Creating a Radiation Request

Use *Radiation Requests* to activate radiation simulation for selected elements. TMG computes radiative conductances between shell elements using a view factor technique, which assumes diffuse emission and reflection from surfaces.

For every *Radiation Request*, black-body view factors (form factors) are calculated between the selected element sets. These are then used to calculate radiant heat load emitted, reflected and absorbed through the enclosure. You can control the accuracy of the view factor shadowing calculations with the *Error Criterion* or *Fixed Subdivision* options.

Only beam and 2-d thin shell elements participate in radiation. For an element to radiate, it must have defined optical material properties. If you define these properties only on one side, either front or reverse, this side will participate in the radiation calculation but the other will not. Always turn *ON* the element triad visibility (see *Display Options*) to determine shell elements' front side.

You can also activate the reverse (-Z) side of shell elements using the *Reverse Side* tool. A Reverse Side entity, when it exists, always supersedes the reverse side material properties of the elements on which it is applied.

Element Types for Radiation Modeling

- Solid Elements

  are ignored for radiation analysis: they do not radiate, nor do they block radiation. To model radiation from a face of a solid element, you must surface coat that face with a thin shell element.

  Shell elements coating solid elements should NOT have reverse side material properties defined. The only exception to this is if you have a transparent solid. In this case you can enable radiation through the solid by defining material properties on both sides of the coating elements. For non-transparent solid, the front sides must face outwards. Check the direction of the +Z triad of the coating elements.

- Shell Elements

  model the radiating surfaces. Only shells with emissivity values between 0 and 1 can radiate or block radiation. If one side does not have its emissivity defined, the element will not radiate from this side but it will still block radiation.

  You can also define a *Reverse Side* entity to enable radiation from the reverse sides of the elements. A *Reverse Side* entity always supersedes the material properties defined for the reverse side (if any).

- Beam Elements

  model regular cylinders. TMG uses the beam's perimeter from its beam section definition and constructs an equivalent six-sided cylinder. The view factors for the six faces are computed individually then merged together. Only beams with emissivity values between 0 and 1 can radiate or block radiation.

- Axisymmetric Elements

can be included in a radiation model. See *Axisymmetric Modeling*.

- Fluid Elements

  cannot radiate.

Options

You can control model complexity by using the *Enclosure* type radiation request. In this type of *Radiation Request*, shadowing checks are limited to elements included in the *Radiation Request*.

For all models which can radiate to an ambient environment, activate the *Include Space Elements* option.

A ray tracing option can be used to improve the view factor radiation model for diffuse solar reflection and infrared specular or transparent surfaces: see *Ray-Tracing.*

You can also model radiative heat transfer using *Radiation* type Thermal Couplings or Thermal Boundary Condtions; radiative heat transfer can also be modeled using the *I-DEAS Boundary Conditions* task. These methods may be simpler to use when the gray-body view factors are known.

Radiation Request Types

- *All Radiation*

  Radiation from all surface elements will be modeled. TMG will calculate view factors for all surface elements in the model.

- *Enclosure*

  View factors and shadowing checks are limited to elements included in the enclosure, reducing the view factor calculation load.

  In order to simplify the model, you may choose to omit certain surfaces from your model, leaving a small gap between elements. Or, for another example, a certain element might bridge two enclosures, effectively creating a leak.

  Enclosure enables you to define a set of elements as an enclosure even if they are not contiguous. This type of request ignores any gaps or bridging elements in the enclosure. Any gap between elements will cause inaccuracy in view factor calculations. However, you may choose to ignore these if the gaps are small enough.

  Even if you want to model a topology that radiates to the environment an *Enclosure* radiation request is appropriate. Select the elements on all external surfaces and pick the *Include Space Elements* option; then use *Space Enclosure* to create a non-geometric element surrounding your model.

  Since 2D elements can radiate independently from both sides, you must specify the elements for which the front side is active and the elements for which the reverse side is active in the enclosure. Elements that are inside the enclosure (by opposition to those that are on its boundary) have to be selected twice to activate radiation from both sides. If a *Reverse Side* entity exists for elements selected to radiate from their reverse side, TMG will apply the properties defined on the *Reverse Side* entity. (see *Front and Reverse Element Side).*

You can select elements and Reverse Sides by either the *group* or *visible* method. Geometry groups ensure that the request will remain valid even if you have to re-mesh or modify dimensions.

- *Group to Group*

  TMG will calculate only those view factors from Element Set 1 to Element Set 2. All elements in the model are checked for shadowing.

- *Among Group*

  Only view factors between the selected elements will be calculated. With this option, all elements in the model are checked for shadowing. Use this option to recalculate the view factor of specific elements with more precision. For example, first create an Enclosure Radiation Request to calculate view factors for all elements in the enclosure. Then create an Among Group Radiation Request for the specific elements requiring more precision. Since Radiation Request are done sequentially, the view factors calculated by the second Radiation Request will replace the previous values only for the elements specified.

- *Group to All*

  TMG will calculate all view factors for the selected elements. All elements in the model are checked for shadowing.

Shadowing Checks

Include Shadowing Checks should normally be performed for all Radiation Requests. The only situation in which you may deactivate these checks is where you are certain that all element pairs will have an unobstructed view (e.g. a uniformly concave enclosure such as a room with only four flat rectangular walls).

If you specify an *Enclosure* radiation request, *Include Shadowing Checks* performs checks only for those elements included in the enclosure. For the other types of radiation requests, every element in the model is checked.

The *Error Criterion* is the default option for shadowing granularity. It specifies a view factor error tolerance with respect to shadowing checks. When you specify an error criterion, the software will estimate a subdivision level for each view factor, using the lowest subdivision level that should satisfy the error criterion you specified. This is the recommended option to use for computing shadowed view factors. (See the article on *Shadowing Checks* for more information).

The *Element Subdivision* menu sets the granularity of the element subdivision for computing shadowed view factors. Choose one of six levels of granularity numbered 0 to 5: a higher subdivision level will yield more accurate radiative conductances at the cost of additional computation time. The *Global Subdivision Parameter* is set under *Radiation Control* and is the default value for all view factor requests.

Note that the sequence of the view factor requests can be important. If a computed view factor is recalculated by a subsequent request, the original value is overwritten. You can use this feature to improve the view factor accuracy for selected elements, as in the following example:

1. Create an *All Radiation* request with the *Use Global* parameter.

2. Create subsequent view factor requests to recalculate the view factors for selected

elements using a higher *Fixed Subdivision* parameter. This can be repeated for as many elements as you wish.

Hemicube Method

The hemicube algorithm is an alternate method to calculate shadowed view factors. It uses your workstation's graphics card in conjunction with the Open Graphics Library (OGL) to speed calculations. You must set your display mode to True Color 24-bit or True Color 32-bit. The current version of the hemicube method does not support ray tracing, axisymmetric elements or articulation.

If the hemicube option is active, a small window pops in the top left hand corner of your screen during the solve. In this window, the hemicube calculation engine uses your graphics hardware to draw the scene of elements as seen from each element in your *Radiation Request.* The software post processes these images to determine the view factors. You can hide the hemicube calculation window by setting an Advanced Solver Option under Solver Control.

Because it uses graphics hardware to draw the scene, the hemicube algorithm is potentially very fast. However, the accuracy of the algorithm depends on the number of pixels used to draw the images, and there is always a resolution limit associated with the minimum view factor contribution of one pixel.

You can adjust the accuracy of shadowing checks by setting a Fixed Subdivision parameter. (The Error Criterion option is ignored)

In general, OGL graphics hardware supports the Hemicube method. The following graphics cards have been tested to support the hemicube method on Windows 2000 and Windows NT:

- 3D Labs Oxygen VX1
- 3D Labs Wildcat 4110
- Matrox G400
- ATI Fire GL2
- Nvidia Quadro 2Pro
- Nvidia GeForce2 GTS Plus

Notes on Setting Up Radiation

- If you have surface coating elements or if you use materials for which the optical properties are defined only on one side, verify that element orientation is correct using the element triad display. Check shell normals to enforce consistency. Use the *Element Reverse Connectivity* command in the TMG menus to reverse the connectivity of the selected elements.
- If you know the gray-body view factors beforehand, use *Thermal Couplings* or the *I-DEAS Boundary Conditions* task to model radiation instead of calculating them with a TMG simulation.
- To deactivate elements for radiation, use the *Element Radiation Switches*. This can greatly reduce solve time.
- If on a subsequent run you want to change some element emissivity values, you can reuse previously calculated black body view factors (see *Restarting the Solution*).
