

## Form - Diaphragm

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*Diaphragm* works as an element-factory, which conveniently creates boundary elements for a variety of shapes: From a very simple disc to a complicated oval-cone including the magnet. The Diaphragm component can be used to model the acoustic boundaries of a loudspeaker or microphone membrane as well as to provide virtual couplers to the [LEM-part](#). An example of the latter is the aperture of the port of a vented loudspeaker cabinet.

Create a new *Diaphragm*-component with the help of the [New Component Form](#). The home of a *Diaphragm*-component is page *BEM*. Edit an existing component by dbl-click its entry on page *BEM* or issue menu *Edit/Parameters* or press CTRL+E.

The rigid body motion of the moving part of the diaphragm is assumed to be in direction of the normal of the disc or the main-axis of the loudspeaker cone. Currently other motions and higher mechanical modes are ignored.

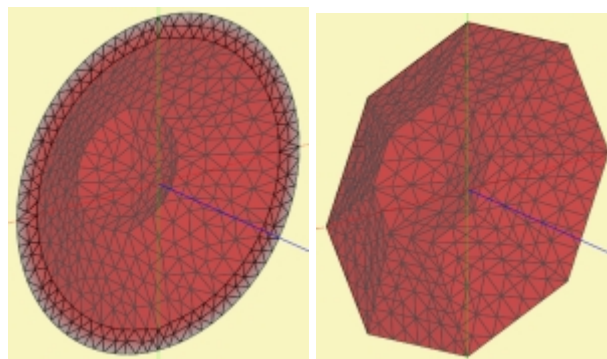
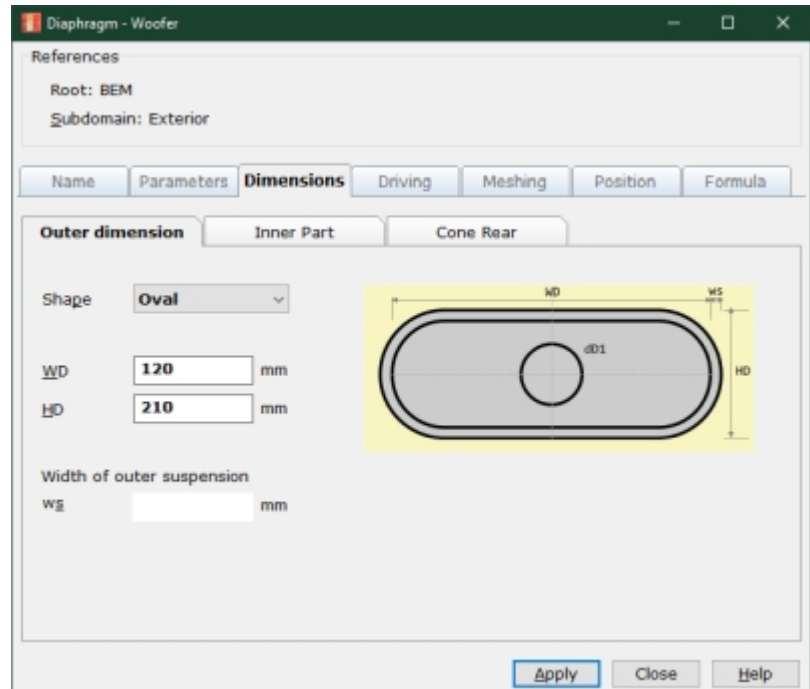
### Page - Name

On page *Name* provide the name of the component in form of a [string](#). Further there is space for annotations.

### Page - Parameters

#### Modeling

**Side:** A technical Diaphragm has two



sides. The component is going to create acoustic boundaries only for its *front* or *rear* side, respectively. Hence, if you are going to model the front and the rear boundaries you would need two Diaphragm components. The Side-parameter helps to ease the specification. The idea is to specify all size-parameter only at the first component. The second component would use the **Inheritance**-link in order to receive all parameters from the first. The second Diaphragm would over-write the Side-parameter to Side=Rear.

The Side-parameter also controls the direction of the normals and the driving direction. Hence, even if you indent to model the rear boundaries you would input the Diaphragm forwards, however with Side=Rear.

**Model:** Selection which controls the level of details taking into account for modeling. For details see chapter **Diaphragm - Modeling**.

**Num Rings:** This integer can refine the shape of a dome, poles or sphere. If left blank the default of Num Rings = 2 is used.

### Baffle

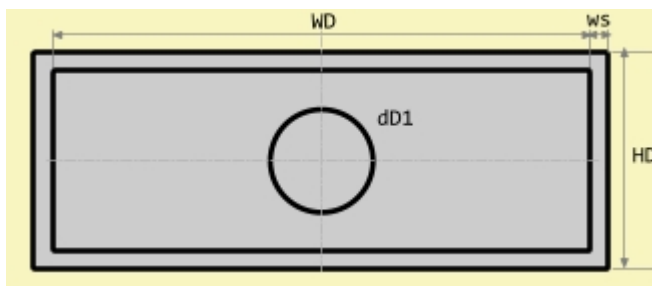
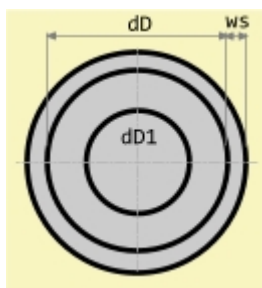
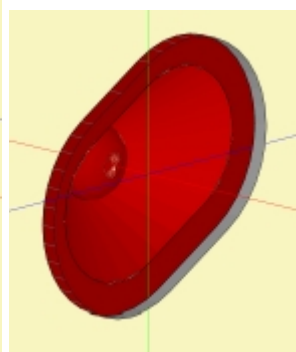
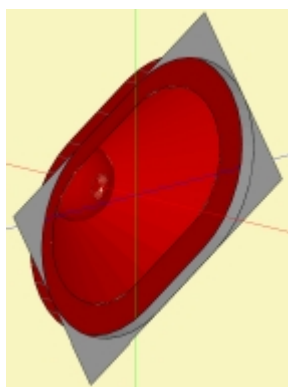
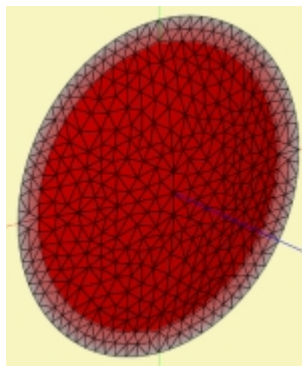
The local baffle helps to embed circular shapes into an otherwise rectangular environment. See chapter **Sub-Baffle** for details of parameters *Baffle Type* and *Offset*.

### Colors

*Color of Boundary* specifies the color of non-vibration parts, such as the sub-baffle, pole or magnet. By default this color is gray.

*Color of Vibrating Parts* can be specified individually. The default color is red.

You can alter the settings at the



## Color-Form.

**Page - Dimensions - Outer Dimension****Shape**

Specifies details of the outer shape such as the a circle, a rectangle, an ellipse or an oval, respectively. *Area* yields a circular shape.

**dD, WD, HD, SD**

*dD* is the outer diameter of a circular diaphragm.

*WD* and *HD* are the outer dimensions of a rectangular diaphragm. *WD* is the width and *HD* is the height. The particular shape can be selected with the help of parameter *Shape*. The width is along the local horizontal direction. Use *Rotate Axial* of *Scaling* in order to rotate the diaphragm about its axis.

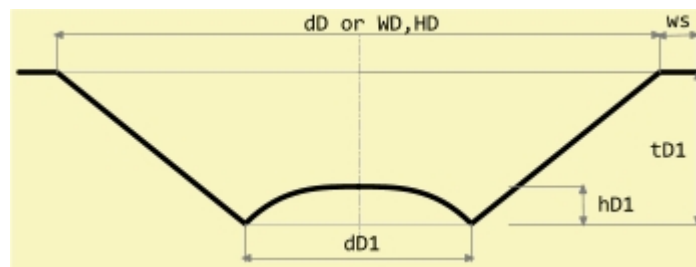
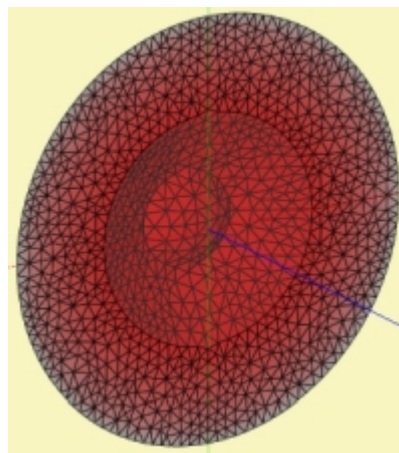
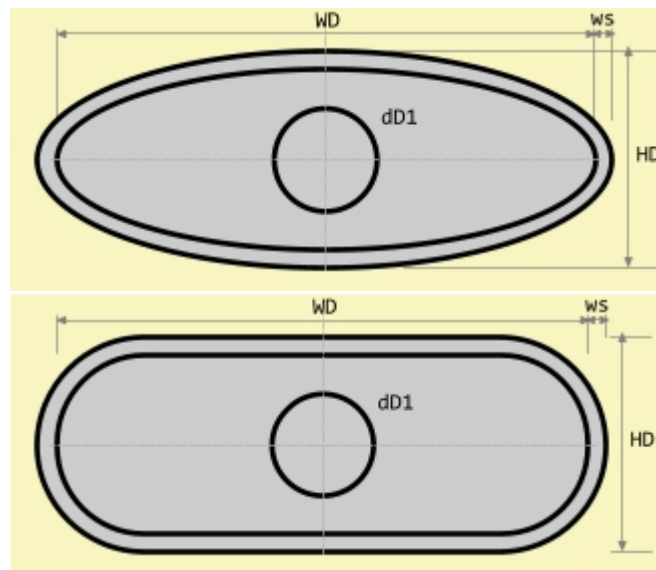
*SD* specifies a diaphragm of circular shape with the help of the value of the projected area.

**Width of Outer Suspension**

*ws* specifies the width of the outer suspension.

Elements, which are generated for the suspension, feature a velocity-gradient. The velocity-weight-factor is one for points close to the diaphragm and zero at the outside rim of the suspension. As demonstrated in the picture the viewer displays the velocity gradient by a shade of grey after meshing.

For the *Simplified Model* the value of *ws* is ignored. In this case we assume the suspension is part of the diameter of the Diaphragm. Typically, half of the actual width of the suspension should be added



$$dD = dD_0 + ws.$$

## Page - Dimensions - Inner

The Diaphragm can have an exclusion, a dome or a pole at its center. The inner feature is always centered and of circular shape.

A loudspeaker cone is created by specifying the depth  $tD1$ . A flat membrane you get with  $tD1 = 0$  and  $hD1 = 0$ . A dome is rendered with  $tD1 = 0$  and  $hD1 < 0$ .

### The Inner Part of Cone

*Diaphragm* means there is a dust-cap vibrating with same velocity as the main-membrane.

*Pole* creates a dome-shaped rigid boundary, i.e. it is not vibrating.

*Hole (exclusion)* leaves a void in the center of the diaphragm.

### dD1

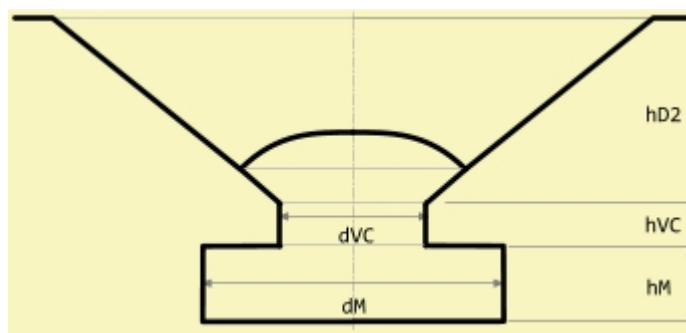
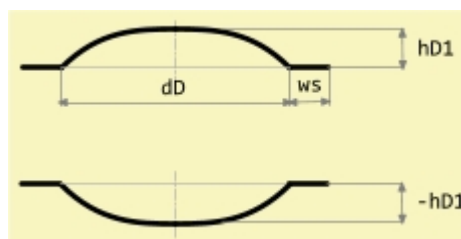
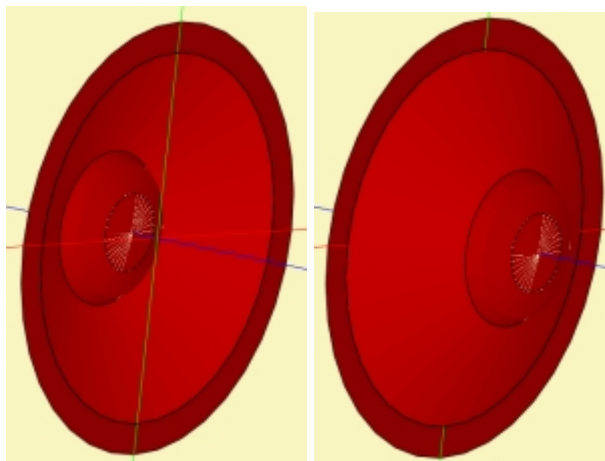
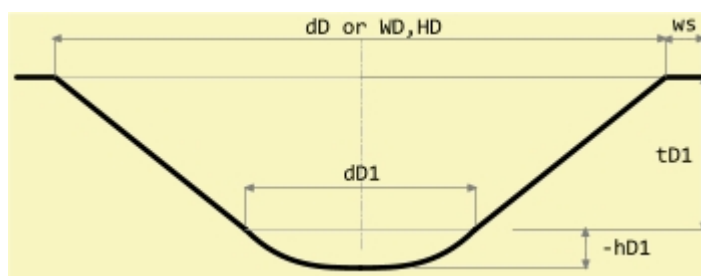
$dD1$  specifies the diameter of the inner feature, which can be a dust-cap, a pole or a hole depending on the selection of *The Inner Part of Cone*.

### tD1

Positive values create a concave cone otherwise it is convex or flat.  $tD1$  measures at the front side of the diaphragm and from the level of the suspension down to the base of the dust-cap.

### hD1

$hD1$  is the height of the dust-cap, dome or pole. If  $hD1 > 0$  then the feature is rendered convex, if  $hD1 = 0$  flat and if  $hD1 < 0$  its shape is concave.  $hD1$  is also the height or depth of a dome-type Diaphragm with  $tD1 = 0$ .



## Page Dimensions - Cone Rear

Parameter on this page take only effect if *Modeling Side = Rear* (see above). However, because of the possibility of inheritance it can be of advantage to specify the rear-parameter also at the ancestor.

### hD2

hD2 measures the outside of the cone from the outer suspension down to the voice-coil mounting point.

### dVC

dVC measures the diameter of the voice-coil cylinder on the outer side of a cone-shaped Diaphragm.

Even for *Modeling-Side=Front* you would need to specify dVC if *The Inner Part of Cone = Pole*. In this case the pole automatically is assigned the diameter of dVC.

If there is no magnet (dM=0 or hM=0) the hole is closed by a non-vibrating boundary.

If dVC < 0 and there is no magnet and then the hole is left open.

There is no dedicated pole for the *Modeling Side=Rear*, however a pole can be approximated by using the magnet parameters dM and hM.

### hVC

hVC is the height of the "visible" part of the voice-coil former on the outside. By default hVC=0. The motion of this particular part of the diaphragm is always tangential. Because of this the voice-coil former appears as a non-vibrating boundary.

### hM, dM

hM is the height or thickness of a simplified magnet. dM is its diameter. If not specified then the magnet is replaced by a non-vibrating disc of diameter dVC.

## Page - Driving

At solving stage the driving velocity is  $v = 1$  m/s. This is the default value. At observation stage this value will be multiplied by the corresponding parameter of the [lumped element network](#) or of the [fixed driving table](#).

### Amplitude

Value of amplification. By default the amplitude is  $v = 1$  m/s.

### Delay

Value of signal delay  $\tau$  in seconds:

$$v_2 = v_1 \cdot \exp(-j \cdot \omega \cdot \tau)$$

### Direction of Motion

*Normal* means that boundary elements' vibration is in direction of the normal of the triangle. It is like the

structure is "breathing".

*Axial* means that motion is assumed to happen in axial direction, such as a typical loudspeaker should do. *Axial* is the default setting for a Diaphragm.

### Boundary Property

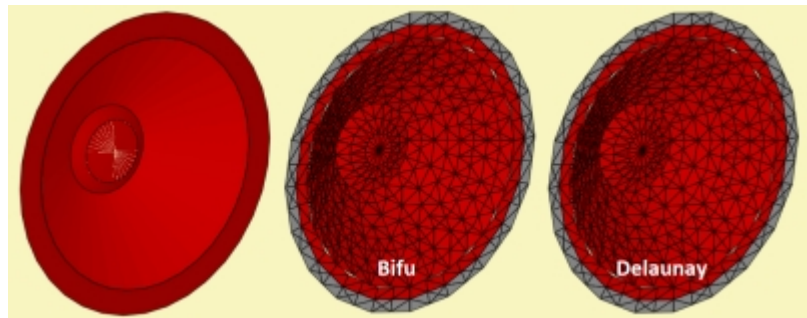
*Neumann* makes all boundaries reflective and non-vibrating.

*Vibrating* enables the vibration of the diaphragm. This is the default. This means that the acoustic velocity is equal to the mechanic velocity at the surface and in normal direction.

## Page - Meshing

On this page you can control the way the finite element mesh is generated for the Diaphragm. If not specified Diaphragm uses Meshing parameters of its Parent, which is a [Subdomain](#). This in turn defaults to global settings (see menu *Global/Meshing...*).

**Spec Type:** For a Diaphragm, which is linked to another Diaphragm from which it [inherits](#) parameters, there is the option to select from where to receive default values.



**Meshing Type** and **Edge Length** and further parameters are described in chapter [Form - Meshing](#).

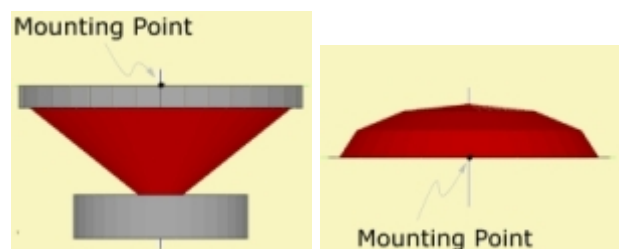
The Diaphragm is a complex component. For most of its parts the Meshing Type can be chosen. However, the magnet of the Diaphragm is always meshed with the help of bifurcation (Bifu). Also, there would be performed a special meshing if [Diaphragm - Modeling](#) = Simple. Also the local baffle is meshed in a special way.

If there is a suspension part specified ( $w_s > 0$ ) the application tries to mimic a velocity gradient. This goes to zero at the outer edge. With *Meshing Type* = *Bifu* there will be two rings of finite elements the first with velocity and the second without. With *Meshing Type* = *Delaunay* the gradient is smooth.

## Page - Position

A Diaphragm is positioned by attaching it to a coordinate from a [Node-database](#), to mesh-file-planes or by using the Shift parameter of the Scaling feature. The mounting point is the center of the outer edge of the diaphragm.

Positioning and orientation is specified at page *Position* of the form and described in chapter [Form - Position](#).





## Page - Formula

All parameters of format **floating-point** can be assigned a formula. Please check chapter **Frame - Formula** for further details. Formula-identifiers for Diaphragm parameters are:

### Parameter

tB                      Recess of local baffle

### Outer Dimensions

dD                      Diameter

WD                      Width

HD                      Height

ws                      Width of suspension

### Inner part

dD1                      Diameter inner part

tD1                      Depth/height of cone

hD1                      Height/depth of dome

### Cone Rear

hD2                      Height of cone

dVC                      Diameter voice coil

hVC                      Height voice coil

dM                      Diameter of magnet

hM                      Height of magnet

### Driving

Weight                      Signal amplification

Delay                      Signal delay

### Meshing

EdgeLength                      Length of largest edge

EdgeLengthMin                      At which to stop meshing

PointDistance                      Steiner points of Delaunay

SkinnyAngle                      Min angle at Delaunay

QuadRatio                      Aspect ratio of quads

### Position-Scaling

RotateVert                      Local rotation vertical

RotateHoriz                      Local rotation horizontally

RotateAxial                      Local rotation axially

OffsetAxial                      Shift on-axis

RotateX                      Rotation about x-axis

RotateY                      Rotation about y-axis

RotateZ                      Rotation about z-axis

ShiftX                      Shift in x-direction

ShiftY                      Shift in y-direction

ShiftZ                      Shift in z-direction

## Inheritance

Because often, the rear of the diaphragm needs to be modeled as well, a *Diaphragm* can inherit parameters from another *Diaphragm*. Of course, this feature is also practical if you implement multiple copies of the same *Diaphragm*.

A Diaphragm-component is linked to its ancestor with the help of the [Inheritance-Form](#).