Designation: E3028 – 16ε1

Standard Practice for Computing Wheelchair Pathway Roughness Index as Related to Comfort, Passability, and Whole Body Vibrations from Longitudinal Profile Measurements[1]

This standard is issued under the fixed designation E3028; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε1 NOTE—Corrected 5.1.1 editorially in October 2016.

1. Scope

1.1 This practice covers the mathematical processing of longitudinal profile measurements to produce a wheelchair pathway roughness statistic called the Wheelchair Pathway Roughness Index (WPRI).

1.2 This provides a standard practice for computing and reporting an estimate of pathway roughness for sidewalks and other pedestrian surfaces.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E867 Terminology Relating to Vehicle-Pavement Systems

E1364 Test Method for Measuring Road Roughness by Static Level Method

E1926 Practice for Computing International Roughness Index of Roads from Longitudinal Profile Measurements

E1927 Guide for Conducting Subjective Pavement Ride Quality Ratings

E2133 Test Method for Using a Rolling Inclinometer to Measure Longitudinal and Transverse Profiles of a Traveled Surface

3. Terminology

3.1 *Definitions:*

3.1.1 *longitudinal profile measurement, n*—a series of elevation values taken at a constant interval along a wheel track.

3.1.1.1 *Discussion*—Elevation measurements may be taken statically, as with rod and level per Test Method E1364 or dynamically using a rolling inclinometer per Test Method E2133.

3.1.2 *traveled surface roughness*—the deviations of a surface from a true planar surface with characteristics dimensions that affect vehicle dynamics, ride quality, dynamic loads, and drainage, for example, longitudinal profile, transverse profile, and cross slope.

3.1.3 *wave number, n*—the inverse of wavelength.

3.1.3.1 *Discussion*—Wave number, sometimes called spatial frequency, typically has units of cycle/m or cycle/ft.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *Wheelchair Pathway Roughness Index (WPRI), n*—an index computed from a longitudinal profile measurement using a standard 70 mm (2.5 in.) diameter wheel with no deformation and no affects from speed. The index represents the total vertical deflection of that wheel as it travels over a surface.

3.2.1.1 *Discussion*—WPRI is reported in either millimeters per meter (mm/m) or inches per foot (in./ft).

3.2.2 *Mean Wheelchair Pathway Roughness Index (MWPRI), n*—the average of the WPRI values for multiple trials expressed in millimeters per meter or inches per foot.

3.2.3 *True Wheelchair Pathway Roughness Index, n*—the value of WPRI computed for a longitudinal profile measurement with the constant interval approaching zero.

3.2.4 *wheel path, n*—a line or path followed by a non-deformable tire of a wheeled vehicle on a traveled surface as it approaches zero speed.

4. Summary of Practice

4.1 This practice was developed specifically for estimating wheelchair pathway roughness from longitudinal profile measurements.

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[1] This practice is under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and is the direct responsibility of Subcommittee E17.33 on Methodology for Analyzing Pavement Roughness.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

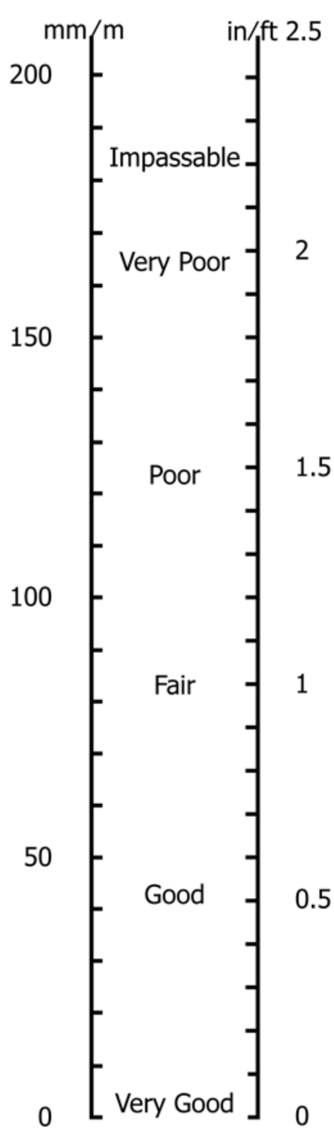
4.2 Longitudinal profile measurements for one wheel track are transformed mathematically by a computer program and accumulated to obtain the WPRI. The profile shall be represented as a series of elevation values measured at equally spaced intervals along the traveled path.

4.3 The WPRI scale starts at zero for a surface with no roughness and covers positive numbers that increase in proportion to roughness. Fig. 1 provides WPRI value descriptors derived from simulated and community surfaces made of wood, segmental paving units, cast-in-place concrete, and asphalt.

5. Significance and Use

5.1 This practice provides a means for obtaining a quantitative estimate of a surface property defined as roughness using longitudinal profile measuring equipment.

5.1.1 The WPRI can be obtained from instruments which can capture high-resolution (described in X1.1.2) longitudinal profiles.



NOTE 1—The MWPRI scale is identical to the WPRI scale.

FIG. 1 Wheelchair Pathway Roughness Index and Ratings

5.1.2 The WPRI is stable with time because true WPRI is based on the concept of a true longitudinal profile, rather than the physical properties of a particular type of instrument.

5.2 When profiles are measured simultaneously for multiple traveled wheel tracks, the MWPRI is a better measure of wheelchair pathway surface roughness than the WPRI for either individual wheel track.

5.3 Wheelchair pathway roughness data can be useful in determining the vibration exposure experienced by a wheelchair user. (See Fig. 1.)

5.3.1 Vibration exposure has been linked to pain and injuries in wheelchair users and the WPRI of traveled surfaces provides the ability to quantify the vibration exposure a wheelchair user will experience when traveling that surface.[3,4]

5.3.2 Knowledge of the vibration exposure a wheelchair will experience on traveled surfaces will allow steps to be taken to minimize their exposure, reducing the likelihood of pain and injury.

6. Longitudinal Profile Measurement

6.1 The longitudinal profile measurements can be obtained from equipment that operate in a range of speeds, but the speed shall not affect the longitudinal profile data.

6.2 The elevation profile measuring equipment used to collect the longitudinal profile data used in this practice shall have accuracy to measure the longitudinal profile attributes for computation of the WPRI in accordance with X1.2.2.

7. Computation of Wheelchair Pathway Roughness Index

7.1 This practice computes a WPRI from an algorithm shown in Appendix X2.

7.2 This practice presents a sample computer program for the computation of the WPRI from the recorded longitudinal profile measurement.

7.2.1 The computer program accepts the elevation and horizontal profile data sets as input and then calculates the WPRI values for that profile data set.

7.2.2 A listing of the computer program for the computation of WPRI is included in this practice as Appendix X2.

7.2.3 A provision has been made in the computer program listing (Appendix X2) for the computation of WPRI from recorded longitudinal profile measurements in either SI or inch-pound units.

7.2.4 The input to the sample WPRI computer program is a numerical profile data set stored in a 2×N .xls format. In this format, the profile data appear as a multi-row, two column array with the longitudinal distance data points in Column 1 and the vertical distance data points in Column 2. The profile data point interval should be in the range of 0.5 to –2.0 mm.

7.2.4.1 The computer program shall round the input to 3 decimal places no matter the input.

[3] Boninger, M.L., et al., "Investigating neck pain in wheelchair users," *Am J Phys Med Rehabil*, Vol. 82, No. 3, 2003, pp. 197–202.

[4] DiGiovine, C.P., et al., "Whole-body vibration during manual wheelchair propulsion with selected seat cushions and back supports," *IEEE Trans Neural Syst Rehabil Eng*, Vol. 11, No. 3, 2003, pp. 311–322.

7.2.4.2 If the input to the WPRI computer program is in inch-pound units, alternative code has been provided to convert the data to millimeters with the least significant digit being equal to the least significant digit provided by the input or 0.1 mm.

7.3 The distance interval over which the WPRI is computed is discretionary, but shall be reported along with the WPRI results. An interval of 16 ft (4.87 m) has been used successfully in the past and has been shown to be repeatable.

7.4 Validation of the WPRI program shall be completed when it is installed. Provision for the WPRI program installation validation is in this practice.

7.4.1 The sample profile data set SAMPLE DATA.XLS has been provided in SI units in Appendix X2 for validation of the computer program installation.

7.4.2 Using the sample profile data set SAMPLE DATA.XLS in Appendix X2 as input to the WPRI computer program, a WPRI value of 72.64 mm should be computed.

8. Report

8.1 Include the following information in the report for this practice:

8.1.1 *Profile Measuring Device*—The name, serial number, manufacturer, and class of the profile measuring device used to make the profile measurement per Test Method E1364 and Test Method E2133.

8.1.2 *Longitudinal Profile Measurements*—Data from the profile measuring process shall include the date and time of day of the measurement, the location of the measurement (latitude/longitude coordinates), length of measurement, and the descriptions of the surface being measured.

8.1.3 *WPRI Resolution*—If units reported are mm/m, then the WPRI shall be reported to the nearest one tenth of a mm/m. If the reported units are in./ft, then report the WPRI to the nearest hundredth of an in./ft.

8.1.4 *Profile Segment*—If a continuous profile contains sections that cannot be measured using the profile measuring device, the report shall note the location, length, and include a description of each discontinuity.

9. Precision and Bias

9.1 The precision and bias of the computed WPRI is limited by the procedures used in making the longitudinal profile measurement.

9.2 For the effects of the precision and bias of the measured profile on the computed WPRI, see precision and bias in Appendix X1.

10. Keywords

10.1 longitudinal profile; pathway; pedestrian; roughness; sidewalk; wheelchair; Wheelchair Pathway Roughness Index

APPENDIXES

(Nonmandatory Information)

X1. PRECISION AND BIAS

X1.1 Precision

X1.1.1 The precision of the computed WPRI is limited by the procedures used in making the longitudinal profile measurement

X1.1.2 WPRI precision depends on the interval between adjacent profile elevation measures. Reducing the interval typically improves the precision. An interval in accordance with X1.2.2 is recommended. For some surface types, a shorter interval will improve precision. More information about the sensitivity of WPRI to the profile data interval is being developed.

X1.1.3 WPRI precision is limited by the degree to which a traveled path on the pedestrian pathway can be profiled. Errors in locating the traveled path longitudinally and laterally can influence the WPRI values, because the WPRI will be computed for the profile of the traveled path as measured, rather than the travel path as intended. These errors are reduced by using longer profiles.

X1.1.4 If measurements are taken so that the least significant digit is 0.1 mm or smaller, computational errors due to rounding can be safely ignored.

X1.2 Bias

X1.2.1 The bias of the computed WPRI is typically limited by the procedures used in making the longitudinal profile measurement.

X1.2.2 WPRI bias depends on the interval between adjacent profile elevation measures. An interval of between 0.5 and 2.0 mm is necessary. Shorter intervals improve precision but have little effect on bias. More information about the sensitivity of WPRI to the profile data interval is being determined.

X1.2.3 Many forms of measurement error cause an upward bias in WPRI due to variations in profile elevation from measurement error not correlated with the profile changes. Some common sources of positive WPRI bias are: height-sensor round-off, mechanical vibrations in the instrument that are not corrected, and electronic noise. Bias is reduced by using profiler instruments that minimize these errors.

X2. WHEELCHAIR PATHWAY ROUGHNESS INDEX COMPUTER PROGRAM

X2.1 Included in this appendix is the coding in Matlab language for a computer program (see Fig. X2.1) which calculates the Wheelchair Pathway Roughness Index as prescribed by this practice. The .xls file *standard_data.xls* should have columns 1 and 2 filled with data; Column 1 with longitudinal distance and Column 2 with vertical distance.

X2.2 The sample program can process data files containing two columns of data: one for the longitudinal distance and one for the vertical distance. For SI data, the program assumes the input amplitudes are stored in millimeter units; if inch-pound, inches for vertical and feet for horizontal.

X2.3 The sample data file shown in Table X2.1 is in SI units (mm) and contains 400 profile data point pairs. The recording interval for the data was 1.0 mm. The WPRI calculated should be 72.64 mm/m.

```
%Clears all variables.
clear all

%Imports data from Excel file.
datafile='standard_data.xls';
data=importdata(datafile);

%Takes the longitudinal data from column 1 and transposes it to row "x"
%Alternatively, x=((data(:,1))*12*25.4)'; could be used to convert
%longitudinal distance data from feet to millimeters.
x=(data(:,1))':

%Takes the vertical data from column 2 and transposes it to negative row
%"y".  Alternatively, y=-((data(:,2))*25.4)'; could be used
%to convert elevation data from inches to millimeters.
y=-(data(:,2))';

%Finds length of elevation data
datalength=length(y);

%Creates an array from 0.2 millimeters to the last point of the longitudinal
%data (rounded up) by 0.2 millimeters.
x_arc_step=.2;
x_end=x(datalength);

%Defines the wheel diameter in millimeters.
wheel_mm=70;
start=1;
new_profile=[];
X_average=x_end/datalength;
begin=start;

%WHILE-loop repeats process throughout length of input data.
while begin<datalength
    x_Profile=[];
    y_val2=[];
    y_init=y(1,begin);
    x_init=x(1,begin);
```

FIG. X2.1 Sample Matlab Program to Compute Wheelchair Pathway Roughness Index

```
%IF-statement determines if the data is within a wheel diameter from
%the end of the data. If it is, it finds the last point within a
%wheel diameter. If it is not, it takes the last point.
if ((x_init+wheel_mm))<x_end
    i=1;
    while (x(begin+i)-x(begin))<wheel_mm
        i=i+1;
    end
    y_max=y(begin+i);
    y_max_yindex=i;
else
    y_max=y(datalength);
    y_max_index=datalength-begin;
end

%Finds the longitudinal distance of the last elevation data point of
%this section.
x_max=x((begin)+y_max_index);
x_max_new=0;

%WHILE-loop determines if x_max is still being iterated because there
%are more points to check. If this is false, the only longitudinal
%point that satisfies the wheelpath algorithm is the next longitudinal
%point, and it will become the next initial point.
while x_max~=x_max_new

    %This code determines the equation and center of the circle that
    %has the wheel diameter and contains the initial and maximum
    %points.
    chord_length=sqrt(((y_max-y_init)^2)+((x_max-x_init)^2));
    t=sqrt(((wheel_mm/2)^2)-(((chord_length)^2)/4));
    chord_midpoint_y=((y_max+y_init)/2);
    chord_midpoint_x=((x_max+x_init)/2);
    chord_angle=atand((y_max-y_init)/(x_max-x_init));
    circle_center_x=chord_midpoint_x+(t*cosd(90+chord_angle));
    circle_center_y=chord_midpoint_y+(t*sind(90+chord_angle));

    %Finds all of the longitudinal data points from the start to the
    %maximum point found.
    x_eval=x(begin:(begin+y_max_index));
```

FIG. X2.1 Sample Matlab Program to Compute Wheelchair Pathway Roughness Index *(continued)*

```
%Finds all of the longitudinal data points from the start to the
%maximum point found.
x_eval=x(begin:(begin+y_max_index));

%Finds the bottom “y” coordinates of every "x" point for the
%circle.
y_vall=-sqrt(((wheel_mm/2)^2)-((x_eval-circle_center_x)).^2))...
      +circle_center_y;

%Defines i as 1 to start checking the points from the end of
%the arc to the first.
i=1;

%WHILE-loop determines if all data points were checked to
%see if they are greater than the wheel profile.
while i <= y_max_index
    %IF-statement determines if the only point that can be used
    %is the next point. Meaning that the wheel is free to just
    %move there.
    if x_max==x(1,begin+1)
        x_max_new=x_max;
        break
        %ELSEIF checks all of the points to see if they are greater
        %than the wheel profile. If they are it finds the next
        %maximum before the last maximum.
    elseif i==(y_max_index)
        x_max_new=x_max;
        break
        %ELSEIF checks to see if this data point is higher than
        %the circle data point at the same longitudinal distance.
        %If it is, then it moves the final point for the evaluation
        %one point closer and makes it big enough to exit the while
        %loop and start the circle calculations again using the new
        %last point.
    elseif y((begin)+i) > y_val1(1+i)
        x_max=x((begin)+y_max_index-1);
        y_max=y((begin)+y_max_index-1);
        i=(y_max_index+1);
        y_max_index=y_max_index-1;
    else
```

FIG. X2.1 Sample Matlab Program to Compute Wheelchair Pathway Roughness Index *(continued)*

```
-               i=i+1;
            end
        end
    end

    %Finds the longitudinal points that satisfied the wheel path algorithm.
    for i=1:y_max_index;
        x_profile(i)=x(begin+i-1);
    end

    %Finds the wheel path points that match the longitudinal points that
    %satisfied the wheel path algorithm
    y_val2=-sqrt(((wheel_mm/2)^2)-((x_profile-circle_center_x).^2))...|
    +circle_center_y;

    %Adds the wheel path data points to the end of the previous data.
    new_profile=[new_profile y_val2];

    %Makes the new begin point the end point of the wheel path.
    begin=begin+y_max_index;

end

%Finds roughness caused by slopes by using a moving average filter over
%approximately a 1-foot (300mm) section
i=2;
while x(i)-x(1)<300
    i=i+1;
end
slope=smooth (x,y,i);
slope=slope (1:length(slope)-1);
Profile=new_profile;
roughness_profile=0;
roughness_slope=0;

%Calculates the sum of the vertical deviations of the true profile and the
%smoothed profile
for k=2:datalength-1
    diff_slope=abs(slope(k)-slope(k-1));
    diff_profile=abs(new_profile(k)-new_profile(k-1));
    roughness_profile = roughness_profile+diff_profile;
    roughness_slope = roughness_slope+diff_slope;
end

%Calculates the WPRI index in mm/m
WPRI_index=(roughness_profile-roughness_slope)/(x(length(x))/1000);

%This code can be used to convert the index to inches per foot
%e_end_feet=x_end/12/25.4;
%WPRI_index_feet=(WPRI_index/25.4)/x_end_feet;
```

FIG. X2.1 Sample Matlab Program to Compute Wheelchair Pathway Roughness Index *(continued)*

TABLE X2.1 Sample Profile Data from STANDARD DATA.XLS for Longitudinal (Lon) measurements recorded with an encoder and Vertical (Vert) measurements recorded with a laser (mm)

Lon	Vert	Lon (cont)	Vert (cont)	Lon (cont)	Vert (cont)	Lon (cont)	Vert (cont)	Lon (cont)	Vert (cont)
0.0	130.3	40.0	130.1	80.0	134.9	120.0	131.8	160.0	130.6
1.0	130.3	41.0	130.1	81.0	135.5	121.0	131.5	161.0	130.5
2.0	130.3	42.0	130.1	82.0	136.1	122.0	131.3	162.0	130.4
3.0	130.3	43.0	130.1	83.0	136.7	123.0	131.1	163.0	130.4
4.0	130.3	44.0	130.2	84.0	137.5	124.0	131.0	164.0	130.4
5.0	130.3	45.0	130.2	85.0	138.3	125.0	131.0	165.0	130.5
6.0	130.3	46.0	130.2	86.0	138.9	126.0	130.9	166.0	130.6
7.0	130.3	47.0	130.2	87.0	139.5	127.0	130.9	167.0	130.6
8.0	130.3	48.0	130.2	88.0	140.3	128.0	130.9	168.0	130.7
9.0	130.3	49.0	130.2	89.0	141.0	129.0	130.9	169.0	130.6
10.0	130.4	50.0	130.2	90.0	141.7	130.0	130.9	170.0	130.6
11.0	130.4	51.0	130.2	91.0	142.2	131.0	130.8	171.0	130.3
12.0	130.4	52.0	130.2	92.0	142.5	132.0	130.8	172.0	130.3
13.0	130.3	53.0	130.2	93.0	142.7	133.0	130.7	173.0	130.3
14.0	130.3	54.0	130.2	94.0	142.8	134.0	130.6	174.0	130.3
15.0	130.2	55.0	130.3	95.0	142.7	135.0	130.5	175.0	130.3
16.0	130.1	56.0	130.3	96.0	142.5	136.0	130.5	176.0	130.3
17.0	130.1	57.0	130.3	97.0	142.4	137.0	130.5	177.0	130.3
18.0	130.1	58.0	130.3	98.0	142.2	138.0	130.5	178.0	130.3
19.0	130.1	59.0	130.2	99.0	142.1	139.0	130.5	179.0	130.3
20.0	130.1	60.0	130.2	100.0	142.1	140.0	130.5	180.0	130.3
21.0	130.2	61.0	130.3	101.0	142.1	141.0	130.5	181.0	130.4
22.0	130.2	62.0	130.4	102.0	142.2	142.0	130.5	182.0	130.4
23.0	130.2	63.0	130.5	103.0	142.2	143.0	130.5	183.0	130.4
24.0	130.2	64.0	130.6	104.0	142.2	144.0	130.5	184.0	130.3
25.0	130.1	65.0	130.8	105.0	142.2	145.0	130.4	185.0	130.3
26.0	130.1	66.0	130.9	106.0	142.2	146.0	130.4	186.0	130.2
27.0	130.1	67.0	131.0	107.0	142.0	147.0	130.4	187.0	130.1
28.0	130.0	68.0	131.2	108.0	141.8	148.0	130.4	188.0	130.1
29.0	130.0	69.0	131.3	109.0	141.0	149.0	130.4	189.0	130.1
30.0	130.0	70.0	131.6	110.0	138.9	150.0	130.4	190.0	130.1
31.0	130.1	71.0	131.8	111.0	137.5	151.0	130.4	191.0	130.1
32.0	130.1	72.0	132.1	112.0	135.7	152.0	130.4	192.0	130.2
33.0	130.1	73.0	132.3	113.0	134.5	153.0	130.5	193.0	130.2
34.0	130.1	74.0	132.6	114.0	134.0	154.0	130.6	194.0	130.2
35.0	130.1	75.0	132.9	115.0	133.5	155.0	130.6	195.0	130.2
36.0	130.1	76.0	133.2	116.0	133.1	156.0	130.7	196.0	130.1
37.0	130.0	77.0	133.6	117.0	132.7	157.0	130.7	197.0	130.1
38.0	130.0	78.0	134.0	118.0	132.4	158.0	130.7	198.0	130.1
39.0	130.0	79.0	134.4	119.0	132.1	159.0	130.6	199.0	130.0

TABLE X2.1 Sample Profile Data from STANDARD DATA.XLS for Longitudinal (Lon) measurements recorded with an encoder and Vertical (Vert) measurements recorded with a laser (mm) *(continued)*

Lon	Vert	Lon (cont)	Vert (cont)	Lon (cont)	Vert (cont)	Lon (cont)	Vert (cont)	Lon (cont)	Vert (cont)
200.0	130.0	240.0	131.3	280.0	141.0	320.0	130.4	360.0	130.1
201.0	130.0	241.0	131.6	281.0	138.9	321.0	130.4	361.0	130.1
202.0	130.1	242.0	131.8	282.0	137.5	322.0	130.4	362.0	130.1
203.0	130.1	243.0	132.1	283.0	135.7	323.0	130.4	363.0	130.2
204.0	130.1	244.0	132.3	284.0	134.5	324.0	130.5	364.0	130.2
205.0	130.1	245.0	132.6	285.0	134.0	325.0	130.6	365.0	130.2
206.0	130.1	246.0	132.9	286.0	133.5	326.0	130.6	366.0	130.2
207.0	130.1	247.0	133.2	287.0	133.1	327.0	130.7	367.0	130.1
208.0	130.0	248.0	133.6	288.0	132.7	328.0	130.7	368.0	130.1
209.0	130.0	249.0	134.0	289.0	132.4	329.0	130.7	369.0	130.1
210.0	130.0	250.0	134.4	290.0	132.1	330.0	130.6	370.0	130.0
211.0	130.1	251.0	134.9	291.0	131.8	331.0	130.6	371.0	130.0
212.0	130.1	252.0	135.5	292.0	131.5	332.0	130.5	372.0	130.0
213.0	130.1	253.0	136.1	293.0	131.3	333.0	130.4	373.0	130.1
214.0	130.1	254.0	136.7	294.0	131.1	334.0	130.4	374.0	130.1
215.0	130.2	255.0	137.5	295.0	131.0	335.0	130.4	375.0	130.1
216.0	130.2	256.0	138.3	296.0	131.0	336.0	130.5	376.0	130.1
217.0	130.2	257.0	138.9	297.0	130.9	337.0	130.6	377.0	130.1
218.0	130.2	258.0	139.5	298.0	130.9	338.0	130.6	378.0	130.1
219.0	130.2	259.0	140.3	299.0	130.9	339.0	130.7	379.0	130.0
220.0	130.2	260.0	141.0	300.0	130.9	340.0	130.6	380.0	130.0
221.0	130.2	261.0	141.7	301.0	130.9	341.0	130.6	381.0	130.0
222.0	130.2	262.0	142.2	302.0	130.8	342.0	130.3	382.0	130.1
223.0	130.2	263.0	142.5	303.0	130.8	343.0	130.3	383.0	130.1
224.0	130.2	264.0	142.7	304.0	130.7	344.0	130.3	384.0	130.1
225.0	130.2	265.0	142.8	305.0	130.6	345.0	130.3	385.0	130.1
226.0	130.3	266.0	142.7	306.0	130.5	346.0	130.3	386.0	130.2
227.0	130.3	267.0	142.5	307.0	130.5	347.0	130.3	387.0	130.2
228.0	130.3	268.0	142.4	308.0	130.5	348.0	130.3	388.0	130.2
229.0	130.3	269.0	142.2	309.0	130.5	349.0	130.3	389.0	130.2
230.0	130.2	270.0	142.1	310.0	130.5	350.0	130.3	390.0	130.2
231.0	130.2	271.0	142.1	311.0	130.5	351.0	130.3	391.0	130.2
232.0	130.3	272.0	142.1	312.0	130.5	352.0	130.4	392.0	130.2
233.0	130.4	273.0	142.2	313.0	130.5	353.0	130.4	393.0	130.2
234.0	130.5	274.0	142.2	314.0	130.5	354.0	130.4	394.0	130.2
235.0	130.6	275.0	142.2	315.0	130.5	355.0	130.3	395.0	130.2
236.0	130.8	276.0	142.2	316.0	130.4	356.0	130.3	396.0	130.2
237.0	130.9	277.0	142.2	317.0	130.4	357.0	130.2	397.0	130.3
238.0	131.0	278.0	142.0	318.0	130.4	358.0	130.1	398.0	130.3
239.0	131.2	279.0	141.8	319.0	130.4	359.0	130.1	399.0	130.3