87 -10.90 2.0 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.30 4.0 7.78 300.0 .318 .0 1.95 .759 1531.56 1014.98 -10.30		2	0	. า		4	• •	41	6	1	9(	).	0				. 6	3	5			ŋ		7	•	78	i	1.	2	6	7	1	4 E	14	• 3	8	5	99	4.	. 8	7	<b>-</b> 1	٥.	, Q+	)	
RHA 1.0 7.78 135.0 .046 .0 1.95 .759 888.49 848.87 -10.00 2.0 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.00 4.0 7.78 300.0 .318 .0 1.95 .759 1531.56 104.98 -10.00																																														
1.0 7.78 135.0 .046 .0 1.95 .759 888.49 848.87 -10.00 7.0 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.00 5.0 7.78 300.0	R۲	I۸																																												
2.0 7.76 135.0 .152 .0 1.95 .759 1211.58 1014.98 -10.30			!	• 0		7	۰.	71	3	1	3:	5.	Ç			,	. 1	4	6			0		1	•'	95			7	59	9		86	8	• 4'	9	Į	;4	8,	8 .	7	-1	0.	0	`	
			٦	• 0		7	۰.	71	þ	1	35	5.	0				. 1	5	2		•	ð		1	•	95		•	.7	59	)	1	21	.1	• 5	8	10	)1-	4.	, 9	8	-1	0.	3	1	
			3	• 0		1	•	78	8	3	00	).	0				. 7	1	ß			ŋ		1	•	95		•	7	59	9	1	52	1	. 2	6	11	9	6.	. 3	4	-1	0.	. 3	}	

.
4.0	7.78	305.0	.635	.0	1.95	.759	1394.46	460.25	=10.00
5.0	7.78	393.0	.152	.0	1,95	.759	609,90	367.89	-10.00
6.0	7.78	135.0	.046	.0	3.89	1.013	302,06	277.37	-10.00
7.0	7,78	135.0	152	.0	3.89	1.013	393,50	256.03	-10.00
8.0	7.78	135.0	.318	.0	3.89	1.013	883,62	542.54	-10.00
9.6	7.78	300.0	.315	.0	3.89	1.013	879.65	583.69	10.00
10.0	7.78	300.0	.310	.0	3.89	1.013	1466.09	1164.34	=10.00
11.0	7.78	300.0	.635	.0	3,89	1.013	1466,09	687.32	-10.00
12.0	7.78	300.0	.318	.0	7.78	1.267	909,52	690.37	-10.00
13.0	7.78	300.0	.318	.0	15,36	1.491	916,53	754.38	-10.00
14.0	7.78	300.0	.318	.0	15.56	1.491	1425.55	1179.58	-10.00
15.0	7,78	300.0	.635	.0	15,56	1.491	1432,56	1037.84	-10.00
16.0	7.78	305.0	.635	.0	15.56	1.491	1556.00	1109.47	-10.00
17.9	7.78	332.0	1.270	•0	15,56	1.491	1660,55	759.56	-10,00

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END

SECTION OF A SUMPTICE PREMICTING RESUME VERDITY

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t n Mar i no yaya saa

**F**.

TITA' IUS ALI'Y

-,160 -,160 ,02 ,022 -,137 ,021	.022137 .020		023160 .02		,229 ,018 ,08	.100 .117 .001.	1,301 1,419 1.78	.029 1.447 1.76		362 1.048 1.91			.185 1.042 1.97		.228 1.225 2.03	056 1.189 2.03	012 1.176 2.03	001 1.175 2.03	-,027 1.148 2.03	.025 1.173 2.03	
6920.2		775/.9	7942.2	11052.1	35601,8	48197.8	294850.5	295218.2	296454.7	329353.1	336378.4	339703.4	360247.6	362217.5	459182.4	460960.3	461007.9	461009.0	461473°3	462092.4	
		-54,3	-67.9	123,6	33.0	145.3	641.9	661.1	625 <b>,</b> 9	444 .5	360,7	302.4	442.4	401.0	712.4	670.3	<b>663</b> .4	662.3	640.8	665.7	
	-83,2	28.9	-13.6	-55.8	1,56.7	112.2	496.6	19,2	-35,2	-181.4	83 <b>.</b> 5	-58.4	143.1	4.44-	311.4	-42,2	-6.9	-1.0	-21.5	24.9	
	0.664	1323,1	576.8	1,127,8	940.0	1239.4	a78,3	691.9	922.5	<b>9</b> "61E	499.0	1193.5	317.6	934.9	1578,7	1123.7	554.5	973.8	763.9	1019.8	
	521.2	1294.2	590°4	1083.6	683.4	1127.1	381.6	672.7	957.7	500.8	582.8	1251.8	774.5	619.3	1367.3	1165.9	561.4	E74.8	785.5	6**66	
	000.	cre.	505°	.000	000	000.	000*	ເບັນ"	,001	000.	000.	000.	C1:0.	000.	000.	000	000.	000.	000.	0.0.	
	1.:8	16.	-12.00	1.63	1.73	<b>6</b> 4.	-1).(9	3.13	1.72	3 <b>.</b> F3	1ª.e	2.43	3.24	-17.03	.12		7.72	7.72	7.72	-17,00	
	567.	1441.5	-9 HC - 9	1355.5	1491.1	1785.4	2371.7	796.9	1,332.7	5-024	773.3	1400°i	1505.7	1526.1	2455.2	3•1252	64 <b>1</b> .C	359.2	976.C	1494.4	
	. 759	. 759	. 759	. 159	.759	65ž°	.759	1.713	1.913	1.713	1.113	1.713	L, JI3	1.113	1.013	1. 113	1,257	1.267	1.267	1.267	
		l.9>	1.95		1.95	1.95	1.35	ен, <b>с</b>	С н <sup>с</sup> н <sup></sup>	3,39	€§°¢	5é°£	69 °	0,49	9°8'	63°E	1.7:	, , , ,	7,7=	7.7.	ۍ ز
	٢.	•	•		•	<b>`</b> •	•	٢.	٢.	٢.	<b>·</b>	٢.	•	•	•	ſ,	۴.	r. •	•	•	
	121.	7-1-7	÷16.	AI'.	• ÷ 15	.615	1.270	121.	.127	.318	.318	.318	.635	.635	•635	1.270	.127	.127	.318	÷635	F DINTS
	Г. • .Т	0° 61 -	1.161 :	61	. 19: .	19.0	· 19	. 19 9	191.0	196.0	0"(6I .	19)	19:01	1910	19:00	<b>19</b> . C	Ú (6]	19-10	19:00	0-161 -	มก รฐธุง:
	. 4 * 4	4.4	4.4	4° 4	4.4	4.4	4.4	4.4	4	4.7	4.4	4,4,		4.4	4.4	4.4	1 <b>4</b> 1	5 <b>*</b> 5	1. A. A.	4 * 4 -	2.
Ķ	<b>C•1</b>	2.0	3.0	<b>6.</b> 0	ວ ຫ	5.0	2.0	ຣ <b>ູ</b> ເ	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	

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152.2 33,3 23154,6 HEALS VARIANCE AND STANDARD DEVIATION DE DEVIANTS \* <u>ر</u> ر 1: PBER DF POINTS =

,

.32148 ¢10335 ,05854 "EARLANCE AND STAIDARD DEVIATION OF RELATIVE ERROR

50 11.1"9ER OF POINTS =

116

....,

SAIPLE DETAILED. ZVF EDUATION PREDICTES RUSTOUAL VELOCITY

SQ	000.	000	6EQ.	132	.184	.192	.197	661.	.273	105.	.360	-95.	.409	¢0≯.	. 426	564.	- 200	
SUR	019	029	· . 225	531	757		-,922	-,662	-1,155	-1.321	-1.565	-1.798	-1.864	-1.88	-2,017	-2,111	-2,366	
R.E.	-,019	- , 609	197	305	- , 226	-,090	075	040	- , 273	-,166	- 244	-,193	-,106	-,025	-,129	+60°-	- , 255	•
So	267.0	357.2	55780.0	75509.2	62438.4	83061.2	93429.9	83894 .4	109259.5	146676.8	174783.1	192482.1	198881.4	199719.0	217626.3	228499.5	265952.4	
5U:4	-16.3	-25,3	-261,3	-401.7	-4.65.0	~509 9	-529,1	-507.6	-666.3	-860,3	-1027.9	-1161.0	-1241.0	-1269,9	-1403.7	-1508.0	-1701.5	
DEV	-16,3	-9,5	-235.4	-140.5	-63.2	-25,0	-19.2	21.6	-159,3	-193.4	-167,6	-133.0	-90.08-	-28.9	-133,6	-104,3	-193,5	
٨N	332.5	1 105.5	960.9	319,8	284.6	252.4	236,8	564.1	424.4	970.9	519.7	557.3	574.4	1150.6	904.0	1 705.2	566.0	
VRE	348,9	1015.0	1196.3	460.3	367.9	277.4	256.0	542,5	583.7	1164.3	687.3	690°4	754.4	1179.6	1C37.8	1109.5	759.6	
AICH	010.	.000	500.	0רני	.000	600.	0C0.	000.	060.	.000	<b>000</b>	6.0"	000	000.	000.	000.	•000	
VS RHASS	380.5 -10.r0	211.4 -10.00	521.3 -1).(0	C''.(1- C.+96	609.° -10.CO	02.1 -10.00	393.5 -1J.(O	383.6 -10.CO	379.4 -10.63	466.1 -1J.00	466.1 -10.CO	909.5 -10.00	916.5 -13.CO	423.6 -13.CO	432.r -10.CO	556.( -19.60	560.5 -10.00	
ELCA SS:	1.95 . 759	1.0753 1:	1.95 .759 1	1.95 .759 1	1.95 .759 (	3. A. J. 113	1,99 L.JI3	3.99 L.)13	3.69 L.713 3	3,45 L.013 L	3.39 L.113 L	7.70 1.267	5.55 1.491	5,50 1.491 1/	0,56 1,491 L	5.56 1.491 1	5.55 1.491 10	
513	٢.	-	٢.		r.	٢.	<u>د</u> .	ŗ.	•	ŗ.	· ·	r,	.1		1	<u>،</u>	- -	
T IICK	94U.	.152	.315	÷535	.152	•0*0	.152	.316	<b>916</b>	.316	<b>6</b> E <b>0</b> .	.318	.318	.316	. 4 15	.615	1.270	POINTS
TR-1 Taty	7.7 135.7	7.7.135.)	7.7 301.0	7.7- 305.1	1° + CE - L° L	7.7' 135.3	7.7 135.0	7.7' 135.7	0°008 2°2	7.7- 300.0	0.00 7.7	7.7 30°.0	7.7~ 300.9	7.7- 300.0	7.7. 300.0	7.7- 305.0	7.7. 332.0	TUMBER OF
x	1.0	2.0	3,0	••	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	

E.11 -100.1 5978.1 H HEAM, VARIANCE AND STANDARD DEVIATION OF DEVIANTS 17 THILLER OF POINTS =

12E01. .01065 - 13918 MEAN, VARIANCE AND STANDARD DEVIATION OF RELATIVE ERROR HUPBER OF POINTS = 17

END GF RUN

; ) 1 /

RHA

,				1
C				2
Č				3
CU	чм	PROGRAM	I USING THE THOR EQUATION TO PREDICT RESIDUAL VELOCITY	5
ç		GLOSSAR	N DE VARIARIES	6
c		OLOJJAN	A OL ANKINDELT	7
č	•			
Ĉ	***	10	DENTIFIES REQUIRED INPUT DATA	10
C	*	10	DENTIFIES INPUT DATA WHICH IS NUL REQUIRED	11
Ç				12
C C	***	ANG	- THE ANGLE OF THE TARGET PLATE WITH RESPECT TO	13
č			LINE OF FLIGHT - OBLIQUITY (DEGREES)	14
č		ARFA	- THE PROJECTED CROSS-SECTIONAL AREA OF PROVECTILE	12
C			ON IMPACT	17
C.		n Lin Lin	THE DEVIANT & COMPUTED VALUE MINUS CAPERIMENTAL VALUE	16
Ĺ			- THE AVERAGE (REAR) VALUE OF THE DEVIANTS	19
Ċ		050 0TOP	- CONVERSION FACTOR - DEGREES TO RADIANS	20
c		OVAR	- THE VARIANCE OF THE DEVIANTS	21
Ĺ		F 1	- CUNSTANT BASED ON LEAST SQUARE FIT TO DATA	22
Ċ		.2	- CONSTANT BASED ON LEAST SQUARE FIT TO DATA	23
C		<b>ċ 3</b>	- CONSTANT BASED ON LEAST SQUARE FILL TO DATA	25
C		. 4	CONSTANT BASED ON LEAST SQUARE FIT TO DATE	26
ç		<b>ح</b>	THE AVERAGE (MEAN) VALUE OF THE RELATIVE ERROR	27
Ċ		ESD	- THE STANDARD VEYIATION OF THE RELATIVE ERROR	28
č		L VAR	- THE VARIANCE OF THE RELATIVE ERROR	29
č	*	HDIA	- THE DIAMETER OF THE HOLE MADE IN THE TARGET (CM)	30
С		10.1	- INDEX TO COUNT NUMBER OF DATA CARDS FOR UNE TARGET	34
C		CTD	- INDEX COUNTER ON NUMBER OF POINTS FOR RELATIVE FRADR	33
Ĺ	<b>.</b>	· C I E	AN TOENTYFICATION NUMBER OF FOUNDER DESIGNATES SHOT NR.	34
د د	¥ سنديد		- DIAMETER OF THE PROJECTILE (CM)	35
č	***	PMASS	- MASS OF PROJECTILE (GRAMS)	36
č		RELERR	- THE RELATIVE ERROR OF COMPUTED VS. EXPERIMENTAL	37
Ċ	*	RMASS	- THE RECOVERED PROJECTILE MASS (GRAMS)	30
С		SUMD	- THE SUM OF THE DEVIANTS	40
C		SUMDSQ	THE SUM OF THE DEVIANT SWOARED	41
C		CLIMPRE	THE SUM OF THE RELATIVE EKROR SQUARED	42
r r	*	1 BHol	- THE TARGET BRINELL HARDNESS NUMBER (KG/SQ MM)	43
Č	<b>*</b> **	THICK	- THE THICKNESS OF THE TARGET PLATE (CM)	44
č	¥	тяно	- THE DENSITY OF THE TARGET PLATE (G/CC)	45
С		VR	- PREDICTED RESIDUAL VELOCITY (M/S)	40
С	*	VRE	- THE EXPERIMENTAL RESIDUAL VELUCITY (M/SI	

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- THE EXPERIMENTAL STRIKING VELOCITY (M/S)
   ***
         VSP
С
C
      DATA PIDTOR / 3.141592634, 0.0174532925 /
   10 FURMAT( 46,2F6.1,F8.3,F5.1,2F6.3,2F8.1,2F7.2)
   11 FURMAT(5F10.3)
   12 FURMAT(10A6)
   20 FORMAT(1HO, 10X, 13HEXPONENTS ARE , 5F10.3 / )
  100 CONTINUE
      WRITE(6,103)
  103 FOR 1AT (1H1)
      WRITE(6,106)
                                                                                 38
  106 FURMAT(1H0,20X,42HSAMPLE OUTPUT FOR THOR EQUATION PREDICTING >
                                                                                 59
         18H RESIDUAL VELOCITY / )
                                                                                 60
     1
          READ CARD WHICH IDENTIFIES TARGET MATERIAL
C
                                                                                 61
      REAU(5,12)TGT1,TGT2,TGT3
                                                                                 62
      WRITE(6,12) (GT1, TGT2, TGT3
                                                                                 63
      REA0(5,11)E1,E2,E3,E4,E5
                                                                                 64
      WRITE(6,20)E1,E2,E3,E4,E5
                                                                                 65
      WRITE(6,110)
                                                                                 66
  110 FUR IAT (1HO, 4X, 39HNR TRHO TBHN
                                         THICK ANG MASS PDIA (6X)
                                                                                 67
         2HV5,2X,12HRMASS HDIA ,5X,3HVRE,6X,2HVR,5X,3HDEV,5X,
                                                                                 68
     1
          3HSUM, 8X, 2HSQ, 4X, 4HR, E., 5X, 3HSUM, 0X, 2HSQ )
                                                                                 69
     2
      10T =0
      10TU#0
      SUMU=0.0
      SUM054=0.0
      SUMRE=0.0
      SUMRES=0.0
      IGT=0
Ĺ
         INE BLANK CARD USED TO SEPARATE DAIA FUR DIFFERENT TARGETS
С
         CARD WITH END PUNCHED IN THE FIRST THREE COLUMNS.
                                                                                 78
                                                                                 79
Ċ
         WILL TERMINATE THE PROGRAM
  150 READ(5,10)IDN, TRHD, TBHN, THICK, ANG, PMASS, PDIA, VSP, VRE, RMASS, HDIA
      IF(TRHD LE.C.O)GOTU 200
         COMPUTE PROJECTILE CROSS-SECTIONAL AREA
С
      AREA=PI*(PDIA/2.0)**2
         THE UNIT OF VELOCITY TO BE USED IS CHISEC
ί
      VS=VSP#100.0
      31=10,0*≠E1
      D2=(THICK=AREA)==E2
      Q3=PMA5S**E3
      Q4=(1.0/CUS(ANG*0TUR))**E4
      05=VS**E5
         - DMPUTE THE PREDICTED RESIDUAL VELUCITY
Ċ
      VR=(VS-Q1+Q2+Q3+Q4+Q5)/100.0
         JOMPUTE DEVIANT AND RELATIVE ERROR AND CORRESPONDING SUMMATION
6
      J=VR=VRE
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SUMU=SUMD+D
      SUMUSQ=SUMDSQ+D##2
      ICTN=ICTD+1
      RELERR=1000.0
      IF(VRE.LE.0.0)GDTD 186
      RELERR=D/VRE
      GULD 187
  186 1F(VR.LE.0.0) RELERR*0.0
  187 IF(KELERR.GE.500.0)G0T0 189
      ICTE=ICTE+1
  159 CONTINUE
      SUMRE = SUMRE+RELERR
      SUHRES=SUMRES+RELEKR##2
      WRITE(6, 195) IDN, TRHO, TBHN, THICK, ANG, PMASS, POIA, VSP, RMASS, HDIA,
     VRF, VR, D, SUMD, SUMDSQ, RELERR, SUMRES SUMRES
  195 FORMAT(1H , A6, F6.2, F6.1, F8.3, F5.1, F6.2, F6.3, F8.1, F7.2)
         F7.3,4F8.1,F10.1,3F8.3 )
     1
      107=107+1
      GOTE 150
  200 CONTINUE
         FIND THE MEAN, VARIANCE AND STANDARD DEVIATION OF
C
         DEVIANTS AND RELATIVE ERROR
C.
      CT=ICTD
      CT1=1(TD=1
      05AR=SUMD/CT
      -)VAK=(SUMDSQ-DBAR=*2+CT)/CT1
      USD=SORT(DVAR)
      CTITCTE
      CT1=ICTE=1
      EBAR=SUMRE/CT
      EVAR=(SUMRES-EBAR+*2+CT)/CT1
      ESD=SQRT(EVAR)
      WRITE(6,220)ICTD
      WRTFEL6,210)DBAR,DVAR,DSD
      WRITE(6,220)ICTE
      WRITE(6,215)EBAR, EVAR, ESD
  210 FURDATCIHO, 10X, 37HMEAN, VARIANCE AND STANDARD DEVIATION ,2X,
        14HDF DEVIANTS = 3 3F10.1 )
    1
  215 FORMAT(1HO, 10X, 37HMEAN, VARIANCE AND STANDARD DEVIATION ,2X,
     1 . 17HOF RELATIVE ERROR > 3F10.5)
         PRINT NUMBER OF POINTS
С
      WR1TE(6,220)ICT
  220 FURMAT(1H0,10X,18HNUMBER DF PDINTS = > 15)
      IF (IDI .FQ. 6HEND )GOTD 900
      GULE TOO
  900 WRITE(6,905)
  905 FORMAT(1H0,30X,10HEND DF RUN )
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STOP								
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TITANTUM ALLI	- YC							
4,888	1.103	-1.095		1.36	9	0.167	•	_
1.0 4.48	190.0	.127	.0	1.95	.759	567.84	521:21	1.88
2.0 4,48	190.0	.127	.0	1.95	.759	1461.82	1294.18	•91
3.0 4.48	190.0	.318	.0	1,95	•759	880.26	390,40	-10.00
4.0 4.48	190.0	.318	.0	1.95	.759	1355.45	1043.56	1.63
5.0 4.48	190.0	.635	.0	1.95	.759	1491.08	683.36	1.73
6.0 4.48	190.0	. 5	.0	1.95	.759	1986.38	1127.15	. 56
7.0 4.48	190.0	1.270	.0	1.95	.759	2371,65	381.61	-10.00
8.0 4.46	190.0	.127	.0	3.89	1.013	798.88	\$72.69	3.83
4.48	190.0	.127	.0	3.89	1.013	1032.66	957.68	1.72
10.0 4.40	190.0	.318	.0	3.89	1.013	620.27	500.79	3.83
11.0 4.45	190.0	.318	.0	3.89	1.011	773.28	582.78	3.81
12.0 4.48	190.0	.318	.0	3.89	1,013	1499.01	1251.61	2.43
13.0 4.48	190.0	.635	Ō	3.89	1.013	1505.71	774.50	3.24
14.0 4.48	190.0	.635	0	3.89	1.013	1526.13	979.32	-10.00
15.0 4.48	190.0	635	. 0	3.89	1.013	2455.16	1367.33	.12
16.0 4.48	190.0	1.270	ĨŌ	3.89	1.013	2551.79	1165.86	.57
17.0 4.48	190.0	.127	. Ő	7.78	1.267	640.99	561.44	7.72
18.0 4.45	190.0	.127	ĨŐ	7.78	1.267	959.21	874.78	7.72
12.0 4.48	190.0	318	.0	7.78	1.267	975.97	785.47	7.72
20.0 4.48	190.0	.635	0	7.78	1.267	1484.38	994.87	-10.00
		••••	• -					
RHA								
5,690	0.889	-0.945		0.98	19	0.019		
1.0 7.78	135.0	.046	.0	1.95	.759	888,49	848.87	-10,00
2.0 7.78	135.0	.152	.0	1.95	.759	1211,58	1014.98	-10.00
3.0 7.78	300.0	.318	.0	1.95	.759	1521.26	1196.34	-10.00
4.0 7.76	305.0	.635	.0	1.95	.759	1394.46	460.25	-10,00
5.0 7.78	393.0	.152	.0	1.95	.759	609,90	367.89	-10.00
5.0 7.76	135.0	.046	.0	3.89	1.013	302.06	277.37	-10.00
7.0 7.78	135.0	152	.0	3.89	1.013	393.50	256.03	-10.00
5.0 7.75	135.0	.316	.0	3.89	1.013	883.62	342.54	-10.00
9.0 7.78	300.0	318	0	3.89	1.013	879.65	583.69	-10.00
10.0 7.75	300.0	.318	0	3.89	1.013	1466.09	1164.34	-10.00
11.0 7.70	300.0	.635	0	3.89	1.013	1465.09	687.32	-10.00
12.0 7.78	300.0	.318	.0	7.78	1.267	909.52	690.37	-10.00
13.1 7.76	300.0	318	.0	15.56	1.491	916.53	754.38	-10.00
14.0 7.78	300.0	318	.0	15.56	1.491	1425.55	1179.58	-10.00
15.0 7.78	300.0	.635	a.	15.56	1.491	1432.56	1037.84	-10.00
10.0 7.78	305.0	.635	.0	15.56	1.491	1556.00	1109.47	-10.00
17.0 7.78	332.0	1.270	- n	15.56	1.491	1660.55	759.56	-10.00

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NAMPLE FITS I STATE FOULTION ARENICITED RESIDING VELOCITY

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1.201 1.5	220*	2.101624	6.00	£°22	2•71C1	6.466		-1,00	1454.4	·7-1-267	r.	¢; 9.	• • • · 1 - • · ·	•
1.229 1.3	eto"-	422069.0	O*EEB	-12.6	772.8	785.5	.000	7.72	976.5	.7" 1.267	•••	.316		• •
1.255 1.3	1012	422509.2	845.6	10.8	365.6	874.8	000	7.72	959.2	.7- 1.267	~ •	.127	4.4 19 J	* •
1.242 1.9	•010	422391.9	834.8	10.7	572.2	561.4	000.	7,72	541.0	.7: 1.267	<u>.</u>	.127	C*-61 -9**	4 0
1.223 1.5	0+0	422276.4	824.1	9.94-	1119,3	1165.9	000.	-51	2551.4	.49 1.113	r.	1.270	0°	ч Ср
1.203 1.3		420105.3	870.7	425.2	1792.5	1367.3	060.	.12	2455.2	ell.1 45.	r.	.615	6 . 4 . 19 . J	0
	067	239304.3	445.5	-65.2	914.1	6 ° 5 4 6	°000°	-10°c1-	1526.1	610°1 55°	ŗ.	.635		, 0
1.019 L.2	156	235048.8	510.7	120.5	895.0	774.5	.000	J. 66	1505.7	.99 L. 113	- -	. 675	Ú°.6[ -∳°5	ч 0
.863 1.2	-,030	220518.7	390.1	-37.4	1214.4	1251.8	.000	2.43	1499.5	El'.1 2F.	r,	.316	6.4n 19. J	~ ~
	-,110	219121.6	427.5	-64,3	518.5	562.6	000°	3 <b>.</b> F1	773.3	.39 1. 113	<b>.</b>	<b>515.</b>	6.4° 197.0	ч 0
1.003 1.2	-,252	214987.6	491.8	-126.1	374.7	500.8	•000	3.13	52(++3	.47 1.º13	- -	.316	i• 61 .+••	м О
1.255 1.1	023	199085.1	617.9	-22.2	935.5	957.7	60c.	1.72	1.32.7	.40 1.13	۳. •	127	6.4- 19's)	ч 0
1.278 1.1	.049	196593.1	640°I	<b>19</b> 66	705.8	672.7	1000 <b>*</b>	3,63	798.0	.59 L.113	ŗ.	.127	0. 19.40	*
1.229 1.1	1.036	197497.1	607.0	395.5	177.1	381.6	• • • •	69.01-	2371.7	.95 . 759	- -	1.270	4.4. 191.J	~
. 193 .0	.123	41086.0	211.5	138,5	1265.7	1127.1	000.	•56	1936.4	.95 .759	- -	• 6 15	6 • • · 19 • • •	ч ч
.070 .0	.177	21891.2	73.0	120.7	304.1	683.4	<b>0</b> 00.	1.73	[*164]	est . 59		•6.15	6.6 19 .j	4
107 .0	040	7312.9	-47 <sub>e</sub> 8	+9°+	1.40.1	1083.5	000.	1.63	1355.5	.95 .759	<i>.</i> .	316.	(*** 13)	ч С
067 .0	006	5427.2	1.1	-3.5	585.9	590.4	ົບບູ	-1.1.60	€*')86	. 35 . 759	 	•31e	3. · · · · · · · · · · · · · · · · · · ·	4
-,061 .0	040	5414.8	6 -	51.6	1345.8	1294.2	•000 •	16.	1441.5	759	· •	.127		, 0
101 .0	101	2750.4	-52.4	- 25 . 4 .	464.8	521.2	(ju)	L.r.d	567 r	.95 . 759	 د	.17	· · · 1.) ·	° n
55	R.E.	So	N)S	DEV	γR	VRE	ADIA	RIASS	SN	ASS PULA	113	1-1CK	Tell Tour,	- 2

14. 9FR OF FOINTS = 2-

142.6 42.8 20346.8 MEANA VARIANCE AND STATIARD DEVIATION OF DEVIANTS -

areases of points = an

2577L .06642 .06376 MEANS VARIANCE AND STAUNARD DEVIATION OF RELATIVE ERROR

LINGER UF PULLTS = 20

SEVELE WITS I FUN THUR EQUATION AREUICTIES RESIDENT VELOCITY

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STI'BHUG*3	

×			ic	101	12 . EE						16 <b>. 748</b>	12	17 · • 828	128.			****	
t.E. SU	015 01	10317	,216 -,31	<b>3107</b> 0	150 - 01	229 -1,02	465 -1.54	.297 -1.84	.353 -2.19	176 -2,37	,231 ~2,60	. 249 -2.83	142 -2.99	022 -3.01	104 -9.11	11"8- 150"	848 ~3°E	
22	+080+0	15037.7 -	81763.0 -	02092.5 -	05197.5 -	- 6.24190	23372.0	- 0.4164	91 <b>5</b> 20.1 -	- 8°E56EE	59168.7 -	e7842+1 -	- a*00464	30069.B	11742.5 -	- 6.46647	14062.1 -	
202	·	-166,6	-426.9	-569.4 1	-624°8 1		-807.4 1		-1174.6. 1	-13.9.9 2	-1535.6 2	-1708.1 2	-1915,5 2		£ 7°67€3-	-2000-4 3	-2035.1 3	
DEV	-63.	-104.7	-258,3	-142 eb	-55.4	-63.5	-119.1	-161.1	-206.2	-205,3	-158.9	-169.3	-107.4	-25,9	-108.0	-57.0	-32.7	
A N	785.0	6°016	936.0	317.7	312 <b>.</b> 5	213,8	137.0	381.5	377.5	1.959	526.5	521.0	647.0	1153.7	929,8	1.352.4	726.9	
VRE	848,9	1015.3	1196,3	460,3	367.9	277.4	256.0	542.5	583.7	1164.3	667.3	690.4	754.4	1179.6	1037.8	1109.5	759.6	
A I OH	C00.	, 000	000.	000.	<b>000</b>	000	000.	000.	.000	000.	ōCù°	•000	.000	000	.000	.000	• 000	
RIASS	-13.03	-13.60	-10,00	-17.00	-17.60	-13.00	-13,00	-10.00	-10.00	-10,00	~10,00	-13,60	-10.10	-10.00	-10,00	-10.00	00*01-	
SN SN	385.5	1211.6	1521.3	1394.5	609°5	302.1	393.5	983.A	379.6	1466.1	1466.1	909.5	916.5	1425 c	1432.6	1556.F	1467.5	
₽](d	759	. 759	. 759	.759	. 759	1.713	1,013	1.013	1.013	1.513	1.13	1.267	1.491	1.491	1.491	194.1	1.491	
5 4ASS	0 1.95	1.95	1.95	1.95	- 1 - 67	63.6 1	3,89	9. 30	99.6 0	68 ° E 0	9.39	34.4 0	7 15.50	5 15.56	0 15.50	0 15.56	15.56	,
	. 940	. 52	318	515	152	046	152	318	318		635	918	318	318	615	. 515	270	-
エー・アイ				Ē			•				C	0	0	0		0	•0	
RH7 T3	.7~ 135	71 33	006 -2	205 -1-	-7° 393	7. 135	.79 135	-7- 135	215 300	COE #1.	CUE - 2.	COE 22.	78 300	7. 300	7F 100	1.75 305	74 332	
а. Т	1.0 7	0.6	0.6	0.4	5.0	0.9	0.1	0.6		0.0	0	0.6	0.6	0	0	0.4	1.0	

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HUMBER OF POINTS = 17

66.**8** 4466,9 -119.9 MEAN& VARIANCE AND STAVDARD DEVIATION OF DEVIANTS =

HUMBER OF POINTS = 17

.12150 e1476 MEAN, VARIANCE AND STANDARD DEVIATION OF RELATIVE ERROR -,18908

NUMBER OF POINTS = 17

END OF RUN

RHA

C C				
č				
00	M'1	PROGRA	USING THE Z/F EQUATION TO PREDICT PLATE THICKNESS	
¢				
ç		11 DCC 4		
č		+L0228	AT UF VARIABLES	
č				
Ĉ	***	I	DENTIFIES REQUIRED INPUT DATA	
ζ.	*	1	DENTIFIES INPUT DATA WHICH IS NOT REQUIRED	
i,				
C				
Ç	本未存	NG	- THE ANGLE OF THE TARGET PLATE WITH RESPECT TO	
<b>(</b> .			LINE UP FLIGHT - UBLIQUITY (DEGREES)	
۲ د		AREA	- THE PRUJECTED CRUSS+SECTIONAL AREA OF PROJECTILE	
ć		<i>(</i> )	UN IMFREI Commerable Block om FRET FOLLADE FIT FO TUDB DATA	
C C		• •	- CUNSIAMI DASED UN LEAST SMUARE FIL IN IMUR DATA	
ç		- 2	- CONSTANT DASED UN LEAST SOURCE FIT TO THOM DATA	
è		; j	- THE DEVIANT - COMBUTED VALUE NINUE EVDEDIMENTAL VALUE	c
с. С		119.50	THE REVIANT - CURPUTED VALUE MINUS EXPERIMENTAL VALUE. THE AVERAGE (MEAN) VALUE DE THE DEVIANTE	C
,		1150	THE SYERAGE (HEAR) VASOE OF THE DEVIANTS	
č		ាហាខ	- CONVERSION FACTOR - DEGREES TO PADIANS	
č		OVAR	THE VARIANCE OF THE DEVIANTS	
č		FBAR	- THE AVERAGE (MEAN) VALUE OF THE RELATIVE ERROR	
ĉ		" S E	- THE STANDARD DEVIATION OF THE RELATIVE ERROR	
Ċ.		-VrR	- THE VARIANCE UF THE RELATIVE ERROR	
Ĉ	*	H DIA	- THE DIAMETER OF THE HOLE MADE IN THE TARGET (CM)	
C		I C T	- INDEX TO COUNT NUMBER OF DATA CARDS FOR ONE TARGET	
6	*	101	- AN IDENTIFICATION NUMBER OR SYMBOL-DESIGNATES SHOT NR	
Ú.	4 <b>* *</b>	PE14	- DIAMETER OF THE PROJECTILE (CM)	
C	***	PH455	- MASS OF PROJECTILE (GRAMS)	
C		~ELERR	- THE RELATIVE ERROR OF COMPUTED VS. EXPERIMENTAL	
r	*	RM1.55	- THE RECOVERED PROJECTILE MASS (GRAMS)	
L.		501.0	- THE SUM OF THE DEVIANTS	
C.		SUPDSO	- THE SUM OF THE DEVIANT SQUARED	
C.		SUMRE	- THE SUM OF THE RELATIVE ERROR	
Ç		SUMPES	- THE SUM OF THE RELATIVE ERROR SQUARED	
Ç	***	LEHN	- THE TANGET BRINELL HARDNESS NUMBER (KG/SQ MM)	
6	*	THICK	- THE THICKNESS OF THE TARGET PLATE (CM)	
G	<i>₹₹¥</i>	1 PPU	- THE DENSITY OF THE TAKGET PLATE (G/CC)	
C .	计选择	VEL	- THE EXPERIMENTAL RESIDUAL VELUCITY (M/S)	
ц. У	医黄霉	V 5 F	- THE PARENTAL STRINING VELUCITY (M/S)	
ι i		A 1	- THE AKENICIEN TAKAET LEATE THICKNESS (CW)	
۲.	DA	TA PLO	TR / 3.141592654, 0.0174532925 /	

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 135 135 •

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10 FORMAT( A6,2F6.1,F8.3,F3.1,2F6.3,2F8.1,2F7.2)
   12 FORMAT(10A6)
      C1=0.70
      C2=0.23
      C3=U,50
  100 CONTINUE
      WRITE(6,101)
  103 FORMAT(1H1)
      WRITE(6,106)
  106 FURMAT(1H0,20X,42HSAMPLE OUTPUT FOR Z/F EQUATION PREDICTING ,
     1 16H PLATE THICKNESS / )
C
          READ CARD WHICH IDENTIFIES TARGET MATERIAL
      READ(5,12)TGT1,TGT2,TGT3
      WRITE(6,12)TGT1,TGT2,TGT3
      WRITE(6,110)
  110 FORMAT(1HO,4X,31HNR TRHO TBHN ANG MASS PDIA , 6X,2HYS,6X,
          24HVR RMASS HDIA
                                THICK > 6X>2HXT>5X>3HDEV>5X>
     1
          3HSUM, 6X, 2H5Q, 4X, 4HR. E., 5X, 3HSUM, 6X, 2HSQ )
     2
      SUM0=0.0
      SUMDSQ=0.0
      SUMRE=0.0
      SUMRES=0.0
      1CT=0
         DNE BLANK CARD USED TO SEPARATE DATA FOR DIFFERENT TARGETS
С
С
         A CARD WITH END PUNCHED IN THE FIRST THREE COLUMNS
C
         WILL TERMINATE THE PROGRAM
  150 READ (5, 10) IDN, TRHO, TEHN, THICK, ANG, PHASS, PDIA, VSP, VRE, RHASS, HDIA
      IF(TRH0.LE.C.0)G0T0 200
С
         COMPUTE PROJECTILE CROSS-SECTIONAL AREA
      AREA=PI+(PDIA/2.0)++2
C
         THE UNIT OF VELOCITY TO BE USED IS CHISEC
      VS=VSP#100.0
      VR=VRE#100.0
         COMPUTE COEFFICIENTS AND OTHER QUANTITIES
C
C
            (NOTE : 9.8E7 CONVERTS THE BRINELL MARDNESS NUMBER
Ĉ
                     FROM KG/MM##2 TO DYNE/CN##2 )
      CA=9.8E7#TBHN#C1
      CB=SQRT($.857+TBHN+TRHD)+C2
      CC=TRHO#C3
      QX=4.0+C1+C3-C2++2
      Q=QX+9.8E7+TBHN+TRHD
      00=SORT(0)
      Q1=CA+CB#V$+CC#V$#*2
      Q2=CA+CB+VR+CC+VR++2
      03=2.00CC+VS
      Q4=2.0+CC+VR
      Q5=(CUS(ANG+DTOR))++1.05
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51 52 53

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61 62

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71 72 73

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79 80

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Q9=(.S/CC+(PMASS/AREA) 95 COMPUTE THE PREDICTED TARGET PLATE THICKNESS 96 C XT=Q9+(ALDG(Q1/Q2)+2,04C8/Q0+(ATAN((Q4+C8)/Q0)-ATAM((Q3+C8)/Q0))) 97 C ACCOUNT FOR OBLIQUE ANGLE IMPACT 98 XT=XT+05 99 COMPUTE DEVIANT AND RELATIVE ERROR AND CORRESPONDING SUMMATION C 100 D=XT-THICK 101 SUMD=SUMD+D 102 SUM )SQ=SUMDSQ+D+=2 103 RFLERR=D/THICK 104 SUHRE=SUMRE+RELERR 105 SUMRES=SUMRES+RELERR##2 100 WRITE(0,155)IDN, TRHO, TBHN, ANG, PMASS, PDIA, VSP, VRE, RMASS, HDIA, 107 THICK, XT, D, SUMD, SUMDSQ, RELERR, SUMRE, SUMRES 1 106 109 1CT=1CT+1 110 GOTO 150 155 FURMAT(1H > A6,F6.2,F6.1,F5.1,F6.2,F6.3,2F8.1,2F8.1,2F7.2,8F8.3) 111 200 CT=ICT 112 CT1=1(T=1 113 + IND THE MEAN, VARIANCE AND STANDARD DEVIATION OF Ĺ 114 DEVIANTS AND RELATIVE ERRUR Ĺ 115 OPAK=SUMD/CT 116 DVAR=(SUMDSQ-DBAR+\*2+CT)/CT1 117 DSD-SQRT(DVAR) 118 - BAR=SUMRE/CT 119 FVAR=(SUMRES-EBAR##2#CT)/CT1 120 ESO=SURT(EVAR) 121 WRITE(6,210)DBAR, DVAR, DSD 122 WRILE(6,215)EBAR, EVAR, ESD 123 210 FORMATCHHO, 10X, 37HMEAN, VARIANCE AND STANDARD DEVIATION , 2%, 124 14HOF DEVIANTS = , 3F10.5 ) 125 1 215 FURMAT(1HO)10X337HMEAN, VARIANCE AND STANUARD DEVIATION ,2X. 126 THUF RELATIVE FRROR , 3F10.5) 127 PRINT NUMBER OF POINTS 6 128 WRITE(6,220)ICT 129 220 FOR 'AT(1H0,10X,18HNUMBER OF POINTS = , 15) 130 IF(IDN.EQ. 6HEND )GUTO 900 131 GHTH 100 132 201 WRITE(0,905) 133 905 FOR AT (1HO, 30X, 10HEND OF RUN ) 134 135 STIP FND 130 UATA 137 TIT GOUL ALOY .0 1.95 .127 1.0 4.48 190.0 .759 567.84 521.21 1.88 .127 • ) 1.95 4.4% 190.0 2.0 .759 1461.82 1294.18 .91 1.95 3.0 4.48 190.0 .318 . 0 .759 880.26 590.40 -10.30

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4.0	4.48	190.0	.318	•0	1.95	•759	1355.45	1083.56	1.63
5.0	4.48	190.0	.635	• )	1.95	.759	1491.08	683.36	1.73
6.0	4.48	190.0	635	.0	1.95	.759	1986.38	1127.15	.56
7.0	4.48	190.0	1.270	.0	1.95	.759	2371.65	381.61	-10.00
8.0	4.48	190.0	.127	.0	3.89	1.013	798.88	672.69	3,83
9.0	4.48	190.0	.127	.0	3.89	1.013	1032.66	957.68	1.72
10.0	4.48	190.0	.318	.0	3,89	1.013	620.27	500.79	3.83
11.0	4.48	190.0	319	່ງ	3.89	1.013	773.28	582.78	3.81
12.0	4.48	190.0	.318	.0	3.89	1.013	1499,01	1251.81	2.43
13.0	4.48	190.0	.635	.0	3.89	1.013	1505.71	774.50	3.24
14.0	4.48	190.0	.635	្ល	3.89	1.013	1526,13	979.32	
15.0	4.48	190.0	635	.0	3.89	1.013	2455,16	1367.33	- 12
16.0	4.45	190.0	1.270	.0	3.89	1.013	2551.79	1165.56	.57
17.0	4.48	190.0	.127	.0	7,78	1.267	640,99	561.44	7.72
18.0	4.48	190.0	.127	.0	7.78	1.267	959.21	874.78	7.72
19.0	4-48	190.0	318	.0	7.78	1.267	975,97	785.47	7.72
20.0	4.48	190.0	.635	.0	7.78	1.267	1484.38	994.87	-10.00
RHA									
1.0	7.78	135.0	.046	•0	1,95	.759	888,49	848.87	-10.00
2.0	7.78	135.0	.152	.0	1,95	.759	1211,58	1014.98	-10.00
3.0	7.78	300.0	.318	.0	1,95	•759	1521,26	1196.34	-10.00
4.0	7.78	305.0	.635	•0	1.95	•759	1394,46	460.25	-10.00
5.0	7.78	393.0	.152	.0	1.95	•759	609,90	367.89	-10.30
6.0	7.78	135.0	.046	.0	3.89	1.013	302,06	277.37	-10.00
7.0	7.78	135.0	.152	.0	3.89	1.013	393,50	256.03	-10+00
8.0	7.78	135.0	.318	.0	3.89	1.012	883,62	542.54	-10,00
9.0	7.78	300.0	.318	.0	3.89	1.013	879.65	583.69	-10.00
10.0	7.78	300.0	.318	.0	3.89	1.013	1466,09	1164.34	-10.00
11.0	7.78	300.0	.635	.0	3.89	1.013	1466.09	687.32	-10.30
15.0	7.78	300.0	.318	,0	7.78	1,267	909.52	690.37	-10.00
13.0	7.78	300.0	.318	. O	15,56	1.491	916,53	754.38	-10.00
14.0	7.78	300.0	.318	.0	15.56	1.491	1425,55	1179.58	-10.0?
15.0	7.78	300.0	.635	•0	15.56	1.491	1432.56	1037.84	-10.00
16.0	7.78	305.0	.635	• 0	15.56	2.491	1556.00	1109.47	-10,00
17.0	7.78	332.0	1.270	ຸ າ	15.56	1.491	1660,55	759.56	-10.00

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				522	0 15	0 <b>*</b> 0400	(1 <b>.</b> 7324		DEVIANTS	40 ∾€1	U BEVIAT	TAVUAR	11 × 4	I ANCE	WA SE	r .	
1.650	000°0-	0.058	0.480	0.005	€0°°	n.672	0.035	0 <b>°</b> 0	<b>-1</b> v.eG	F. 407	1444.4	1.2.1	7.74	<b>"</b> "	194.61	× 7 * 8	20°0
1.645	-0.564	-0.103	0.479	0.628	-0°033	C 82° J	4 <b>1</b> 5°u	n <b>,</b> 00	7.12	765.5	916.0	1.207	7.70	•	19.0.0	4.45	19.0
1.636	-0.484	-0-00	0.477	0.661	-0.001		0.127	00.0	7.72	874.5	959.2	1.267	7.75	2 <b>•</b> 2	190.0	4.4.1	18.5
1.536	-0.475	-0.076	0.477	0.662	-0.010	111°u	n.127	n 0 • 9	7.12	101.ª	0.1.0	1.201	7.78	и <b>•</b> н	140.0	C 4 . 4	17.0
1.630	860°0-	-0.037	0.477	0.072	-1.047	1.223	1.270	50 ° C	10.07	1155.9	2551.8	1.013	3.89	τ.•	141.01	4.4.3	16.9
1.626	-0°363	0.480	0.475	0.719	0.305	r.94u	1.635	9 <b>0</b> °1	1.12	156/.5	2455.2	1.015	3.49	6 <b>.</b> ,	4.141	52.5	15.0
940*1	578.0-	-0.050	0.382	0.414	-0.051	n.544	3.035	0°0'	-16°-01-	5.22	1.9941	L.015	5 <b>*</b> *?	•	140.01	4.43	14.0
1.291	-0.765	0.266	0.360	0.464	0.169	1 80 <b>4</b>	0.035	0,0°.U	41.5	C.+11	1505.7	1.013	5.5.4	7. 1	194.61	4.43	13.0
1.321	-1.929	-0.200	0.351	0.295	-0.054	6,254	オレク・ビ	ចម្លាំព	2.43	1251.4	1494.0	1.013	3.84		1 4 11 4 11	24.4	12.0
1.250	-0.529	-0.298	0.347	0.359	-0°035	0.22S	515°()	0970	3.61	581.5	775.5	1.113	5, A 4	1	14.141	а 1 1	11.0
1.192	-0.531	-0.574	0.336	434	-U.162		0.510	4°0u	3.63	4 AUC	52. S	1.013	3.49		15.0.01	A . A L	10.0
5.8.0	0.043	-0.322	0.305	0,636	-0.045	0.630	1.127	n Ú * G	1./2	451.7	1.32.7	1.113	ジオ・デ	:. :	1 • 11 • 11	~ v · v	0.0
0.759	0.365	0.173	0.303	0.677	1,022	4×1.4	n.127	0.000	3.63	072.7	194.5	1.013	5.83		4-3-1	49.3	<b>A.</b> 0
0.729	0.192	0.396	0.303	0,655	0,503	1.773	1.274	1 <b>.</b> 04	-11°-11	4.548	2371.7	4c1. 1	ς <b>, °</b> .	<b>.</b>	1 4 10 4 1	× W * 7	7.0
0.572	-0.204	0.172	050 0	0,153	0,109	R.744	11 <b>03</b> 3	9•ûn	0 <b>.</b> 56	112/ 2	1445.	5-2-1	1.95	н. -	196.00	444	6.0
0.543	-0.376	0,262	0,036	0.043	0.166	1.49G	1.535	11 <b>.</b> 14	1.73	553.A	1.021	94Z * 1	1,92	11 <b>•</b> 11	0.0051	~ <b>~ ~ ~</b>	6.d
0.474	-0.638	-0.175	0.010	-0.123	-0.056	0.252	115.0	1 <b>1</b> ti 11	1.03	1050.0	1.555.4	écl.	۲. ۲			د <b>و</b> م	
0.444	-0.462	-0,044	00000	-0.067	<b>-</b> 0.014	1, 394	1.319	110 <b>°</b> 11	•1·••1-	4.040	H 313 . T	¥4.1 **	Co.1		11-1-51	- 4 - 4	3.5
0.442	-0.419	0,211	0.007	-0,053	0.027	11 <b>1</b> 1 1 4	10.177	4° • 0 11	5.41	1,44.7	8.1251	225.01	65.1	-	1	~ * * * *	2°-1
0.397	-0.630	-0.630	0.006	-0.050	-0.980	4,047	n.127	10°	1.49	5.142	547 <b>.</b> 5	**/**	1.45		5. • Jul	C 7 • F	د -
05	# <b>N</b> #	R.E.	38	=ns	130	L X	THICK	Hela	いうくいて	ť	5.	م¦⊿	· • • •	<u>11</u> •∎	1		J.

0.04608 U.29340 MEAL, VANJARCE AVIN STARUARD PEVLATION OF RELATIVE ERROR -0.02651

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SA PLE PUTPUT FOR 716 FORTLY PERMITTED PLATE INTURESS

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	,			. 900	1 0.07	0.0049	18460.0		ION OF SEVIANTS	L NEVIAL	TANCE AND STANDAR	VEAN, VAN	
	+9 <b>•</b> •	-0.189	0.201	-1.442	-0-241	1.029	1.270	00.0	759.6 -1A.UU	1060.5	e.º 15.56 1.491	7.78 332.4	17.0
108.1		200°0-	<b>btte</b>	-1.201	-0.129	0.500	0.000	00.0	1109.51 - 10.001	1950.0	194.15.56 1.441	7.78 345.0	16.0
1	-3,661	4×2°0-	0.126	-1.072	-0.171	0.454	0.035	0000	1037 <b>.8 -1</b> 0,00	1432.6	194.15.56 1.491	1.78 300.0	0.51
5 × 1 7 8	-1.542	-0.119	0.00	-0 <b>~0</b> 2	-0-035	0.283	9.618	0.00	1179.6 -10.UO	1425.h	1,0 15,55 1,491	7.78 300.0	14.0
1.165	-1.262	-0.444	0.096	-0.567	-0.106	0,212	9 <b>10</b> .1	0 <b>•</b> 0≎	754.4 -10.00	916.5	n.v 15.56 1.491	7.75 JUN.0	13.0
1.054	-2,948	-0.375	0.065	-0.760	-0,119	0.199	0.318	0°°n	696°4 -10°60	606	U. U. 7.76 1.267	1.76 3UD.0	12,0
0.914		5.8°2 885	0.071	-0.941	-0.117	0.518	0.035	0°°	68/.5 -10.00	1466.1	1°4 3.89 1.013	7.78 3un.	11.0
	-2,300.	-0.411	0°057	-0.524	-0.131	0.16/	915.0	00.0	1164.3 -10.01	1466.1	0.0 3.89 1.013	/ "78 3UU n	10.0
0.710	-1°077	955°0-	0,040	10 C - 0 C	-0.108	0.216	112.0	00 • 0	5×3.7 -10.00	679.b	U." 3.89 1.013	7.78 30P.D	ð.0
566.0		0.472	0.028	-0,255	0.023	9.341	0.318	0.00	542°5 -19.00	843 <b>.</b> 6	U. D 3,84 1.015	7.0 155.0	с <b>•</b> 9
965"9	-1.710	~0 <b>.107</b>	0.027	-0.308	-0.016	0.130	0.152	00°n	256.4 -19.49	393.5	0.0 5.59 1.015	1.74 135.1	7.9
0.570	-1.602	-0,486	0.027	-0.292	-0.022	0.024	0.045	ù0°⊓	277.4 -1n.nn	562.1	0.01 3.84 1.015	7.73 135.0	¢.0
9,240	-1.118	-0.216	0.027	-0,269	-0.033	6.119	9,152	00•0	0A*91- 5*/48	9.994	1.95 U.95 U.75 U	1.70 343.F	<b>2°</b> 0
0.293	-0.99	-0.117	0.026	-0.237	-0.074	r,561	0.035	0.00.0	460.4 -10.00	d.4951	0.6 1.95 U.759	/.78 305.0	••
0.279	00°P81	544.0-	0.020	-0.162	-0.141	0.177	9.315	9 <b>0</b> °0	1195.5 -10.00	1521.3	847 ** 35 ** 758	7.74 300.0	0°0
0.094	<b>675°0-</b>	-0.055	0000 0	-0.021	801.0-	5.144	9.152	00.00	04°01- 0°4161	1211.6	edf. 1.95 0.759	7.7× 135.P	د <b>د</b>
0.061	-0.284	-0.284	C00°n	-0.013	-0.013	1, <b>033</b>	940.0	ն • ուլ	11°1]- A°494	C.885	U.0 1.95759	7.73 155.n	1.0
<u>.</u>	N Dig	R.E.	3	¥ 3 9	DEV	× I	1-104	- in	53417 17	۲S א			a ř

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0.15010 0.02253 HÉAN, VAMIANCE AND STANDARU DEVIAIION DF KELATIVE EVROP =0.23842

17 WITH THE POINTS . EVE OF RUN

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С				1
C C				2
čΟ	MM	ROGRA	M USING THE THOR EQUATION TO PREDICT PLATE THICKNESS	4
c C		JLUSSA	RY OF VARIABLES	5
C				7
C C	***	Ţ	DENTIFIES PEOLINGED INDUT DATA	8
č	*	Ī	DENTIFIES INPUT DATA WHICH IS NOT REQUIRED	10
Ç				ĨĨ
C C	×**	NG.	- THE ANGLE OF THE TADGET BLATE WITH BECORAT TO	12
č			LINE OF FLIGHT - OBLIQUITY (DEGREES)	14
C		NRA	- THE PROJECTED CROSS-SECTIONAL AREA OF PROJECTILE	15
C			ON IMPACT	16
C C		1) 1) II (1) II	- THE DEVIANT = COMPUTED VALUE MINUS EXPERIMENTAL VALUE	17
c		050	- THE C ANDARD DEVIATION OF THE DEVIANIS	10
č		DINR	- CON' JON FACTOR - DEGREES TO RADIANS	20
Ċ		OVAR	- THE LANCE OF THE DEVIANTS	21
С		<u>~1</u>	- CONST NT BASED ON LEAST SQUARE FIT TO DATA	žž
С		C2	- CONSTANT BASED ON LEAST SQUARE FIT TO DAYA	23
Ç		3	- CONSTANT BASED ON LEAST SQUARE FIT TO DATA	24
C		<sup>6</sup> 4	- CONSTANT BASED ON LEAST SQUARE FIT TO DATA	25
C		5	- CONSTANT BASED ON LEAST SQUARE FIT TO DATA	26
Ĉ		+ BAR	- THE AVERAGE (MEAN) VALUE OF THE RELATIVE ERROR	27
Ç		L S ()	- THE STANDARD DEVIATION OF THE RELATIVE ERROR	28
۲ ۲	ىد		- THE VARIANCE OF THE RELATIVE ERROR	29
ĉ	*		- THE DIAMETER OF THE HULE HAVE IN THE TARGET (CM)	30
ĉ	*	101	- INUER IN CUUNT NUMBER OF DATA CARDS FUR UNE TARGET - AN INCENTRETEATION NUMBER OF SYNDID DECISIATES SUDT NO	31
č	***	PDIA	- DIAMETER OF THE PROJECTIVE (CM)	36
č	***	THASS	- MASS OF PROJECTILE (GRANS)	34
Ċ		RELERR	- THE RELATIVE ERROR OF COMPUTED VS. EXPERIMENTAL	35
C	*	KMASS.	- THE RECOVERED PROJECTILE MASS (GRAMS)	36
¢		SUMD	- THE SUM OF THE DEVIANTS	37
С		SUHDSQ	- THE SUM OF THE DEVIANT SQUARED	38
C		SUHRE	- THE SUM OF THE RELATIVE ERROR	39
Ç	•	SUMRES	- THE SUM OF THE RELATIVE ERROR SQUARED	40
C	*	LBHN	- THE TANGET BRINELL HANDNESS NUMBER (KG/SQ MM)	41
L r	يە بە	TAUCK	- THE THICKNESS OF THE TARGET PLATE (CM)	42
c c	平 ★ 放 ★		THE UCHOINT UP THE TANGET PLAFE (6/00)	43
č	***	VSP	- THE EXPEDIMENTAL RESIDUAL VELOCITY (M/S) - THE EXPEDIMENTAL STOLKING VELOCITY (M/S)	44
č		XT	THE DREDYCTED TARGET PLATE THICKNESS (CM)	43
ć		•	the file.Tailo indone imple nitoured four	47
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DATA PI, DTOR / 3.141592654, 0.0174532925 /
   10 FORMAT( 46,2F6.1,F8.3,F5.1,2F6.3,2F6.1,2F7.2)
   11 FORMAT(5F10.3)
   12 FORMAT(10A6)
   20 FORMAT(1H0,10X,13HEXPONENTS ARE , 5F10.3 / )
  100 CUNTINUE
      WRITE(6,103)
  103.FURMAT(1H1)
      WRITE(6,106)
  106 FURMAT(1H0,20X,42HSAMPLE OUTPUT FOR THOR EQUATION PREDICTING .
     1 16H PLATE THICKNESS / )
          READ CARD WHICH IDENTIFIES TARGET MATERIAL
C
      READ(5,12)TGT1,TGT2,TGT3
      WRIFE(6,12)TGT1,TGT2,TGT3
      READ(5,11)E1,E2,E3,E4,E5
      WRITE(6,20)E1,E2,E3,E4,E5
      WRI)E(6,110)
  110 FORMAT(1H0,4X,31HNR TRHO TOHN ANG MASS PDIA , 6X/2HVS,6X)
          2444VR RMASS HDIA THICK , 6X, 2HXT, 5X, 3HDEV, 5X,
     1
          3HSUM26X,2HSQ,4X,4HR.E.,5X,3HSUM26X,2HSQ )
     2
      SUMD=0.0
      SUM-1SQ=0.0
      SJMRE=0.0
      SUMRES=0.0
      101=0
         UNE BLANK CARD USED TO SEPARATE DATA FOR DIFFERENT TARGETS.
Ċ
         A CARD WITH END PUNCHED IN THE FIRST THREE COLUMNS
С
         WILL TERMINATE THE PROGRAM
Ĺ.
  150 REAU(5,10)IDN, TRHU, TBHN, THICK, ANG, PMASS, PDIA, VSP, VRE, RMASS, HDIA
      IF(TRHD.LE.0.0)GDT0 200
         - ONPUTE PROJECTILE CROSS-SECTIONAL AREA
L
      AREA=PI*(PDIA/2.0)**2
         THE UNIT OF VELUCITY TO BE USED IS CHISEC
C
      VS=VSP#100.0
      VR=VR-*100.0
      Q1=10.0**E1
      QJ=PMASS+*E3
      Q4=(1.0/COS(ANG+DTOR))++E4
      05=VS**E5
         UDMPUTE THE PREDICTED TARGET PLATE THICKNESS
C.
      XT=((\S-VR)/(Q1+Q3+Q4+Q5))++(1.0/E2)/AREA
         COMPUTE DEVIANT AND RELATIVE ERROR AND CORRESPONDING SUMMATION
Ċ
      U=XT=THICK
      SUMD=SUMD+D
      SUMDSG=SUMDSQ+D++2
      RELERR=D/THICK
      SUMRE=SUMRE+RELERR
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		SUMRE	S=SU	MRES	+RELE	RR##	2					
		WRITE	(6,1	55)1	DNATR	HO, TI	Внνи	ANGP	MASSI	DIA, VSP,	VRE,RMASS,	HDIA
	1	L TI	ICK	2XT3	D . SÚM	DISU	HDSG	A-RELE	RR>SU	ARE, SUMRE	5	
		ICT=I	CT+1		•	-						
		GUTO	150									
	155	FORMA	7(1H	JA6	F6.2	> F6 .:	1, F5	5.1,F6	.2. F6.	3,288.1,	2F7.2,8F8.	3)
	200	CT=1C	T		• -					•		-
		CT1=1	CT-1									
Ċ		r II	ND T	HE M	EAN, V	ARIA	NCE	AND S	TANDAR	RD DEVIAT	TON DF	
C		0 E Y	VIAN	TS A	ND RE	LATI	VEE	RRIOR				
		DHAR=	SUMD	/CT			•					
		DVAR=	(SUM	DSQ-I	DBAR+	*2*C	1)/(1	11				
		050=50	QRT(	DVAR	)							
		EBAR	SUMR	E/CT								
		EVAR=	(SUM	RES-	EBAR#	*2#C	r)/(	CT1				
		ESD=S(	QRT(	EVAR	)							
		WRITE	(6,2	10)01	BAR,D	VARFI	0.5.0					
		WRITE	(6)2	15)EI	BAR, E	VARJ	ESD					
	210	FURMA	1(14	0,10	X=37H	MEAN	, VA	ARIANC	E AND	STANDARD	DEVIATION	,2X,
	1	141	-IOF	DEVI	ANTS	÷,	3F1	10.5)				
	215	FORMA	T(1H)	0,10	X > 37H	MEAN,	<b>,</b> v <sup>1</sup>	ARIANC	E AND	STANDARD	DEVIATION	,2X,
	1	י 17י	10 5	RELA	TIVE	ERROI	۲,	3F10.	5)			
С		PR	INTI	NUMBI	ER NF	POl	NTS					
		WRITE	(6)2	20)1(	C T							
	SJC.	FUR 'A'	( <b>1</b> H)	0,10	¥•18H	NUMBI	ER i	)E 601	NTS =	ə (5)		
		F. (ID)	N.EQ	• 6HI	END	) (1).	rn S	900				
		COLO	100									
	907	WRITE	(629)	05)		• .	_					
	305	FURIA	( <b>T</b> H	0,30	Ки 10н	END (	JE 4	SUN )				
		SIDY										
		END										
¥.	-	961A 										
		.99 YU	.UY			1						
	. 4.	.938 	1	•10,	-	1.07	```	1 • 5	07 754	0.107		
	• • •	· · · · · · · · · · · · · · · · · · ·	: 10		• •	24	• •	1.73	• ()1	1441 00	721.24	1+28
		· · · · ·	1 1 2		• 1	10	- 2	1.08	+/21 760	1401.02 000 m	1274+10 800 (0	• 7
		· • • • • •	, <u>,</u> ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		•••	10 10	• %	1.73	9721	- 00V⊕20 5 1365 /s	5 370,40 -	10+10
		· · · · · ·	. 10		.,	A K	- 5	1 95	.750	1/61 /0	493.34	1.71
	6.0	· · · · ·	190	0.0	.0	35	•	1.94	.750	1986.20		4+73 .4A
		4.45	1 1 9	0.0	1 2	10	ò	1.95	.756	2371.65	381.61 -	10.01
	5	4.4	19	0.0	1	27	.ŏ	3.89	1.011	798.88	672.69	3.83
		4.4	. 12	0.0	1	27	lo	3.89	1.01	1032.66	957.68	1.72
	17.7	) 4.4	19	0.0		18	.ŏ	3.89	1.013	420.27	500.79	3.83
	11.0	4.4	19	0.0		18	Ĵ	3.89	1.013	773.28	582.78	3.51
	12.0	4.4.	190	0.0	. 3	18	.0	3.89	1.013	1499.01	1251.81	2.43
	13.0	4.48	19	0.0	. 6	35	Ō	3.89	1.013	1505.71	774.50	3.24

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14.0	4.48	190.0	.635	. 0	3.89	1.013	1526.13	979.32	-10.20
15.0	4.48	190.0	635	Ĩ	3.49	1.011	2455.16	1167.33	.12
16 0	4 4 9	190 0	1 276	• ~	2 89	1.011	2551 70	1145.84	
17 6	4.4.	100.0	1.27	• •	7 78	1.347	640 00	841.44	7.72
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18.0	4.48	140.0	+147	• •	1.10	1.201	927.21		1 . 12
19.0	4.48	190.0	.316	•0	7.78	1.207	975.97	752.47	7.72
\$J•0	4.48	190.0	.635	.0	7.78	1.267	1484,38	994.87	-10.00
RHA									
5.6	90	0.889	0.94	45	0.9	89	0.019		
1.0	7.78	135.0	.045	.0	1,95	.759	888.49	848.87	-10,00
2.0	7.78	135.0	152	.0	1.95	.759	1211.58	1014.98	-10.00
3.0	7.75	300.0	318	.0	1.95	.759	1521.26	1196.34	-10.00
4.0	7.78	305.0	.635	Ĩ	1.95	.759	1394.46	460.25	-10.00
5.0	7.78	393.0	152	. õ	1.95	.759	609.90	367.89	-10.30
6.0	7.78	135.0	046	10	3.89	1.013	302.06	277.37	+10.00
7.1	7 74	135 0	152	•	1 40	1.011	393.50	256.03	-10.00
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12.0	7.78	300.0	.318	•0	7.78	1.267	909.52	690.37	-10.00
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14.0	7.79	300.0	.318	. ?	15.56	1.491	1425.55	1179.58	-10.0)
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-0.228 P.	0.177	0.155	U.299	0.113	5 <b>7 4</b> 8	1.e35		3.24	174.5	1,4941	4 3.416	¥.,	•	1°11 - 2°
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LIST OF SYMBOLS Projectile cross-sectional area at impact (cm<sup>2</sup>) Acceleration Projectile shape factor Empirical constants (i = 1, 2 and 3) °i Resistive force Brinell hardness of target plate (dynes/cm<sup>2</sup> F Ht A coefficient =  $C_1 H_t$ K<sub>1</sub> A coefficient =  $C_2 \sqrt{\rho_t H_t}$ K<sub>2</sub> A coefficient =  $C_3 \rho_t$ K<sub>3</sub> Mass T. Projectile mass (grams) A discriminant - 4  $K_1 K_3 - K_2^2$ <sup>m</sup>p Time to penetrate to depth x (sec) q т<sub>х</sub> Time t Velocity V Residual velocity (cm/sec) v<sub>r</sub> Striking velocity (cm/sec) ۷<sub>s</sub> Distance into the target measured from impact surface Velocity at depth x V<sub>x</sub> x Target plate thickness (cm) Density of target plate (g/cc) Xt Pt

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