Interim Metric Design Guide

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This section provides some miscellaneous information about designing projects in metric units.

Sheet Size and Allowable Units of Measure

The actual size of all plan sheets is remaining 34" × 22" to maintain compatibility with existing reproduction equipment. However, the designer must show all dimensions on metric plans in metric units only. All angles should be expressed in degrees, minutes, and seconds (angles shall not normally be expressed in radians). Distances and dimensions shall be expressed in meters (m), millimeters (mm), and kilometers (km) only. Areas shall be expressed in either square meters (m^2) or hectares (ha). Volumes shall be expressed in either cubic meters (m^3) or liters (L). Masses shall be expressed in grams (g), kilograms (kg), or megagrams (Mg).

All metric units have “symbols” which shall be used in plans. The symbols for the units are found in parentheses in the paragraph above. These symbols are lower case unless noted, a space is placed between the number and symbol, and the symbols are used for both singular and plural values.

Correct usage:	350 mm		
Incorrect usage:	350 MM	350mm	350 mms

Rather than using AASHTO conventions, we will use a comma to separate every three digits in a number and a period for the decimal point. The department has issued PPM 030.02, which defines the metric system and its units. This policy also describes proper use of metric units, as determined by the Department.

Conversion Rules

There are two types of conversion possible: soft and hard. Soft conversion means an English size is expressed in metric units. In other words, there is no physical change in a soft conversion: a 10-foot shoulder equals a 3.01-meter shoulder. Hard conversion, on the other hand, means that the size of an item changes so that a clean, round metric number can be used: a 10-foot shoulder becomes a 3-meter shoulder. Most of our metric conversions will be hard converted. However, lengths and distances should be soft converted, based on the exact conversion of the US survey foot shown below:

$$\frac{39.37\ \text{in}}{1\ \text{m}} \times \frac{1\ \text{ft}}{12\ \text{in}} = \frac{39.37\ \text{ft}}{12\ \text{m}} = 3.2808\bar{3}\ \text{ft/m}$$

The designer should judge the level of precision needed in the conversion factor depending on what part of the project is being designed. For example, the station equation and horizontal alignment calculations require an exact conversion to achieve the necessary precision. However, on field entrances, which are generally located to the nearest foot, the required precision is not as high.

Stationing

Metric stationing will be based on the one-hundred meter station (1 STA = 100 m). For example, STA 9+54.567 indicates a point 54.567 meters (54 meters and 567 millimeters) forward of the 900 meter station. Stationing and full tickmarks are to be at each 100 meters (1+00, 2+00, 3+00, etc.), with half tickmarks at every 50 meters (1+50, 2+50, 3+50, etc.).

A station equation that relates the metric stationing to the English stationing established by previous surveys will be placed at the beginning of project (BOP) and the end of project (EOP). The metric station will be established by dividing the station value in English units by the conversion factor for the U.S. survey foot. For example, if the English BOP is at STA 492+00 (E), the metric BOP is at STA 149+96.190 (m).

The calculation for the conversion is:

$$49200\ \text{ft} \times \frac{\text{m}}{3.2808333\ \text{ft}} = 14996.190\ \text{m} = \text{STA}\ \ 149 + 96.190$$

The format for the station equation is:

$$\frac{\text{STA}\ \ 149 + 96.190\ (\text{m}) - \text{this survey}}{\text{STA}\ \ 492 + 00.00\ (\text{E}) - \text{as built}}$$

If the existing English station at the BOP is under 10+00 and does not allow for additional survey in front of the BOP, the survey crew will set an arbitrary metric station of 10+00.000. This will prevent the possibility of negative stationing on a project.

Scales and Plan & Profile Sheets

On metric plans, scales are to be expressed in ratios only. So if the scale is 1 m = 1000 m, it would be expressed as 1:1000. If the scale is 10 mm = 5 m, it would be expressed as 1:500. For reference, our current 100 scale (1" = 100') would be 1:1200 when expressed as a ratio.

The scales for metric plan sheets are listed below. The designer must choose the appropriate plan scale for the project. For most rural projects, the scale will be 1:1000. However, the 1:500 scale may be used in rural areas where the complexity of the project requires greater detail. For urban projects, the designer may choose between the 1:500 and 1:250 scales.

Each of the plan scales has a different Plan & Profile Sheet. The main difference between the sheets is the grid spacing on the profile portion of the sheet. The correct sheet for a given plan scale will be chosen based on the appropriate profile grid indicated below. Once the correct sheet is selected, the profile scale and increments of elevation should be correct.

Table 1

	Rural	Urban
Plan Scale	1:1000	1:500 or 1:250
Profile Grid	50 × 50 mm	20 × 20 mm or 40 × 40 mm
Scale (Vertical)	1:100	1:50 or 1:25
Increments of Elevation	5 m	2 m or 1 m

Based on the scales given above, Plan & Profile Sheets will cover the following ranges:

Table 2

	Rural	Urban
Plan Portion	800 m	400 m (or 200 m)
Profile Portion	750 m	380 m (or 190 m)

In addition, the scales below should be used for the specialized plan sheets as indicated:

Table 3

Geometric Plans (Interchange Layout)	1:1000
Geometric Details (Intersection Layout)	1:250
Staking Details	1:250 Horizontal/1:12.5 Vertical
Culvert and Bridge Plats	1:250

These scales should be considered normal practice. However, designers may alter them as necessary to improve the plan's presentation.

Table 4

	Rural	Urban
Cross Section Scale	1:100 Horizontal/1:50 Vertical 1:200 Horizontal/1:100 Vertical	1:50 Horizontal/1:10 Vertical

The normal scale for rural cross sections is 1:100 Horizontal/1:50 Vertical. The 1:200/1:100 scale for rural areas should be used only in cases where cross sections do not fit on the sheet due to high fills or deep cuts. This usually happens on mainline cross sections on four-lane divided roadways. When using the 1:200/1:100 scale, the text sizes and spacing should be legible.

On a given project, the designer may change the scales of the cross sections on the mainline if necessary, but the number of these changes should be kept to a minimum. The scales on all cross sections should be clearly labeled.

Cross sections, as with other plan sheets, will be on 34" × 22" paper. The grid should have the following dimensions:

Large square: 50 mm × 50 mm

Small squares: 10 mm × 10 mm with 1 mm grid

An example of acceptable paper would be the Dietzgen 305R Metric Cross Section Paper: 22" wide, 1 mm separation. Cross sections shall be provided according to the following guidelines:

Rural and Urban Interval: 25 m, and at breaks and culverts

Plan Conventions

Slopes previously expressed in percentages (%) or ratios of horizontal to vertical (6:1) will continue to be expressed in the same manner in metric plans. AASHTO has adopted a different, though not necessarily metric, international convention for expressing slopes. This convention is a vertical-to-horizontal ratio (opposite of our practice). AASHTO has incorporated this V:H convention in the 1994 *Policy on Geometric Design of Highways and Streets.* Be careful to keep any references to slope in the proper context to minimize confusion.

Elevations on the Plan & Profile Sheets shall be calculated and placed every 10 meters and should be expressed to the nearest 0.001 meter. Other elevations will also be expressed to the nearest 0.001 meter with the exception of elevations on culvert sheets. On culvert sheets, the elevations will be given to the nearest 0.01 meter. We realize that the elevations will be expressed to a number more accurate than can be measured. The following tolerances apply:

Bench Elevations	± 1 mm
Pavement Elevations	± 3 mm
Ground Elevations	± 10 mm

Distances for horizontal alignments, tie-ins, pluses, and offsets, will be expressed to the closest 0.001 meter. These distances have the following tolerances:

Horizontal Alignment Data	± 3 mm
Pavement Tie-ins	± 3 mm
Pluses	± 3 mm
Offsets	± 3 mm

The location of proposed features will be as follows:

Entrance Locations	Closest 0.01 m
Culvert Locations	Closest 0.1 m
Horizontal Ditch Grade Breaks	Closest 10 m
Vertical Elevation of Ditch Grades	Closest 0.01 m

When a proposed joint entrance is located on the property line, the proposed entrance location should be the property line station.

Vertical Alignment

Vertical profile alignment should be designed with the vertical PI stations on even 10-meter increments. The length of vertical curve should be in 20-meter increments. The designer may choose an odd location for the vertical PI if moving the vertical PI to an odd location will produce a better design. The vertical PI elevation shall be shown to the closest 0.001 meter. Grades shall be shown as a percent grade carried to four places after the decimal (1.0000 %).

Pipe Diameters and Lengths

All pipe diameters are expressed in hard converted sizes. The actual pipe diameters have not changed. However, the English-sized pipes are labeled with nominal metric diameters since the pipes fit within the tolerances established for metric pipes. These diameters are found in ASTM C14 M for nonreinforced concrete pipe, in ASTM C76M for reinforced concrete pipe, and in ASTM A760/A760 M for metal pipe. Also, in Appendix B of this section, we provide a table showing allowable metric sizes for both concrete and metal pipe. For unclassified metal pipe, use the concrete pipe diameters to specify size.

The total length of pipe should be soft converted to the nearest tenth of a meter. The convention for either a proposed or an existing pipe will have the diameter in millimeters and the length in meters. For example, 300 × 3.7 would represent a 300-millimeter pipe with a length of 3.7 meters.

For labeling pipes which have diameter only, do not use the millimeter (mm) symbol. For example, 600 Uncl. or 900 RF-1. This is consistent with the labeling for pipe diameter and length (600 × 4.5).

For reinforced concrete box (RCB) culverts, the dimensions should be shown in meters. As in past practice, the convention for expressing the dimensions of an RCB culvert is width by height by length. For existing RCB culverts on road plans and pinks, the dimensions should be carried out to the nearest hundredth of a meter (3.05 × 3.05 × 12.26). For proposed RCB culverts on the road plans and pinks, the dimensions should be carried out to the nearest tenth of a meter (1.8 × 1.2 × 9.8). No symbol will be used with these dimensions.

The following table lists equivalent pipe strengths under the metric and English systems.

Table 5

Metric	English
75D	1500D
100D	2000D
150D	3000D

Converting English Plans to Metric

When re-establishing points from a previously-run survey (one ran in English units), use the following guidelines:

1. Soft convert the survey alignment, using the U.S. survey foot conversion factor. This includes distances, elevations, and points of intersection (PI's). Round to the nearest millimeter, even though that represents a greater accuracy than surveyed.
2. Horizontal curves can be soft-converted in most situations. If the design warrants an office location, the designer should then choose an even 5-meter radius for curves.
3. Use hard-converted metric typical sections.

Title Sheet

To create a title sheet, copy the file SEEDMET.A01. This file is designed to be the preliminary and final title sheet, depending on which levels are turned on. The two scales available for the map are 1:500 for rural plans and 1:50 for short urban plans. To scale the county map attachment to display the 1:500 scale, a 1:0.0305 scale ratio must be used. To scale the county map attachment to 1:50, a 1:0.305 ratio must be used.

The Project Length Summary contains columns for both meters and kilometers. The kilometer column should be used for the total project length only.

Metric CADD Files

The following guidelines are the basic information that a designer will need to know to start working in a metric CADD file.

1. Global Origin: GO = 0,0
2. The fixed location point to the left of the plan sheet in any given sheet file is at the coordinate location xy = 10,000; 10,000.
3. CADD working units:

    Master Units: meters

    Subunits: millimeters

    Positional units: 2 per millimeter

4. The original graphics for the plan sheet are in file ORIGMET.PLN, which has been referenced into file SEEDMET.D00. SEEDMET.D00 can be copied to produce any desired version of a full plan sheet, full profile sheet, or plan and profile sheet by manipulating the on/off status of the elements on the 63 levels.

Horizontal Curves

On horizontal curves, we will define the curves by radius only, rather than using degree of curve (as we currently do). For example, on a new alignment the designer should refer to a 3 degree horizontal curve as a 580 meter radius curve (radius = 1909.86 ft. = 582.125 m). Metric radii on office-relocated horizontal curves should always be expressed in increments which are multiples of 5 meters. Points of intersection (P.I.'s) will remain constant.

On the other hand, alignments which incorporate a previously defined horizontal curve should continue to express the radius in meters, rounded to the closest 0.001 meter. If the 3 degree curve noted above is a re-creation of a previously established curve, the designer should assign it a 582.125 meter radius. This would be used on inlays where the alignment does not change.

Listed below are three cases defining horizontal curves. In all three cases, the P.I. of the curve remains constant. When soft converted, P.I. STA 302+68.57 (English) becomes P.I. STA 92+25.879 (metric) (conversion factor = 12/39.37). Note that the metric curve distances are given to the closest 0.001 meter.

Case A: Normal English curve definition

Case B: Metric definition assuming that the Case A curve data defined the roadway centerline from a previous survey and that the data is to be retained. All curve data is a direct soft conversion from English to metric.

Case C: Metric definition of an office relocation that starts at P.C. STA 91+62.359 and that has approximately the same curvature as the Case A curve. Note that the radius is given in a 5-meter increment.

Table 6

Case A	Case B	Case C
P. I. = STA 302+68.57	P. I. = STA 92+25.879	P. I. = STA 92+25.879
Δ = 12° 30'	Δ = 12° 30'	Δ = 12° 30'
D = 3° 00'	R = 582.125 m	R = 580.00 m
L = 416.67'	L = 127.000 m	L = 126.536 m

Horizontal Curve Equations (Δ in degrees, R in meters)

$$L = \frac{R\pi\Delta}{180} T \qquad R \tan \tfrac{1}{2}\Delta \qquad E = R\left(\frac{1}{\cos\frac{\Delta}{2}} - 1\right)$$

Plan Curve Data shall always be given in the following order: Δ, R, T, L, and E. The meter symbol shall always be shown following the curve data.

Grading and Right-of-Way Values

For design, we will continue to state all values in metric. ROW needs will be stated in half-meter increments for rural areas and tenth-meter increments for urban areas. For urban areas, the normal required right-of-way will be 3.6 meters from back of curb.

In rural areas, the roll on the backslope will be 1.5 meters, and the intercepting ditch will be 3 meters. Silt ditches will be 6 meters in width. Six meters will be needed from the end of culvert and from the outboard of a bridge.