Helix Technologies Pty Ltd

Project	Helix QA	Client	Helix QA
Project No.	4567	Design Date	17/03/2017
Category	Demo Gas QA	Atmos. Press	1.0015 bar
Network Type	Gas	Calc. Method	Modified Darcy
Description	Steam at sonic velocity Crane 410M Ex4-20		

Steam at Sonic Velocity. ref. 'Flow of Fuids Through Valves, Fittings and Pipe', Crane Technical Paper 410 M Example 4-20 pg 4-13
A header with 12bar absolute saturated steam feeds a tank at atmospheric pressure through 10m of 2" ISO 336 4mm wall steel pipe.
System includes 1 x 90 deg standard bend and one plug type disc globe valve.
Find initial flow rate in kg/hr using modified darcy and continuity equations.
Pipe roughness adjusted to 0.045 mm to give Darcy friction factor close to 0.019 as used in example.
Molecular weight of saturated steam increased (from 18 for H20) to 19.57 to yield a specific volume 0.1632 as used in the Crane example.

Calculation Results		Publication	Helix delta-Q
Fitting loss K for valve		340 ft = 6.46	340 ft => K = 6.46
Fitting loss K for bend		30 ft = 0.57	30 ft => K = 0.57
Shock loss K for entrance	K	0.5	0.5
Shock loss K for exit	K	1.0	1.0
Net Expansion Factor	Y	0.710	0.7107
Mass flow rate W Darcy		5356 kg/hr	5359 kg/hr
Modified Darcy method			
Mass flow rate W Continuity Eq's		5136 kg/hr	5046 kg/hr
Isothermal method			
		Choked flow	Choked flow

Crane note states that the result of 5356kg/hr will be more accurate than the continuity calculation method, therefore Helix
recommends use of the Modified Darcy method especially for choked flow conditions.

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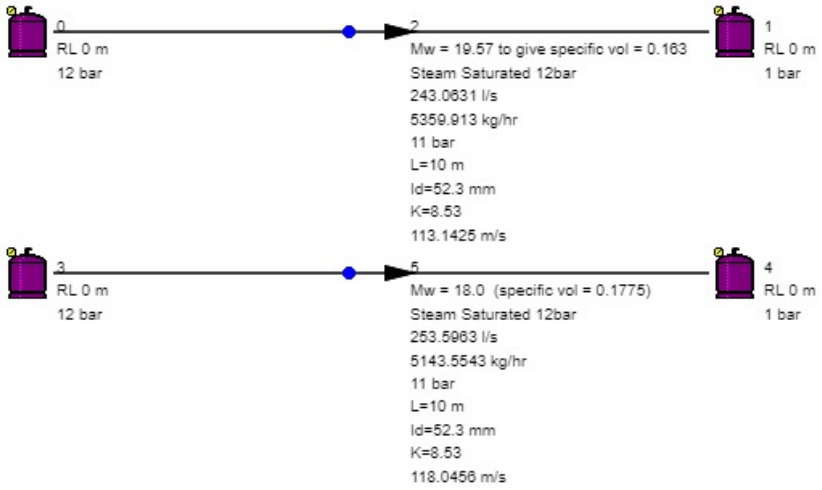

Steam at sonic velocity Crane 410M Ex4-20

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Description	Steam at sonic velocity Crane 410M Ex4-20		

Pipe No	2	From node to node	0 - 1
Description		Equipment No	Mw = 19.57 to give specific vol = 0.163
Gas	Steam Saturated 12bar	Molecular Mass	19.57 kg/kmol
Ratio Cp/Cv	1.3	Viscosity	0.0153 cP
Temperature	187.961 C	Density	6.1254 kg/m3
Gas SG to Air	0.6758	Gas Specific Vol	0.1633 m3/kg
Gas Constant R	424.8539	Abs. Gas Temp.	0.1633 deg K
Flow Condition	Choked Flow	Net Exp.Factor Y	0.7107
Pipe Description	Steel Pipe 2" ISO 336 / BS 3600 4.0mm wall	Pipe Class	
Nominal Diameter	50 mm	Inside Diameter	52.3 mm
Outside Diameter	60.3 mm	Pipe Length	10 m
Pipe Roughness	0.046 mm	Allowable Press.	0 bar
Orifice Plate Dia	-	Non Return Valve	No

Pipe Fitting Description	Qty	K value	Kft value
Bend - Standard 90 degree elbow	1	0.57	30
Globe Valve - 90 degree seat pattern	1	6.46	340
Entrance - flush	1	0.5	0
Exit - Sharp edged	1	1	0

Total Fittings k	8.53	Total Fittings kf	0

Flow Rate	243.0631 l/s	Flow at SMC	1797.9213 l/s
Mass Flow Rate	5359.913 kg/hr	Velocity	113.1425 m/s
Mach number	1		
Friction Loss	7.6557 bar	Fitting Losses	3.3443 bar
Orifice Losses	0 bar	Fixed Pressure Drop	0 bar
Total Pressure Drop	11 bar		
Entry Total Pressure	12 bar	Exit Total Pressure	1 bar
Reynolds No.	14511370.6981	Friction Factor	0.01906 (Darcy f)

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Description	Steam at sonic velocity Crane 410M Ex4-20		

Pipe No	5	From node to node	3 - 4
Description		Equipment No	Mw = 18.0 (specific vol = 0.1775)
Gas	Steam Saturated 12bar	Molecular Mass	18 kg/kmol
Ratio Cp/Cv	1.3	Viscosity	0.0153 cP
Temperature	187.961 C	Density	5.634 kg/m3
Gas SG to Air	0.6215	Gas Specific Vol	0.1775 m3/kg
Gas Constant R	461.9106	Abs. Gas Temp.	0.1775 deg K
Flow Condition	Choked Flow	Net Exp.Factor Y	0.7106
Pipe Description	Steel Pipe 2" ISO 336 / BS 3600 4.0mm wall	Pipe Class	
Nominal Diameter	50 mm	Inside Diameter	52.3 mm
Outside Diameter	60.3 mm	Pipe Length	10 m
Pipe Roughness	0.045 mm	Allowable Press.	0 bar
Orifice Plate Dia	-	Non Return Valve	No

Pipe Fitting Description	Qty	K value	Kft value
Bend - Standard 90 degree elbow	1	0.57	30
Globe Valve - 90 degree seat pattern	1	6.46	340
Entrance - flush	1	0.5	0
Exit - Sharp edged	1	1	0

Total Fittings k	8.53	Total Fittings kf	0

Flow Rate	253.5963 l/s	Flow at SMC	1875.8348 l/s
Mass Flow Rate	5143.5543 kg/hr	Velocity	118.0456 m/s
Mach number	1		
Friction Loss	7.6516 bar	Fitting Losses	3.3484 bar
Orifice Losses	0 bar	Fixed Pressure Drop	0 bar
Total Pressure Drop	11 bar		
Entry Total Pressure	12 bar	Exit Total Pressure	1 bar
Reynolds No.	12808424.2177	Friction Factor	0.0189638 (Darcy f)

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Node No	0	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	12 bar
Ext Flow (+In/-Out)	-	Abs. Node Pressure	12 bar
Int.(Gauge) Head	0 bar		

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Node No	1	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	1 bar
Ext Flow (+In/-Out)	-	Abs. Node Pressure	1 bar
Int.(Gauge) Head	0 bar		

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Node No	3	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	12 bar
Ext Flow (+In/-Out)	-	Abs. Node Pressure	12 bar
Int.(Gauge) Head	0 bar		

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Node No	4	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	1 bar
Ext Flow (+In/-Out)	-	Abs. Node Pressure	1 bar
Int.(Gauge) Head	0 bar		