Chapter 8.

Tolerance Variables and Units

Topic: Ignore

This chapter describes how tolerance variables and units are used in ACIS. This includes information on how these affect the sharing of model data between different applications.

Tolerance Variables

Topic: *Precision and Tolerance

In order to maintain model integrity, the modeler must work to specified tolerances. Applying tolerances insures proper interpretation of positions, such as maintaining that the points of vertices lie on the curves of the edges they bound or correctly determining if a position is inside or outside a volume.

ACIS uses the tolerance variables resabs, resnor, and resfit to control modeling operations. These are global variables defined in the system that affect modeling functionality. All modeling operations in ACIS use these tolerance variables to maintain consistency of mathematical operations. Although resnor should not be changed by the application, resabs and resfit may be changed, with great care, as explained in this chapter.

resabs

Topic: *Precision and Tolerance

resabs is named for *resolution absolute*. It is the smallest meaningful quantity representable in ACIS. This can be interpreted as the distance below which ACIS considers two points to be coincident. If two points, *A* and *B*, are separated by less than resabs, they are considered to be the same point.

resabs also represents the smallest feature being modeled, since it is the smallest distance between two points. The default value is 10^{-6}. The default value was chosen assuming that at least an order of magnitude *guard band* around resabs is required. Refer to the section *Dynamic Range* for more information.

resnor

Topic: *Precision and Tolerance

resnor is named for *resolution normalized*. This is the ratio of the smallest meaningful quantity representable in ACIS (resabs) to the largest. This reflects the precision to which numerical values are calculated and stored. The default value is 10^{-10}.

From the definition resnor = resabs/largest, the largest quantity representable in ACIS is:

$$\text{largest} = \frac{\text{resabs}}{\text{resnor}} = \frac{10^{-6}}{10^{-10}} = 10^{4}$$

resfit

Topic: *Precision and Tolerance

resfit is named for *resolution fit*. This is used as a guide to the fitting algorithms for the fit tolerance of an approximate curve or surface. The default value is 10^{-3}.

Polynomial approximations are computed for some curves and surfaces in ACIS. The approximations are stored in the model together with their corresponding curve or surface definitions. The approximations are used:

- Alone when approximate geometry is sufficient (e.g., for drawing).
- Together with the curve or surface definitions when more precise geometry is required; using the two together can make algorithms faster than using the curve or surface definitions alone.

Some fitting algorithms are adaptive, and therefore may produce tighter fits than resfit in certain circumstances; for example, in regions of high curvature.

Dynamic Range

Topic: *Precision and Tolerance

Within object space, the model world is characterized by the magnitude of the numbers on the entities being modeled; e.g., the smallest and largest coordinates existing on the model and the smallest and largest difference between any two coordinates. All object space numbers are represented in ACIS as double precision floating point numbers which contain roughly 14–16 significant digits. ACIS considers four of the least significant digits to represent numeric round-off errors that occur during calculations. Thus, there are roughly 10–12 digits to represent the *dynamic range* of numbers (smallest and largest numbers) within object space. ACIS has used the more conservative estimate of ten digits as a rough guideline to set the tolerances used internally to the modeler.

As described in the section *Tolerance Variables*, resabs is the smallest quantity representable in ACIS, and resnor represents the ratio of the smallest quantity to the largest quantity. The default values are 10^{-6} for resabs and 10^{-10} for resnor. The largest quantity which can be represented with the ten digits of precision is therefore 10^{4} (resabs/resnor = $10^{-6}/10^{-10}$).

The default values were chosen assuming:

- The units of the parts being modeled were approximately millimeters.
- Machining operations on parts would require 10^{-3} accuracy.
- Modeling operations would require several orders of magnitude more accuracy than machining.
- At least an order of magnitude guard band around resabs is required. For practical reasons, there can be ambiguity about distances that are close to resabs, so this guard band is a safety margin to improve reliability.

Practically speaking, this means that the dynamic range of models is 10^{-5} to 10^{4}. The dynamic range can be shifted by scaling resabs, but its magnitude cannot be expanded.

Theoretically, the magnitude of the dynamic range could be increased by altering resnor. However, this is **strongly discouraged** because the default value of resnor reflects limitations in double precision arithmetic, consideration of round-off errors, and the limit of 10 significant digits.

Note *If* resnor *is altered, the behavior of the modeling algorithms is unpredictable.*

Units and Sharing Model Data

Topic: *Precision and Tolerance

ACIS was designed around the concept that all parts are modeled in a single *unitless* number space (object space). One could think of the numbers as being inches, or millimeters, or any other unit.

Although ACIS has historically been a unitless modeler, the sharing of model data between applications can be difficult if no units are applied, because different applications may *assume* different units of measure. For example, application *M* may assume the units are millimeters, while application *N* assumes feet. If application *M* reads in a model that was stored in an ACIS *save file* (.sat or .sab file) by application *N*, there is an incompatibility.

To avoid incompatibilities when applications share model data, ACIS has chosen *millimeters* as the default unit of measure. Internally, ACIS does not apply any unit of measure to numbers. However, an underlying unit of measure is required for persons and applications to properly interpret data. When data is written to a save file, ACIS assumes this underlying unit to be millimeters.

To support the sharing of model data between various applications having different internal units, the save file format enables an application saving the model to indicate the units assumed when the model was created. This is done by indicating the number of millimeters (the default unit) represented by each unit in the save file data. The current value of resabs and resnor are also saved when a part is written to the file. Refer to the *Kernel Component Manual* for information about how this data is saved in the file.

ACIS takes no action upon seeing values for the millimeters per unit, resabs, or resnor in the save file that are different from those set in the restoring application, other than producing a warning message using sys_warning. It is the responsibility of the application to take appropriate actions, such as setting a body transformation on the model via a scaling transformation. This unit and tolerance data in the save file simply enables the application restoring the model from the file to determine the units and tolerance in effect when the model was written to the file. The application can then compute an appropriate scaling factor.

Scaling Tolerance Variables

Topic: *Precision and Tolerance

For interchange of model data between systems, the “real-world” distance represented by resabs and the actual numeric value of resnor in the two systems should agree. The “real-world” distance refers to an application’s interpretation of the numerical value of resabs in conjunction with the assumed units as the distance represented.

For example, two applications may use different numeric values for resabs, but if they assume different units as well, the distance represented by resabs may be the same. If application *M* uses a unit of millimeters and has a resabs value of 10^{-6} and application *N* uses a unit of meters and has a resabs value of 10^{-9}, the “real-world” distance represented by resabs is the same in each application, because 10^{-6} millimeters = 10^{-9} meters. The largest dimension represented in each is also equivalent, because resnor does not change. In application *M*, the largest dimension is 10^{4} millimeters, which is equivalent to the 10^{1} meters representable in application *N*.

The object transferred should be scaled by the restoring system to maintain the object’s original “real-world” size in the restoring system’s units. When an object is scaled, the absolute tolerance for which the model is valid is scaled by the same amount.

resabs scaling

Topic: *Precision and Tolerance

To change internal units, only resabs should be changed to reflect the new numerical value of the old “real-world” distance (as represented with the previous units). Even if the application does not need to interchange data, resabs may need to be changed so that the numbers used to represent distances are appropriate for the application. This shifts the dynamic range, but does not change its magnitude.

When different systems share model data, they should agree on the “real-world” distance represented by resabs. This means that they don’t necessarily have to agree on the numeric value of resabs, depending on the units being used.

resnor scaling

Topic: *Precision and Tolerance

resnor should not be modified by an application. resnor is a unitless ratio of the smallest number to the largest, and therefore should not be scaled when modifying the unit of measure. The value for resnor needs to be the same between applications that share model data.

Note *If* resnor *is altered, the behavior of the modeling algorithms is unpredictable.*

resfit scaling

Topic: *Precision and Tolerance

There is no inherent requirement for resfit to be equivalent among applications sharing data, because the fit values that are stored with the restored model will be scaled if the model is scaled. For normal operation (fit accuracy and speed), however, resfit should be a reasonable multiple (e.g., 1000) of resabs; therefore, if resabs is scaled, resfit should be also.