MicroStation V8 Working Units for Civil Engineering

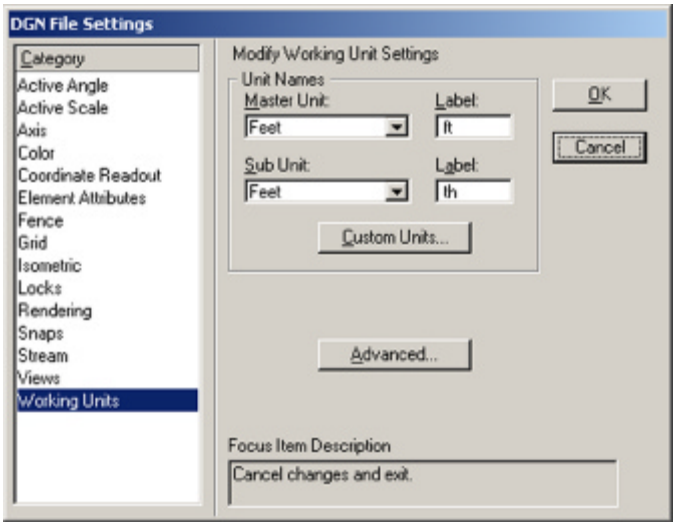
Working Units

Working units have been, and continue to be, a significant part of MicroStation. In the past, the working unit divided up a fixed drawing space into a grid. Since the drawing space was fixed, there was a trade off between decimal places and drawing size. The larger the drawing, the fewer decimal places were available.

MicroStation V8.5 has a practically unlimited drawing space. Every coordinate in the drawing space is calculated and stored to a full double precision number.

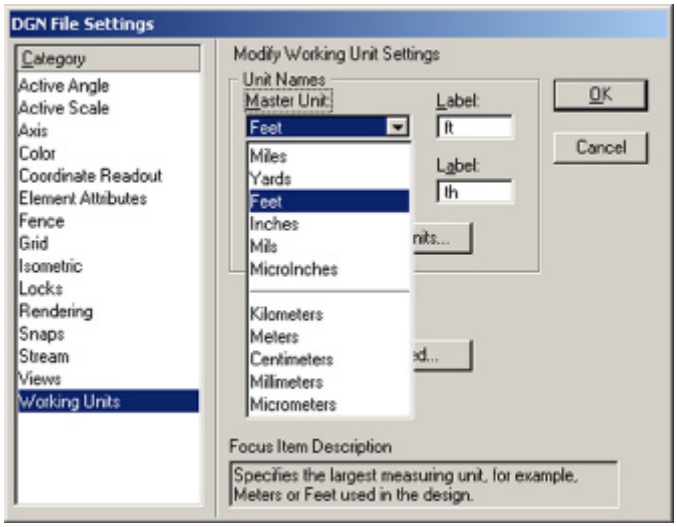
In MicroStation V8.5 working units have a different purpose. They now define the drawing unit so that MicroStation can properly compare two drawings and compensate for different units if they exist. For example, since MicroStation V8.5 understands units, it can correctly reference together a drawing in feet with a drawing in meters without the user having to adjust the scale, position or global origin.

The working unit definition remains on the DGN File Settings dialog box.



DGN File Settings dialog box

Working units define the unit of measure in each model. Every model in a .dgn file has its own working units and each can be different. In most situations the only working unit definition that needs to be done with MicroStation V8.5 is to identify the primary (master) and secondary (sub) units of measure. The Advanced and Custom settings are not typically needed. Since most everyone uses a small set of common units of measure, they have been built into MicroStation V8.5 and are selectable from an option list.



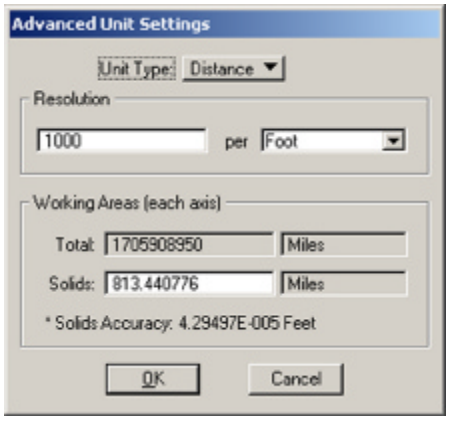
DGN File Settings dialog box with master unit option list

To define the working units, select the desired unit for the primary (master) and secondary (sub) unit. If desired, the Label for each unit can be modified. MicroStation understands the mathematical relationship between the units and can accommodate any selection of units. For example, a valid, albeit strange, set of working units could be feet for the master unit and millimeters for the sub unit.

There is almost never a need to use the Custom Units button. Later you will learn a better method to define units that are not included in the default MicroStation interface. The most common additional unit needed by Engineers is the US Survey Foot.

Advanced Working Unit Settings

The Advanced button opens the Advanced Unit Settings dialog box. These settings define two items. The first establishes the size of a grid (similar to the design plane in MicroStation/J) that overlays the drawing area. This grid is used for backward compatibility with older versions of MicroStation. The resolution value does not affect the accuracy of a MicroStation V8.5 model. Changing its value will not increase or decrease the accuracy of the model. However, it can make it such that the model is not properly exported back to a MicroStation V7 file.



Advanced Unit Settings dialog box

ⓘ NOTE: The Resolution setting is critical to the proper operation of GEOPAK. The Resolution unit (Foot in the illustration) must match the Master Unit and the Unit System defined in the GEOPAK Preferences. This is discussed in more detail later.

The second setting is used by the solids modeling engines built inside of MicroStation V8.5. The solids modeling engines require a finite working cube, but MicroStation V8.5 has an unlimited drawing plane. Therefore, a fixed design cube must be defined for the solids modeling engines to function properly.

Understanding MicroStation V8 Coordinates

Previously it was stated that MicroStation's new Working Unit definitions allow it to understand the relationship between different units and automatically compensate for different drawing units when attaching cells and references. How does it work?

Understanding MicroStation Working Units requires understanding a little bit about descriptive geometry and mathematical coordinate systems.

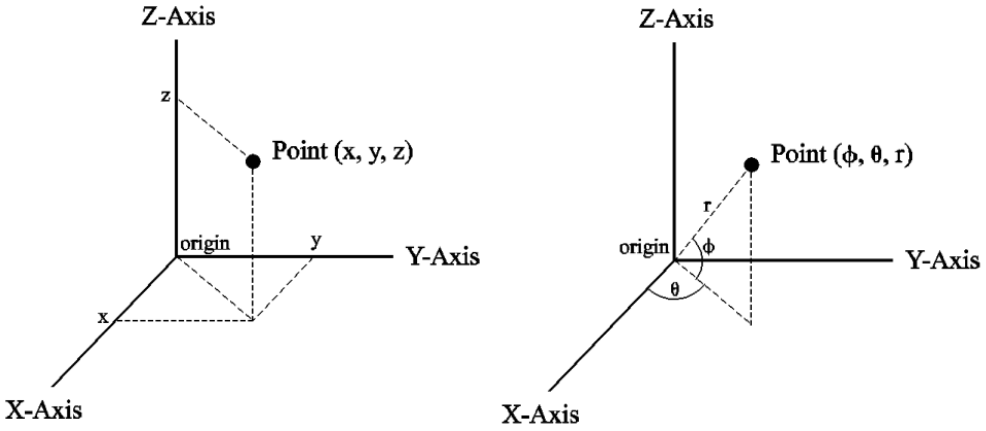
What is a coordinate system?

Although there are many different types of coordinate systems, they are all systems to locate the position of a point relative to another known location. MicroStation uses both Cartesian and polar coordinate systems. Both systems locate a point position measured along two axes (two-dimensional coordinate system) or along three axes (three-dimensional coordinate system) from an origin location.

The origin is the location where the reference axes intersect. The origin has the coordinate 0,0,0 by definition.

The Cartesian coordinate system locates the point as a linear measurement along each axis. For example, a point at location (3, 5, 2) is three units in the X direction, five units in the Y direction, and two units in the Z direction from the origin.

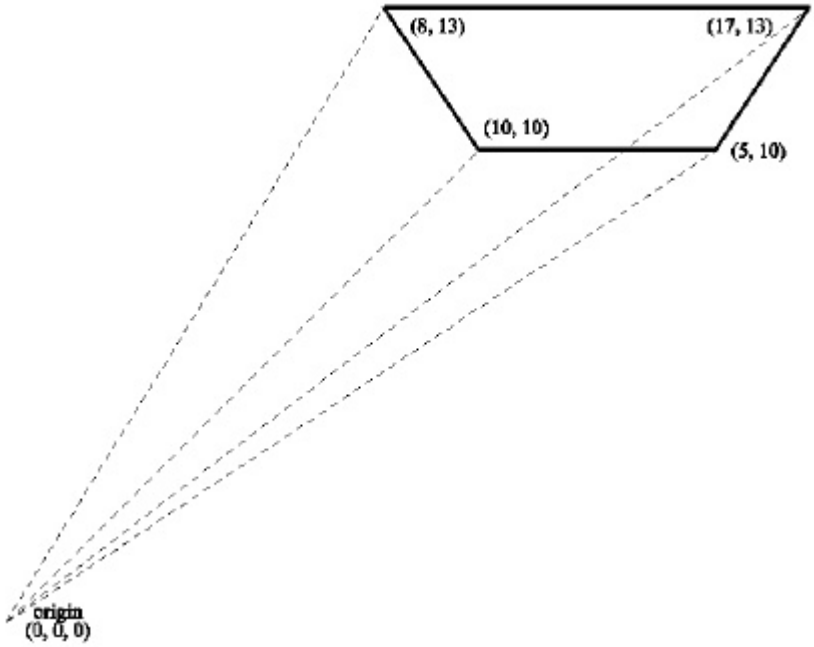
The polar coordinate system is based on the same coordinate axes, the difference is the point is located by measuring the distance and the angles between the axis and a line drawn between the origin and the point.



Cartesian and Polar coordinate systems

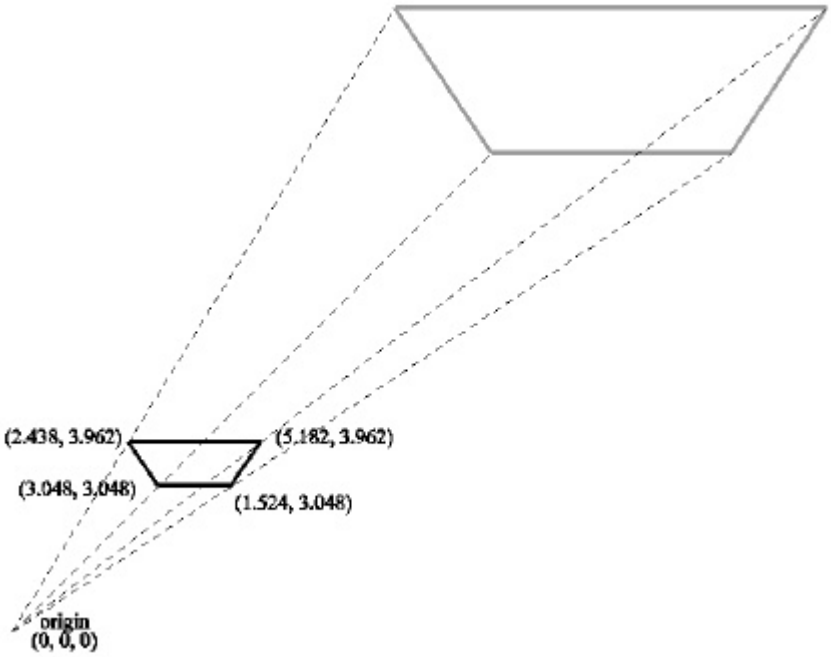
The key to understanding how MicroStation converts graphics from one coordinate system to another is understanding that the origin or 0, 0, 0 coordinate is the common point between all coordinate systems. When MicroStation coverts from one coordinate system to another, it does so by scaling the coordinates relative to the 0, 0, 0 origin point.

For example, consider a trapezoid drawn in a file with English units (feet). The coordinates of each vertex are shown in the following illustration.



Trapezoid drawn in English coordinates

If the file is converted to, or attached to a file with Metric units (meters), the trapezoid is resized by scaling the coordinates along a line between the original graphic vertex and the origin. In the following illustration, the trapezoid is scaled to be at the equivalent metric coordinates.



Trapezoid drawn in Metric coordinates

Foot vs. Survey Foot

Did you know there are two different lengths of a foot in the United States? There are, and MicroStation V8 must be setup correctly or you may not be drawing what you think you are drawing.

Internally MicroStation stores everything as a meter. Actually the meter is the official base unit of measure throughout the world. Even though feet and inches are the dominant units of measure in the United States, they are legally defined relative to a meter.

MicroStation uses the working unit definition to convert coordinates and distances to and from meters. Therefore, when the working units are set to feet and inches, MicroStation still stores the coordinates in meters and converts to feet and inches to display coordinates, distances, measurements, dimensions, etc.

Because MicroStation V8.5 converts all values from feet (or any other unit) to meters to store the data, it is critical that you understand the conversion process and the desired foot measurement. If not, your data may not be correct.

Before we get into MicroStation further, take a minute to review the difference between a foot and a US Survey foot. The following definition is taken from the 1991 edition of ASTM publication E380-89a (*Standard Practice for Use of International System of Units*).

> "The U. S. Metric Law of 1866 gave the relationship, 1 metre equals 39.37 inches. Since 1893 the U.S. yard has been derived from the metre. In 1959 a refinement was made in the definition of the yard to bring the U.S. yard and the yard used in other countries into agreement. The U.S. yard was changed from 3600/3937 m to 0.9144 m exactly. The new length is shorter by two parts in a million.
>
> At the same time it was decided that any data in feet derived from and published as a result of geodetic surveys within the U.S. would remain with the old standard (1 ft = 1200/3937 m) until further decision. This foot is named the U.S. survey foot."

Therefore the following definitions are in existence today:

1 foot = .3048000 m

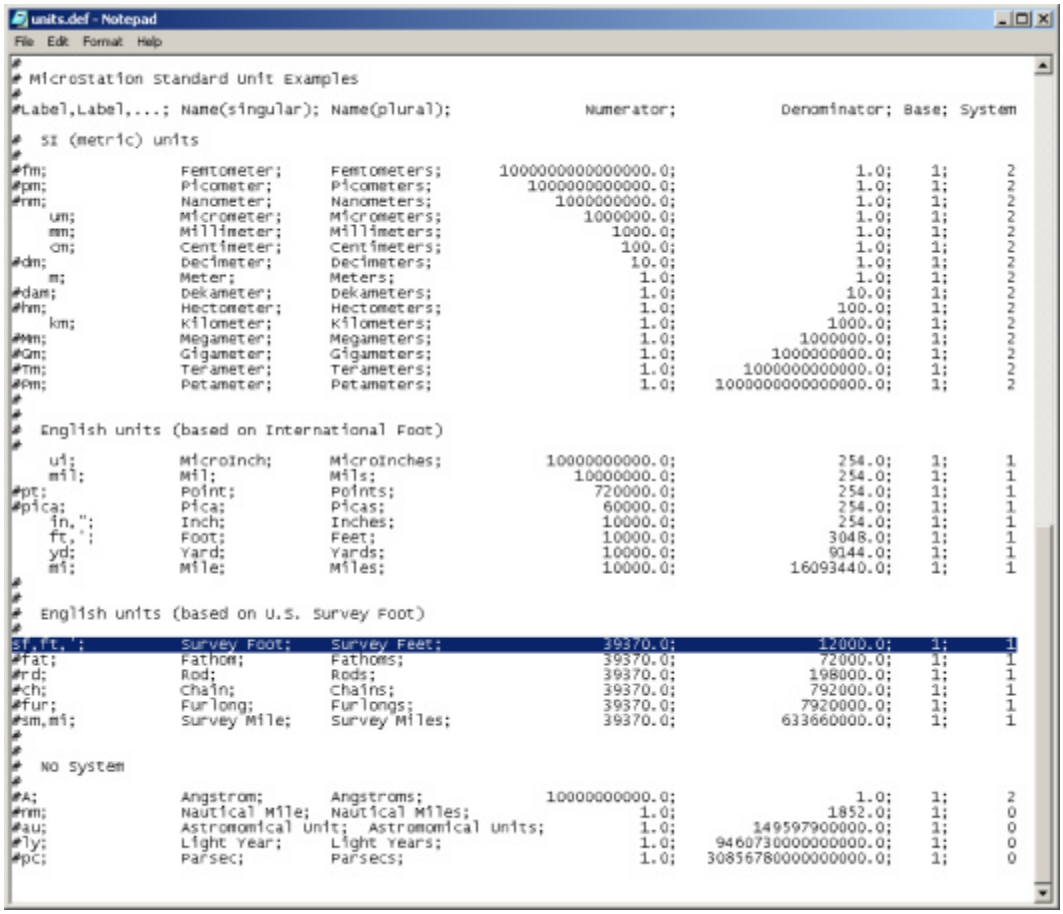
1 survey foot = 1200/3937 m ≈ .3048006 m

ⓘ IMPORTANT: The foot used by MicroStation in the standard unit list is based on the International Foot definition, not the US Survey Foot definition. This is the correct definition for most work outside of the civil engineering and surveying disciplines. Many states continue to base their survey work on the US Survey Foot. You must verify the basis of the survey for your projects to ensure you are working in the correct units of measure.

If the data is based on US Survey Foot survey measurements, using the standard foot definition (International Feet) in MicroStation will yield incorrect results on the order of 6 feet at a coordinate of 1,000,000.

MicroStation does not include the survey foot in the standard unit list to avoid confusion for those who do not understand the difference between a foot and a survey foot. However, MicroStation does understand the survey foot, the definition simply needs to be enabled.

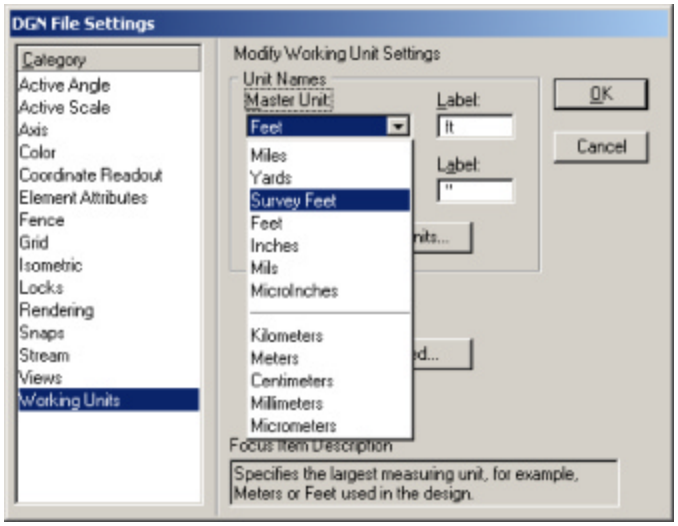
All MicroStation units are defined in a *units.def* file. The survey foot is already included in this file, it just needs to be activated. The *units.def* file is an ASCII text file located in the */Workspace/System/Data* folder within the MicroStation installation folder.



Units.def file in Notepad with survey foot line enabled

The units.def file already contains the survey foot unit definition, however it is commented out by default. Remove the pound (#) symbol from the beginning of the line as shown in the above illustration to enable the unit definition.

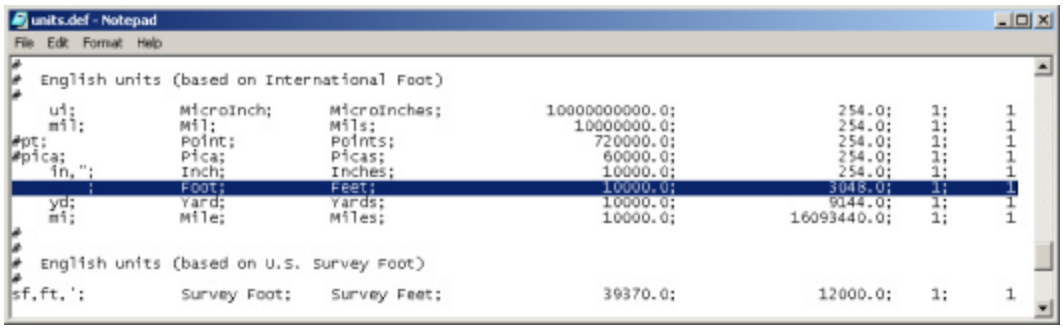
Once enabled in the units.def file, the units are available for selection in the Master Unit and Sub Unit boxes.



Master Unit drop down with Survey Feet included

ⓘ NOTE: The inclusion of custom units in the Master Unit and Sub Unit drop down lists is new to MicroStation V8.5. In MicroStation V8.0 and V8.1, the custom units such as Survey Feet had to be defined by either importing a V7 file or using a keyin as described below.

The labels at the beginning of each unit definition line in the units.def file are used when a MicroStation V7 file is converted to a MicroStation V8 file. For example, when a MicroStation V7 file working unit labels *ft* or ‘ is imported into MicroStation V8, it is automatically converted to International Feet because the label on the Foot definition in the units.def file includes *ft* and ‘. When multiple definitions contain the same working unit labels, such as the Foot and Survey Foot do in the default units.def file, the first definition is used. Therefore, when both the Foot and Survey Foot definitions are active (# removed from beginning of line), the Foot definition will always be used. To force the Survey Foot definition to be used, either move it above the Foot definition in the units.def file or delete the *ft* and ‘ labels from the Foot definition.



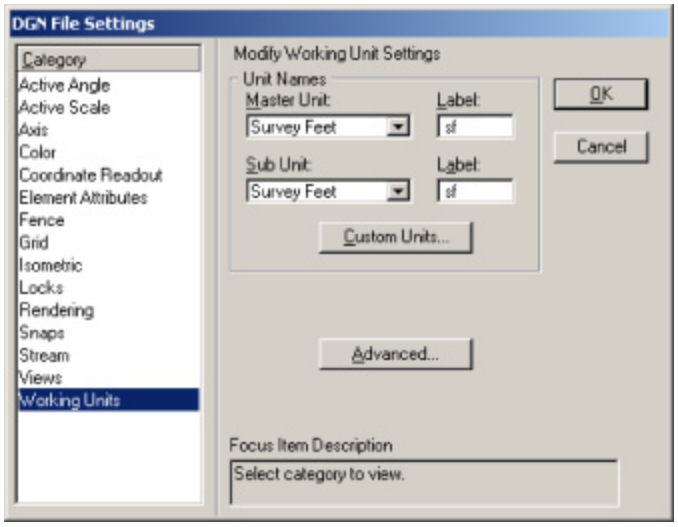
Foot definition with ft and ‘ unit labels removed

When using MicroStation V8.0 or V8.1, the survey foot units are activated in MicroStation in one of two methods. Both of these methods still work in MicroStation V8.5, but are not required since the survey foot unit can be selected directly from the dialog box.

Method 1: If a MicroStation V7 file is converted to MicroStation V8 and the Master Unit in the V7 file matches one of the label units for the survey foot in the units.def file, the working units in the MicroStation V8 file are automatically set to Survey Feet.

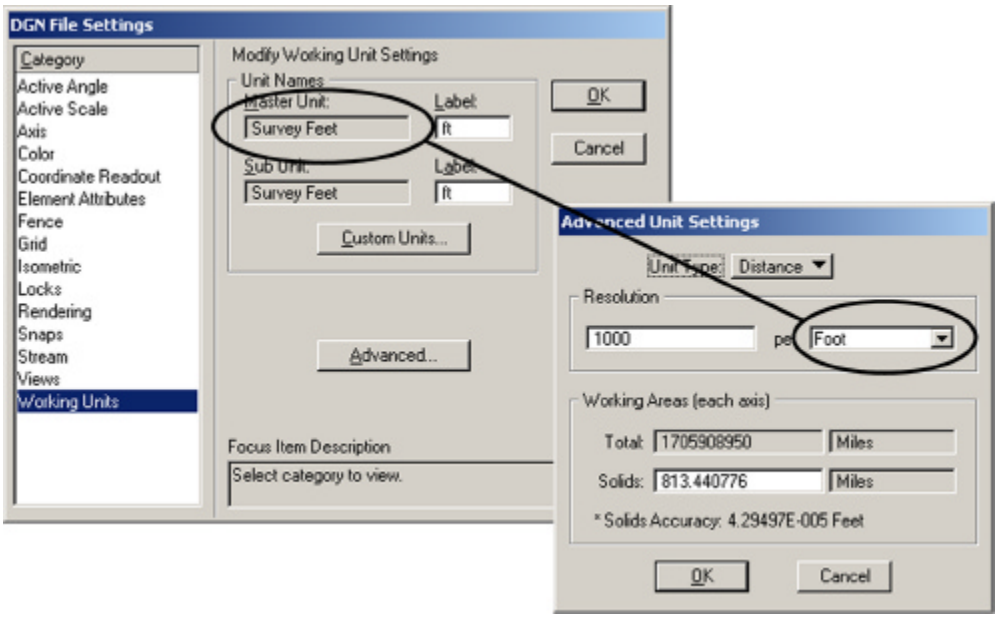
Method 2: An existing MicroStation V8 file is updated to the Survey Foot working unit by issue the keyin: set units "Survey Feet"

The working units are set to the survey foot definition instead of the default foot definition.



Survey Foot working unit definition

ⓘ WARNING: The ‘set units’ keyin method only sets the Master Unit and Sub Unit values to Survey Feet. It does not set the Resolution Unit on the Advanced Unit Settings dialog box. The Resolution Unit remains with its previous definition resulting in the Master Unit and the Resolution Unit having different values as shown below.



The SET UNITS keyin does not update the Resolution Unit

For GEOPAK users this is a critical issue. The issue is that GEOPAK looks at the Resolution Unit to determine the unit system and MicroStation looks at the Master Unit. Therefore, the result is that MicroStation is working in US Survey Feet and GEOPAK is working in International Feet.

To avoid this problem, GEOPAK users can create a new MicroStation V8 seed file by converting a MicroStation V7 file. When the V7 file is converted, and the units.def file is active with the survey foot definition, both the Master Unit and the Resolution Unit are set to Survey Feet. This seed file can then be used in MicroStation V8 to create all future files.

In MicroStation V8.5, you can also select the Survey Foot unit on the Advanced Unit Settings dialog box. Prior to MicroStation V8.5, the Survey Foot unit could not be selected on the dialog box. The only option was to create a new MicroStation V8 file by converting a MicroStation V7 file.

If you are working in InRoads or pure MicroStation, this will not be an issue.