Deltares
Enabling Delta Life

WANDA 4.0

Architecture,
T-fitting,
Applications.

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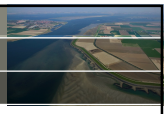
November 19th 2008

Overview



1. Why WANDA 4 ?
2. Architecture WANDA 3
3. Connection points
4. T-fitting
5. Gas, quantity's are configurable
6. Area's of application
7. Architecture WANDA 4
8. Questions, discussion

Why WANDA 4?

Questions besides normal waterhammer study's

- non-liquid systems (gas, steam)
- multiple liquids (warm/cold) in the same system
- Oil/gas needs mechanical models, which fit Wanda perfectly
- Tee- and X-fittings (3 and 4 connection points)
- enthousiasm about WANDA user interface

Market expansion based on the stability of the WANDA system

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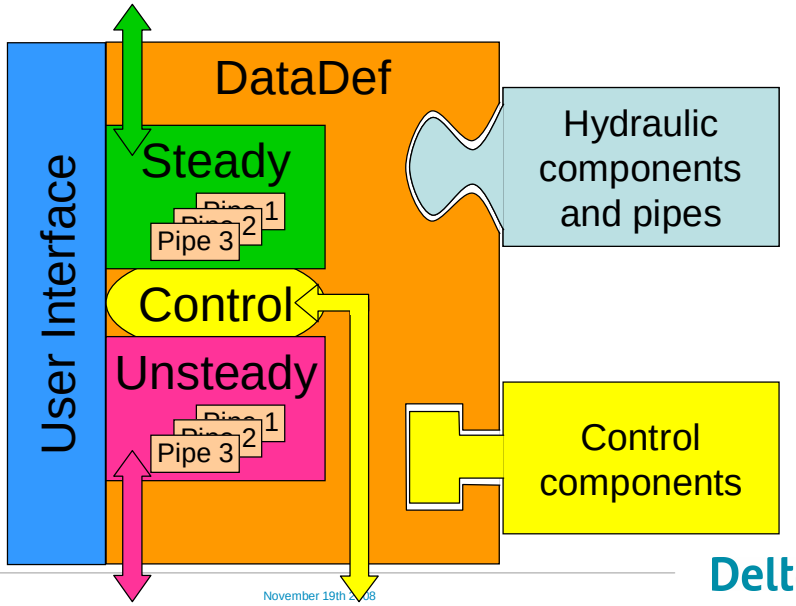
Architecture WANDA 3



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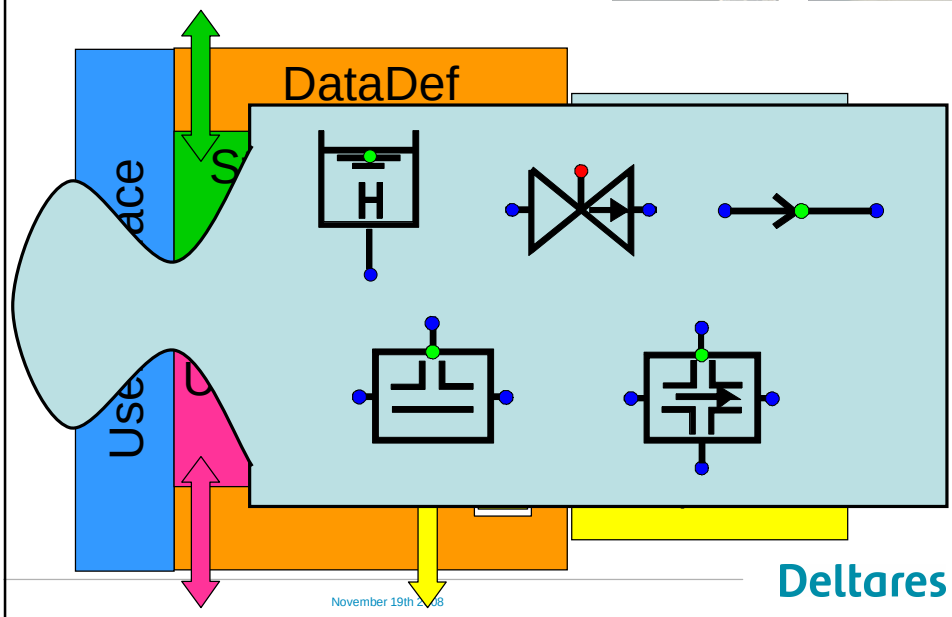
Connection points



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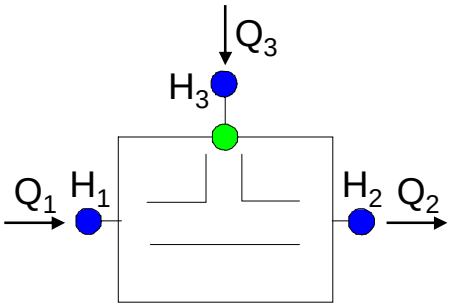
Tee-fitting



3 equations:

2 headloss: $H_1 - H_2 = C_1 Q_2^2$

$H_3 - H_2 = C_2 Q_2^2$

1 conservation of mass: $Q_1 - Q_2 + Q_3 = 0$

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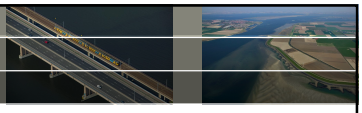
Headloss Tee-fitting



- Miller, graphs
- Idelčik, graphs and equations
- Gardel equations
- Delft Hydraulics equations

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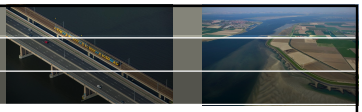
Tee-fitting Miller (1)



Combining Flow

$$K_{13} = \left[\left(\frac{U_1^2}{2g} + h_1 \right) - \left(\frac{U_3^2}{2g} + h_3 \right) \right] \Big/ \frac{U_3^2}{2g}$$

$$K_{23} = \left[\left(\frac{U_2^2}{2g} + h_2 \right) - \left(\frac{U_3^2}{2g} + h_3 \right) \right] \Big/ \frac{U_3^2}{2g}$$

Dividing Flow

$$K_{31} = \left[\left(\frac{U_3^2}{2g} + h_3 \right) - \left(\frac{U_1^2}{2g} + h_1 \right) \right] \Big/ \frac{U_3^2}{2g}$$

$$K_{32} = \left[\left(\frac{U_3^2}{2g} + h_3 \right) - \left(\frac{U_2^2}{2g} + h_2 \right) \right] \Big/ \frac{U_3^2}{2g}$$

Branch 3 contains the total flow, branch 1 is the ‘branch’

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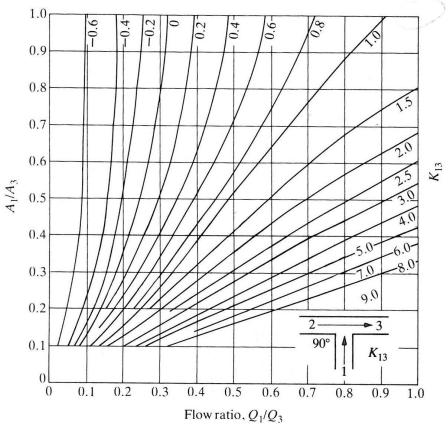
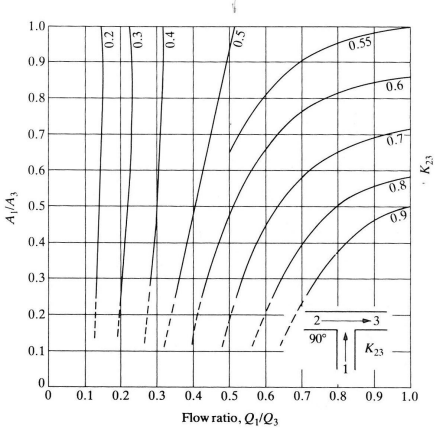
Tee-fitting Miller (2)





K_{13} K_{23}

Combining Flow

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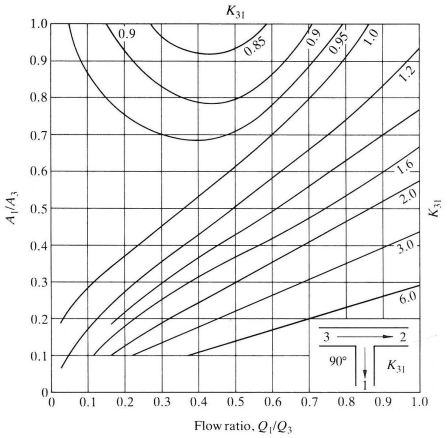
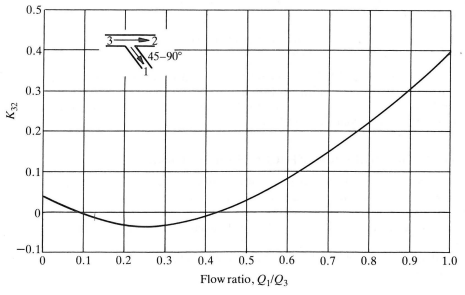
Tee-fitting Miller (3)





K_{31} K_{32}

Dividing Flow

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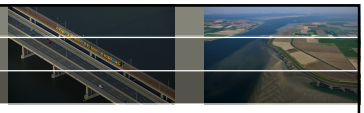
Tee-fitting Idelčik



Lots of graphs and equations.
based on equations of Levin and Taliev
Experiments by Levin, Gardel, Kinne, Peterman, Vogel

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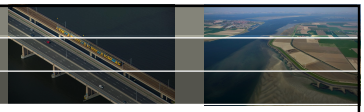
Tee-fitting Gardel equations



Combining flow

$$K_{13} = -0.92(1-q)^2 - q^2\left\{\left(1.2-\sqrt{r}\right)\left(\frac{\cos(\alpha)}{a}-1\right)+0.8\left(1-\frac{1}{a^2}\right)-(1-a)\frac{\cos(\alpha)}{a}\right\}$$
$$+(2-a)(1-q)\,q$$

Dividing flow

$$K_{31} = -0.95(1-q)^2 - q^2\left\{\left[1.3\cot\left(\frac{180-\alpha}{2}\right)-0.3+\frac{0.4-0.1a}{a^2}\right]\left[1-0.9\sqrt{\frac{r}{a}}\right]\right\}$$
$$-\ 0.4\,q\,(1-q)\left(1+\frac{1}{a}\right)\cot\left(\frac{180-\alpha}{2}\right)$$

q = flow ratio, Q_1/Q_3
a = area ratio, A_1/A_3
r = radius into branch
α = angle of branch to forward flow direction

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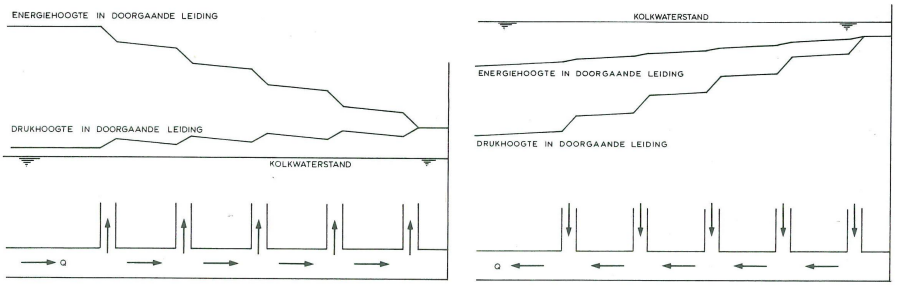
Tee-fitting Delft Hydraulics Equations

In the early 80's, Delft Hydraulics has formulated several equations for the resistance- and regain-coëfficiënts for use in multi-port sewar systems used for the filling and emptying of sluices



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Quantity's

Liquid	Gas
H H,Q	p,v,ρ,T
H,Q — H,Q	p,v,ρ,T — p,v,ρ,T
H,Q — H,Q	p,v,ρ,T — p,v,ρ,T

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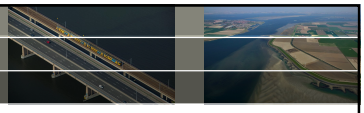
Area's of Application (1)



Liquid

Wanda Liquid

- Transport systems
- Proces systems
- Power piping, hydraulics
- Pumptrip, turbine runaway
- Closing valves
- Waterhammer, pressure surges
- Oscillations, pulsations

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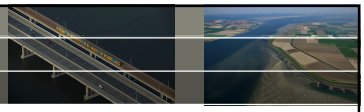
Area's of Application (2)



Multi-Liquid

Wanda Multi-liquid

- One liquid per pipe
  - > District heating circuits (control systems)
  - > Underground salt-mining
  - > Coolingsystems (startup, shutdown)
- One liquid per calculation node
  - > Batch transport oil pipelines
  - > Heating, cooling of pipelines
  - > Heavy olie, heating stations

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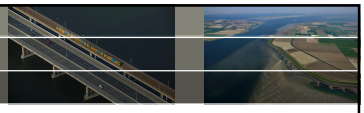
Area's of Application (3)



Wanda Gas

- Choke valve break out, HIPPS
- Blown down
- Transport and booster compressorstations
- Simple slugmodels

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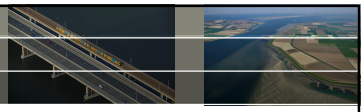
Area's of Application (4)



Wanda Multi-phase

- One phase per pipe
  - > Energy-circuits / Powerplants
  - > Condensors
  - > Boilers
- Multiple phases per calculation node
  - > Oil/gas, slugs, including risers, downcomers
  - > Water/air, CAPWAT
  - > Filling of pipelines

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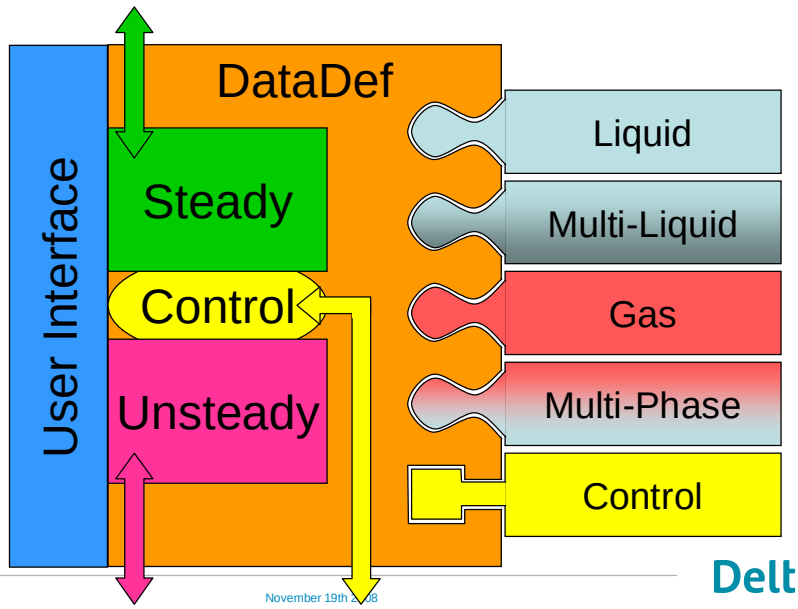
Architecture WANDA 4



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Questions?

WANDA 4

We can't wait!

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