Waterhammer Re-Run

Sommaire

1 Purpose

Re-run of the case "CnesOneraDroit05.eds" and experiment "expWater.exp" from IND_EVAL library (included into ESPSS 2.4) with the last release today of EcosimPro 5.6 and with ESPSS 3.1

note: in the Bounds of the experiment, the line `--FLUID_FLOW_1D.Re_lam = 3000.` *must be commented*

The case is a line priming waterhammer with upstream pressure 2MPa (20 bar) real water and empty lines under 1000 Pa (0.01 bar) GN2.

2 Reference results

The reference results (*Technical note Eai-Kci-Me-01 IndustrialEvaluation02_c dated 16/12/2008* and used for the Adelaide paper *C. Koppel et al., "A Satellite Platform Modelling with EcosimPro: Results of the Simulation Compared to the Ground Tests," SimTecT 2009 Simulation Conference and Exhibition, Adelaide, Australia 15-19 June, 2009.*) were coming from a model listing:

```
-- Generated automatically by - EcosimPro - 4.4.0 - 08/26/2008 12:06:53
```

and using the following libraries:

```
USE FLUID_FLOW_1D VERSION "1.0"
USE FLUID_PROPERTIES VERSION "1.0"
USE THERMAL VERSION "3.0"
```

The main results (in 2008) are reproduce here below with a maximum number of nodes of 27 ==> Pmax=333 bar for the simulation while the test recorded 277.5 bar:

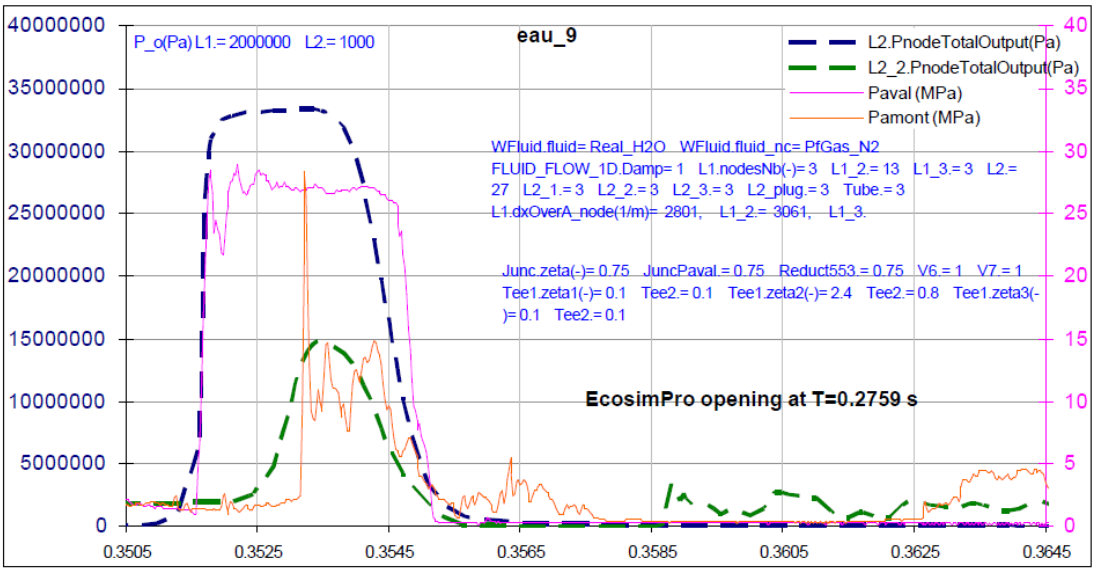
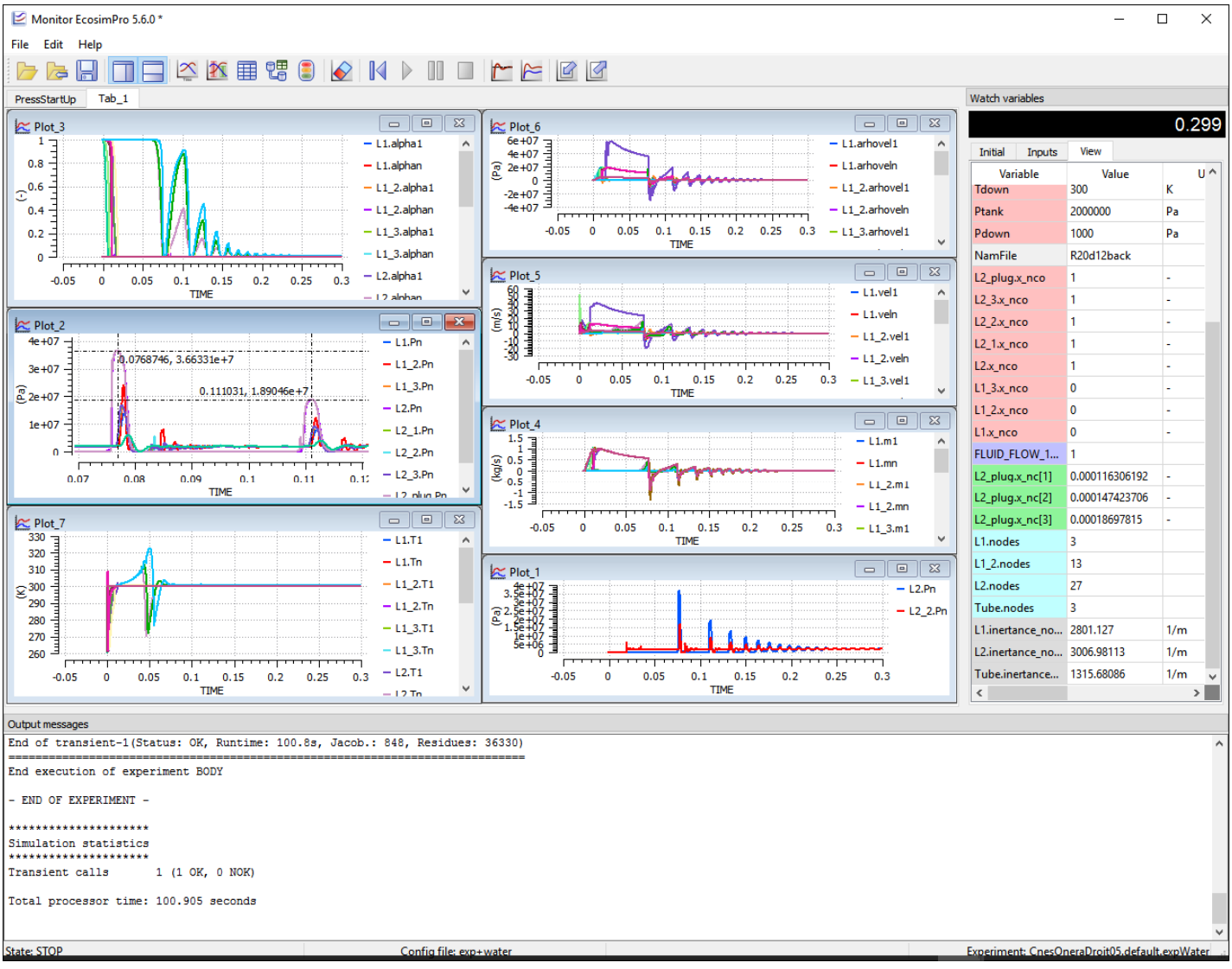


Figure 20: Large zoom on the Superposition of Simulation and Test Results (water at 2 MPa)

3 Re-run results

3.1 Nodes maxi 27 ==>Pmax=366.3 bar



The number of nodes used for each tube is changed in the file "Constant.el" with right lines commented and then compiled, before re-building the model.

```
/*
CONST INTEGER No2 = 3 UNITS "(-)"  --rule inertance 27
CONST INTEGER No5 = 3 UNITS "(-)"
CONST INTEGER No9 =3 UNITS "(-)"
CONST INTEGER No19 =13 UNITS "(-)"
CONST INTEGER No27 = 27 UNITS "(-)"

CONST INTEGER No2 = 3 UNITS "(-)"  --rule inertance 42
CONST INTEGER No5 = 3 UNITS "(-)"
CONST INTEGER No9 =4 UNITS "(-)"
CONST INTEGER No19 = 21 UNITS "(-)"
CONST INTEGER No27 = 42 UNITS "(-)"
*/
CONST INTEGER No2 = 3 UNITS "(-)"  --rule inertance 84
CONST INTEGER No5 = 3 UNITS "(-)"
CONST INTEGER No9 =9 UNITS "(-)"
CONST INTEGER No19 = 41 UNITS "(-)"
CONST INTEGER No27 = 84 UNITS "(-)"
```

3.2 Nodes maxi 42 ==>Pmax=363.5 bar

3.3 Nodes maxi 84==>Pmax=361.5 bar

4 Conclusion

The simulation performed with ESPSS 3.1 produces slightly higher waterhammer maximum pressure than in 2008.

- with a maximum of 27 nodes ==> 366 bar instead of 333 bar, so a +10% increase.
- this is a more conservative value than in the real case tested with 277.5 bar recorded.

The effect of the number of node is negligeble as pointed out in 2008, a very low decrease of the maximum pressure occurs : 366 bar for 27 nodes, 363 for 42 nodes, 361 for 84 nodes maximum.

The major impact of the run performed on new generation PC with the last release of EcosimPro is the large decrease of the computation time (for 27 nodes, results get in less than 2 minutes).

5 Tracability listing

5.1 Files used to perform the new runs

The files used to perform the re-runs are shown below (the model listing .el and the experiment .exp).

```
-- Generated automatically by - EcosimPro - 5.6.0
USE FLUID_FLOW_1D VERSION "3.1.0"
USE FLUID_PROPERTIES VERSION "3.1.0"
USE THERMAL VERSION "3.5.1"

-- '  16/04/2017  16:25:39
COMPONENT CnesOneraDroit05
DATA
        REAL Ptank = 2000000 UNITS "Pa"
        REAL Ttank = 300 UNITS "K"
        REAL Pdown = 1000 UNITS "Pa"
        REAL Tdown = 300 UNITS "K"
        REAL xnc_down = 0 UNITS "-"
TOPOLOGY


  FLUID_FLOW_1D.Pipe( is_a L2_3)
   L1_3(
  L2_3 except:
      P_o = Ptank,      -- Non default value.
      T_o = Ttank,      -- Non default value.
      x_nco = 0,
      L = 0.04,         -- Non default value.
  )

  FLUID_FLOW_1D.Pipe( is_a L2_3)
   L2_1(
  L2_3 except:
      L = 0.04,         -- Non default value.
  )

  FLUID_FLOW_1D.Pipe(
  L2_3 except:
      nodes = No5,      -- Non default value.
  ) L2_plug(
  L2_3 except:
      ht_option = HT_tube,          -- Non default value.
      e_wall = 0.0004,  -- Non default value.
      L = 0.04,         -- Non default value.
      D = 0.00553,      -- Non default value.
  )

  FLUID_FLOW_1D.Pipe(
  L2_3 except:
      nodes = No5,      -- Non default value.
  ) L2_2(
  L2_3 except:
      L = 0.03,         -- Non default value.
      D = 0.004,        -- Non default value.
  )

  FLUID_FLOW_1D.Pipe(
  L2_3 except:
      nodes = No9,      -- Non default value.
  ) L1(
  L2_3 except:
      P_o = Ptank,      -- Non default value.
      T_o = Ttank,      -- Non default value.
      x_nco = 0,
      L = 0.66,         -- Non default value.
  )

  FLUID_FLOW_1D.Pipe(
  L2_3 except:
      nodes = No27,     -- Non default value.
  ) L2(
  L2_3 except:
      ht_option = HT_tube,          -- Non default value.
      e_wall = 0.0004,  -- Non default value.
      L = 1.95,         -- Non default value.
      D = 0.00553,      -- Non default value.
  )

  FLUID_FLOW_1D.Pipe(
  L2_3 except:
      nodes = No5,      -- Non default value.
  ) Tube(
  L2_3 except:
      P_o = Ptank,      -- Non default value.
      T_o = Ttank,      -- Non default value.
      x_nco = 0,
      L = 1.24,         -- Non default value.
      D = 0.02,         -- Non default value.
  )

  FLUID_FLOW_1D.Pipe(
  L2_3 except:
      nodes = No19,     -- Non default value.
  ) L1_2(
  L2_3 except:
      P_o = Ptank,      -- Non default value.
      T_o = Ttank,      -- Non default value.
      x_nco = 0,
      L = 0.5,          -- Non default value.
      D = 0.004,        -- Non default value.
  )

  FLUID_FLOW_1D.Pipe(
      burnerGasesOption =
FLUID_PROPERTIES.noBurnGases,
      AbsorOption = noActive,
      nodes = No2,      -- Non default value.
      n_bends = 1,
      scheme = centred)
   L2_3(
      num = 1,
      order = first,
      init_option = INIT_PT,
      P_o = Pdown,      -- Non default value.
      T_o = Tdown,      -- Non default value.
      x_o = 0,
      rho_o = 1,
      x_nco = 1,        -- Non default value.
      m_o = 0,
      rug = 1.6e-06,    -- Non default value.
      k_f = 1,
      k_d = 1,
      fld_add = 0,
      fld_nod = 0,
      alpha_bend = { 0},            -- Non default value.
      R_bend = { 1},    -- Non default value.
      fr_option = FR_tube_1ph,
      ht_option = HT_tube_Traviss,          --
Non default value.
      hc_dat = 1,
      Isent_Correl =  FALSE ,
      entropy_fix = no_fix,
      entropy_fix_multiplier = 4,
      integration_rule = midpoint,
      dp_correction =  FALSE ,
      limiter = VanAlbada,
      preconditioner = unprecond,
      reconstructed_variables = primitive,
      central_reconstruction =  TRUE ,
      source_upwind_smoothing = 0,
      xd_nco = 0,
      Po_nc = 0,
      UserDefSolubData =  TRUE ,
      A_coef_sol =-521,
      B_coef_sol = 2.3874,
      TI = 0.03,
      Cd = 2,
      Ca = 0.1,
      tau_d = 0.3,
      tau_a = 2,
      Diff_Turb_Factor = 1,
      K_u = 0.25,
      K_p = 0.75,
      h_outside = 0,
      T_outside = 295.15,           -- Non default value.
      mat = Titanium,   -- Non default value.
      E_wall = 100000000000.,
      v_wall = 0.3,
      cp_wall = 500,
      rho_wall = 1500,
      anchor = upstream_anchored,
      e_wall = 0.001,
      L = 0.02,         -- Non default value.
      D = 0.01,
      D_vs_L = { { 0,0.5,1} ,{ 1,1,1} } ,
      dx_vs_L = { { 0,0.5,1} ,{ 1,1,1} })

  FLUID_FLOW_1D.Junction( is_a Reduct553)
   JuncPaval(
   is_a Reduct553)

  FLUID_FLOW_1D.Junction( is_a Reduct553)
   Junc(
  Reduct553 except:
      Ao = 3.14 / 4 * 0.02 ** 2,        -- Non default value.
  )

  FLUID_FLOW_1D.Junction(
      burnerGasesOption =
FLUID_PROPERTIES.noBurnGases,
      choked_option =  TRUE)
   Reduct553(
      x_jun = 0,
      y_jun = 0,
      z_jun = 0,
      Gcr_ideal =  FALSE ,
      Ao = 3.14 / 4 * 0.00553 ** 2, -- Non default value.
      zetaf = 0.5,      -- Non default value.
      zetab = 1,        -- Non default value.
      m_o = 0,
      Re_lam = 2000)

  FLUID_FLOW_1D.DeadEnd( is_a Pamont)
   PvacuumPump(
   is_a Pamont)

  FLUID_FLOW_1D.DeadEnd( is_a Pamont)
   Plug(
   is_a Pamont)

  FLUID_FLOW_1D.DeadEnd(
      burnerGasesOption =
FLUID_PROPERTIES.noBurnGases)
   Pamont(
      x_jun = 0,
      y_jun = 0,
      z_jun = 0)

  FLUID_FLOW_1D.Tee( is_a Tee2)
   Tee1(
  Tee2 except:
      D2 = 0.01,
      P_o = Pdown,      -- Non default value.
      T_o = Tdown,      -- Non default value.
      x_nco = 1,        -- Non default value.
  )

  FLUID_FLOW_1D.Tee(
      burnerGasesOption =
FLUID_PROPERTIES.noBurnGases)
   Tee2(
      Gcr_ideal =  FALSE ,
      D1 = 0.01,
      D2 = 0.004,       -- Non default value.
      D3 = 0.01,
      zeta1 = 0.1,
      zeta2 = 0.8,
      zeta3 = 0.1,
      Re_lam = 2000,
      x = 0,
      y = 0,
      z = 0,
      init_option = INIT_PT,
      P_o = Ptank,      -- Non default value.
      T_o = Ttank,      -- Non default value.
      x_o = 0,
      rho_o = 1,
      x_nco = 0,
      xd_nco = 0,
      Tee_type = right_Tee,
      iangle = { 0,90,0} ,
      Vo = 1,
      L = 0)
```

```
  FLUID_FLOW_1D.VolPT_TMD(
      burnerGasesOption =
FLUID_PROPERTIES.noBurnGases)
   Gas(
      xd_nc = 0)

  FLUID_FLOW_1D.Valve( is_a V7)
   V6(
  V7 except:
      tao = 0.005,        -- Non default value.
  )

  FLUID_FLOW_1D.Valve(
      burnerGasesOption =
FLUID_PROPERTIES.noBurnGases)
   V7(
      x_jun = 0,
      y_jun = 0,
      z_jun = 0,
      Gcr_ideal =  FALSE ,
      Ao = 3.14 / 4 * 0.01 ** 2,      -- Non default value.
      zetaf = 1,          -- Non default value.
      zetab = 1,          -- Non default value.
      m_o = 0,
      Re_lam = 2000,
      valve_char = Linear,
      tao = 0.0001,       -- Non default value.
      zeta_vs_pos = { { 0,1} ,{ 1.7,1.7} } ,
      Arel_vs_pos = { { 0,1} ,{ 0,1} })

FLUID_FLOW_1D.WorkingFluid WFluid(
      fluid = PfLiq_H2O,          -- Non default value.
      fluid_nc = PfGas_N2         -- Non default value.
)
   CONNECT Plug.f_out TO L2_plug.f2
   CONNECT Reduct553.f1 TO L2_3.f2
   CONNECT Reduct553.f2 TO L2.f1
   CONNECT V6.f2 TO L1.f1
   CONNECT Tee1.f2 TO L2_2.f1
   CONNECT Tee1.f3 TO L2_3.f1
   CONNECT V6.f1 TO Tube.f2
   CONNECT Junc.f2 TO Tube.f1
   CONNECT Junc.f1 TO WFluid.f1
   CONNECT Pamont.f_out TO L2_2.f2
   CONNECT V7.f2 TO L2_1.f1
   CONNECT Tee1.f1 TO L2_1.f2
   CONNECT JuncPaval.f2 TO L2_plug.f1
   CONNECT JuncPaval.f1 TO L2.f2
   CONNECT Tee2.f1 TO L1.f2
   CONNECT Tee2.f3 TO L1_3.f1
   CONNECT V7.f1 TO L1_3.f2
   CONNECT Tee2.f2 TO L1_2.f1
   CONNECT PvacuumPump.f_out TO
L1_2.f2
   CONNECT WFluid.f2 TO Gas.f
END COMPONENT
```

With respect to the file used in 2008 (§5.2), in the library IND_EVAL the component L1_3 has been initialized with the right upstream values

```
      P_o = Ptank,      -- Non default value.
      T_o = Ttank,      -- Non default value.
      x_nco = 0,
```

which has about no consequences after the first 25 ms of simulation (waterhammer occurs at simulation time of 77 ms).

Also, the local initialisation of the Reynolds for laminar transition (Re_lam moved from global Bound to local initialisation for ESPSS releases after 2008) has been set for any junction to

```
      Re_lam = 2000,
```

which has no consequences during the high waterhammer because the Reynolds are higher.

```
-- '  16/04/2017  14:36:55
EXPERIMENT expWater ON CnesOneraDroit05.default
 DECLS
     TABLE_1D wl0 =  {{-10, 0, 0.025,  10}, {0, 0, 1, 1}} --timeTableInterp(TIME-0.,wl0 )
                     REAL x_nco_Down =0
                     REAL DampArtificial =1
                     STRING NamFile="ReportsMemory"
 INIT
     -- State variables
   BOUNDS
     -- Set expressions for boundary variables: v = f(t;...)
     FLUID_FLOW_1D.Damp = DampArtificial
     FLUID_FLOW_1D.GRAV = 9.806
     FLUID_FLOW_1D.GRAVx = 0.
     FLUID_FLOW_1D.GRAVy = 0.
     --FLUID_FLOW_1D.Re_lam = 3000.
     Gas.s_pres.signal[1] = Ptank
     Gas.s_temp.signal[1] = Ttank
     Gas.s_xNonCond.signal[1] = 0
     V6.s_pos.signal[1] = 1
     V7.s_pos.signal[1] =timeTableInterp(TIME-0.,wl0 )
 BODY
          Ttank = 300
          Tdown = 300
          Ptank = 2000000 --/2
          Tee1.zeta2=0.8*3
          L2_2.D=0.004
          Tee1.D2=L2_2.D/3
          L1.x_nco=0
          L1_2.x_nco=0
          L1_3.x_nco=0
          Tee2.x_nco=0--Tee2 is the one in the liquid side
          Pdown = 100*10 --1 mb=100 Pa
          x_nco_Down =1  --10/40 --0.5--1
          Tee1.x_nco=x_nco_Down --Tee1 is the one in the vacuum side
          L2_1.x_nco=x_nco_Down
          L2_2.x_nco=x_nco_Down
          L2_3.x_nco=x_nco_Down
          L2.x_nco=x_nco_Down
          L2_plug.x_nco=x_nco_Down
          Tee2.zeta2=0.8
          Tee2.x_nco=0
          DampArtificial =1--0.3
       WFluid.fluid=Real_H2O -- PfLiq_H2O --Real_H2O --
    -- original Fluid libs
     NamFile= "R20Ba" --  error       bar (zeta2*3  D2/2  L2 30 nodes Damp=0.3 and 1 node Tee realfluid 10
mb xnc=1 10 nodes and 1 for short tubes,
     --analysed but not released Eai-Kci Espssph2 Eau9Eau10 droit 20bar.xls
     NamFile= "R20Bb" --        bar (zeta2*3  D2/2  L2 30 nodes Damp=0.3 and 1 node Tee realfluid 40 mb
xnc=1 10 nodes and 1 for short tubes,
     --View PAGE 6 18/06/08 ESTEC Eai-Kci Espssph2 Eau9Eau10 droit 20bar.xls
     NamFile= "R20Bc" --        bar (zeta2  D2  L2 30 nodes Damp=0.3 and 1 node Tee realfluid 40 mb
xnc=1 10 nodes and 1 for short tubes,
     --View PAGE 7 18/06/08 ESTEC Eai-Kci Espssph2 Eau9Eau10 droit 20bar.xls
     NamFile= "R20Bc1" --        bar (idem Damp=1
     ----------------------------------------------------------New report TRACEABILITY but Nodes rule sqrt(Inertance)
     -- added REL_ERROR=1E-4    ABS_ERROR=REL_ERROR  instead of default values
     -- Eai-Kci-Me-01 IndustrialEvaluation02
     NamFile= "R10d5" --   ok(idem previous but water 10 Bar amont upstream instead of 20 bar
     -- Eai-Kci-Me-01 IndustrialEvaluation02
     NamFile= "R10d10" --   ok(idem previous  Pamont upstream =10 bar but  210 mb 42 nodes max
@180mbar  @250
     -- Eai-Kci-Me-01 IndustrialEvaluation02
     NamFile= "R20d12" --   some lack ok(idem previous  but Pamont upstream =20 bar  but 10 mb and rule
inertance 27
     -- Eai-Kci-Me-01 IndustrialEvaluation02  Comparison Real fluid Perfect fluid
     NamFile= "R20d13" --   some lack ok(idem previous  ... rule inertance 27 but Perfect
     NamFile= "R20d12bis" --   ok(idem previous  but Pamont upstream =20 bar  but 10 mb and rule
inertance 27 and L1_3 set to Ptank, Ttank instead of Pdown, Tdown
     NamFile= "R20d12back" --   ok(idem previous  but Pamont upstream =20 bar  but 10 mb and rule
inertance 27 and L1_3 set to Ptank, Ttank instead of Pdown, Tdown
     --   REPORT_TABLE("R20d12back" , " *node* *e.f*.P L*.f*.P TRACEABILITY *NamFile* *zeta *zeta1 *zeta2
*zeta3 *W*d.fluid* *nodesNb* *.Damp *.D *.D1 *.D2 *.D3 *.L *.Ao *.P_o *.x_o *.T_o *.Vo *.x_nco ")
        REL_ERROR=1E-4
        ABS_ERROR=REL_ERROR
        REPORT_MODE=IS_STEP
        TIME =-0.0005
        TSTOP = 0.299
        CINT = 0.1
        INTEG()
END EXPERIMENT
```

5.2 Files used in 2008

For information, in 2008, the listing of the model used for the Technical note "Eai-Kci-Me-01 IndustrialEvaluation02_c" or for the Adelaide papers was:

```
-- Generated automatically by - EcosimPro - 4.4.0 - 08/26/2008 12:06:53
USE FLUID_FLOW_1D VERSION "1.0"
USE FLUID_PROPERTIES VERSION "1.0"
USE THERMAL VERSION "3.0"
-- '  15/04/2017  20:42:58
COMPONENT CnesOneraDroit05
DATA
        REAL Ptank = 2000000 UNITS "Pa"
        REAL Ttank = 300 UNITS "K"
        REAL Pdown = 1000 UNITS "Pa"
        REAL Tdown = 300 UNITS "K"
        REAL xnc_down = 0 UNITS "-"
TOPOLOGY


 FLUID_FLOW_1D.Pipe( is_a L2_3)
  L1_3(
 L2_3 except:
     L = 0.04,          -- Non default value.
 )

 FLUID_FLOW_1D.Pipe( is_a L2_3)
  L2_1(
 L2_3 except:
     L = 0.04,          -- Non default value.
 )

 FLUID_FLOW_1D.Pipe(
 L2_3 except:
     nodes = No5,       -- Non default value.
 ) L2_plug(
 L2_3 except:
     ht_option = HT_tube,
     e_wall = 0.0004,   -- Non default value.
     L = 0.04,          -- Non default value.
     D = 0.00553,       -- Non default value.
 )

 FLUID_FLOW_1D.Pipe(
 L2_3 except:
     nodes = No5,       -- Non default value.
 ) L2_2(
 L2_3 except:
     L = 0.03,          -- Non default value.
     D = 0.004,         -- Non default value.
 )

 FLUID_FLOW_1D.Pipe(
 L2_3 except:
     nodes = No19,      -- Non default value.
 ) L1_2(
 L2_3 except:
     P_o = Ptank,       -- Non default value.
     T_o = Ttank,       -- Non default value.
     x_nco = 0,         -- Non default value.
     L = 0.5,           -- Non default value.
     D = 0.004,         -- Non default value.
 )

 FLUID_FLOW_1D.Pipe(
 L2_3 except:
     nodes = No9,       -- Non default value.
     case = liquid_pipe             -- Non default value.
 ) L1(
 L2_3 except:
     P_o = Ptank,       -- Non default value.
     T_o = Ttank,       -- Non default value.
     x_nco = 0,         -- Non default value.
     L = 0.66,          -- Non default value.
 )

 FLUID_FLOW_1D.Pipe(
 L2_3 except:
     nodes = No27,      -- Non default value.
 ) L2(
 L2_3 except:
     ht_option = HT_tube,
     e_wall = 0.0004,   -- Non default value.
     L = 1.95,          -- Non default value.
     D = 0.00553,       -- Non default value.
 )

 FLUID_FLOW_1D.Pipe(
 L2_3 except:
     nodes = No5,       -- Non default value.
     case = liquid_pipe             -- Non default value.
 ) Tube(
 L2_3 except:
     P_o = Ptank,       -- Non default value.
     T_o = Ttank,       -- Non default value.
     x_nco = 0,         -- Non default value.
     L = 1.24,          -- Non default value.
     D = 0.02,          -- Non default value.
 )

 FLUID_FLOW_1D.Pipe(
     nodes = No2,       -- Non default value.
     n_bends = 1,
     scheme = centred,
     case = gas_pipe)
  L2_3(
     num = 1,
     init_option = INIT_PT,
     P_o = Pdown,       -- Non default value.
     T_o = Tdown,       -- Non default value.
     x_o = 0,           -- Non default value.
     rho_o = 1,         -- Non default value.
     x_nco = 1,         -- Non default value.
     m_o = 0,           -- Non default value.
     rug = 1.6e-006,    -- Non default value.
     k_f = 1,
     k_d = 1,
     alpha_bend = { 0} ,            -- Non default value.
     R_bend = { 1} ,    -- Non default value.
     fld_add = 0,
     ht_option = HT_tube_Traviss,           -- Non default
value.
     hc_dat = 1,
     entropy_fix = no_fix,
     entropy_fix_multiplier = 4,
     integration_rule = midpoint,
     dp_correction = FALSE,
     limiter = VanAlbada,
     preconditioner = unprecond,
     reconstructed_variables = primitive,
     central_reconstruction = TRUE,
     source_upwind_smoothing = 0,
     h_outside = 0,     -- Non default value.
     T_outside = 295.15,            -- Non default value.
     mat = Titanium,    -- Non default value.
     E_wall = 100000000000.,
     v_wall = 0.3,
     cp_wall = 500,
     rho_wall = 1500,
     anchor = upstream_anchored,
     e_wall = 0.001,
     L = 0.02,          -- Non default value.
     D = 0.01,
     D_vs_L = { { 0,0.5,1} ,{ 1,1,1} },
     dx_vs_L = { { 0,0.5,1} ,{ 1,1,1} })

 FLUID_FLOW_1D.Junction Reduct553(
  is_a JuncPaval)

 FLUID_FLOW_1D.Junction Junc(
 JuncPaval except:
     Ao = 3.14 / 4 * 0.02 ** 2,     -- Non default value.
 )

 FLUID_FLOW_1D.Junction JuncPaval(
     x_jun = 0,
     y_jun = 0,
     z_jun = 0,
     Ao = 3.14 / 4 * 0.00553 ** 2, -- Non default value.
     zetaf = 0.5,       -- Non default value.
     zetab = 1,
     m_o = 0)

 FLUID_FLOW_1D.DeadEnd PvacuumPump(
  is_a Pamont)

 FLUID_FLOW_1D.DeadEnd Plug(
  is_a Pamont)

 FLUID_FLOW_1D.DeadEnd Pamont(
     x_jun = 0,
     y_jun = 0,
     z_jun = 0)

 FLUID_FLOW_1D.Tee Tee1(
 Tee2 except:
     D2 = 0.01,
     P_o = Pdown,       -- Non default value.
     T_o = Tdown,       -- Non default value.
     x_nco = 1          -- Non default value.
 )

 FLUID_FLOW_1D.Tee Tee2(
     D1 = 0.01,
     D2 = 0.004,        -- Non default value.
     D3 = 0.01,
     zeta1 = 0.1,
     zeta2 = 0.8,
     zeta3 = 0.1,
     x = 0,
     y = 0,
     z = 0,
     init_option = INIT_PT,
     P_o = Ptank,       -- Non default value.
     T_o = Ttank,       -- Non default value.
     x_o = 0,
     rho_o = 1,
     x_nco = 0)

 FLUID_FLOW_1D.VolPT_TMD Gas

 FLUID_FLOW_1D.Valve V6(
 V7 except:
     tao = 0.005        -- Non default value.
 )

 FLUID_FLOW_1D.Valve V7(
     x_jun = 0,
     y_jun = 0,
     z_jun = 0,
     Ao = 3.14 / 4 * 0.01 ** 2,     -- Non default value.
     zetaf = 1,
     zetab = 1,
     m_o = 0,
     tao = 0.0001)

 FLUID_FLOW_1D.WorkingFluid WFluid(
     fluid = PfLiq_H2O,             -- Non default value.
     fluid_nc = PfGas_N2            -- Non default value.
 )
  CONNECT L2_plug.f2 TO Plug.f_out
  CONNECT L2_3.f2 TO Reduct553.f1
  CONNECT Reduct553.f2 TO L2.f1
  CONNECT L1.f1 TO V6.f2
  CONNECT Tee1.f2 TO L2_2.f1
  CONNECT Tee1.f3 TO L2_3.f1
  CONNECT V6.f1 TO Tube.f2
  CONNECT Tube.f1 TO Junc.f2
  CONNECT Junc.f1 TO WFluid.f1
  CONNECT L2_2.f2 TO Pamont.f_out
  CONNECT V7.f2 TO L2_1.f1
  CONNECT Tee1.f1 TO L2_1.f2
  CONNECT JuncPaval.f2 TO L2_plug.f1
  CONNECT L2.f2 TO JuncPaval.f1
  CONNECT L1.f2 TO Tee2.f1
  CONNECT Tee2.f3 TO L1_3.f1
  CONNECT L1_3.f2 TO V7.f1
  CONNECT Tee2.f2 TO L1_2.f1
  CONNECT L1_2.f2 TO PvacuumPump.f_out
  CONNECT Gas.f TO WFluid.f2
END COMPONENT
```
