New Features in ALE and SPH in LSDYNA

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Dynamore Forum

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New Features in ALE

Mapping 2D to 3D

1- 2 D Run

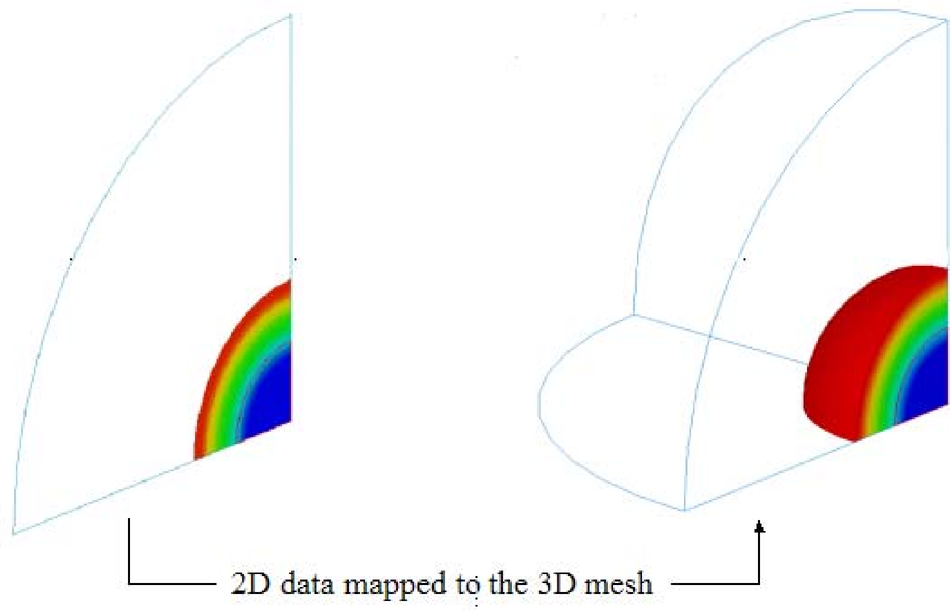
*SECTION_ALE2D

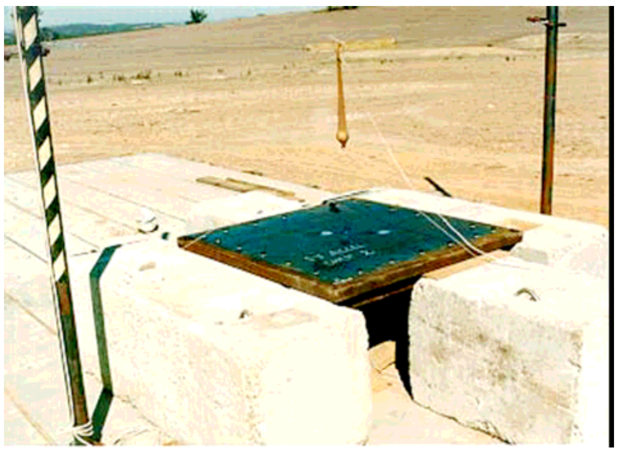
ls971 i= input.2d.k   map=filename

2- 3 D Run

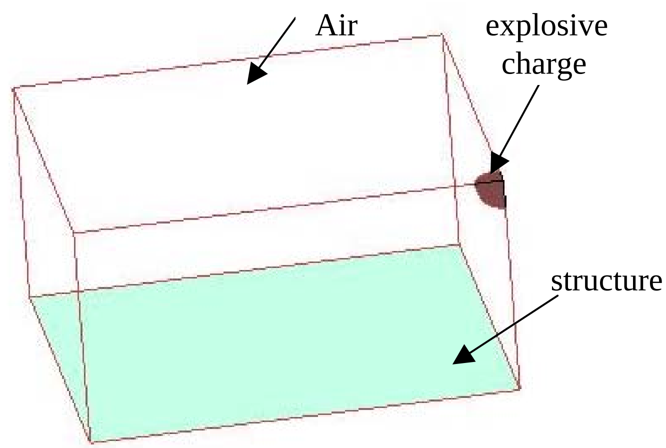
```
*INITIAL_ALE_MAPPING
$    PartId       Part_Set      AMMG
        100              0           200
```

ls971 i= input.3d.k   map=filename


2D data mapped to the 3D mesh



Experimental setup (Boyd 2000)



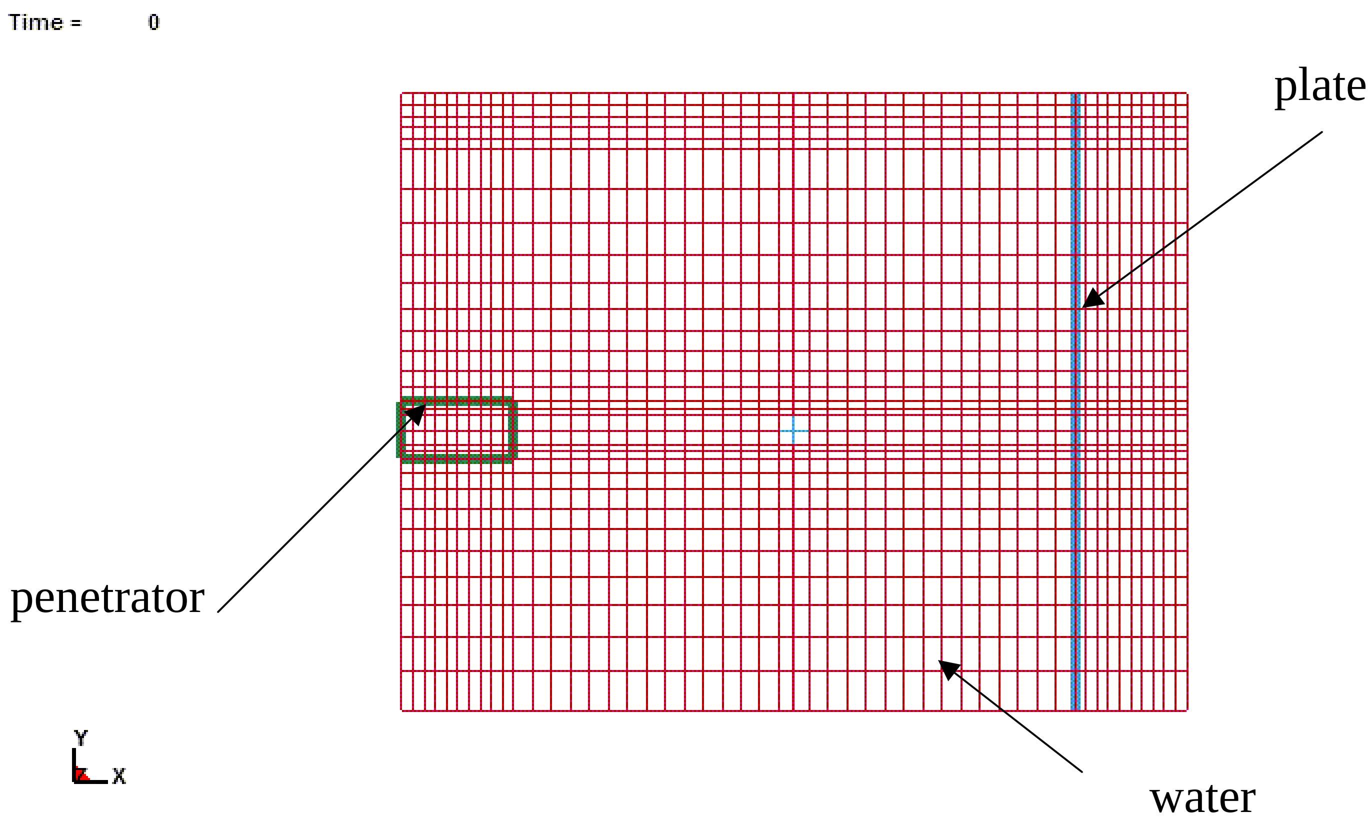
Numerical model 1.2 Million elements

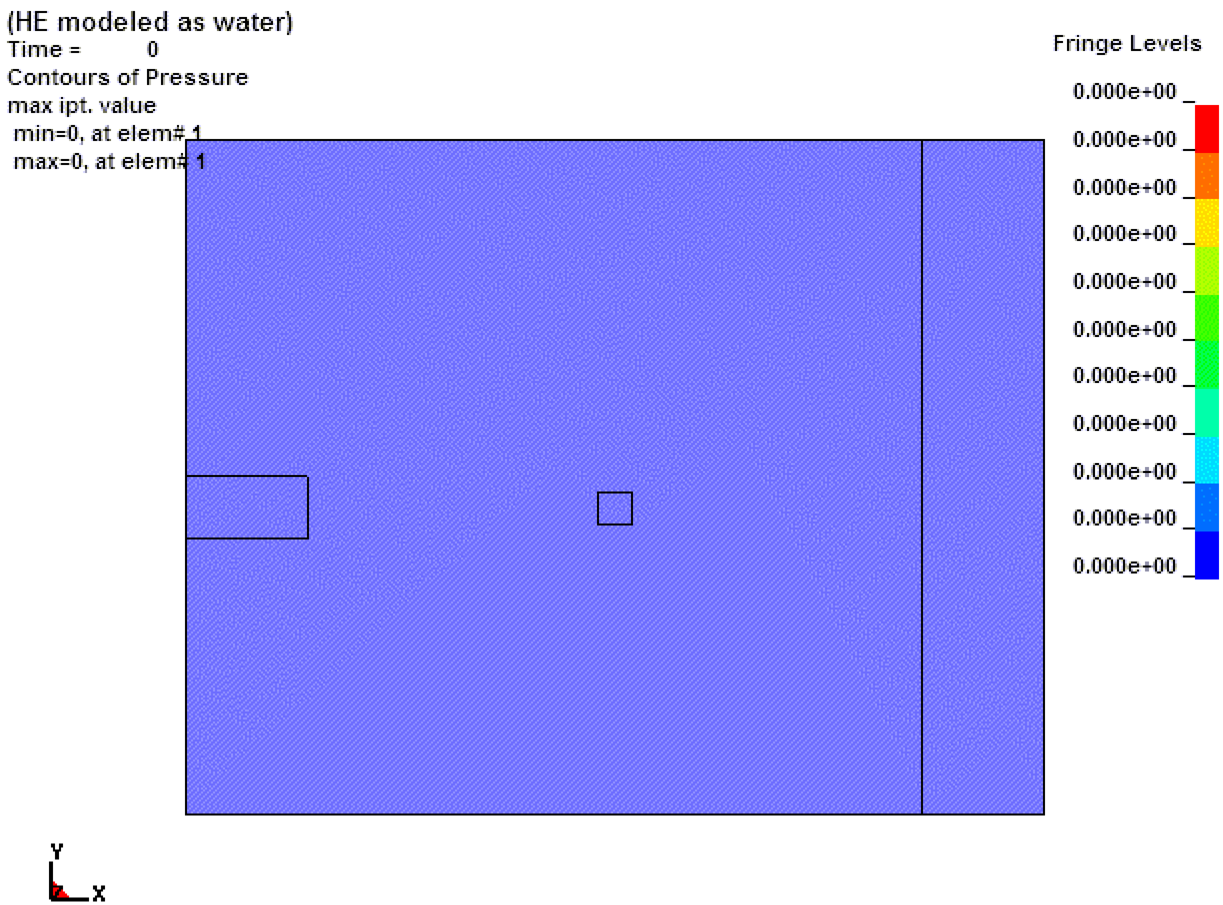
ALEFSI LINK

Useful for design using multiple ALE runs

```
*DATABASE_BINARY_FSLINK
  1.e-4

*CONSTRAINED_LAGRANGE_IN_SOLID_TITLE
$#  coupid
     100
$#   slave    master    sstyp    mstyp    nquad    ctype    direc    mcoup
         3         5        1        0        0        4
$#   start      end     pfac     fric   frcmin     norm  normtyp     damp

$#      cq     hmin     hmax    ileak    pleak  lcidpor    nvent  blockage

$# iboxid   ipenchk  intforc  ialesoft   lagmul
         0         0        1

ls971 i= input1.k   fsilnk=filename
```

Changing the design of the plate




(HE modeled as water)
Time = 0
Contours of Pressure
max ipt. value
min=0, at elem# 1
max=0, at elem# 1
Fringe Levels
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
Y
Z
X

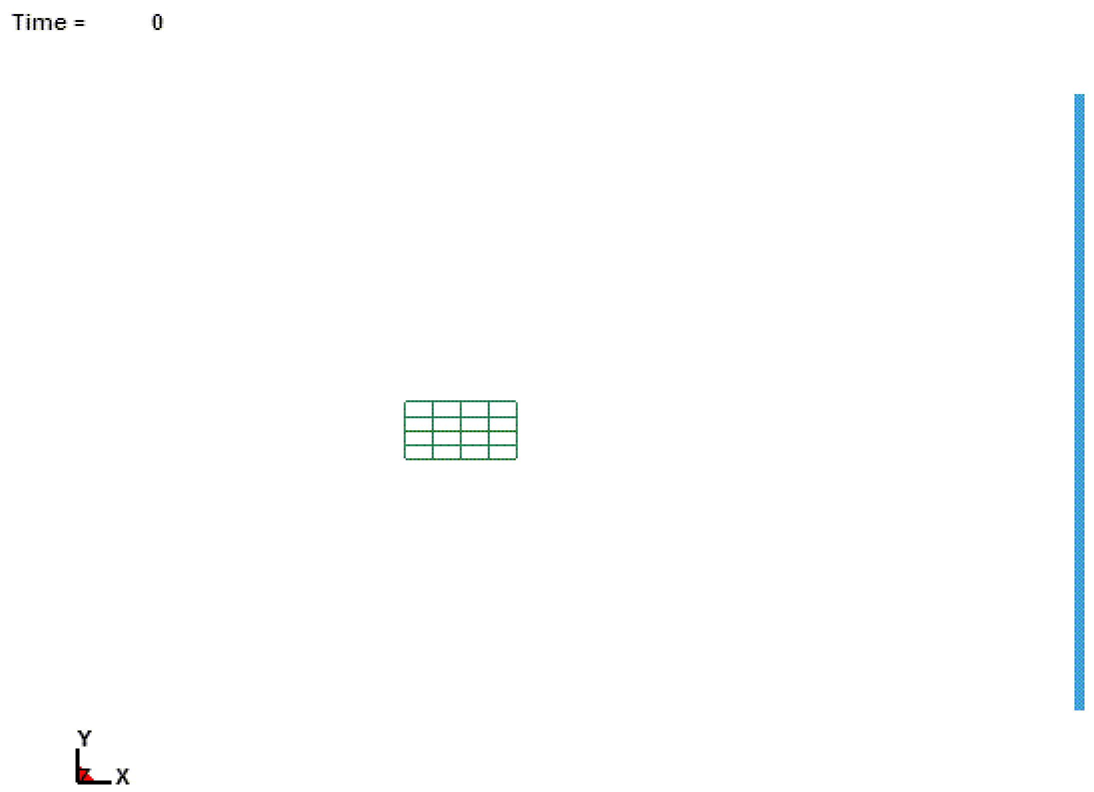
ALEFSI LINK

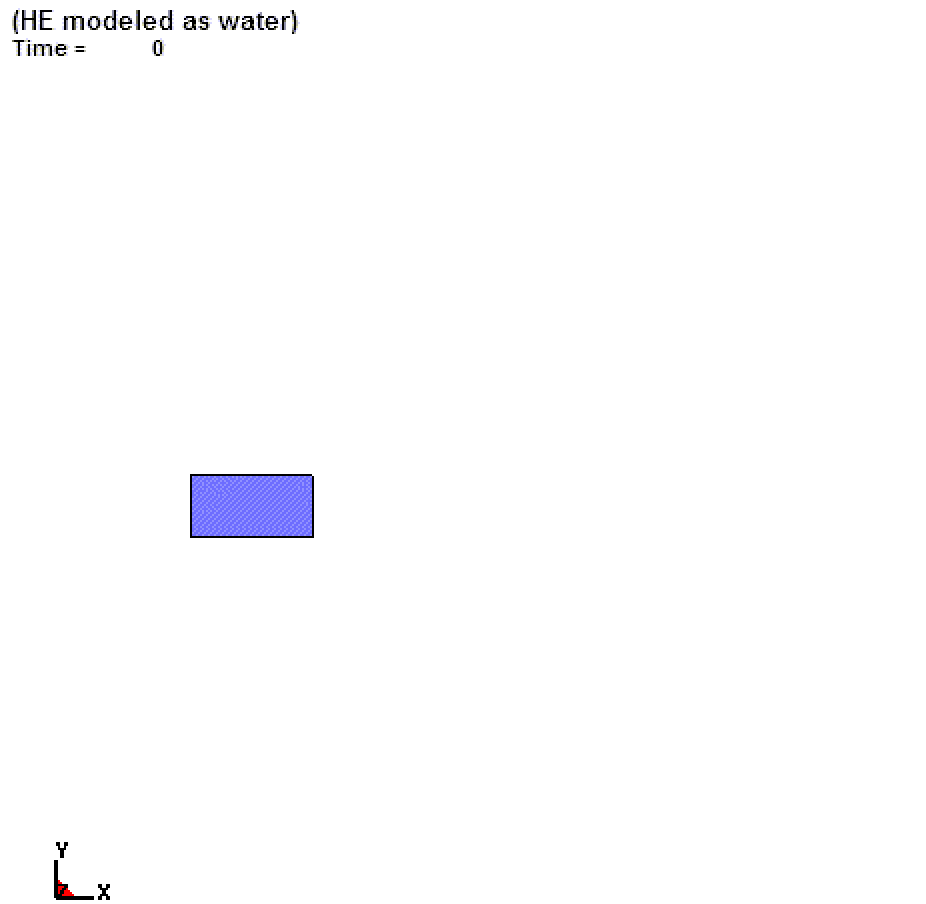
2) Delete all ALE elements from input1.k

Add the following keyword

***LOAD_SEGMENT_FSILINK**
  filename
$ number of interface
         1
$ which interface
      100

run ls971 i=input2.k


Time = 0
Y
X


(HE modeled as water)
Time = 0
Y
X

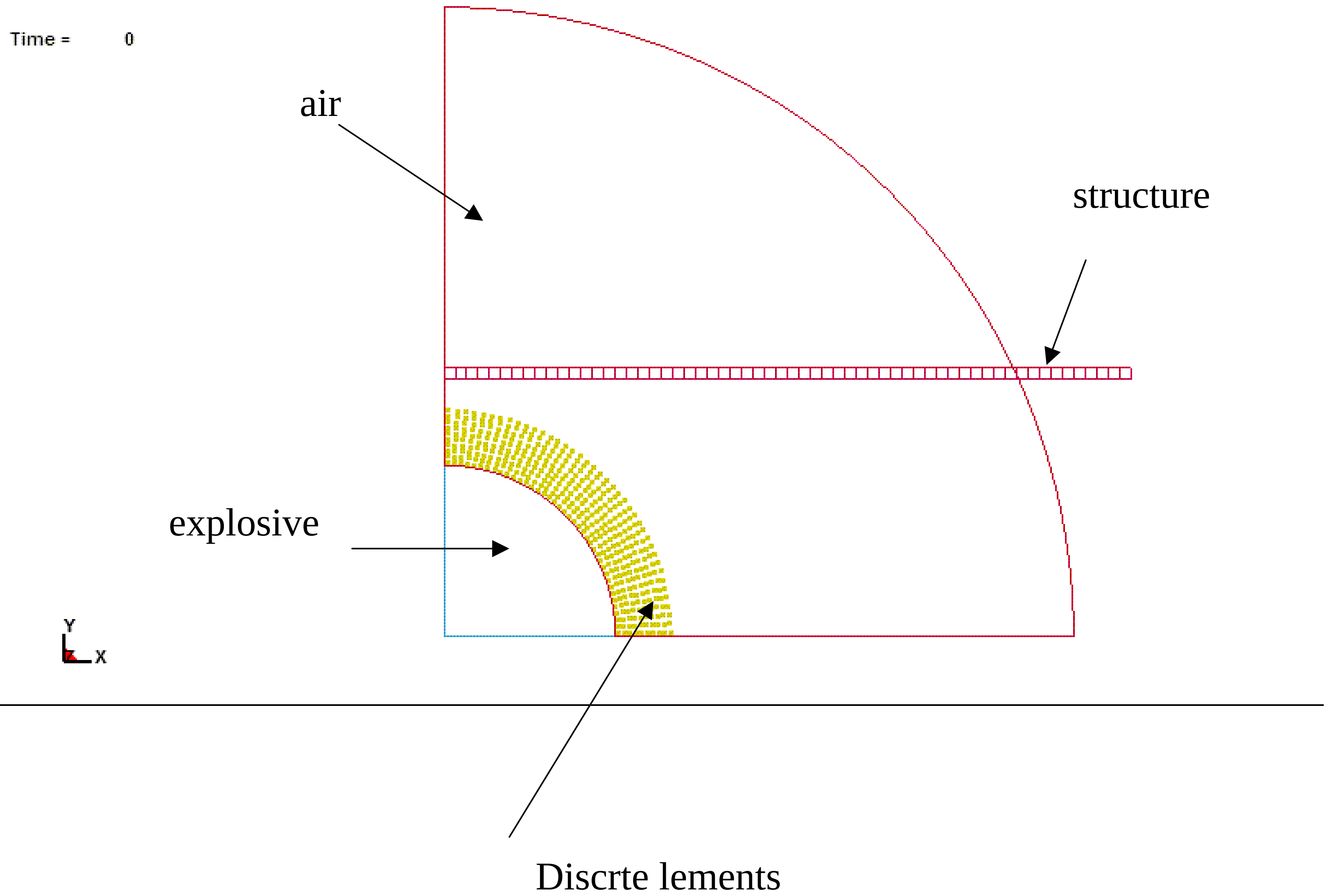
Coupling ALE to Discrete Elements

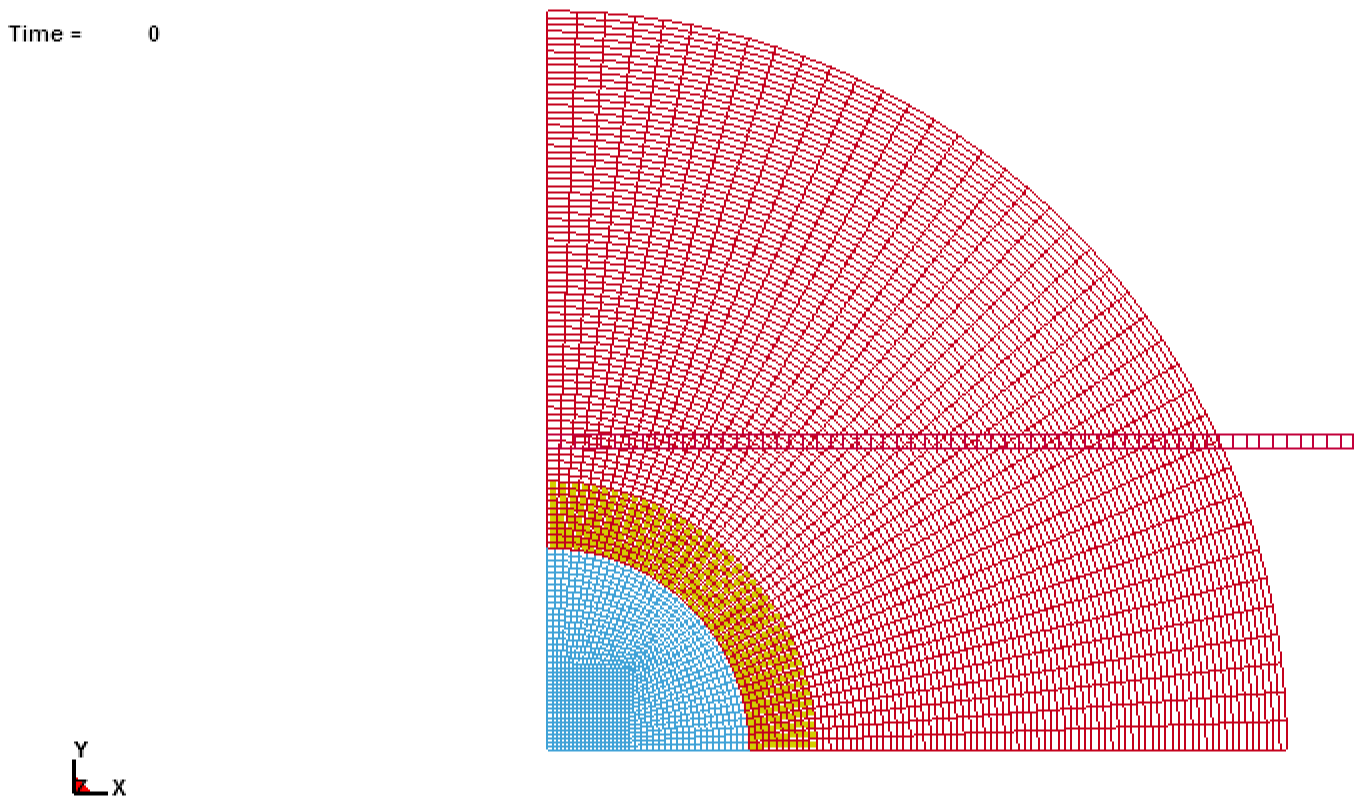
Similar to
*CONTRAINED_LAGRANGE_IN_SOLID (constrained coupling)

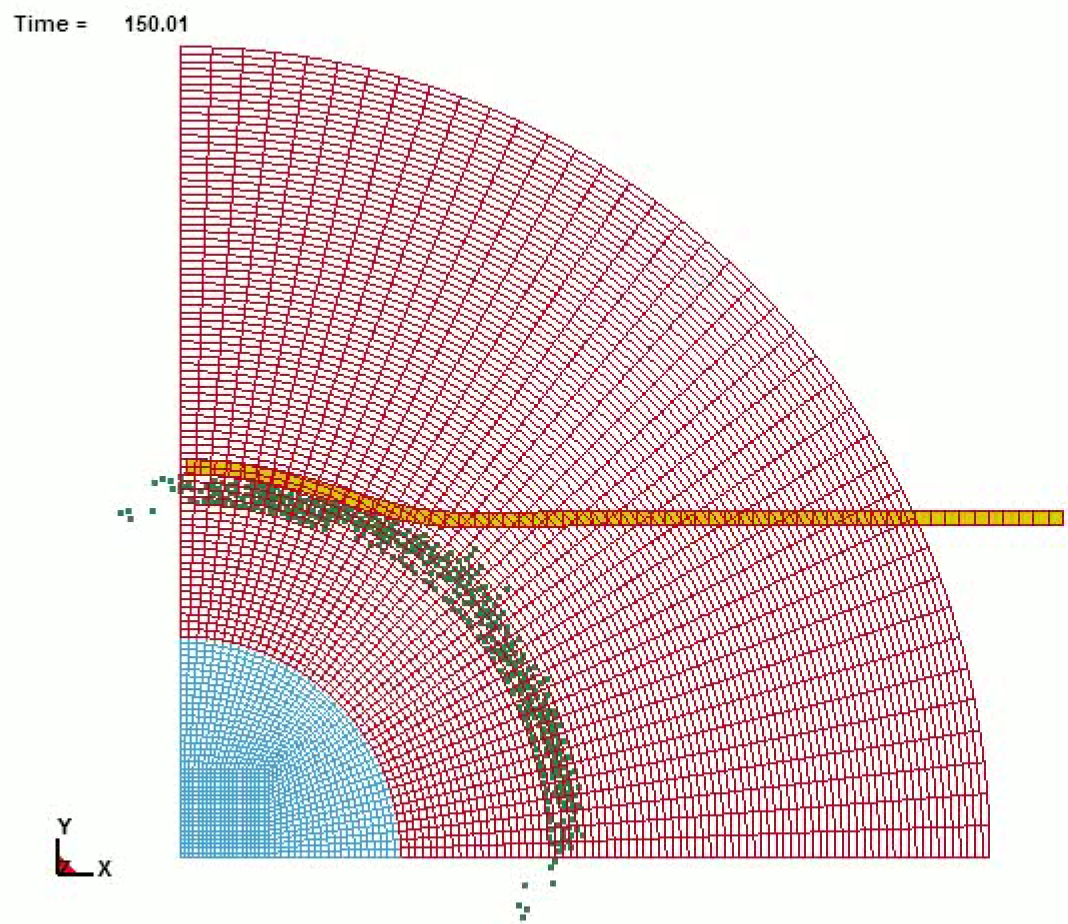
```
*ALE_COUPLING_NODAL
$#   slave    master     sstyp     mstyp     ctype     mcoup
         3         2         1         1         1        -1
$#   start       end
     0.000     0.000
```

Part 3 discrete elements Part : Slave
Part 2 ALE Part : Master

```
*ELEMENT_DISCRETE_SPHERE
$#    nid       pid      mass   inertia    radius
```


Time = 0
air
structure
explosive
Y
X
Discrte lements


Time = 0
Y
X


Time = 150.01
Y
X

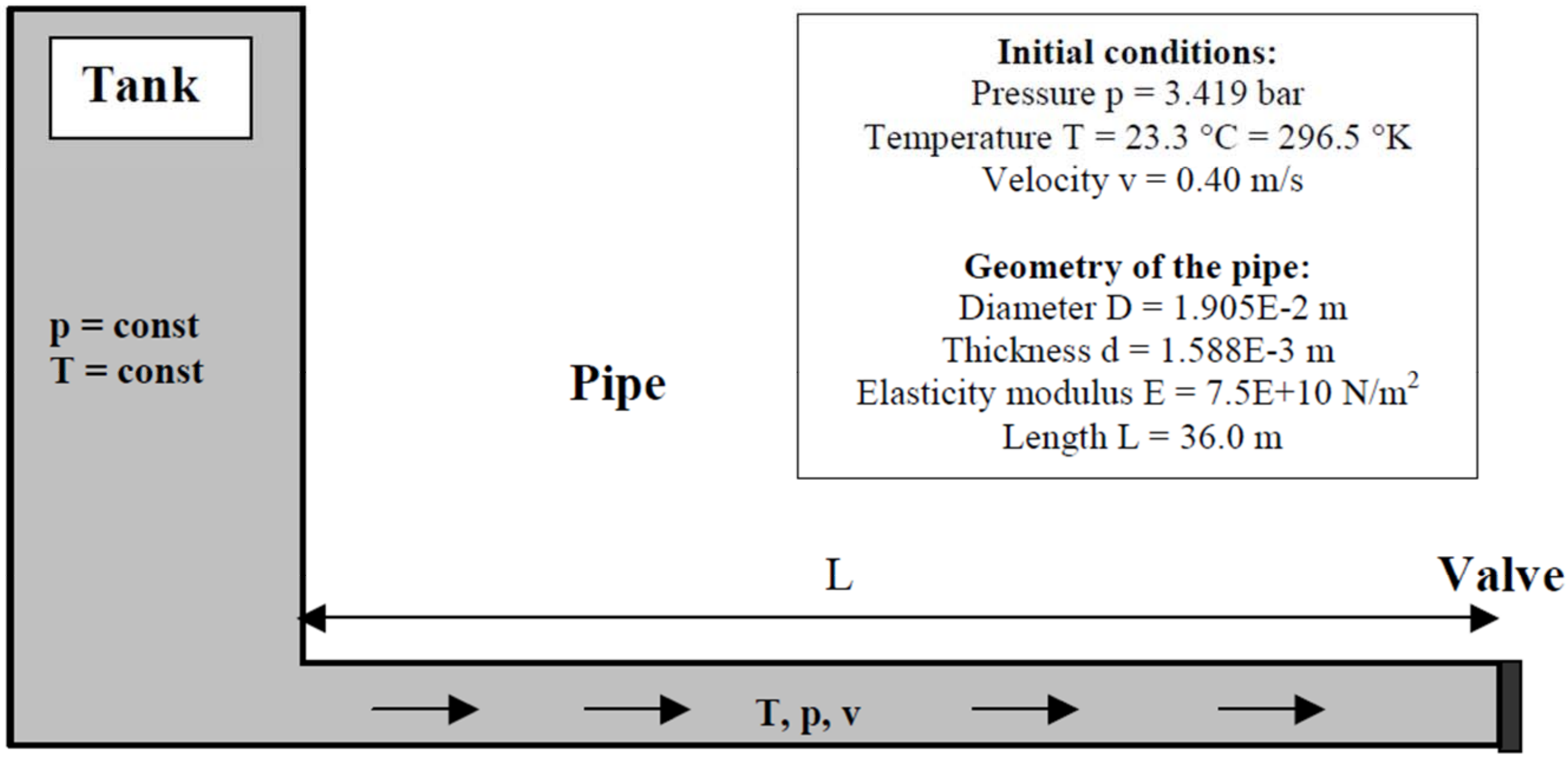
EOS Phase change

*EOS_PHASE_CHANGE

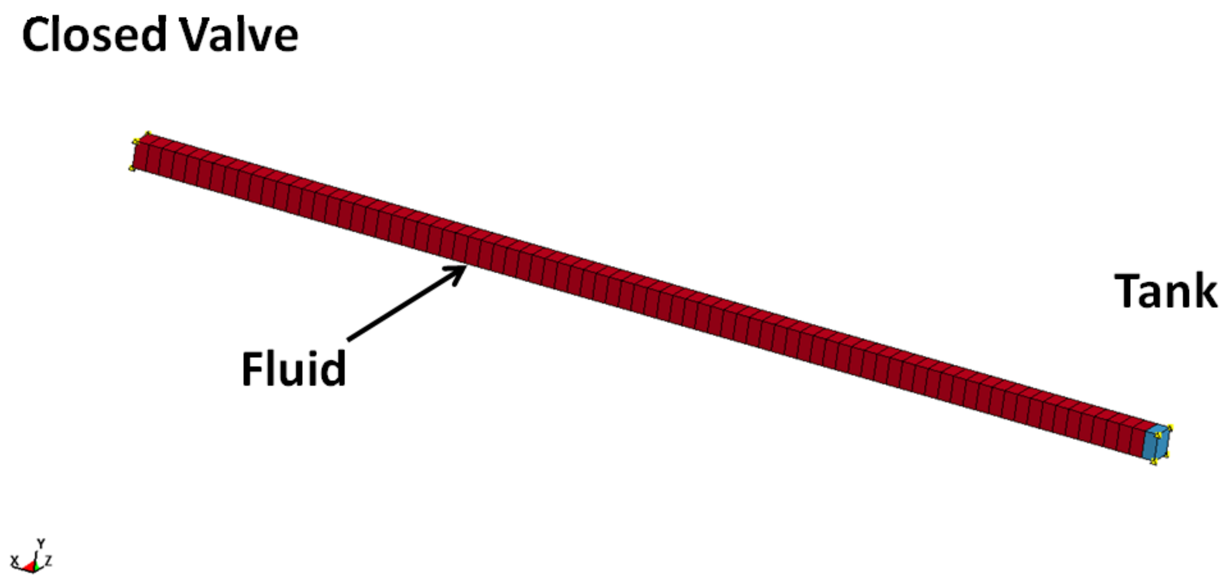
$	eosid	rho_liq	rho_gas	sp_liq	sp_gas	amb _pres	v0
	1	997.	2.095e-2	1492.00	425.00	1.e+5	0.0000

*INITIAL_VAPOR_PART

1

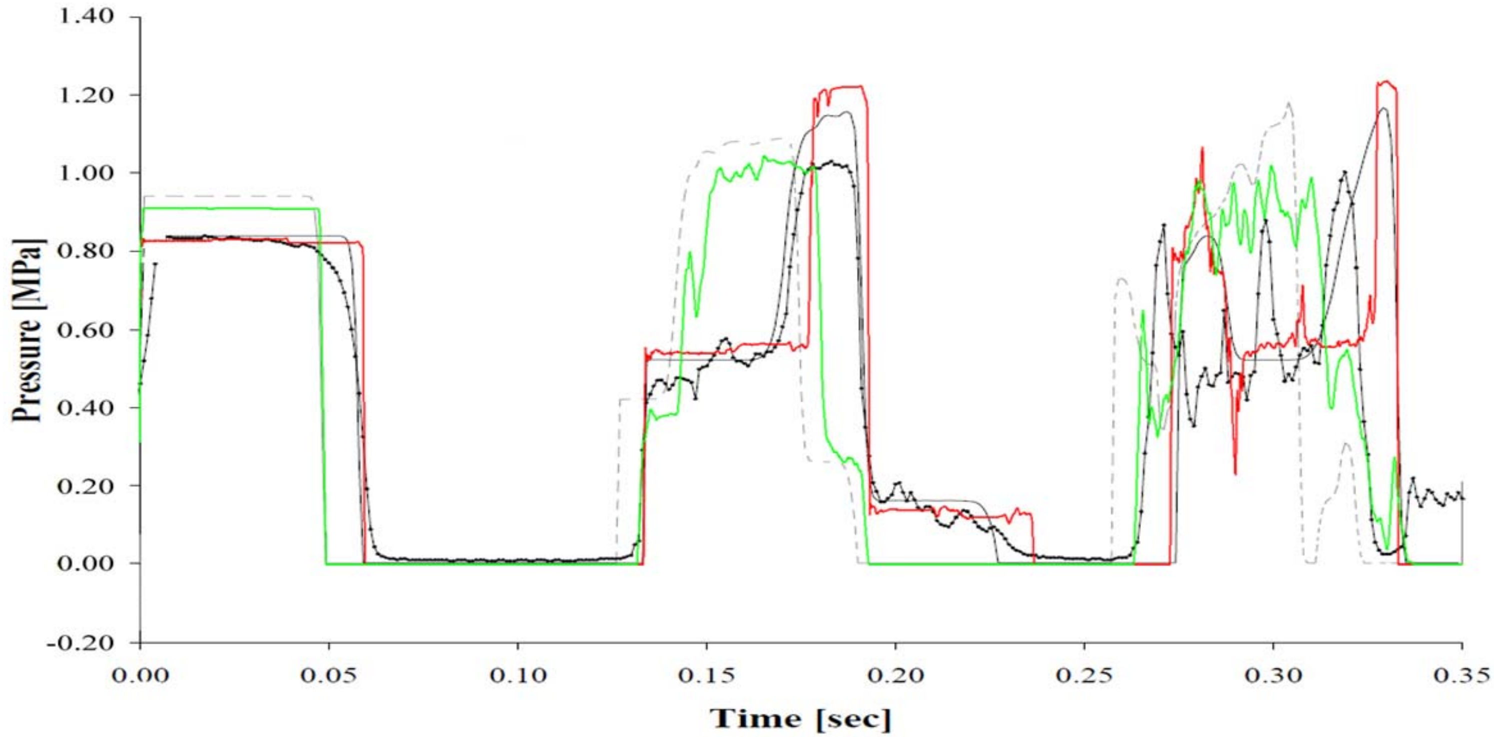


1D WATER HAMMER.



- The simulation starts at the closure of the valve (t=0).
- All nodes at the closed valve location are fixed (velocity = 0) .
- All fluid nodes are fixed in Y and Z directions.
- One directional flow, no fluid-structure interaction.

Simpson's Experiment Results.



Experimental simulation.

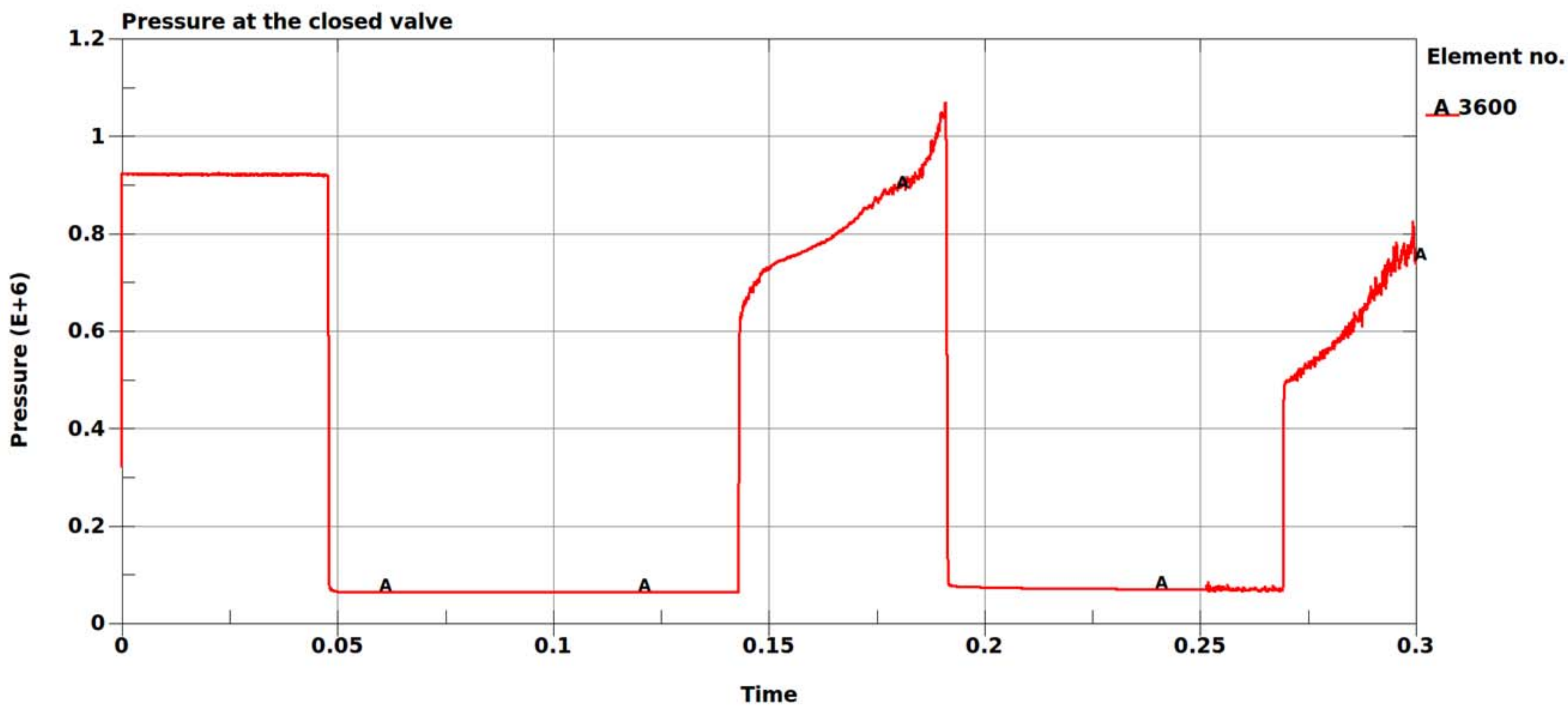
1D simulation.

3D simulation.

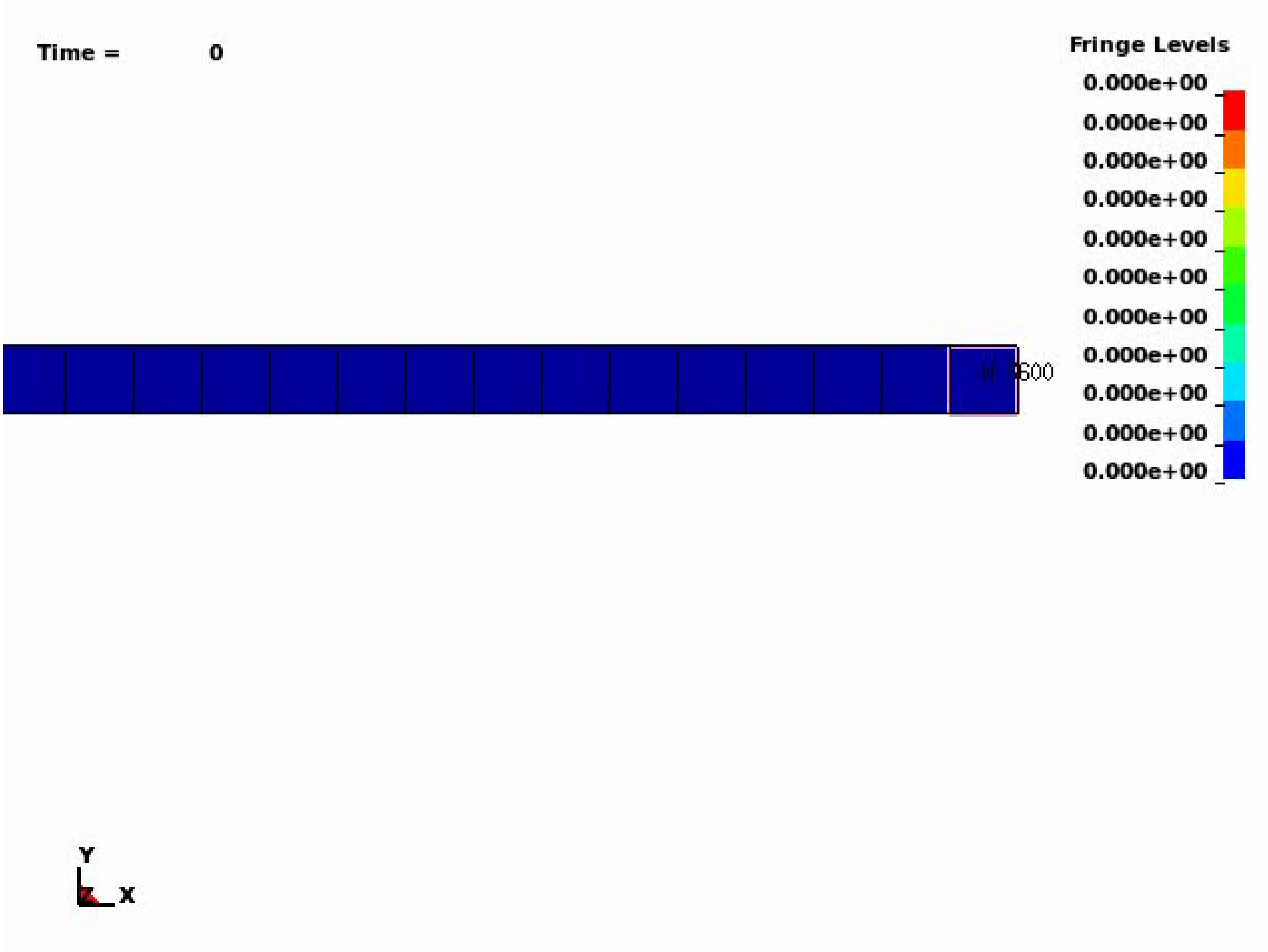
Stiff pipe WAHA CODE.

Elastic Pipe WAHA CODE.

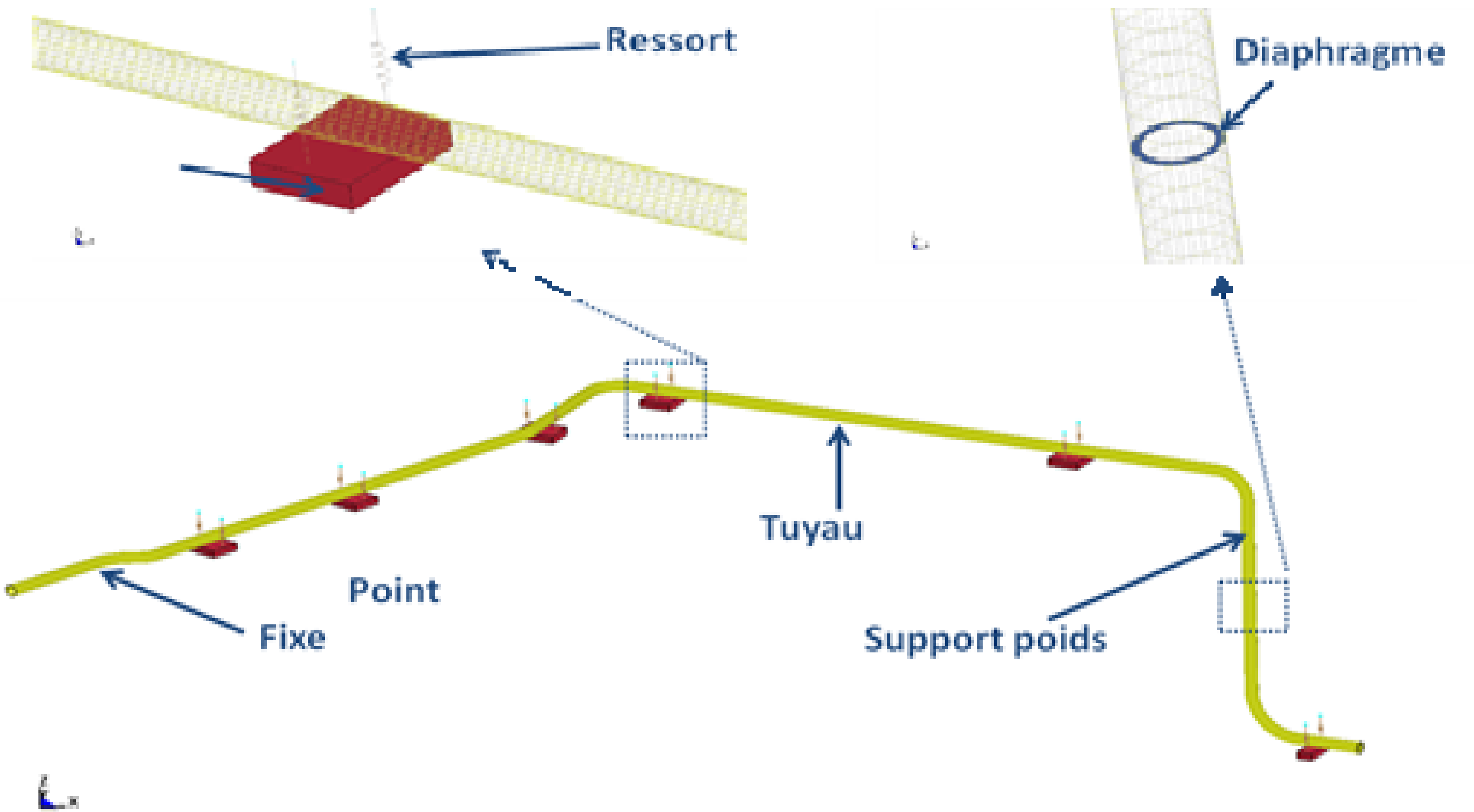
PLOT OF PRESSURE AT THE CLOSED VALVE



Vapor Volume fraction



EOS Phase change



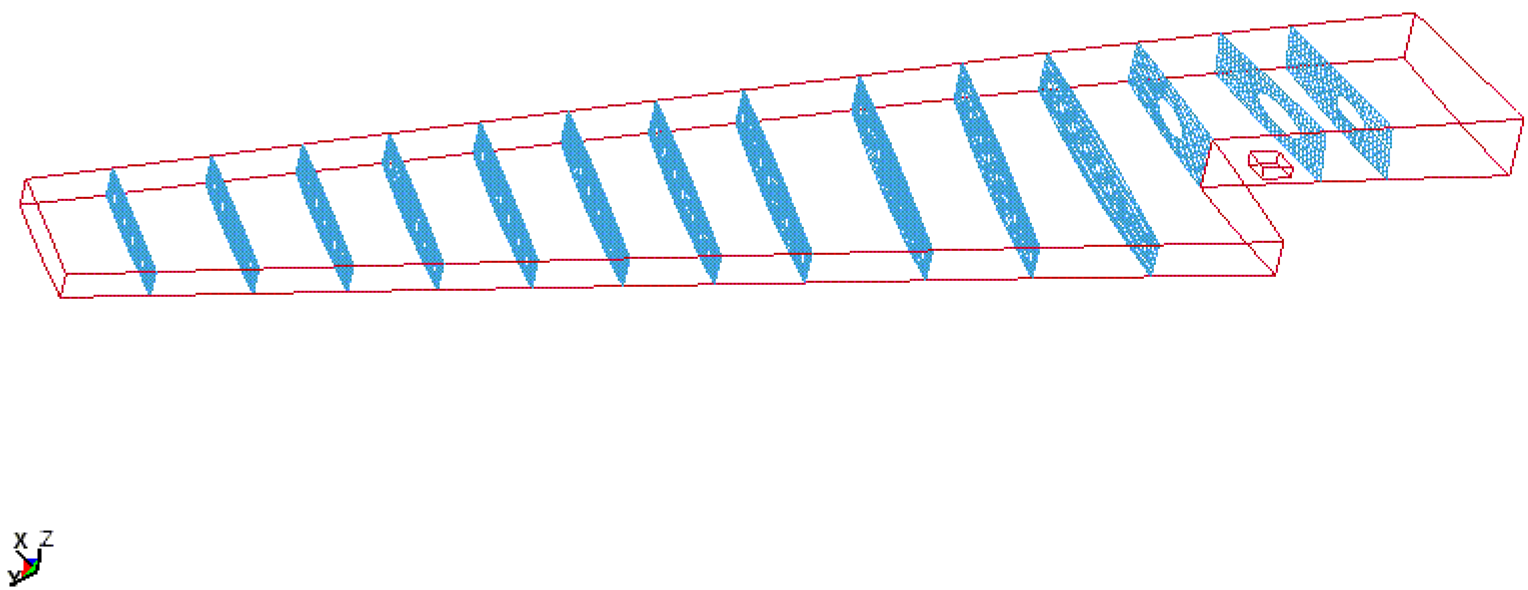
ALE essential Boundary

```
*ALE_ESSENTIAL_BOUNDARY
$#      id     idtype      ictype        iexcl
         1          2           2            0
```

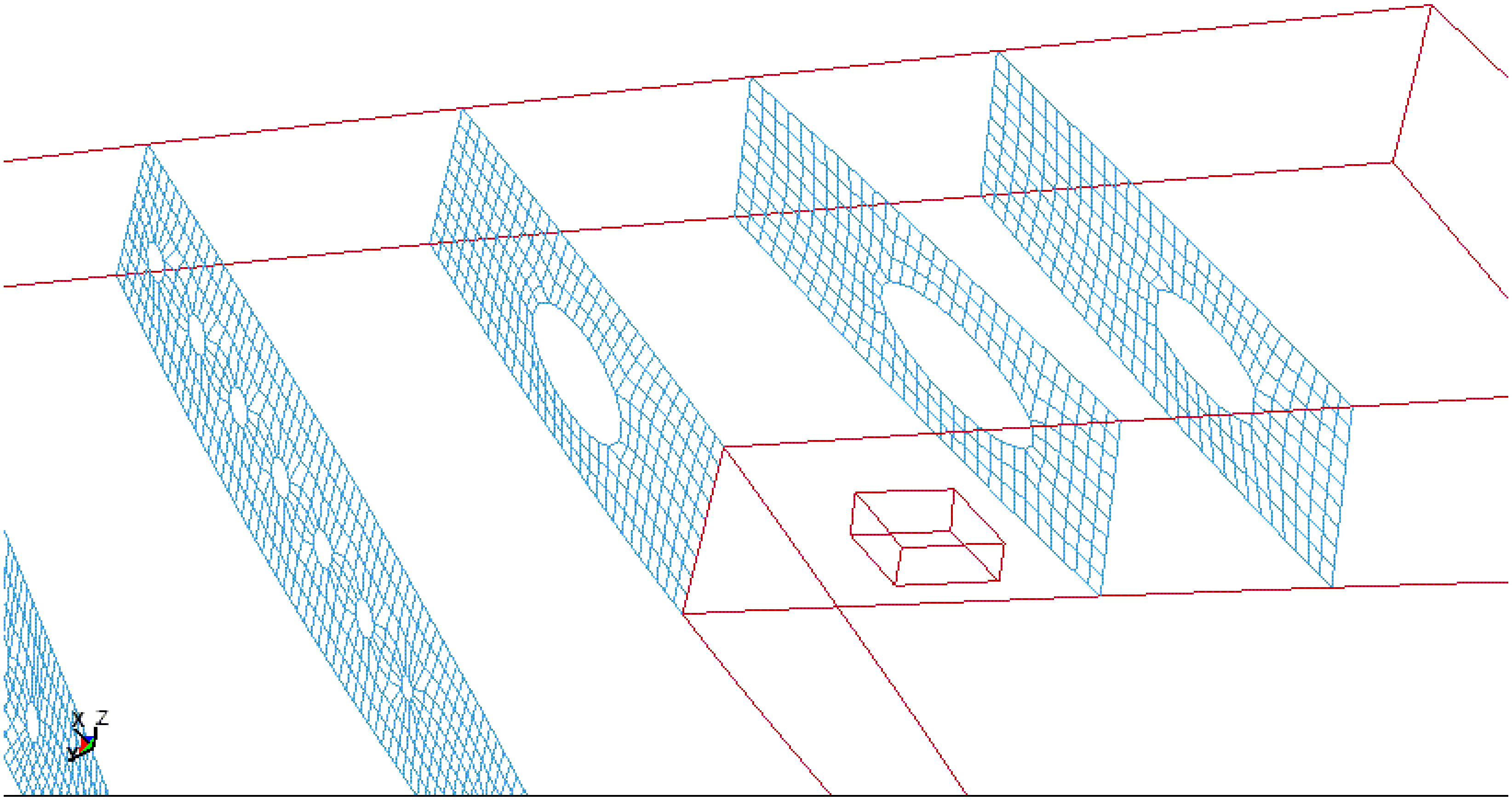
ICTYPE: Constraint type:
EQ.1: No flow through all directions.
EQ.2: No flow through normal direction. (slip condition)

ALE essential Boundary

Filling of airplane tank



ALE essential Boundary



[redacted]

3D Contact

For 3D Lagrangian LSDYNA Contacts are used for SPH

Penalty Based Contact

*CONTACT_AUTOMATIC_NODES_TO_SURFACE

*CONTACT_NODES_TO_SURFACE

Constrained Based Contact

*CONTACT_TIED_NODES_TO_SURFACE

*CONTACT_TIED_NODES_TO_SURFACE_OFFSET

*CONTACT_CONSTRAINT_NODES_TO_SURFACE

CONTACT in SPH

2D Contact only for SPH

*CONTACT_2D_NODE_TO_SOLID

*CONTACT_2D_NODE_TO_SOLID_TIED

*

New Coupling methods for SPH

*DEFINE_ADAPTIVE_SOLID_TO_SPH

*DEFINE_SPH_TO_SPH_COUPLING

***DEFINE_ADAPTIVE_SOLID_TO_SPH**

Variable	IPID	ITYPE	NQ	IPSPH	ISSPH	ICPL	IOPT	
Type	I	I	I	I	I	I	I	
Default	none	none	none	none	none	0	none	

- **IPID** Solid part ID or part set ID
- **ITYPE** Solid part type:

  EQ. 0: IPID is part ID

  EQ. 1: IPID is part set ID

- **NQ** Refinement option:

  EQ. 1: Refine 1 solid element into 1 SPH particle

  EQ. 2: Refine 1 solid element into 8 SPH particles

  EQ. 3: Refine 1 solid element into 27 SPH particles

- **IPSPH** Part ID for newly generated SPH elements

- **ISSPH** Section ID for SPH element

- **ICPL** Coupling with solid element = 0 no coupling to parent solid elements: debris simulation

  =1 coupling to parent solid elements

- **IOPT** Coupling method = 0 coupling SPH from time t=0 (used for tied contact SOLID to SPH)

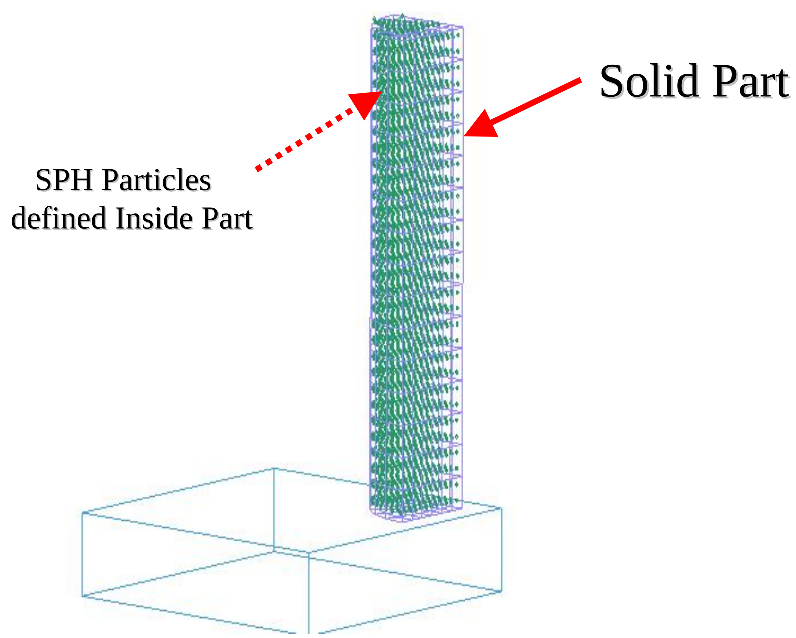
  = 1 coupling SPH after failure of solid element

New Contacts in SPH

*DEFINE_ADPATIVE_SOLID_TO_SPH

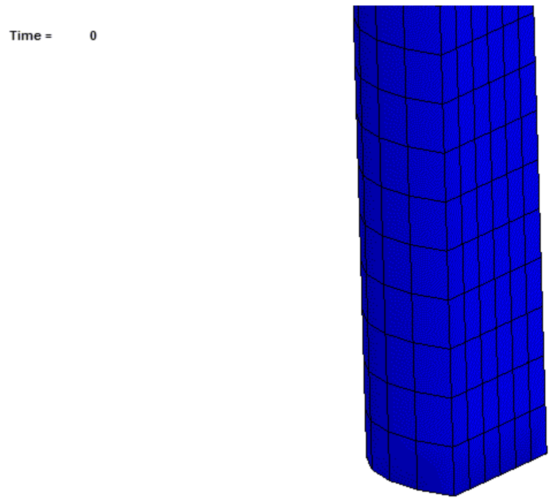
After element erosion, we loose the element mass and momentum

To keep mass and momentum of eroded element, the eroded element is replace by
One or more SPH particles (NQ>1)

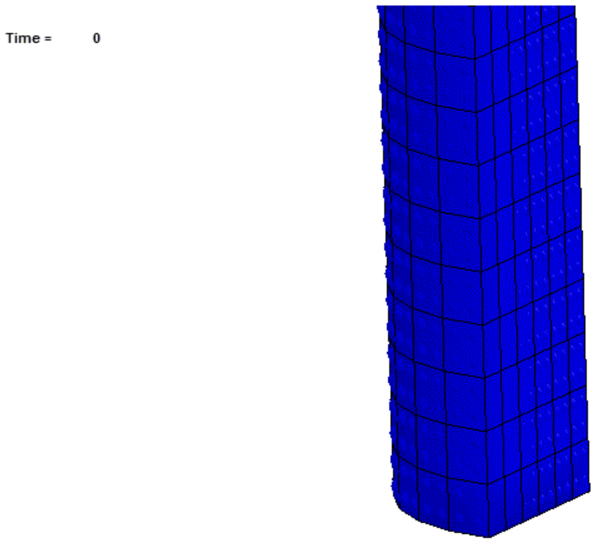


*DEFINE_ADPATIVE_SOLID_TO_SPH

Eroded element are not replaced by particles



Eroded element replaced by particles

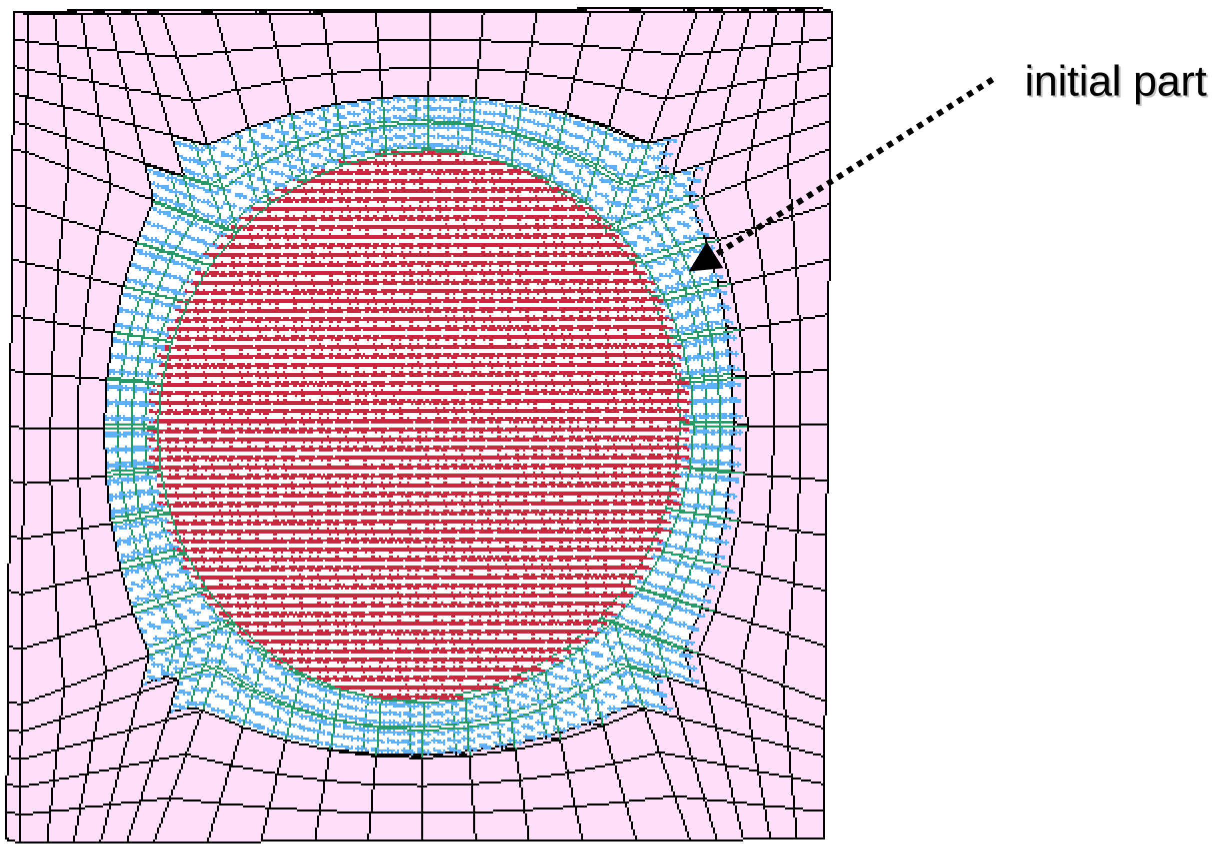


New Contacts in SPH

*DEFINE_ADPATIVE_ SOLID_TO_SPH

ICPL=1 IOPT=0

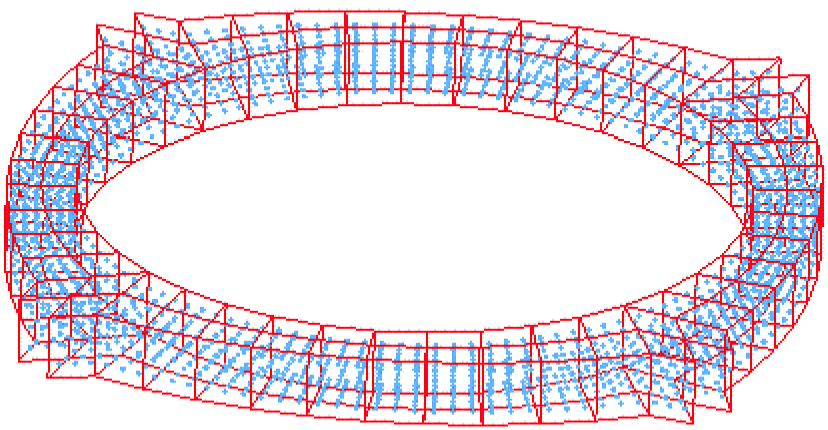
1) Particles are active from start to interact with other particle parts (ICPL=1)
2) Coupling between particles and the initial part (IOPT=0)



New Contacts in SPH

*DEFINE_ADPATIVE_ SOLID_TO_SPH

for tied contact use only **ICPL=1   IOPT=0**



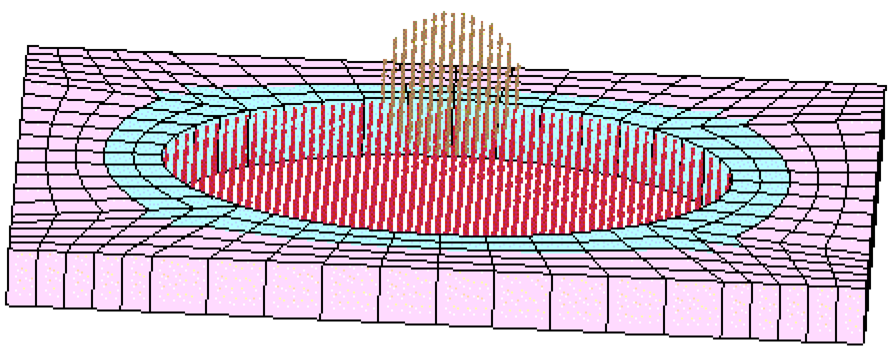
New Contacts in SPH

*DEFINE_ADPATIVE_SOLID_TO_SPH

ICPL=1

ICPL=1 used only as tied contact between FEM and particles

Generated SPH Particles are active from start to interact with other particle parts



New Contacts in SPH

*DEFINE_SPH_TO_SPH_COUPLING

set CONT=1 on *CONTROL_SPH

Variable	SSID	MSID	SSTYPE	MSTYP	IBOX1	IBOX2	PFACT	
Type	I	I	I	I	I	I	I	
Default	none	none	none	none			1.	

This acts like multi-material in ALE

*DEFINE_SPH_TO_SPH_COUPLING

Variables:

SSID: Slave part or part set ID

MSID: Master part or part set ID

SSTYPE SPH part type:
- EQ. 0: SSID is part set ID
- EQ. 1: ISSID is part ID

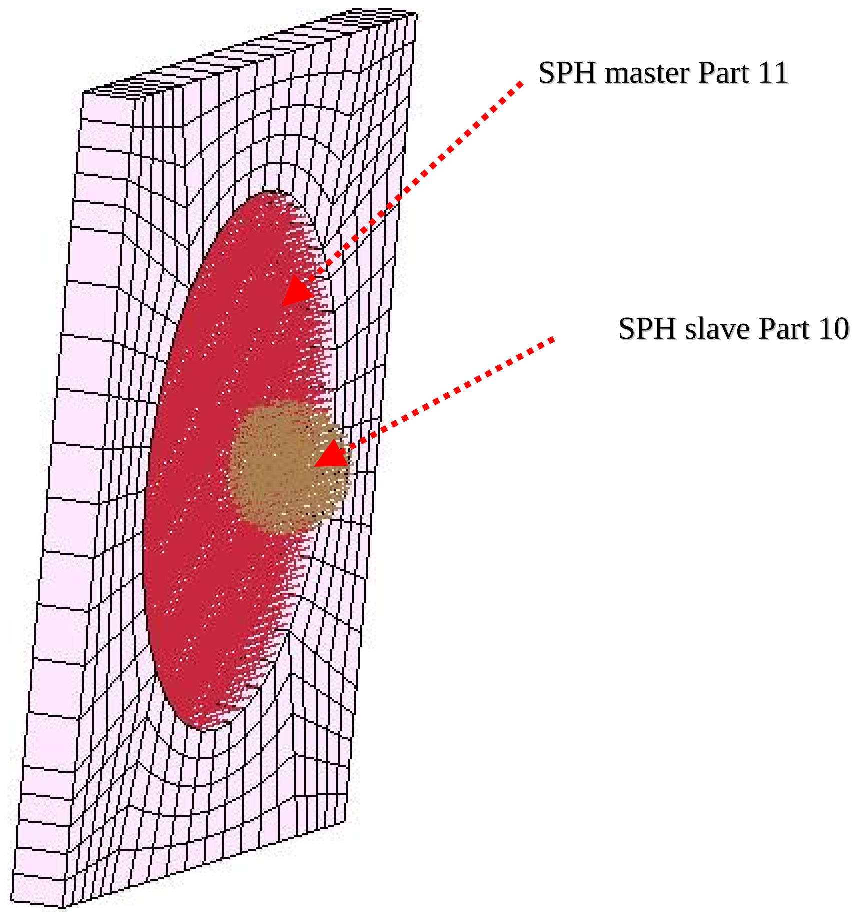
MSTYPE SPH part type:
- EQ. 0: MSID is part set ID
- EQ. 1: MSID is part ID

IBOX1: Box ID for slave parts
IBOX2: Box ID for master parts

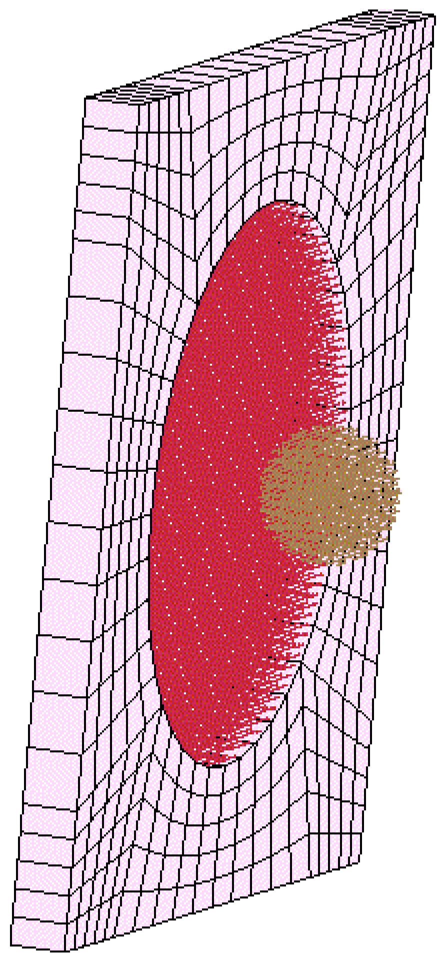
PFACT Penalty scale factor

*DEFINE_SPH_TO_SPH_COUPLING

Used for parts having different densities: gas and water



*DEFINE_SPH_TO_SPH_COUPLING



SPH Thermal

A new explicit thermal conduction solver is implemented for SPH analysis

Following keywords are supported

- *INITIAL_TEMPERATURE_*OPTION*
- *BOUNDARY_TEMPERATURE_*OPTION*
- *BOUNDARY_FLUX_*OPTION*

Thermal coupling with SPH is implemented

SPH Thermal

0=mechanical
1=thermal
2=coupled
(used 2 for SPH thermal)

```
*CONTROL_SOLUTION
$       soln
           2
```

0=steady
1=transient

```
*CONTROL_THERMAL_SOLVER
$       atype        ....      Eqheat      fwork
           1
```

EQHEAT=mechanical equivalent of heat conversion factor
FWORK=fraction of mechanical work converted into heat

```
*CONTROL_THERMAL_TIMESTEP
$          tsc         tip         its
             1         1.0          .1
```

tsc=0 fixed time step
   1 variable time step
tip=1.0 full implicit
   0.5 Crank Nicolson
tts=0.1 initial time step

*MAT_THERMAL_ISOTROPIC for the part TMID option

SPH Thermal

Conductivity equation for Temperature

$$\rho . C_v \frac{\partial T}{\partial t} = \kappa \frac{\partial^2}{\partial x^2} T$$

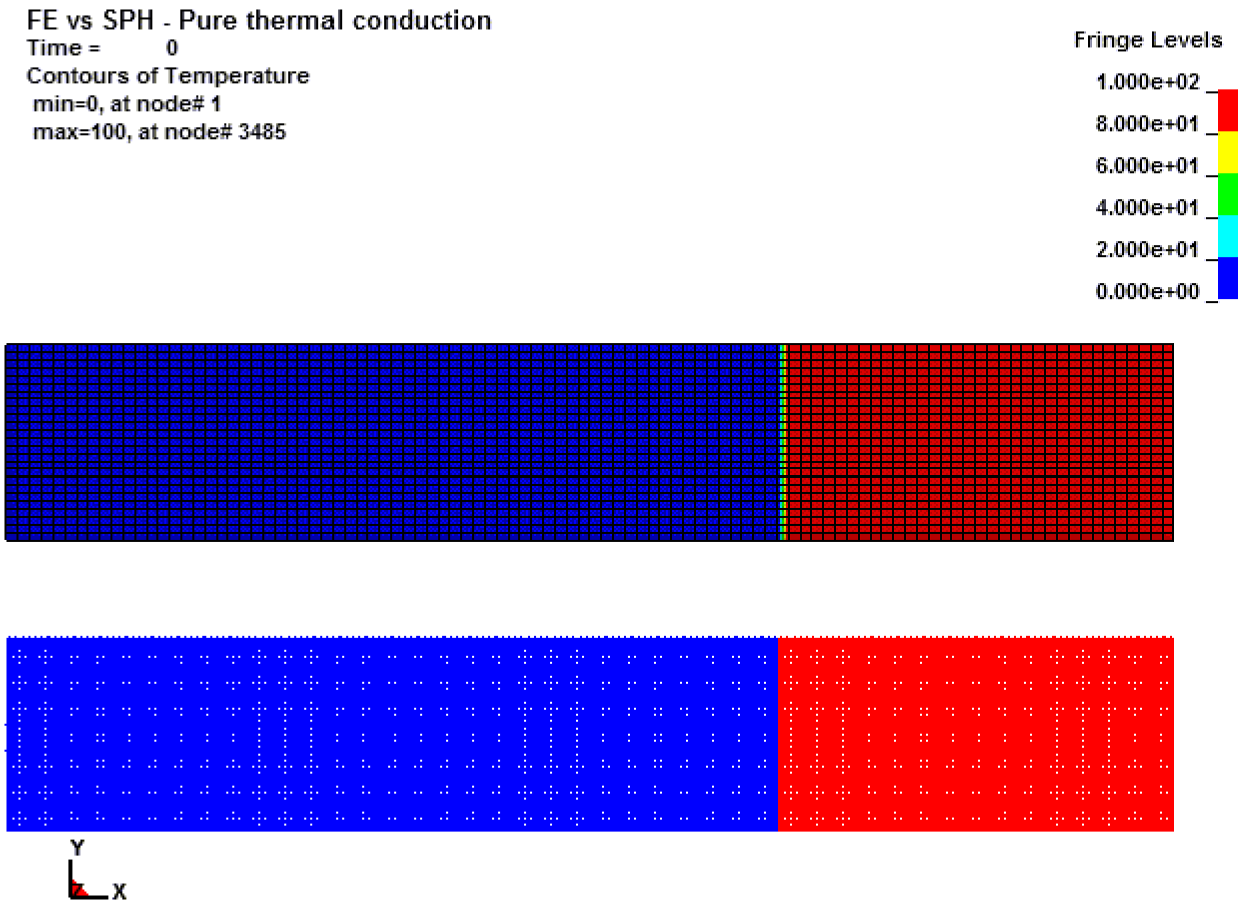
T: temperature

$\rho .$ density

κ thermal conductivity

C_V heat capacity

For SPH thermal equation is solved explicitly
For FEM thermal equation is solved implicitly


FE vs SPH - Pure thermal conduction
Time = 0
Contours of Temperature
min=0, at node# 1
max=100, at node# 3485
Fringe Levels
1.000e+02
8.000e+01
6.000e+01
4.000e+01
2.000e+01
0.000e+00
Y
X

Thank you