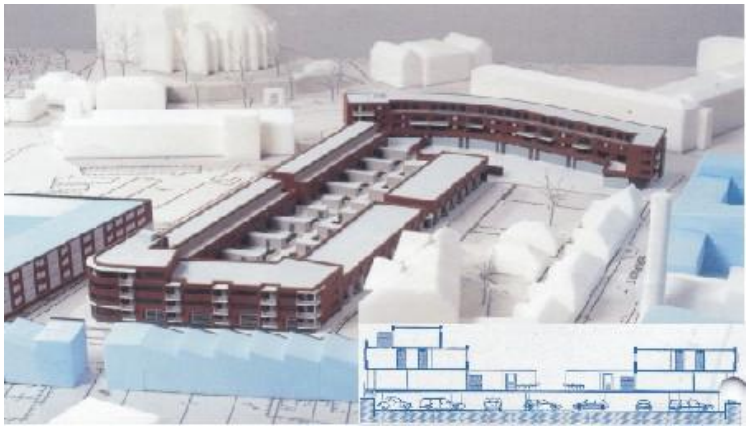
WANDA

Deltares

Wanda 4 Heat

Application

Urban District Heating



Process industry

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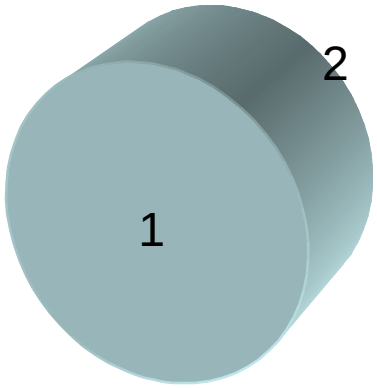
Theory: Variables – Wanda 4 Liquid



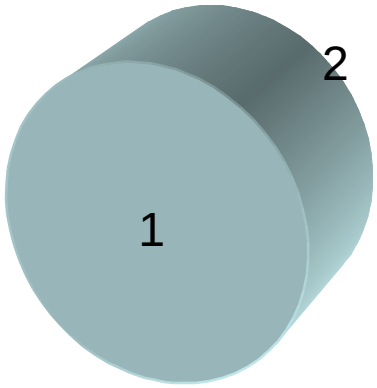
Primary calculation variables:

Discharge	Q	[m3/s]
Head	H	[m]

Derived variables:

Pressure	p	[Pa]
Velocity	v	[m/s]

Theory: Variables – Wanda 4 Heat



Primary calculation variables:

Mass flow rate	$\dot{m}$	[kg/s]
Stagnation pressure	p	[Pa]
Temperature (new)	T	[°C]

Derived variables:

Density	ρ	[kg/m3]
Head	H	[m]
Discharge	Q	[m3/s]
Velocity	v	[m/s]

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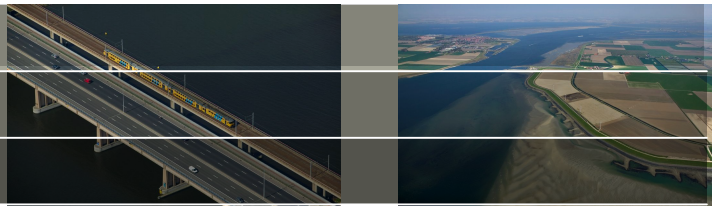
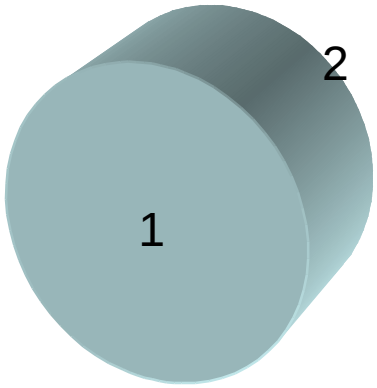
Theory: Relation with QH





$$\dot{m} = \rho Q \qquad p = \rho g (H - z)$$

Primary calculation variables:

Mass flow rate	$\dot{m}$	[kg/s]
Stagnation pressure	p	[Pa]
Temperature (new)	T	[°C]

Derived variables:

Density	ρ	[kg/m3]
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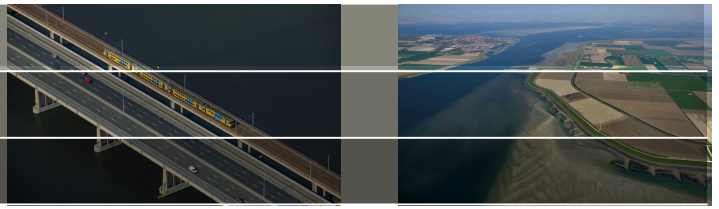
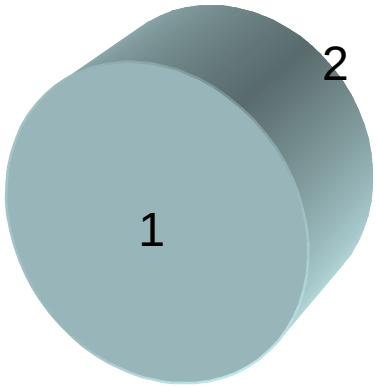
Theory: Relation with QH





$$\dot{m} = \rho Q \qquad p = \rho g (H - z)$$

Mass conservation:

$$\dot{m}_1 - \dot{m}_2 = 0$$

Comparison with QH:

$$Q_1 - Q_2 = 0$$

Primary calculation variables:

Mass flow rate	$\dot{m}$	[kg/s]
Stagnation pressure	p	[Pa]
Temperature (new)	T	[°C]

Derived variables:

Density	ρ	[kg/m3]
Head	H	[m]
Discharge	Q	[m3/s]
Velocity	v	[m/s]

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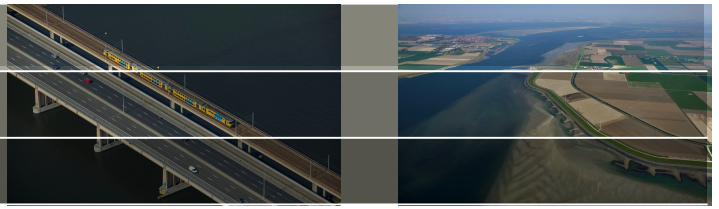
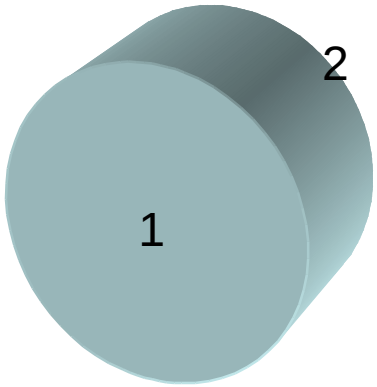
Theory: Relation with QH





Primary calculation variables:

Mass flow rate	$\dot{m}$	[kg/s]
Stagnation pressure	p	[Pa]
Temperature (new)	T	[°C]

$$\dot{m} = \rho Q \qquad p = \rho g (H - z)$$

Derived variables:

Density	ρ	[kg/m3]
Head	H	[m]
Discharge	Q	[m3/s]
Velocity	v	[m/s]

Relation pressure en mass flow rate:

$$p_1 - p_2 = \frac{\xi}{2\rho} \frac{\dot{m}|\dot{m}|}{A^2}$$

Comparison with QH:

$$H_1 - H_2 = \frac{\xi}{2g} \frac{Q|Q|}{A^2}$$

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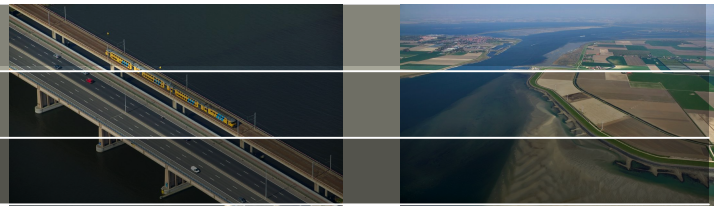
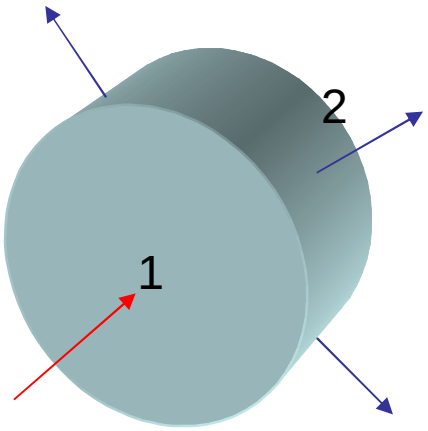
Theory: Temperature en heat





1) Heat by mass flow

2) Heat generated by friction

3) Heat loss to surroundings

Primary calculation variables:

Mass flow rate	$\dot{m}$	[kg/s]
Stagnation pressure	p	[Pa]
Temperature (new)	T	[°C]

Derived variables:

Density	ρ	[kg/m3]
Head	H	[m]
Discharge	Q	[m3/s]
Velocity	v	[m/s]

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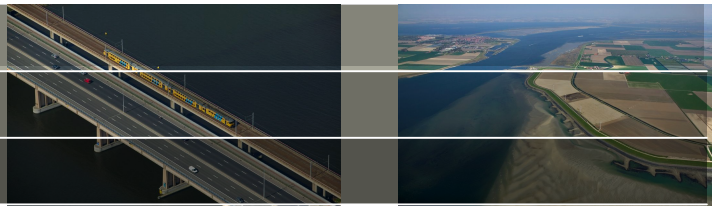
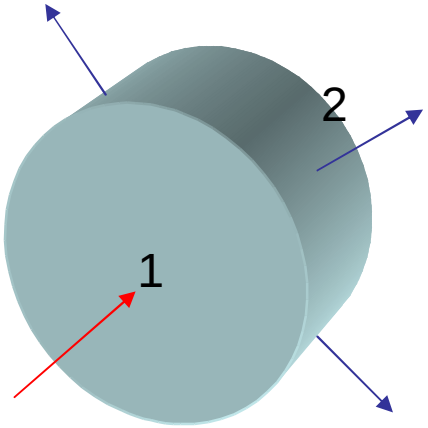
Theory: Temperature en heat





1) Heat by mass flow

$$\dot{Q}_{\text{input}} = \dot{m}c(T_1 - T_2)$$

c: specific heat [J/kg K]

2) Heat generated by friction

$$\dot{Q}_{\text{gen}} = \dot{m}g\Delta H$$

3) Heat loss to surroundings

$$\dot{Q}_{\text{loss}} = h_w A_{\text{exposed}}(T - T_{\text{omg}})$$

h_w: heat transfer coefficient [W/m^2 K]

Primary calculation variables:

Mass flow rate	$\dot{m}$	[kg/s]
Stagnation pressure	p	[Pa]
Temperature (new)	T	[°C]

Derived variables:

Density	ρ	[kg/m3]
Head	H	[m]
Discharge	Q	[m3/s]
Velocity	v	[m/s]

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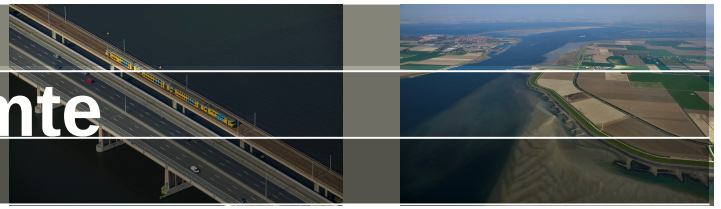
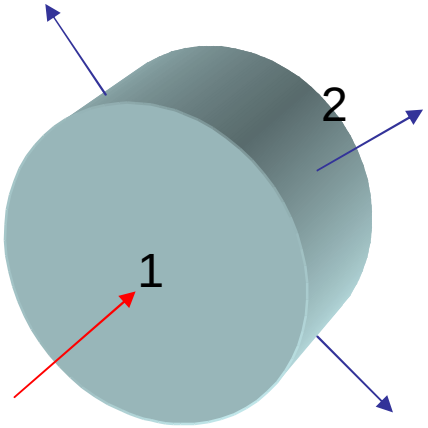
Theorie: Temperatuur en warmte





Primary calculation variables:

Mass flow rate	$\dot{m}$	[kg/s]
Stagnation pressure	p	[Pa]
Temperature (new)	T	[°C]

Derived variables:

Density	ρ	[kg/m3]
Head	H	[m]
Discharge	Q	[m3/s]
Velocity	v	[m/s]

Relation temperature and mass flow rate:

$$T_2 = f\left(\dot{m}, T_1, T_{\text{omg}}, f, D, L, h_{\text{w}}, c, \rho\right)$$

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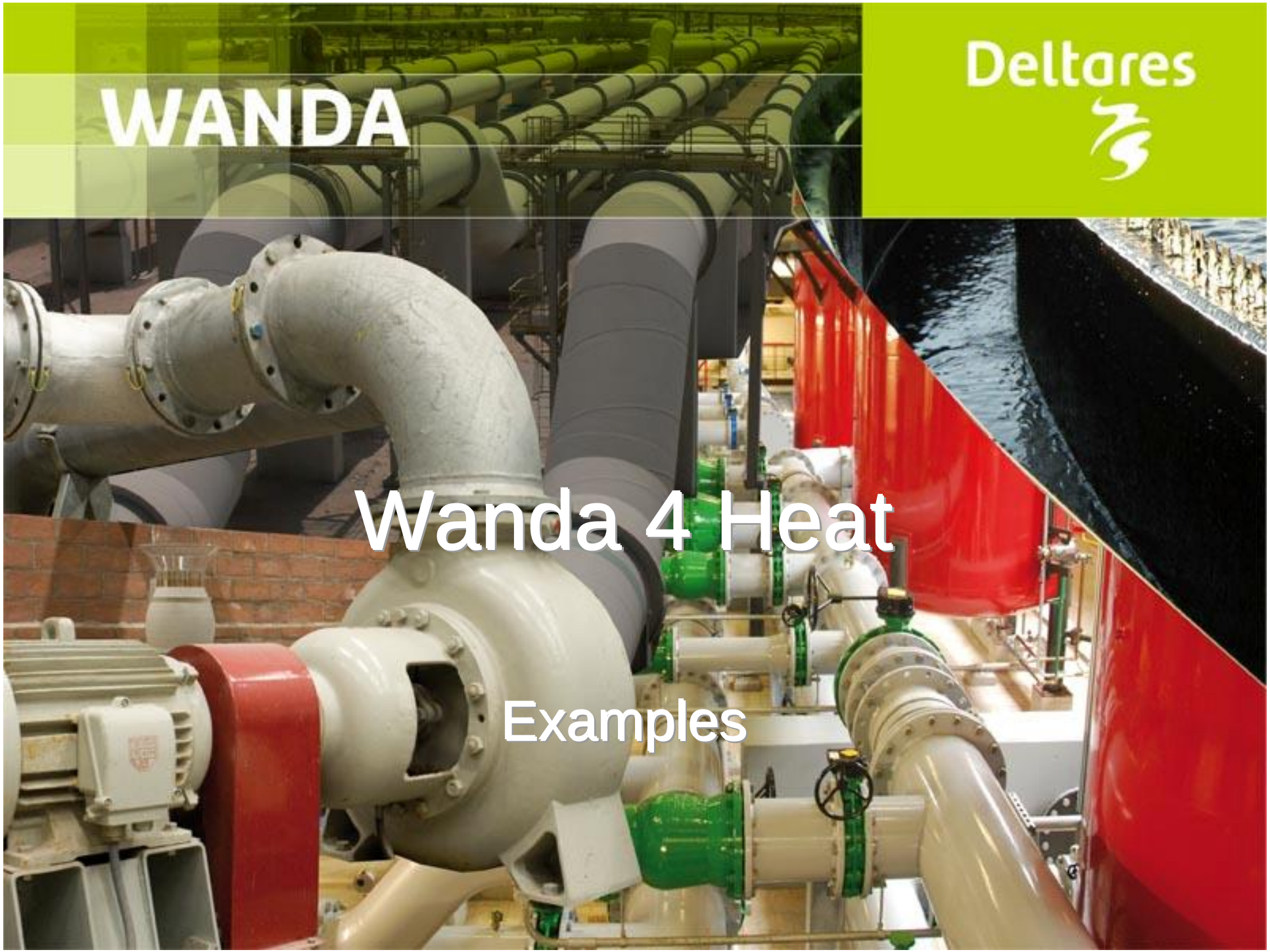
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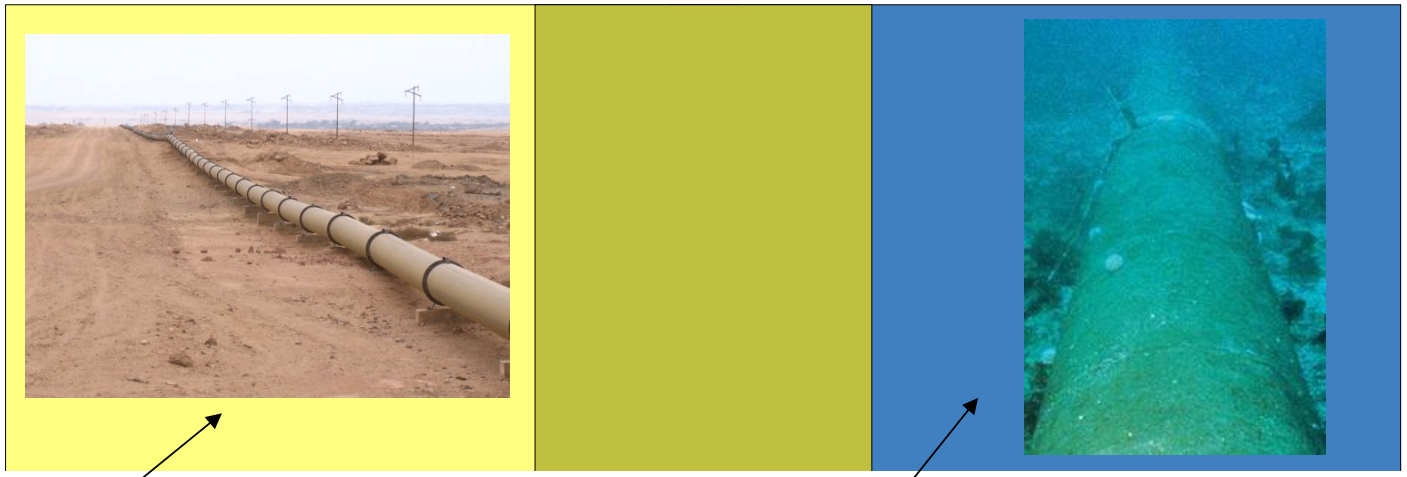
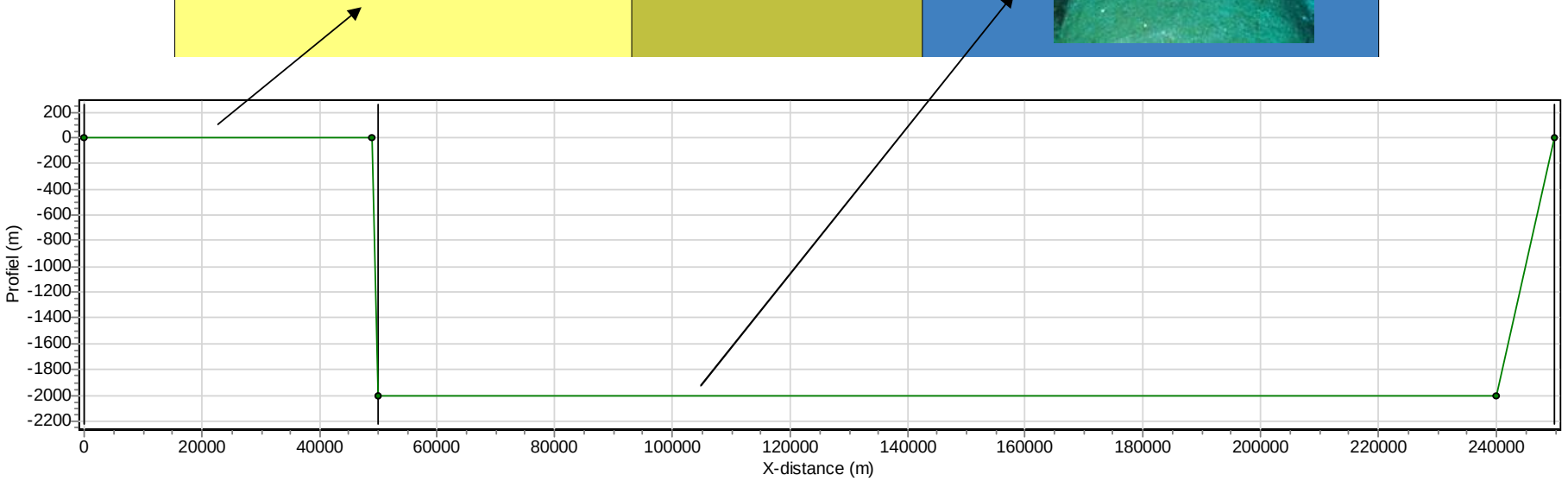
Wanda 4 Heat
Examples

Example 1: heat loss pipelines





50 km

200 km

Labels Profile

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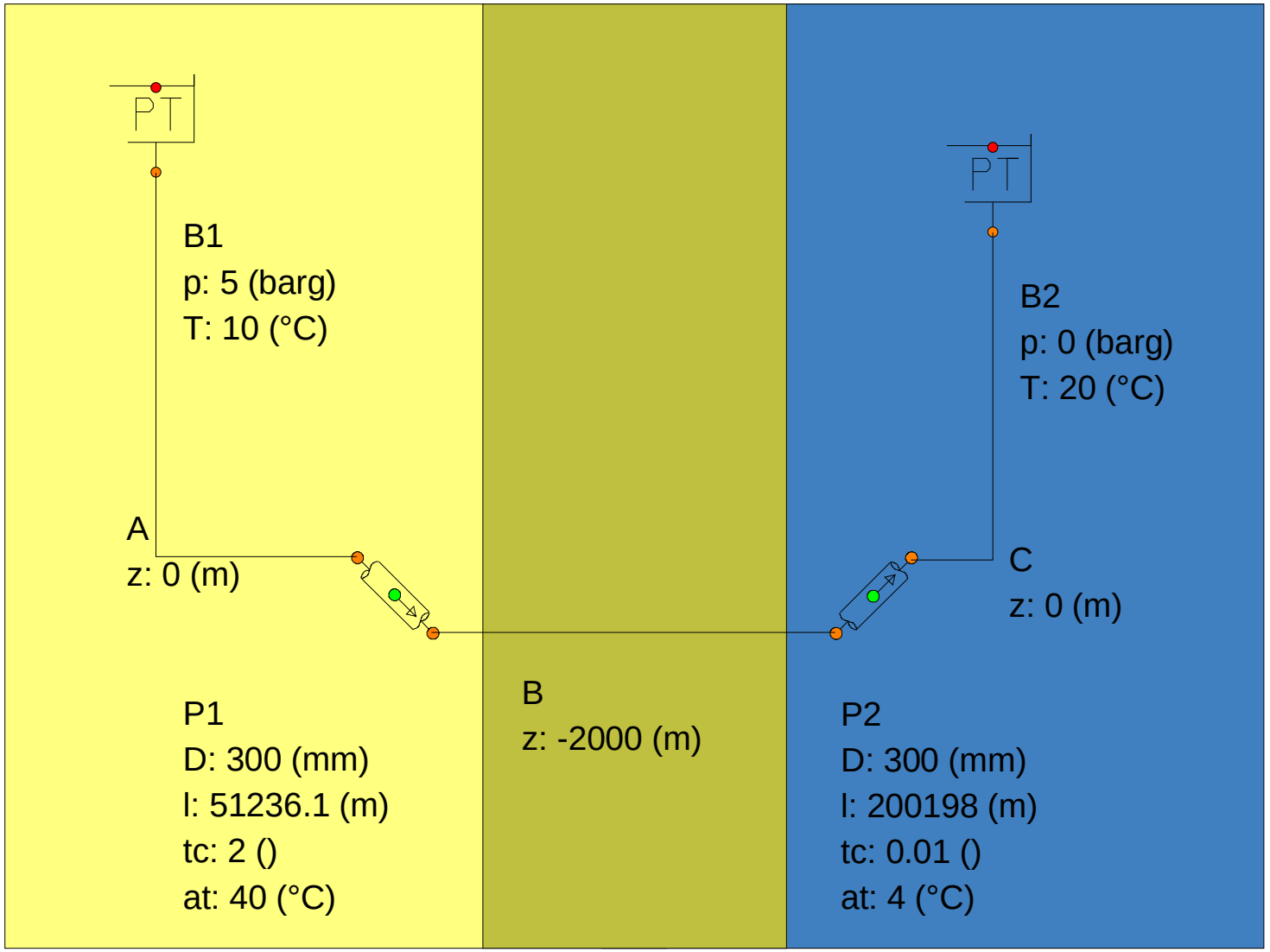
Example 1: heat loss pipelines: inputs



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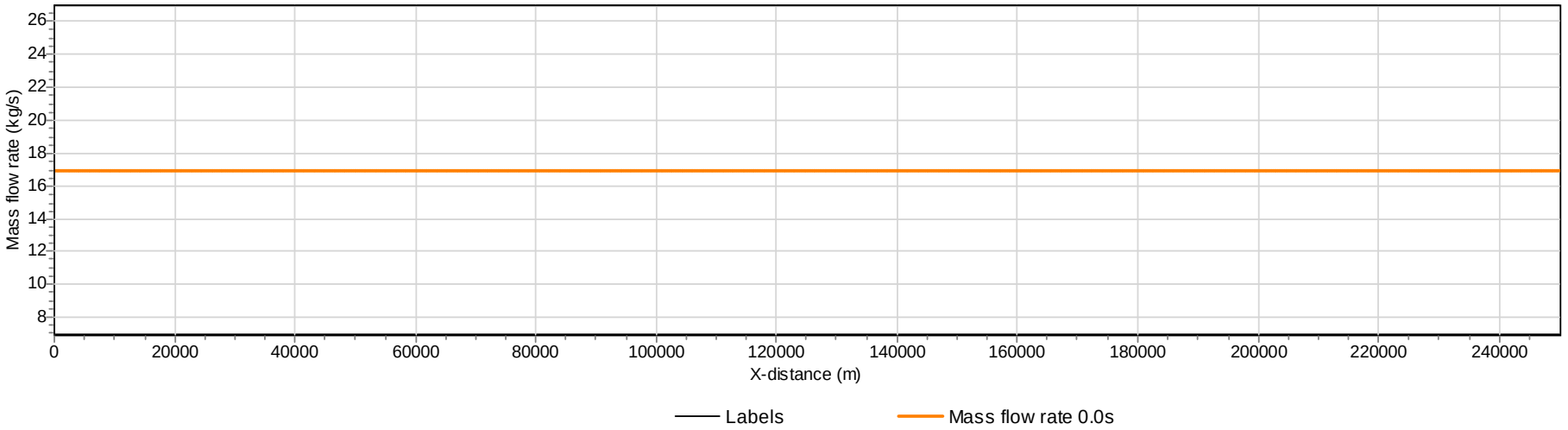
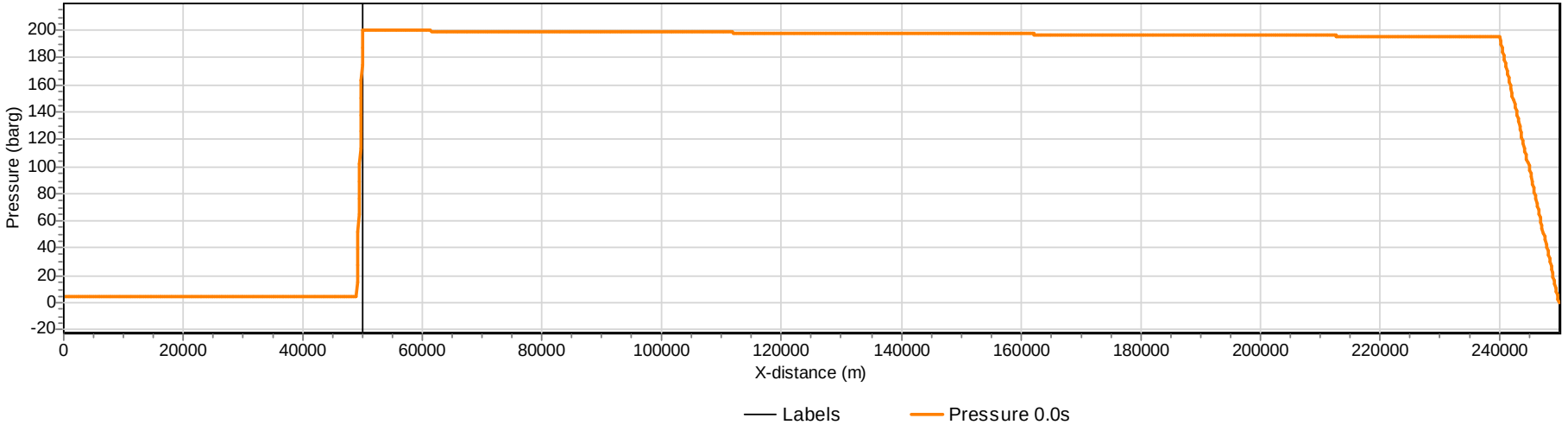
Example 1: heat loss pipelines: outputs





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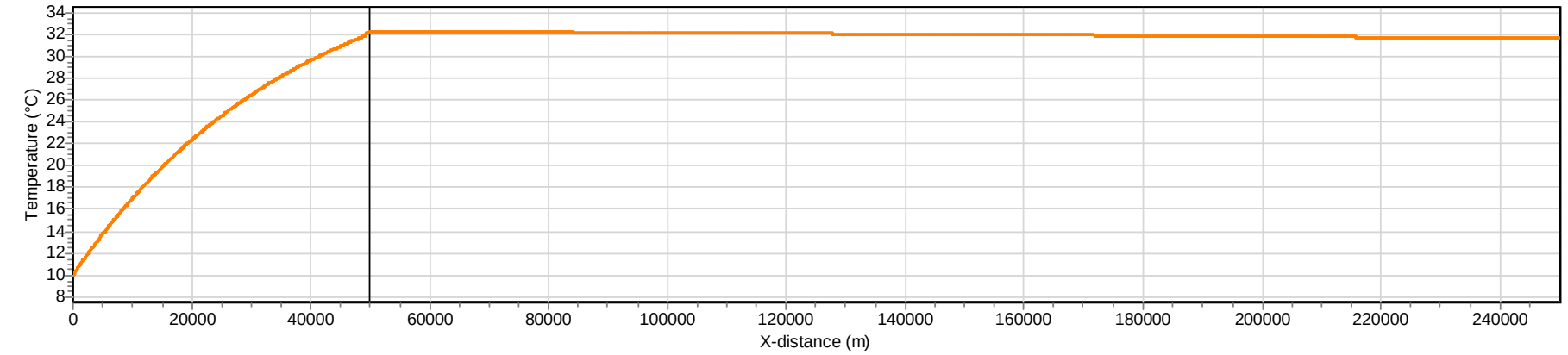
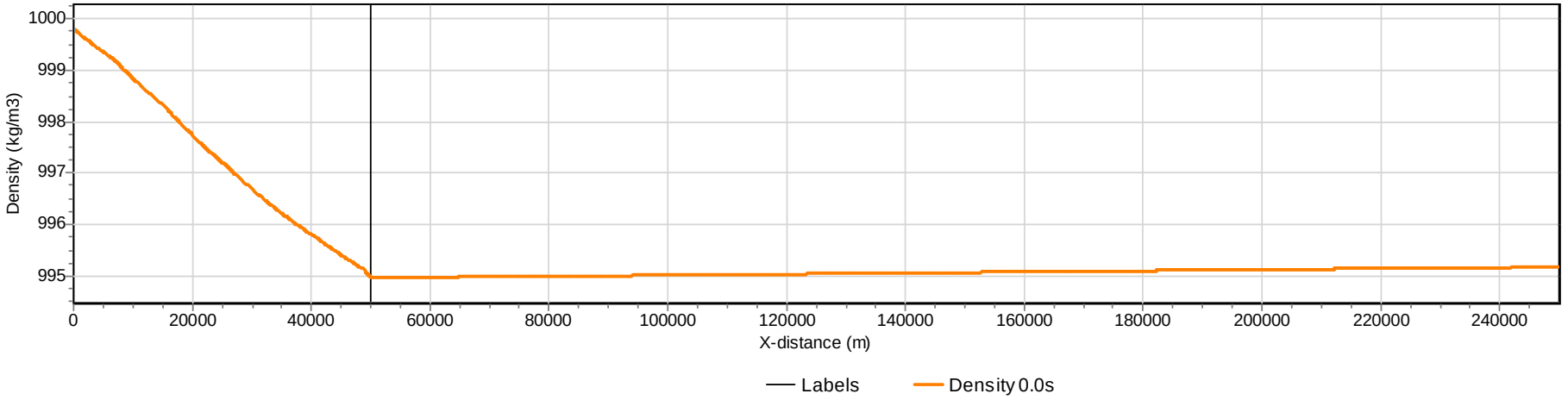
Example 1: heat loss pipelines: outputs





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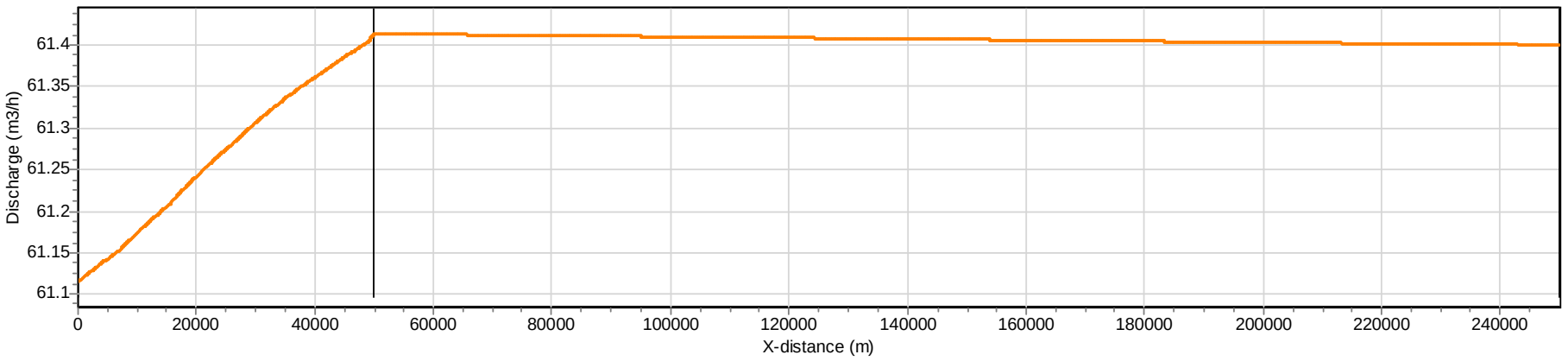
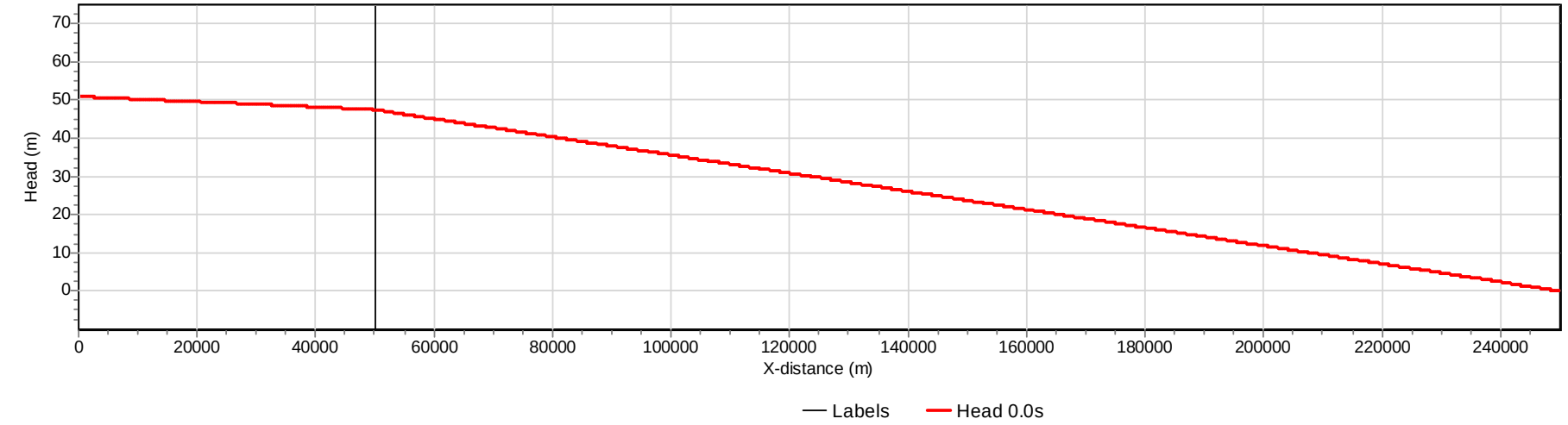
Example 1: heat loss pipelines: outputs





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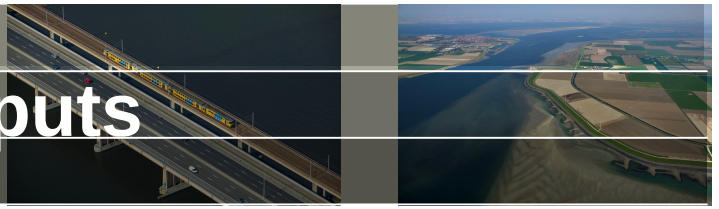
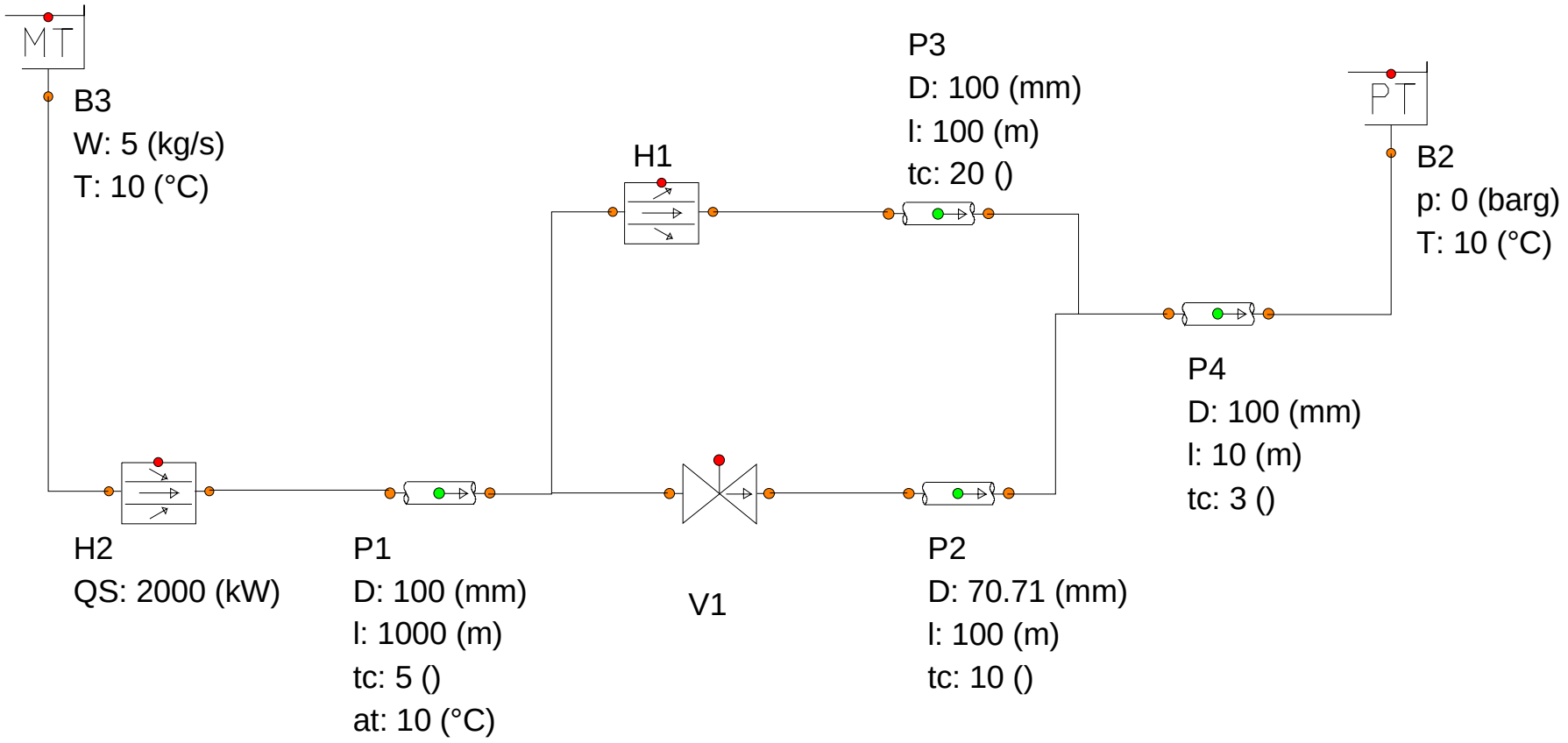
Example 2: heat exchange: inputs





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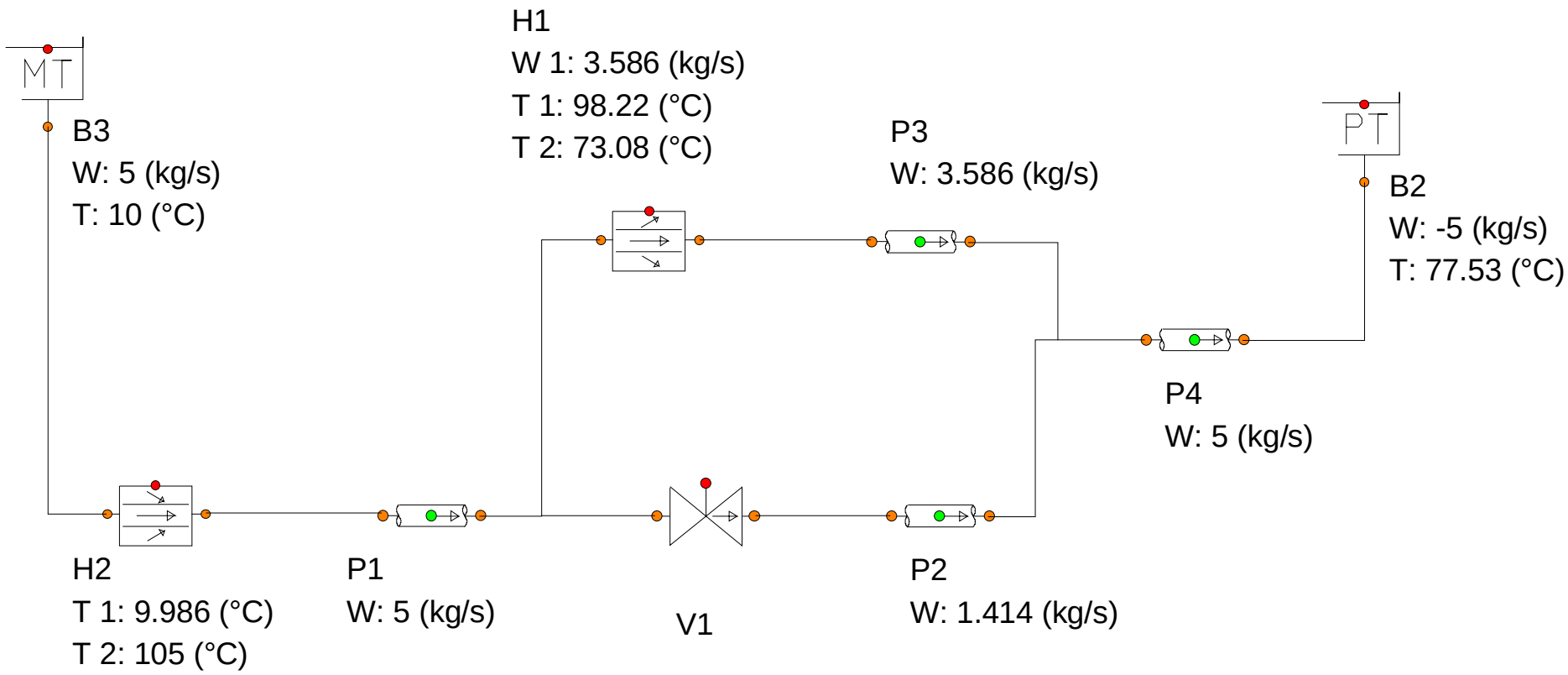
Example 2: heat exchange: outputs



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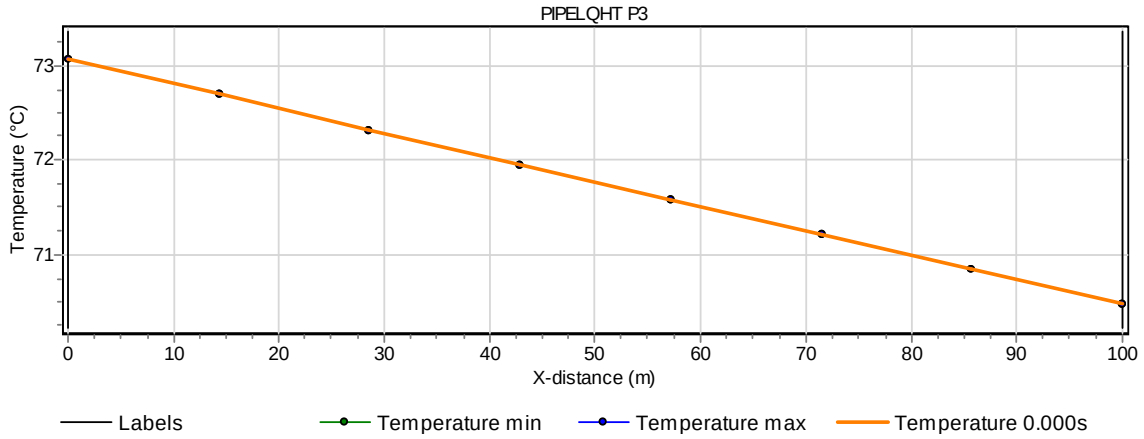
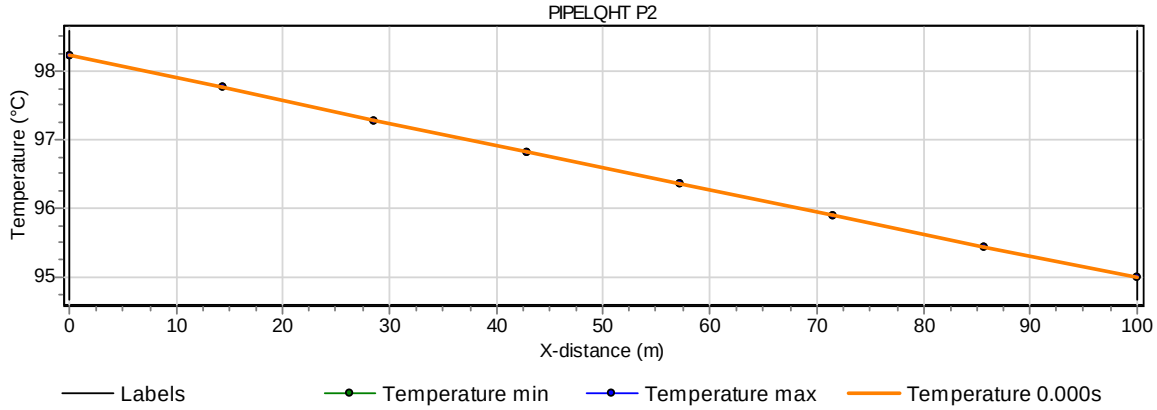
Example 2: heat exchange: temperature





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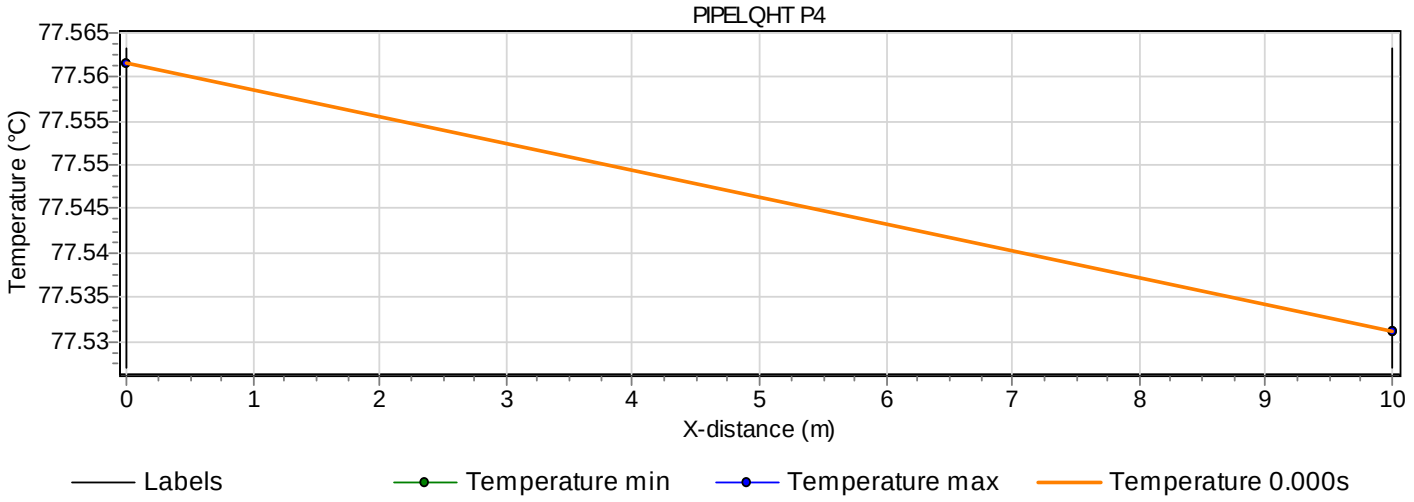
Example 2: heat exchange: temperature



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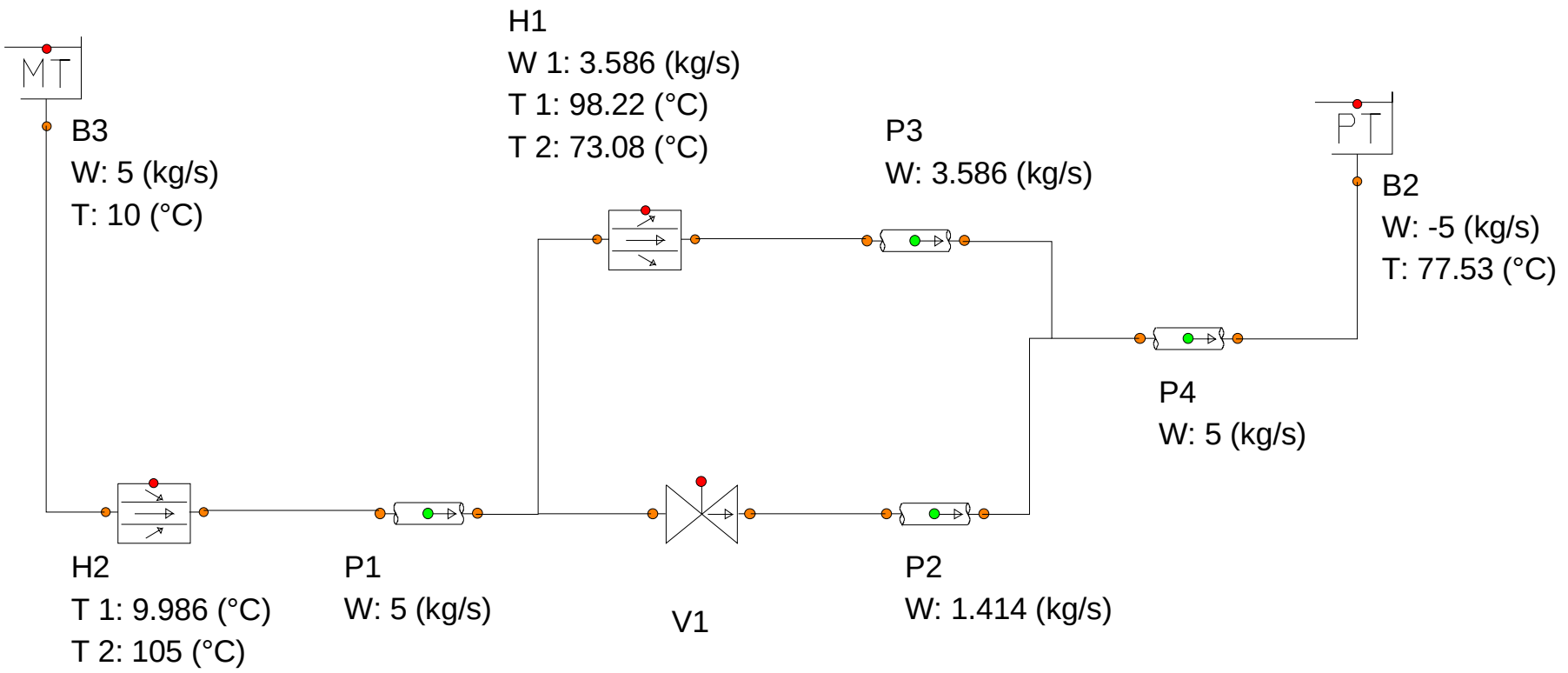
Example 2: heat exchange: valve closure



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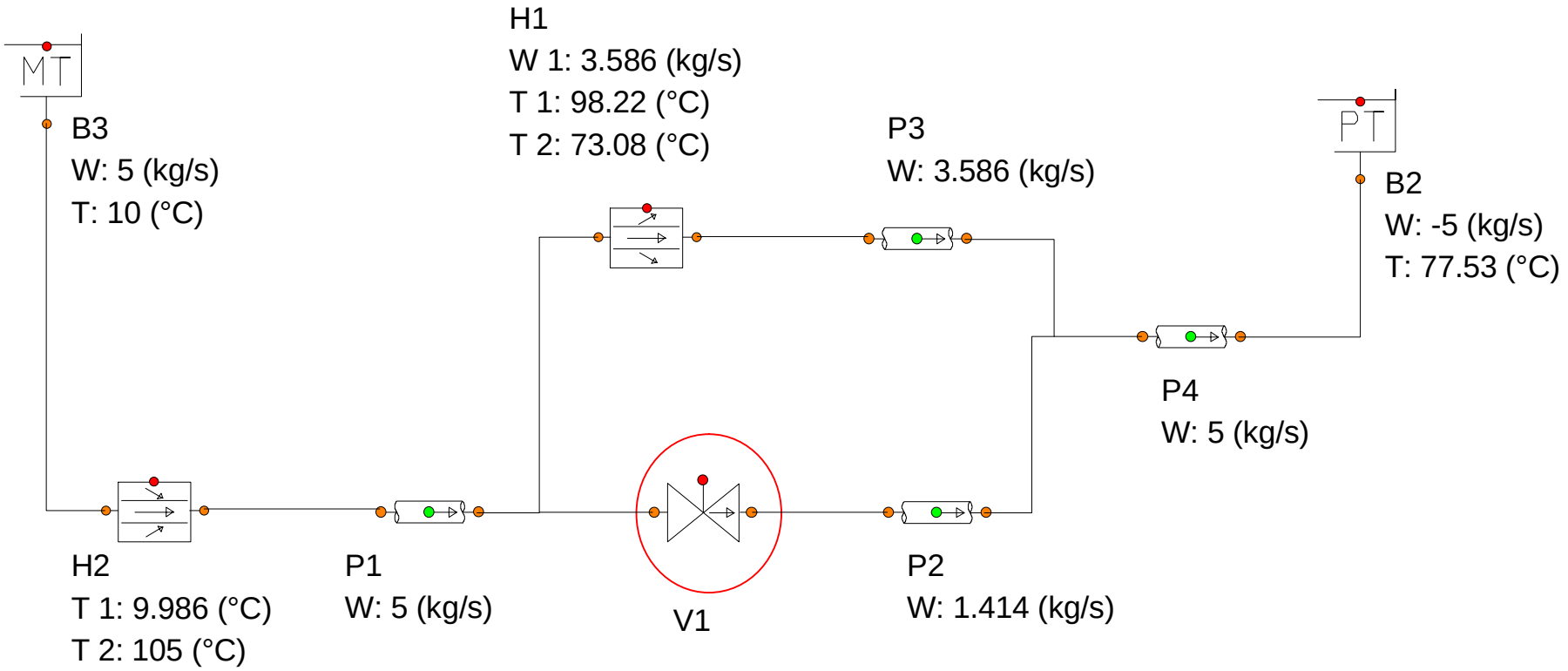

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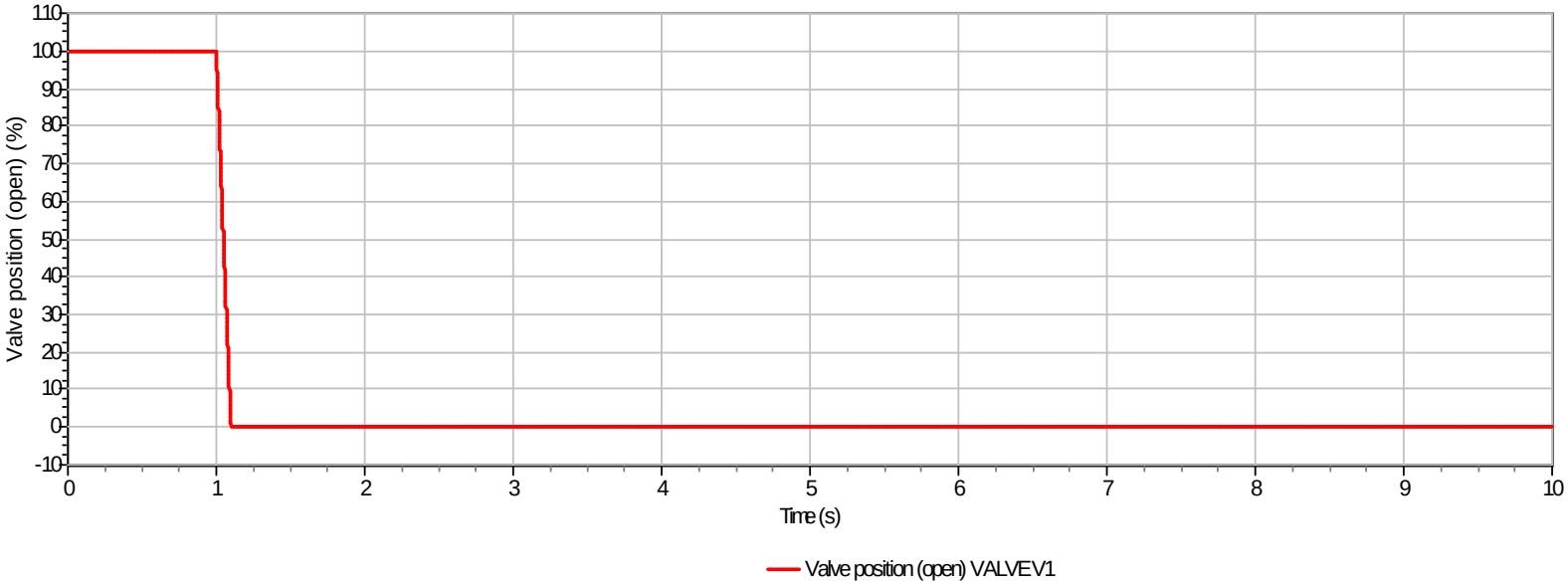

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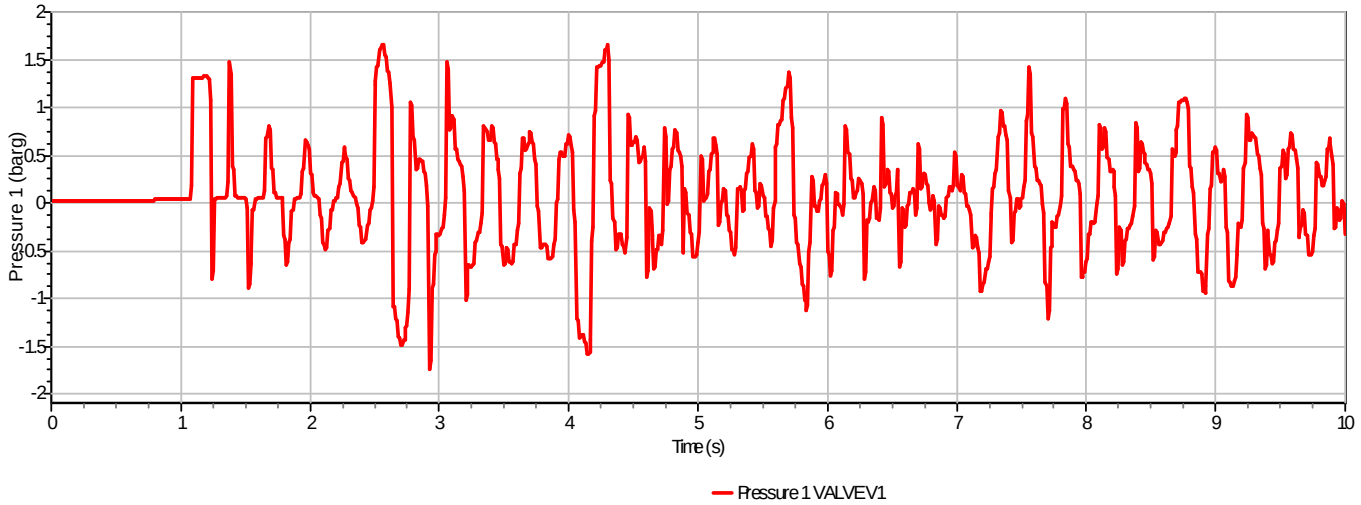

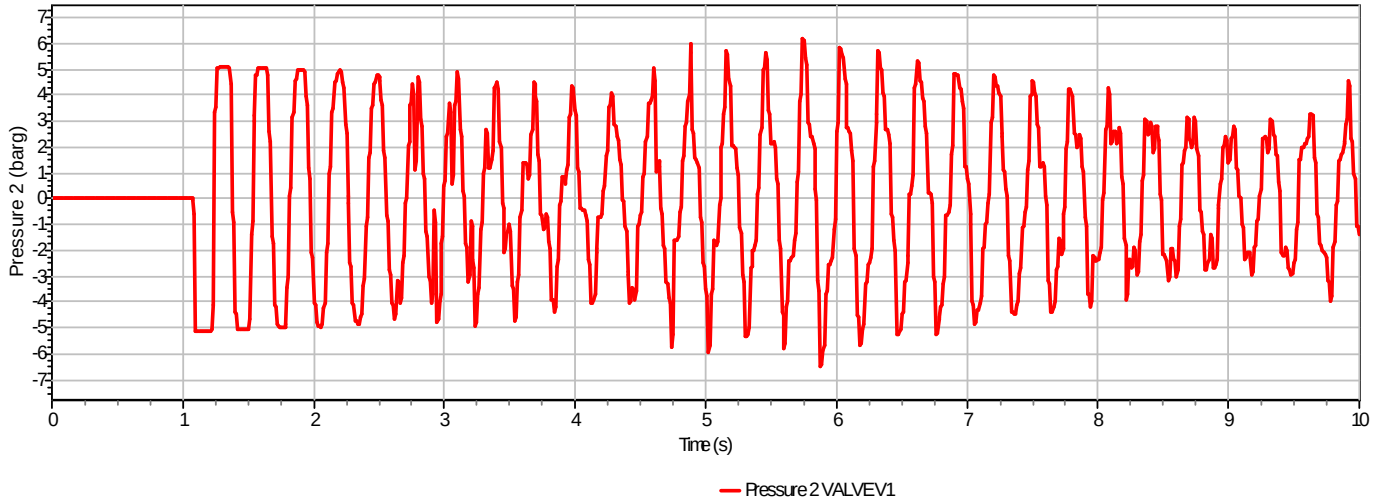

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Conclusions

Wanda 4 Heat versus Wanda 4 Liquid

Temperatures in system & heat transfer

Unsteady: water hammer effects

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