

## **PROGRAM IBMortar – SHORT DESCRIPTION**

### **Purpose**

1. Calculation of burning of grains in barrel.
2. Calculation of velocity, acceleration and traveling path of projectile in barrel of mortar.
3. Calculation of pressure and temperature of gases in barrel .

### **Description**

Program numerically solves (integrates) two degree of freedom equations of motion of a projectile for mortar barrel and one equation of burning powder grain for given characteristics of projectile, barrel and grain, and initial conditions. Program is written in MatLab, organized in modular way, so that it can be easily extended.

### **Assumptions and Limitations**

Main assumptions and limitations of the program are:

- The grain is burning in parallel surfaces without erosion.
- Powder is burning under the mean pressure in the barrel.
- Burning velocity is proportional to the pressure.
- The gas flow through clearance is proportional to the pressure impulse and relative burned web.

### **Input Data**

Input data are supplied through one input file or through interactive graphical interface which gives high working flexibility. Structure of input data are fixed, but format number is free. Input data are organized into following groups:

- System information,
- Projectile characteristics,
- Launcher characteristics
- Grain characteristics,
- Simulation data.

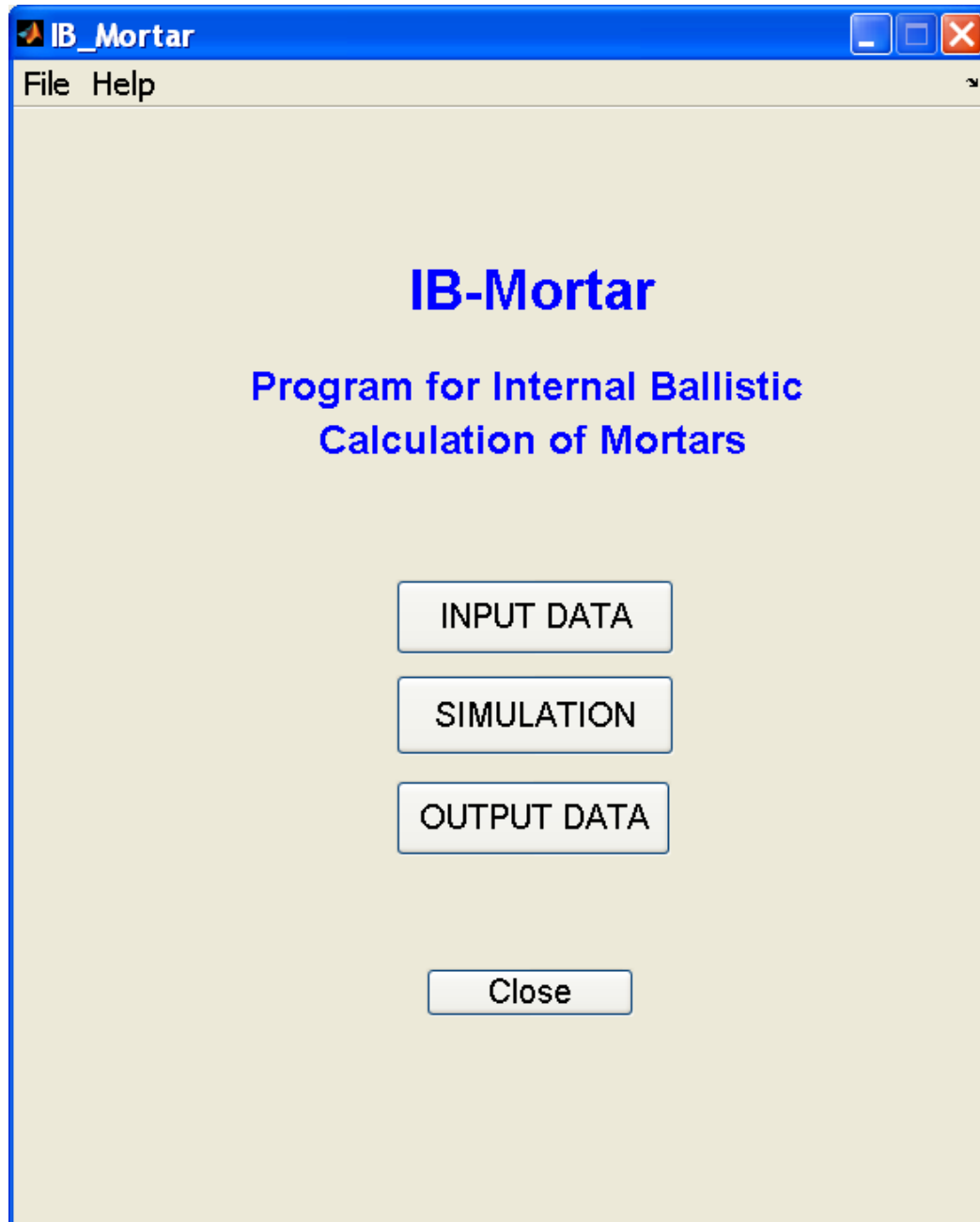
**Output:** Output results are printed in output file and diagrams

**Origin:** Own development based on published literature and own experience.

**Machine:** Personal computer with operating system: Windows XP, Windows Vista.

**Program language:** MATALAB version 6.5 and greater.

**Contents of package:** source code, short theoretical manual, user manual and two examples: mortar 82mm and mortar 120mm.



Input\_Data

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**System Information**

Weapon

Job information

Input data file

**Projectile Characteristics**

Caliber, [m]

Reference area, [m<sup>2</sup>]

Effective proj. cross sec. area, [m<sup>2</sup>]

Initial mass, [kg]

**Launcher Characteristics**

Area of barrel cross section, [m]

Barrel length, [m]

Projectile guidance length, [m]

Length of burning chamber, [m]

Leakage coefficient, [-]

Friction coefficient, [-]

Barrel inclination, [deg]

**Grain Characteristics**

Mass of primer charge, [kg]

Mass of incremental charge, [kg]

Number of incremental charges, [-]

Initial combustion volume, [m<sup>3</sup>]

Powder density, [kg/m<sup>3</sup>]

Powder force, [kJ/kg]

Covolume, [m<sup>3</sup>/kg]

Burning velocity at norm. cond., [m/s]

Burning temperature, [K]

Gas constant, [kJ/(kgK)]

Ratio of specific heat coefficient, [-]

Powder grain semiweb, [m]

Kappa, [-]

Lambda, [-]

Mu, [-]

**Simulation** [min] [max] [close]

Integration Method

- Euler
- Runge-Kutta 4th order

Time Steps

Integration step, [s]

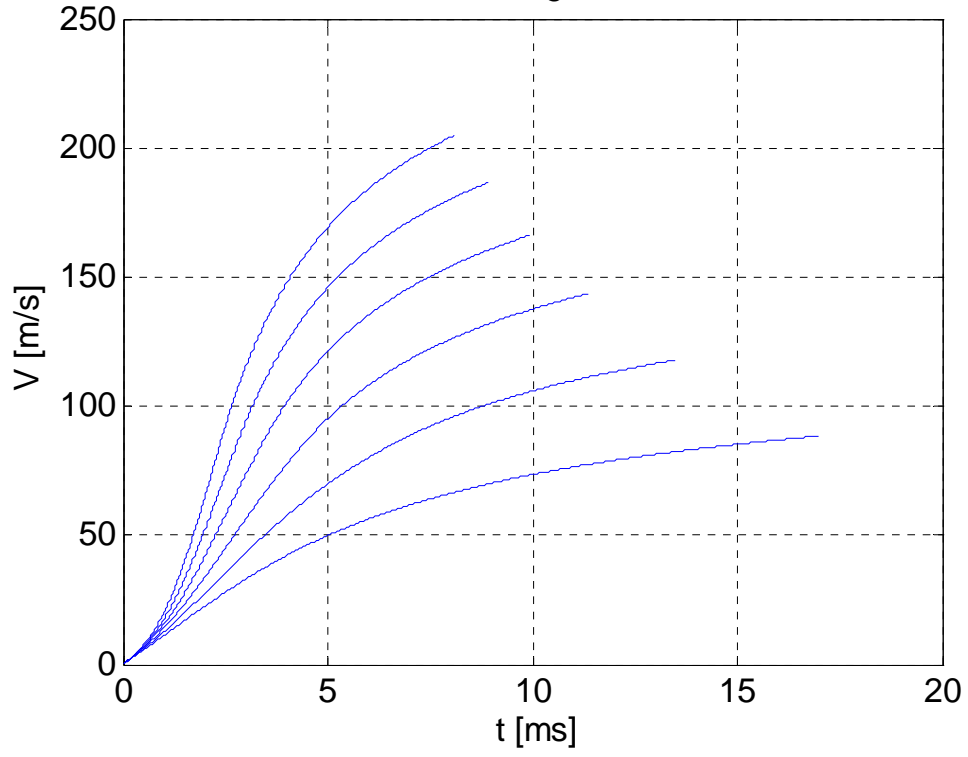
Printing step ratio, [-]

Terminal Conditions

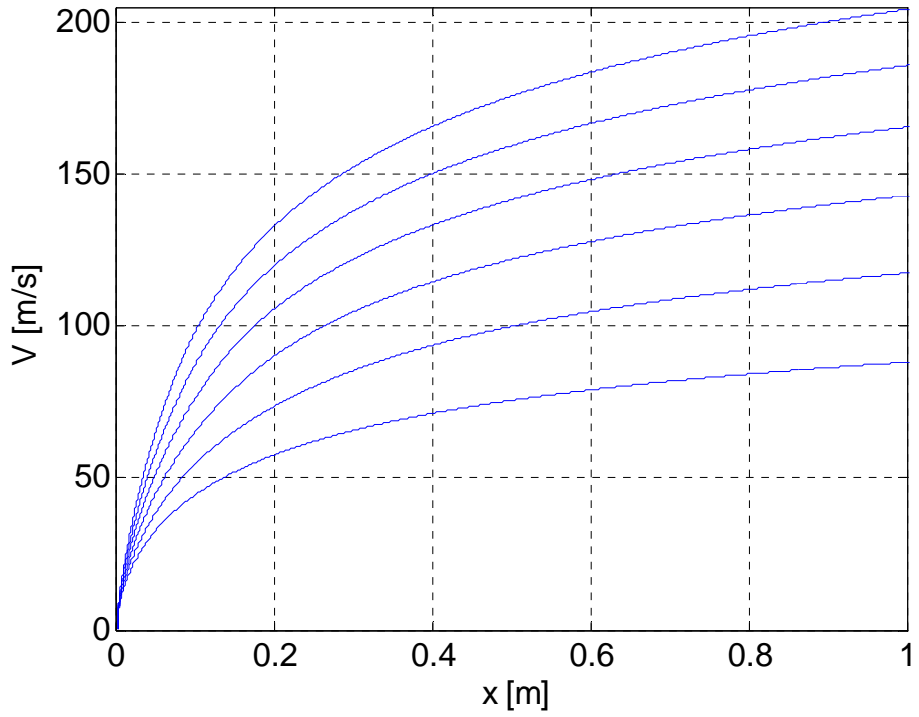
Terminal time, [s]

Terminal path, [m]

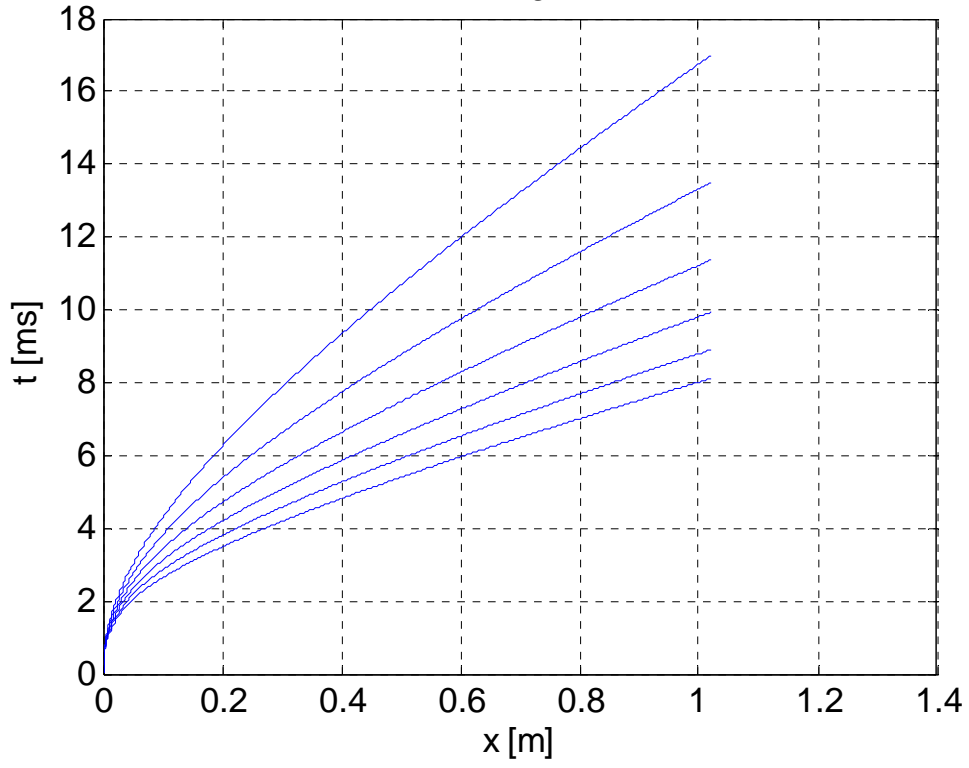
V-t Diagram



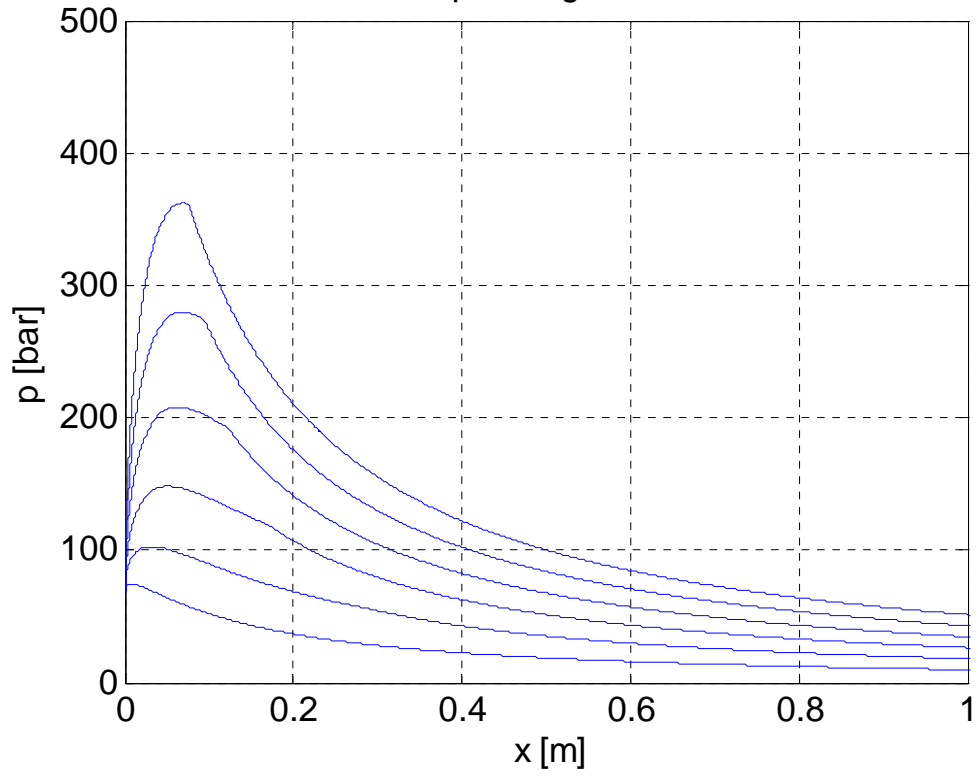
V-x Diagram

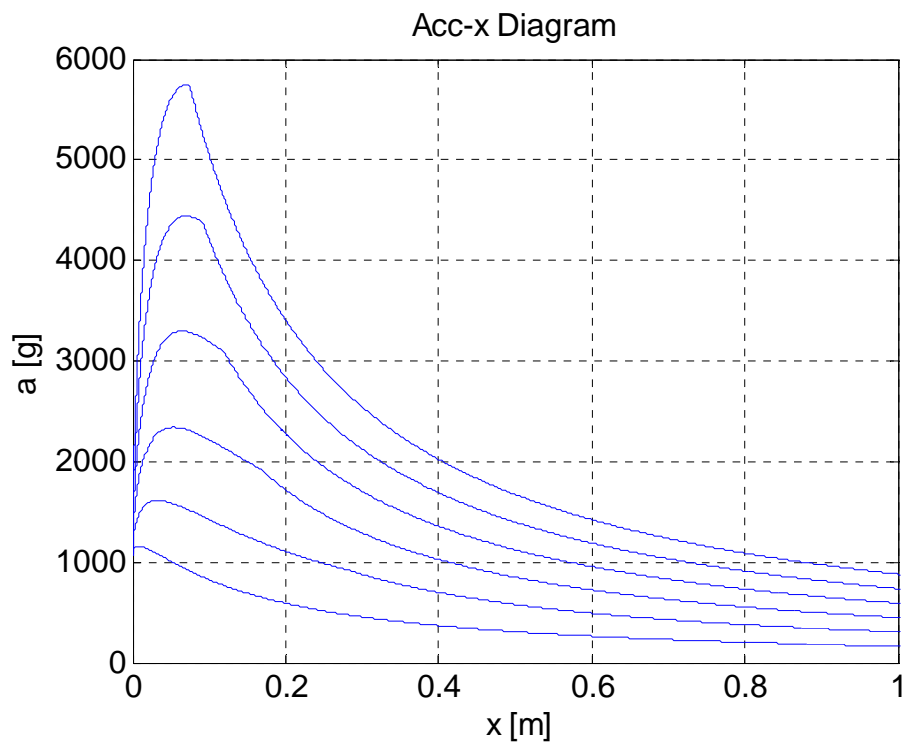
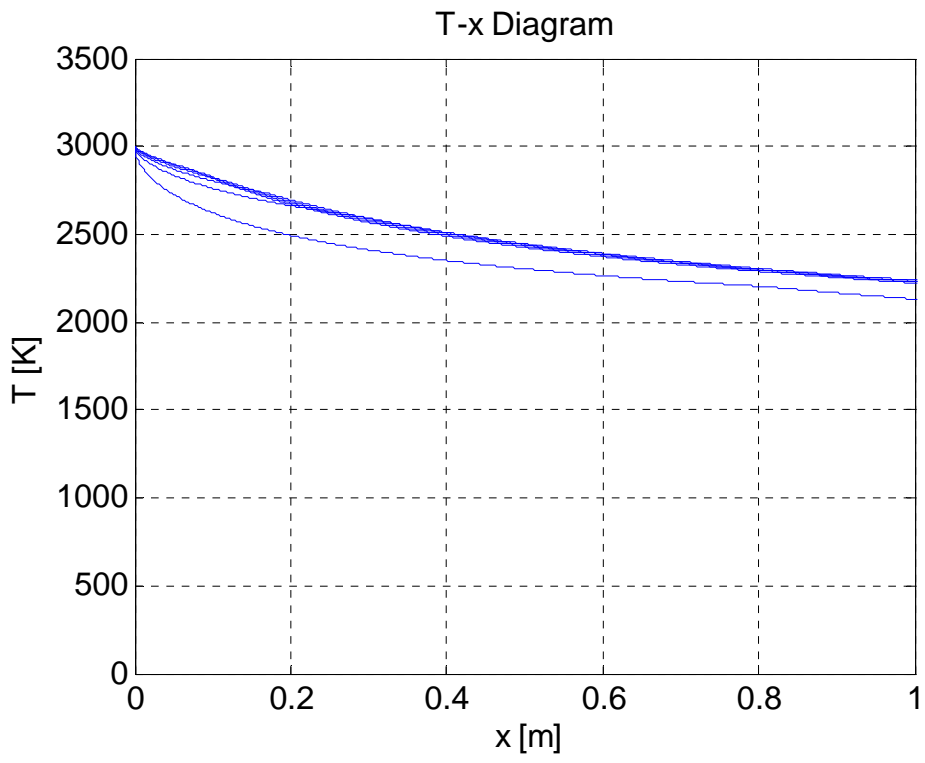


t-x Diagram



p-x Diagram





## Input file IB\_Mortar\_82mm.m

```

% Projectile characteristics
dref    = 0.082;           % m           reference diameter
Sref    = 0.005281;       % m^2        reference area
Sp      = 0.0052282;      % m^2        effective projectile cross section
mass0   = 3.4;           % kg         projectile mass
%
%
% Launcher characteristics
Sbar    = 0.0053074;      % m^2        area of the barrel cros section
Llaunch = 1.02;           % m          barrel lentgh
L0      = 0.136;          % m          lentgh of burning chamber
Lquide  = 0.6;           % m          projectile guidance length
cfric   = 0.10;          % -          friction coefficient
theta0  = 45.0*deg2rad;  % deg        initial inclination
Aceta   = 0.001;         % -          leakage coefficient
%
%
% Grain characteristics
omega0  = 0.0072;        % kg         mass of the primer charge
domega  = 0.0061;        % kg         incrimental charge mass
ncharge = 6;             %           number of incremental charges
W0      = 0.72E-3;        % m^3        initial combustion volume
Rp      = 373.4;          % kJ/kg/K    gas constant
T1p     = 3000;           % K          burning temperature;
alphap  = 0.85E-3;        % m^3/kg     covolume
u1      = 1.1E-9;         % m/s/Pa     burning velocity at norm. cond.
gamap   = 1.15;          % -          ratio of specific heat coeff.
f0      = 679E3;          % kJ/kg      force of the primer charge
deltap  = 1640;           % kg /m^3    powder density
L0      = 0.136;          % m          initial lentgh of burning chamber
e1      = 0.0605E-3;      % m          powder grain semiweb
kappa   = 1.25;          % -          kappa
lambda  = -0.2;           % -          lambda
mu      = 0.0;           % -          mu

```



## Output file IB\_Mortar\_82mm.txt - Basic quantities

Charge = 1

Time	path	Vel	press	Temp	e/e1	Wfree	acc
[ms]	[dm]	[m/s]	[bar]	[K]	[-]	[dm <sup>3</sup> ]	[g]
0.00	0.000	0.0	68.3	3000.0	0.000	0.716	1063
0.50	0.013	5.3	72.1	2973.4	0.063	0.723	1123
1.00	0.053	10.9	74.2	2944.3	0.130	0.744	1155
1.50	0.122	16.6	74.2	2914.0	0.198	0.781	1155
2.00	0.219	22.2	72.4	2883.2	0.264	0.832	1128
2.49	0.343	27.6	69.3	2852.6	0.329	0.897	1078
2.99	0.494	32.7	65.2	2822.7	0.390	0.977	1015
3.49	0.670	37.5	60.7	2794.1	0.447	1.070	944
3.99	0.869	42.0	56.0	2766.8	0.500	1.175	872
4.49	1.089	46.1	51.5	2741.2	0.549	1.291	801
4.99	1.329	49.9	47.2	2717.1	0.594	1.418	735
5.49	1.587	53.3	43.3	2694.7	0.635	1.554	673
5.99	1.861	56.5	39.7	2673.7	0.673	1.699	618
6.49	2.151	59.4	36.5	2654.1	0.707	1.851	567
6.99	2.455	62.0	33.6	2635.8	0.739	2.012	522
7.49	2.771	64.5	31.0	2618.6	0.768	2.179	482
7.99	3.099	66.8	28.7	2602.6	0.795	2.352	446
8.49	3.438	68.9	26.6	2587.6	0.820	2.531	413
8.99	3.787	70.8	24.7	2573.5	0.844	2.715	384
9.49	4.146	72.6	23.1	2560.2	0.865	2.904	358
9.99	4.514	74.3	21.6	2547.6	0.886	3.098	335
10.49	4.889	75.9	20.2	2535.8	0.905	3.297	314
10.99	5.273	77.4	19.0	2524.6	0.923	3.499	295
11.49	5.663	78.8	17.9	2514.0	0.939	3.705	277
11.99	6.061	80.2	16.9	2503.9	0.955	3.915	262
12.49	6.465	81.4	15.9	2494.3	0.970	4.128	247
12.99	6.875	82.6	15.1	2485.1	0.984	4.344	234
13.49	7.290	83.7	14.3	2476.4	0.997	4.564	222
13.99	7.711	84.8	13.6	2464.2	1.000	4.786	211
14.49	8.138	85.8	12.9	2451.3	1.000	5.011	200
14.99	8.569	86.7	12.3	2439.0	1.000	5.239	191
15.49	9.005	87.6	11.7	2427.1	1.000	5.469	182
15.99	9.445	88.5	11.2	2415.6	1.000	5.701	174
16.49	9.890	89.3	10.7	2404.6	1.000	5.935	166
16.84	10.204	89.9	10.4	2397.1	1.000	6.101	161