Tech Tip - Compensating for Thermal Expansion

Working in environments that are not temperature controlled can produce measurement errors due to the temperature of the object being measured. When the object temperature varies from the standard 20˚C or 68˚F the dimensions of any part will change based on the physical properties of the material. This variable is calculated by the Coefficient of Thermal Expansion (CTE). **Formula:** *Material coefficient* x Temperature *deviation from 68°F* x *Length in inches*.

Example: 240 inch piece of Aluminum @ 80° 0.0000130 X 12 X 240 inches = 0.03744 = 240.03744

Note – In Verisurf it is possible to Scale Points, Pointclouds, and Features during the measurement process using Temperature Settings in the Device Manager. It is also possible to Scale after the measurement process has been completed.

This temperature change is particularly important when verifying distance measurements during a measurement task.

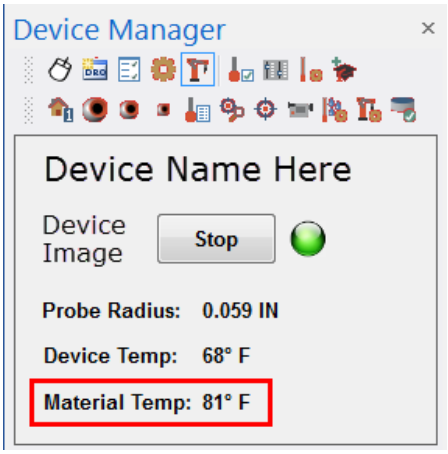
The longer the part being measured the greater affect temperature has on the part. Below is an example of the impact of temperature on Aluminum and Steel over given distances:

Aluminum Part				
Temp. in F	***1 inch/mm***	***100 inch/mm***	***240 inch/mm***	***1000 inch/mm***
65	0.999961	99.9961	239.99064	999.961
68	1.0000	100.0000	240.0000	1000.000
70	1.000026	100.0026	240.00624	1000.026
75	1.000091	100.0091	240.02184	1000.091
80	1.000156	100.0156	240.03744	1000.156
85	1.000221	100.0221	240.05304	1000.221
90	1.000286	100.0286	240.06864	1000.286
Steel Part				
65	0.9999799	99.99799	239.995176	999.979
68	1.0000	100.0000	240.0000	1000.000
70	1.0000134	100.00134	240.003216	1000.013
75	1.0000469	100.00469	240.011256	1000.047
80	1.0000804	100.00804	240.019296	1000.080
85	1.0001139	100.01139	240.027336	1000.114
90	1.0001474	100.01474	240.035376	1000.147

It is easy to see that a small temperature change in material can equate to large distance errors between points. In the case of measurement tasks that involve the measurement of points and comparing to nominal values, compensating for part temperature is critical.

CTE during Measurement in Verisurf

In Verisurf, the compensation for material temperature (Scale) can be done during the measurement process; the active material temperature can be easily viewed in the Device Manager window (shown on right):



Note about Laser Trackers

When using a Laser Tracker, the temperature and air pressure that is entered for the initialization process of the Device is only used to correct the laser's interferometer measurements back to the standard 68° F or 20° C. This is particularly important to note when distances will be measured between points on an object that is *not* 68° F or 20° C.

It is a typical misconception that this entering of Temperature accounts for Part Temperature as well, when in fact; it is only used to insure the Laser Tracker measurements are accurate.

Temperature Settings in Verisurf

Using Temperature Settings applies a Correction Scale Factor to the measurement device, all measurements taken after applying a Correction Scale Factor are therefore compensated for the currently entered material temperature.

*The type measurement task determines whether the part temperature must be considered. If the task requires you to verify distances or dimensions on a part that is NOT 68° F or 20° C you must "**Enable Material Compensation**" in the **Temperature Settings** dialog to achieve accurate measurements.*

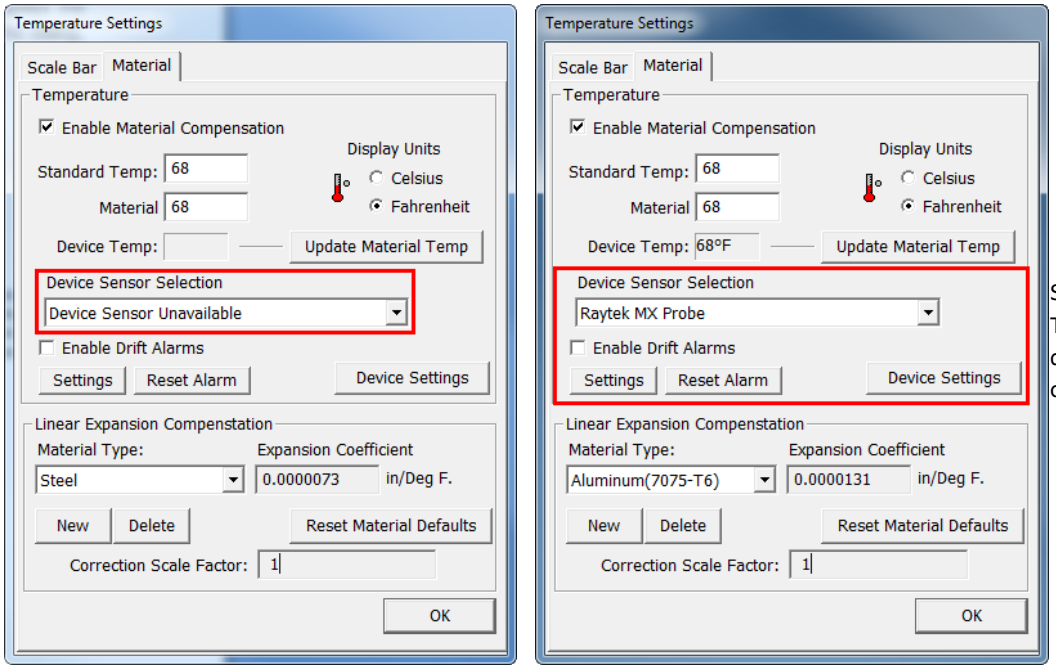
The **Temperature Settings** dialog controls how Verisurf compensates for the temperature of the object during the measurement process. **Temperature Settings** is accessed through the **Verisurf Device Manager** Toolbar only when a Device is active:

NOTE – Changes in the Temperature Settings dialog affect ONLY new measurements, all previous measurements remain unchanged. It is recommended that if Material Temperature must be compensated for the material compensation should be completed at the beginning of the measurement task (before measurements).

Using Material Compensation

In order to use Material compensation for thermal scaling, it is necessary to have one or more temperature probe(s) and an accurate material thermometer.

1. In the **Device Manager** dialog, choose the **Temperature Settings** button for the active device. Verisurf displays the **Temperature Settings** dialog (shown below), if a Temperature Device is not detected it will be noted in the dialog.



Shown when Temperature device is connected.

The Temperature Settings Dialog – Material Compensation

2. Select the Material tab, and choose **Enable Material Compensation**.
3. Enter the reference temperature in the **Standard Temp** input. This is typically 20°C or 68°F.
   – You can toggle the display units using the radio control marked **Celsius/Fahrenheit**.
4. If you know the **Material Temperature**, enter it; otherwise, your system can be configured to read it electronically.

Temperature Sensor Connected

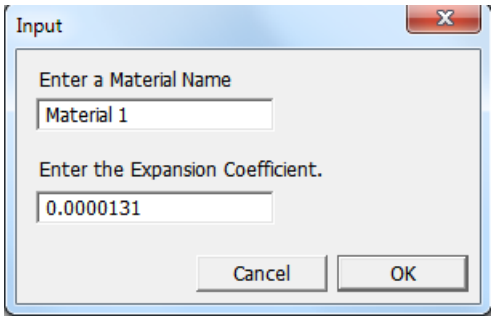
The following options are available if you have a *temperature sensor connected* to the system:

1. Use the drop-down list labeled **Device** to choose the temperature sensor. The list displays all part temperature sensors installed on the system.
2. Select **Enable Device Temperature for Material** to poll the device for part temperature. When you select this option, Verisurf displays the appropriate settings dialog for the selected device.
3. If **Enable Device Temperature for Material** is checked, you can also choose **Auto Update Device Temperature to Material**. With this option set, Verisurf will automatically update the material temperature to the temperature of the device.
4. Choose **Enable Drift Alarms** if you have selected both of the previous options and you want Verisurf to warn you if the part temperature drifts outside a preset limit.

Adding a Material Type

If you want to add a new material-type (and CTE), choose the **New** button. Verisurf opens the **Input** dialog:

1. Use the **Enter a Material Name** field to enter a material name, and then enter the **Expansion Coefficient** in the designated input field
2. Choose **OK** to close the **Input** dialog.
3. Verisurf adds the material to the list.
4. You can use the **Delete** button to remove the current material from the list.
   - The **Correction Scale Factor** in the **Temperature Settings** dialog are the values entered in the **Input** dialog.
5. Choose the **OK** button to close the **Temperature Settings** dialog.

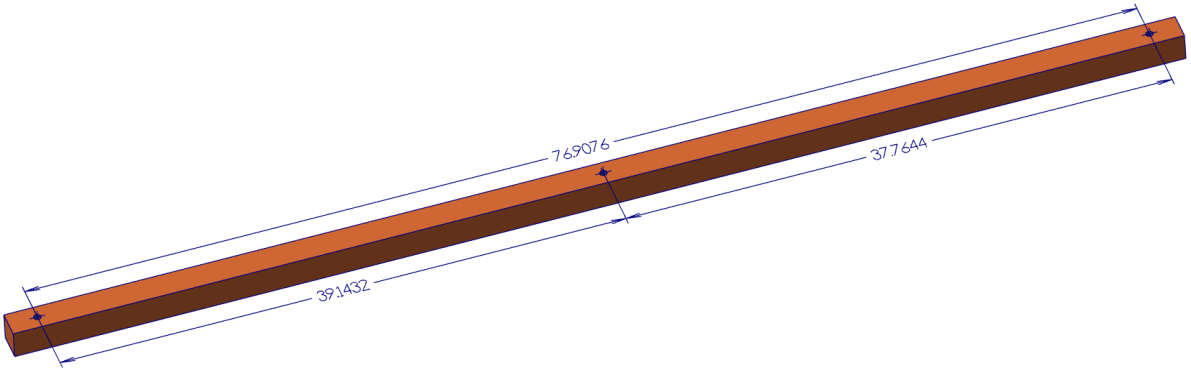


Verifying Scale of a Device

Determining whether a Device is measuring distance (scale) accurately can be accomplished using a Certified Scale Bar, these Scale Bars come in a wide variety of Material types. To perform this check the Scale Bar must be of the same material as the object, and be acclimated to the same temperature as the object being measured.

After applying the Material Compensation (see next section) the Scale Bar may be measured and the distance between the points compared to the calibrated distance of the Certified Scale Bar.

Note – it is common practice when using a Laser Tracker to verify Scale Bar distances after the Alignment has been calculated, due to the ability to "Scale" Auto Alignments and 3- Point Alignments.



Above: Laser Tracker Scale Bar with Three Certified Distances.

CTE after Measurements

When Points and Features have been measured using the Standard 68˚F or 20˚C Material Temperature but the object temperature varies it is possible to correct the measured Points and Features for temperature after the measurement process has been completed.

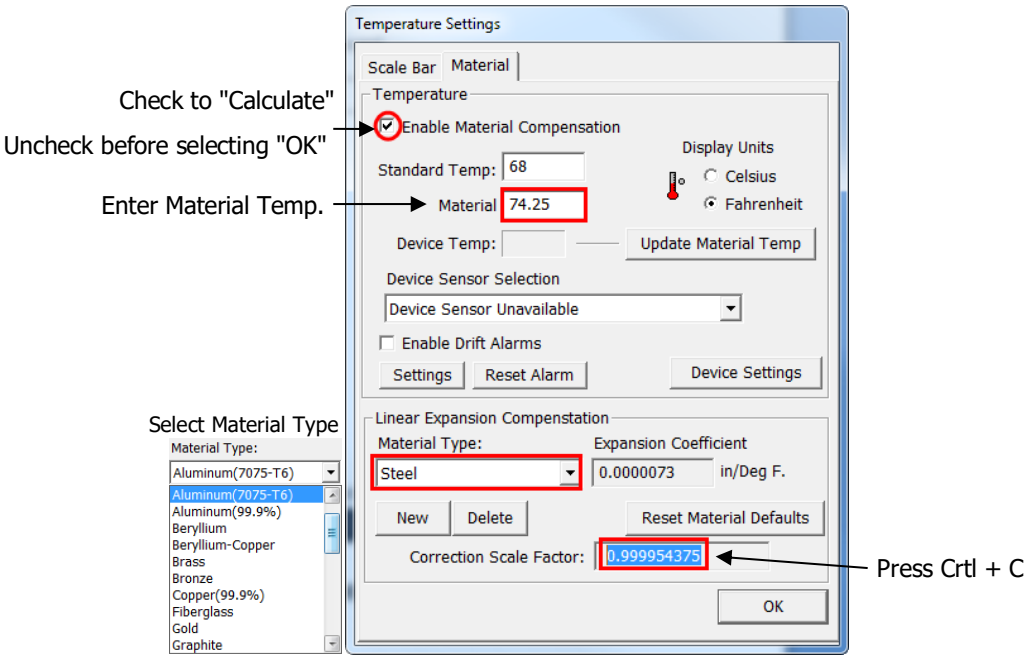
This process utilizes the **Temperature Settings** dialog box to perform the Scale Factor calculation that will be entered into the **XForm** dialog.

Calculate the Scale Factor

Prior to beginning the scaling procedure measure the object Temperature with an accurate (certified) thermometer.

1. Open the **Temperature Settings** dialog from the Device Manager (device must be active):

2. In the **Temperature Settings** dialog
   - Enable **Material Compensation** to activate the **Linear Expansion Compensation** field at the bottom of the Temperature Settings dialog.
   - Enter the **Material** temperature,
   - Select **Material** type
   - View the new **Correction Scale Factor**
   - Copy the **Correction Scale Factor** value using **Ctrl – C** from the keyboard.
3. After copying the Correction Scale Factor, **<u>disable the Material Compensation check box</u>**.
4. Select OK to exit the Temperature Settings dialog, continue to next section.



Use the Correction Scale Factor

The **Correction Scale Factor** can be applied using the **XForm** dialog box found in the speed menu of Points, Pointclouds, Features, and Alignments in the Measure, Analysis, and Reverse Managers.

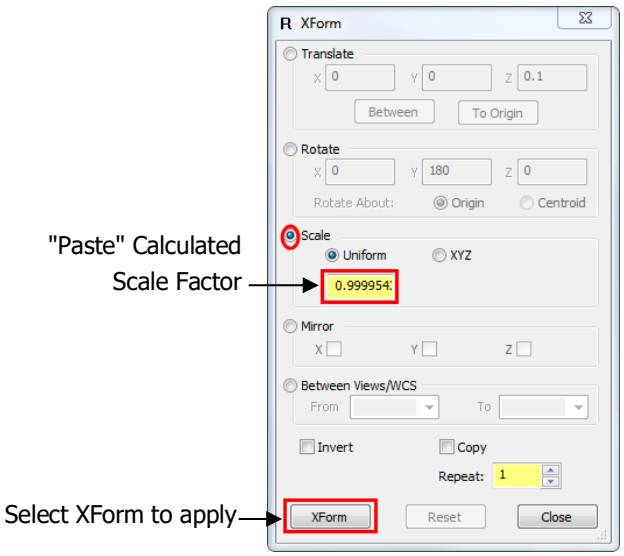
Depending on the application the **Correction Scale Factor** (Scale) can be applied as follows:

Selecting XForm for	How the Correction Scale Factor is Applied
Points	Scale is applied *only* to the selected Points.
Pointclouds	Scale is applied *only* to the selected Pointclouds.
Features	Scale is applied *only* to the selected Features.
Alignments	Scale is applied to *all* Points, Pointclouds and Features that are connected to the selected Alignment. If selected Alignment is also the current Device Alignment, Scale is applied to all future measurements done with the device.

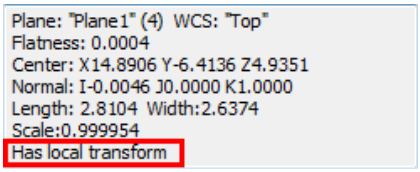
Applying Scale to Points, Pointclouds and Features

In the Measure/Analysis/Reverse Manager it is possible to apply a Scale Factor to single or multiple Points, Pointclouds or Features using this process:

1. In the Data Tree select the Point(s), Pointcloud(s) or Feature(s) to apply Scale Factor.
2. Using a Right mouse click accesses the speed menu, select **Tools – XForm** to open the **XForm** dialog.
3. Using the **Correction Scale Factor** that was "copied" in the previous section (Calculate the Scale Factor) paste the value into the Scale field as shown, then select the XForm button, close the dialog all selected points, pointclouds and features are scaled:



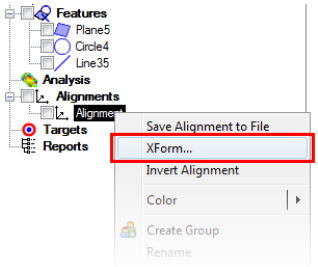
"Has local transform" displays when XForm is applied to Points, Point Clouds, or Features.



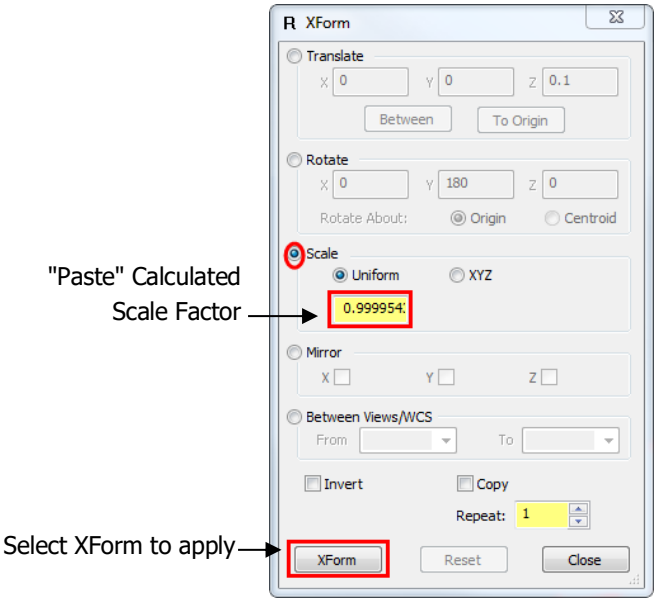
Applying Scale to an Alignment

Using XForm to Scale an Alignment offers the benefit of quickly scaling all Points, Pointclouds and Features that are currently connected to the Alignment. If the selected Alignment is the active Device Alignment all future measurements will be correctly scaled during the measurement process.

1. In the Measure, Analysis or Reverse Manager select the Alignment to apply a Scale Factor.
2. Using a right mouse click select **XForm**

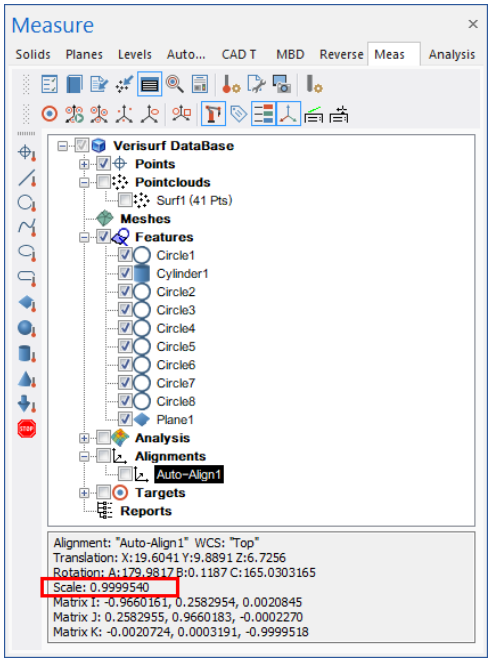


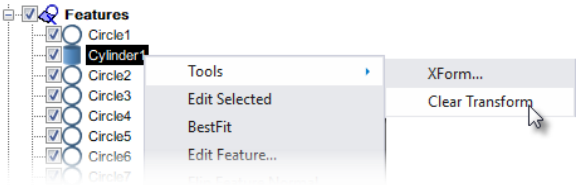
3. In the **XForm** dialog, "paste" the **Correction Scale Factor** that was calculated in the previous section (Calculate Scale Factor) into the **Scale** field, select the **XForm** button then **Close** the dialog:



4. After the Scale has been applied in the **XForm** dialog the Alignment in the Data Tree is shown with the applied Scale Factor when viewed in the Statistics box (shown below).

NOTE: At any time you can "Clear Transform" using "Tools" in the speed menu.





Note – All Points, Pointclouds and Features connected to the selected alignment are scaled. If the active device is connected to the Alignment all future measurements will be scaled.