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MEMORANDUM REPORT NO. 1167

SEPTEMBER 1958

A DRAG COEFFICIENT, K_D, BASED ON THE 155MM SHELL, HE, M101

CHARLES T. ODOM

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BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

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ABERDEEN PROVING GROUND, MARYLAND

B A L L I S T I C R E S E A R C H L A B O R A T O R I E S

MEMORANDUM REPORT NO. 1167

CTOdom/wec
Aberdeen Proving Ground, Md.
September 1958

A DRAG COEFFICIENT, K_D, BASED ON THE 155MM SHELL, HE, M101

ABSTRACT

Firing tables for the 155mm howitzer are being revised to reflect the latest changes in table format and in the process will incorporate the most recent information on performance and drag characteristics of the M107 shell. Drag coefficients, K_D, obtained from transonic range measurements of the M101 shell, identical to the M107 shell except for its wider rotating band, were fitted with a series of polynomials. The fitting expressions and a tabulation of the drag coefficients at small intervals of Mach Number are given in this report.

INTRODUCTION

Firing Tables for the 155mm Howitzer are being revised to reflect the latest changes in the format of artillery firing tables. In the process of revising existing firing tables the practice in BRL has been to incorporate into the revision the latest and best information available on the shell. More recently active efforts have been made to employ in the ballistic computations of any firing table the drag function of the particular shell in question.

There were available from transonic range firings, measurements of the zero yaw drag coefficient of the 155mm Shell, HE, M101. The M101 shell is the standard HE shell for the 155mm gun and except for its wider rotating band, which has a small effect on the drag of the projectile, it is otherwise identical to the M107 shell which is the standard HE shell for the 155mm howitzer.

The transonic range measurements were fitted with a series of polynomials and used in ballistic reductions of M107 shell range firing data. The first time through, the reduction results indicated that some adjustment of the drag coefficients in the subsonic region of velocities was desirable if the ideal goal of a constant ballistic coefficient was to be approached. After the adjustment reductions were again performed, the variation of ballistic coefficient with muzzle velocity was reduced to an acceptable level. The ballistic coefficient was still not a constant but the variation was minimized.

Following are the fitting expressions for the M101 shell drag coefficient. Adjacent expressions were required to give the same value of K_D and its first derivative at the juncture points.

In the Interval	K_D is given by
$0.0 \leq M \leq 0.90$	0.0579080038
$0.90 \leq M \leq 0.96$	$44.26302428 - 138.8317032M + 144.7922431M^2 - 50.12112525M^3$
$0.96 \leq M \leq 1.02$	$414.3525910 - 1262.4596067M + 1280.9650680M^2 - 432.7252631M^3$
$1.02 \leq M \leq 1.22$	$-0.4212674799 + 1.029831902M - 0.4621525076M^2$
$1.22 \leq M \leq 1.3$	$8.911875950 - 20.35167306M + 15.77773047M^2 - 4.085776562M^3$
$1.3 \leq M \leq 2.6$	$\dfrac{(0.9415 + 0.1327M)^2 - 1}{M^2}$

The form factors and ballistic coefficients of the M107 shell with respect to the above drag functions are as follows.

Charge	M. V. f/s	i, form factor	c, ballistic coefficient
1	680	0.9853	2 589
2	770	0.9853	2 589
3	880	0.9853	2.589
4	1020	1.0150	2.513
5	1220	$1.03125-0.000051382\phi$	$2.47379+0.000130806\phi$
6	1520	$1.01293-0.000034844\phi$	$2.51854+0.000090216\phi$
7	1850	$0.99462-0.000018306\phi$	$2.56490+0.000048226\phi$

The above c's are for a standard shell weight of 95 pounds, ϕ is the angle of departure in mils and does not exceed 1155.6 mils. The relation between ballistic coefficient, c, and form factor, i, is given by the expression,

$c = \frac{m}{id^2}$, where m is the weight of the shell in pounds and d is the diameter of the shell in inches. The form factor, i, is defined as the ratio between the actual K_D of the shell and the K_D of the reference drag function used in the ballistic reductions.

Figure 1 is a drawing of the M101 shell, Figure 2 is plot of the drag coefficients which are also shown numerically in the table which follows.

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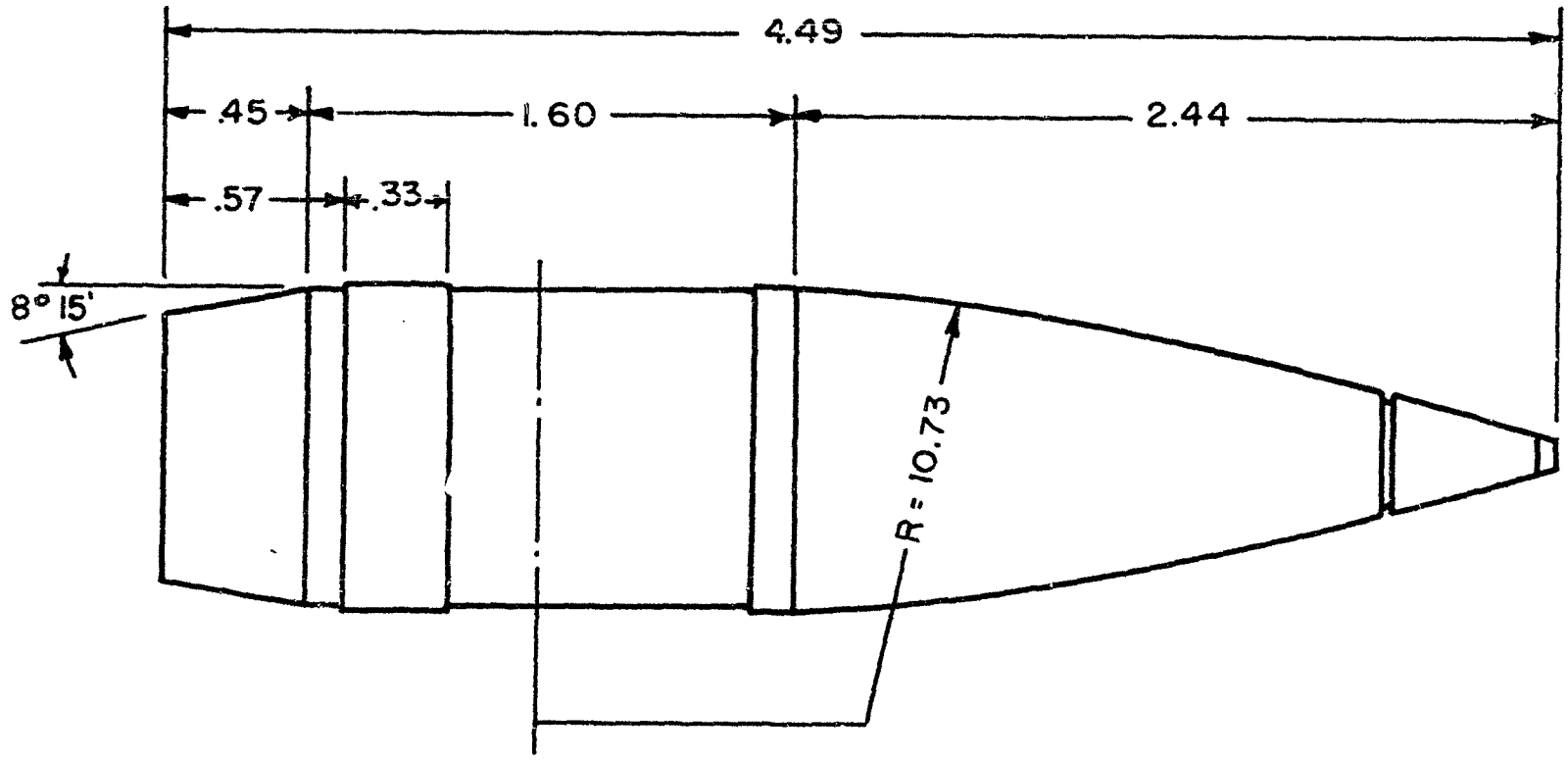

NOTE : ALL DIMENSIONS ARE IN CALIBERS

FIG. 1 SHELL, 155MM, HE, M101 WITH FUZE, PD, M51A5

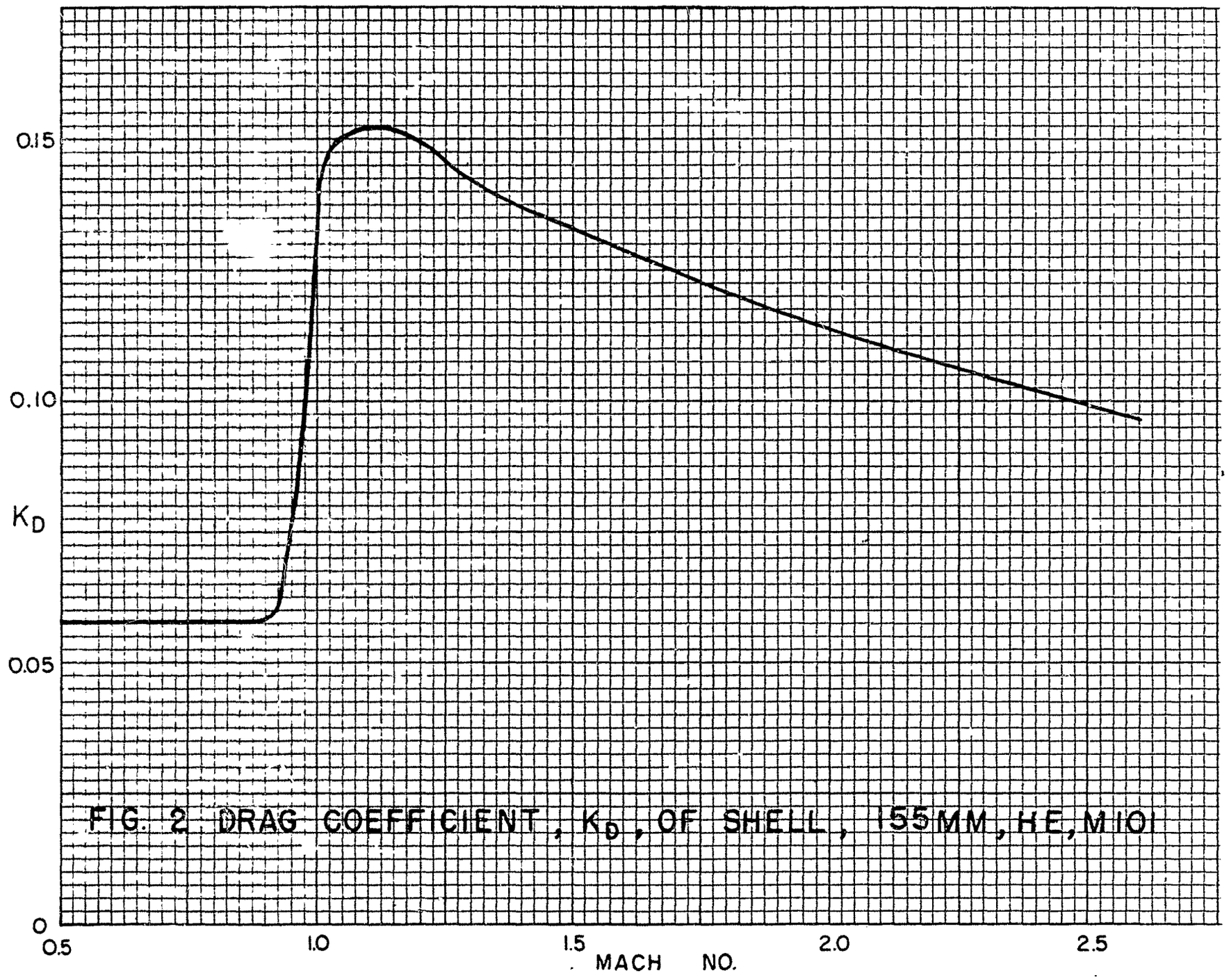

FIG. 2 DRAG COEFFICIENT, K_D, OF SHELL, 155MM, HE, M101

TABLE OF THE DRAG COEFFICIENT, K_D,
BASED ON THE 155MM SHELL, HE, M101

DRAG COEFFICIENT

M	K_D	M	K_D	M	K_D	M	K_D
2.600	.096913	2.200	.107722	1.800	.121373	1.400	.138143
2.590	.097154	2.190	.108026	1.790	.121756	1.390	.138590
2.580	.097397	2.180	.108331	1.780	.122141	1.380	.139038
2.570	.097641	2.170	.108639	1.770	.122528	1.370	.139486
2.560	.097886	2.160	.108948	1.760	.122917	1.360	.139934
2.550	.098133	2.150	.109259	1.750	.123308	1.350	.140381
2.540	.098380	2.140	.109572	1.740	.123701	1.340	.140829
2.530	.098630	2.130	.109887	1.730	.124096	1.330	.141276
2.520	.098881	2.120	.110203	1.720	.124493	1.320	.141723
2.510	.099133	2.110	.110522	1.710	.124893	1.310	.142169
2.500	.099386	2.100	.110842	1.700	.125294	1.300	.142614
2.490	.099642	2.090	.111165	1.690	.125697	1.290	.143047
2.480	.099898	2.080	.111489	1.680	.126102	1.280	.143474
2.470	.100156	2.070	.111815	1.670	.126510	1.270	.143917
2.460	.100416	2.060	.112143	1.660	.126919	1.260	.144403
2.450	.100677	2.050	.112473	1.650	.127330	1.250	.144956
2.440	.100940	2.040	.112805	1.640	.127743	1.240	.145600
2.430	.101204	2.030	.113139	1.630	.128158	1.230	.146360
2.420	.101469	2.020	.113474	1.620	.128575	1.220	.147260
2.410	.101736	2.010	.113812	1.610	.128994	1.210	.148192
2.400	.102005	2.000	.114152	1.600	.129414	1.200	.149031
2.390	.102275	1.990	.114494	1.590	.129837	1.199	.149110
2.380	.102547	1.980	.114837	1.580	.130261	1.198	.149188
2.370	.102821	1.970	.115183	1.570	.130687	1.197	.149265
2.360	.103096	1.960	.115531	1.560	.131114	1.196	.149341
2.350	.103372	1.950	.115881	1.550	.131544	1.195	.149416
2.340	.103651	1.940	.116232	1.540	.131974	1.194	.149491
2.330	.103930	1.930	.116586	1.530	.132407	1.193	.149564
2.320	.104212	1.920	.116942	1.520	.132841	1.192	.149636
2.310	.104495	1.910	.117300	1.510	.133276	1.191	.149708
2.300	.104780	1.900	.117660	1.500	.133713	1.190	.149778
2.290	.105066	1.890	.118022	1.490	.134151	1.189	.149848
2.280	.105355	1.880	.118386	1.480	.134591	1.188	.149917
2.270	.105644	1.870	.118752	1.470	.135031	1.187	.149984
2.260	.105936	1.860	.119120	1.460	.135473	1.186	.150051
2.250	.106229	1.850	.119491	1.450	.135916	1.185	.150117
2.240	.106524	1.840	.119863	1.440	.136360	1.184	.150182
2.230	.106821	1.830	.120238	1.430	.136804	1.183	.150246
2.220	.107120	1.820	.120614	1.420	.137250	1.182	.150309
2.210	.107420	1.810	.120993	1.410	.137696	1.181	.150372
2.200	.107722	1.800	.121373	1.400	.138143	1.180	.150433

DRAG COEFFICIENT

M	K_D	M	K_D	M	K_D	M	K_D
1.180	.150433	1.140	.152127	1.100	.152343	1.060	.151080
1.179	.150493	1.139	.152151	1.099	.152330	1.059	.151029
1.178	.150553	1.138	.152173	1.098	.152315	1.058	.150978
1.177	.150611	1.137	.152195	1.097	.152300	1.057	.150925
1.176	.150669	1.136	.152216	1.096	.152283	1.056	.150872
1.175	.150726	1.135	.152235	1.095	.152266	1.055	.150818
1.174	.150781	1.134	.152254	1.094	.152248	1.054	.150762
1.173	.150836	1.133	.152272	1.093	.152229	1.053	.150707
1.172	.150890	1.132	.152289	1.092	.152209	1.052	.150650
1.171	.150943	1.131	.152305	1.091	.152188	1.051	.150592
1.170	.150995	1.130	.152320	1.090	.152166	1.050	.150533
1.169	.151046	1.129	.152334	1.089	.152143	1.049	.150473
1.168	.151097	1.128	.152347	1.088	.152119	1.048	.150412
1.167	.151146	1.127	.152360	1.087	.152095	1.047	.150351
1.166	.151194	1.126	.152371	1.086	.152069	1.046	.150288
1.165	.151242	1.125	.152382	1.085	.152043	1.045	.150225
1.164	.151288	1.124	.152391	1.084	.152015	1.044	.150160
1.163	.151334	1.123	.152400	1.083	.151987	1.043	.150095
1.162	.151379	1.122	.152408	1.082	.151958	1.042	.150029
1.161	.151422	1.121	.152414	1.081	.151927	1.041	.149962
1.160	.151465	1.120	.152420	1.080	.151896	1.040	.149894
1.159	.151507	1.119	.152425	1.079	.151864	1.039	.149825
1.158	.151548	1.118	.152429	1.078	.151831	1.038	.149755
1.157	.151588	1.117	.152432	1.077	.151797	1.037	.149684
1.156	.151627	1.116	.152434	1.076	.151763	1.036	.149612
1.155	.151665	1.115	.152436	1.075	.151727	1.035	.149539
1.154	.151703	1.114	.152436	1.074	.151690	1.034	.149466
1.153	.151739	1.113	.152435	1.073	.151653	1.033	.149391
1.152	.151774	1.112	.152434	1.072	.151614	1.032	.149316
1.151	.151809	1.111	.152431	1.071	.151575	1.031	.149239
1.150	.151843	1.110	.152428	1.070	.151534	1.030	.149162
1.149	.151875	1.109	.152424	1.069	.151493	1.029	.149084
1.148	.151907	1.108	.152418	1.068	.151451	1.028	.149004
1.147	.151938	1.107	.152412	1.067	.151408	1.027	.148924
1.146	.151968	1.106	.152405	1.066	.151364	1.026	.148843
1.145	.151997	1.105	.152397	1.065	.151319	1.025	.148761
1.144	.152025	1.104	.152388	1.064	.151273	1.024	.148678
1.143	.152052	1.103	.152378	1.063	.151226	1.023	.148595
1.142	.152078	1.102	.152367	1.062	.151178	1.022	.148510
1.141	.152103	1.101	.152356	1.061	.151129	1.021	.148424
1.140	.152127	1.100	.152343	1.060	.151080	1.020	.148338

DRAG COEFFICIENT

M	K_D	M	K_D	M	K_D	M	K_D
1.020	.148338	.980	.103472	.940	.069845	.900	.057788
1.019	.148208	.979	.102017	.939	.069331	.899	.057908
1.018	.147995	.978	.100583	.938	.068825	.	.
1.017	.147700	.977	.099171	.937	.068327	.	.
1.016	.147327	.976	.097784	.936	.067836	.	.
1.015	.146877	.975	.096425	.935	.067354	.001	.057908
1.014	.146355	.974	.095097	.934	.066880	.000	.057908
1.013	.145762	.973	.093802	.933	.066414		
1.012	.145100	.972	.092542	.932	.065958		
1.011	.144373	.971	.091321	.931	.065511		
1.010	.143583	.970	.090141	.930	.065073		
1.009	.142732	.969	.089004	.929	.064646		
1.008	.141824	.968	.087913	.928	.064228		
1.007	.140861	.967	.086871	.927	.063822		
1.006	.139845	.966	.085880	.926	.063426		
1.005	.138779	.965	.084943	.925	.063041		
1.004	.137665	.964	.084063	.924	.062667		
1.003	.136507	.963	.083241	.923	.062305		
1.002	.135306	.962	.082481	.922	.061955		
1.001	.134066	.961	.081786	.921	.061618		
1.000	.132789	.960	.081157	.920	.061293		
.999	.131478	.959	.080563	.919	.060981		
.998	.130134	.958	.079970	.918	.060682		
.997	.128762	.957	.079378	.917	.060397		
.996	.127363	.956	.078789	.916	.060126		
.995	.125939	.955	.078201	.915	.059868		
.994	.124495	.954	.077616	.914	.059626		
.993	.123031	.953	.077034	.913	.059397		
.992	.121551	.952	.076454	.912	.059184		
.991	.120058	.951	.075878	.911	.058987		
.990	.118553	.950	.075306	.910	.058804		
.989	.117041	.949	.074737	.909	.058638		
.988	.115522	.948	.074173	.908	.058488		
.987	.114000	.947	.073613	.907	.058355		
.986	.112477	.946	.073058	.906	.058238		
.985	.110956	.945	.072508	.905	.058138		
.984	.109440	.944	.071963	.904	.058056		
.983	.107931	.943	.071424	.903	.057992		
.982	.106431	.942	.070891	.902	.057945		
.981	.104944	.941	.070365	.901	.057917		
.980	.103472	.940	.069845	.900	.057908		