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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Network Type	Liquid	Calc. Method	Darcy
Description	Raw Portland Cement Slurry (Warman Example)		

Warman Slurry Manual Section 9 page 15.
Bingham Slurry flowing in 888m of 300mm diameter commercial steel pipe.
Calculated Results

	Warman Manual	Helix deltaQ
Slurry Density Sm	1660	1662
Critical Velocity Vc	2.908 m/s	2.906 m/s
Head loss Hf at velocity m/s	Hf	Hf
1.0m/s	19.82m	19.788m
2.0m/s	20.16m	20.104m
2.5m/s	20.27m	20.262m
3.0m/s	20.10m	20.112m
3.5m/s	27.17m	27.229m
4.0m/s	35.00m	35.417m
5.0m/s	53.94m	55.016m

Optimum operating velocity is close to the critical velocity Vc of 2.9m/s.

The results compare very favourably, differences are probably due to rounding errors in the (manual) Warman calculations and also Helix calculations are based on pipe roughness of 0.071mm and Warman values not specified for the Turbulent zone.

Click on the Graph tab above and then click on the pipes in turn to view the System graph with the duty point marked on it for each pipe. You can see the transition to turbulent zone around the 2.9 m/s velocity flow rate.

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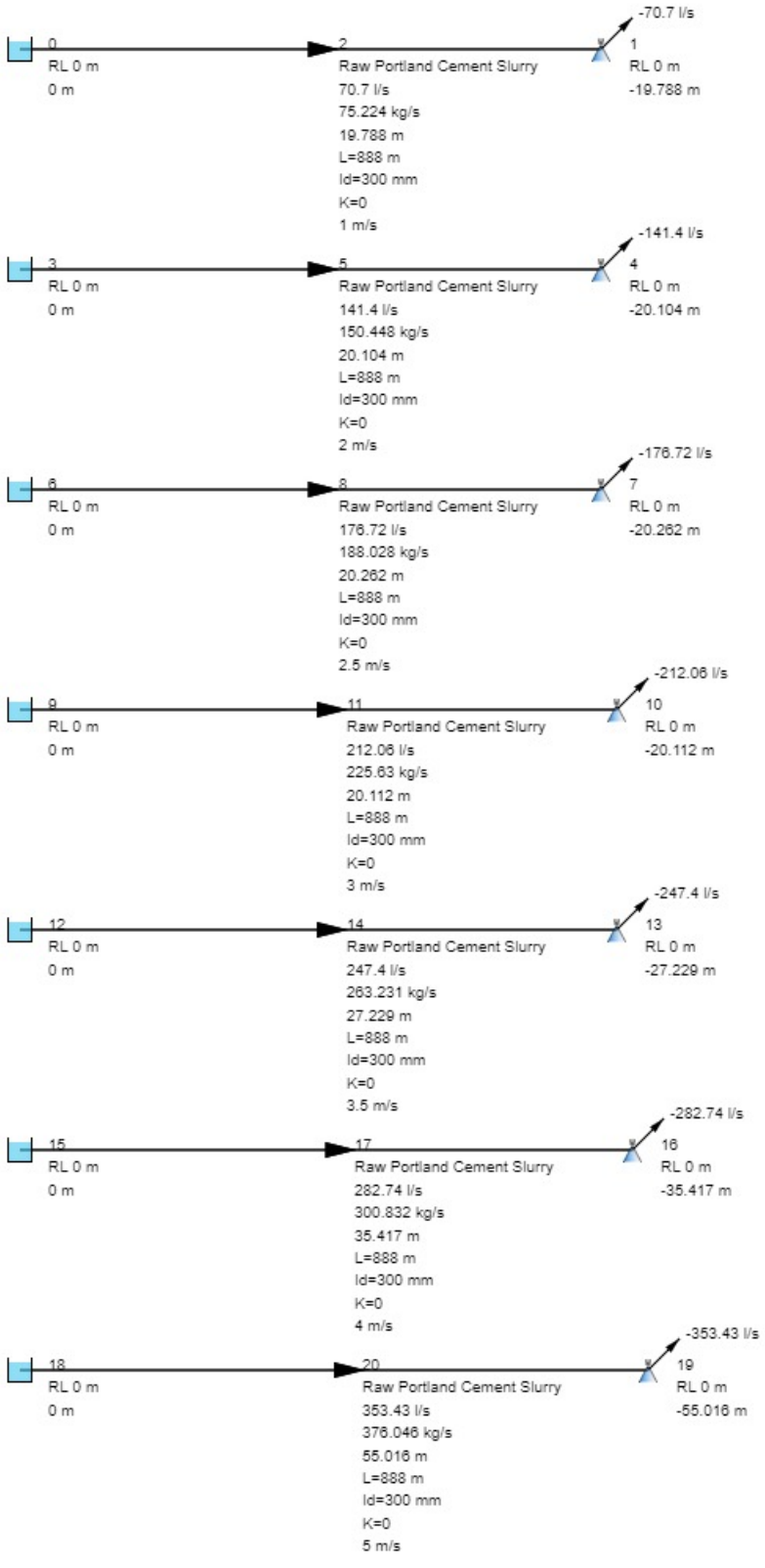
Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		



Helix Technologies Pty Ltd

Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Pipe No	2	From node to node	0 - 1
Description		Equipment No	
Slurry Type	Bingham Plastic		
Slurry Description	Raw Portland Cement Slurry	Slurry Reference	Warman Manual Sect.9 pg15
SG Carrier Liquid Sl	1	Liquid Viscosity	1 cP
SG of Dry Solids	2.65	SG of Mixture	1.662
Conc. by Mass Cw	64 % w/w	Concentration by Vol	1.662 % v/v
Solids Flow Rate	75.224 kg/s	Particle Size d50	0.04 mm
Grading	Closely Graded		
Yield Stress	20.11 Pa	Co-eff of Rigidity n	0.0163 Pa-s
Critical Velocity Vc	2.906 m/s	Critical Flow Rate	205.404 l/s
Pump Wear Factor Pw	1	Pump Head Ratio HR	0.968
Pipe Description	Steel Pipes AS1836 (ANSI B36.10)	Pipe Class	
Nominal Diameter	300 mm	Inside Diameter	300 mm
Outside Diameter	324 mm	Pipe Length	888 m
Pipe Roughness	0.071 mm	Allowable Press.	2780 kPa
Orifice Plate Dia	-	Non Return Valve	No
Total Fittings k	0	Total Fittings kf	0
Flow Rate	70.7 l/s	Velocity	1 m/s
Friction Loss	19.788 m	Fitting Losses	0 m
Slurry Losses	0 m	Orifice Losses	0 m
Fixed Head Loss	0 m	Booster Pump Head	0 m
Total Head Loss	19.788 m	Total Pressure Drop	322.617 kPa
Entry Total Head	0 m	Exit Total Head	-19.788 m
Entry Gauge Head	0 m	Exit Gauge Head	-19.788 m
Reynolds No.	488.299	Friction Factor	0.131067 (Darcy f)

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Pipe No	5	From node to node	3 - 4
Description		Equipment No	
Slurry Type	Bingham Plastic		
Slurry Description	Raw Portland Cement Slurry	Slurry Reference	Warman Manual Sect.9 pg15
SG Carrier Liquid Sl	1	Liquid Viscosity	1 cP
SG of Dry Solids	2.65	SG of Mixture	1.662
Conc. by Mass Cw	64 % w/w	Concentration by Vol	1.662 % v/v
Solids Flow Rate	150.448 kg/s	Particle Size d50	0.04 mm
Grading	Closely Graded		
Yield Stress	20.11 Pa	Co-eff of Rigidity n	0.0163 Pa-s
Critical Velocity Vc	2.906 m/s	Critical Flow Rate	205.404 l/s
Pump Wear Factor Pw	1	Pump Head Ratio HR	0.968
Pipe Description	Steel Pipes AS1836 (ANSI B36.10)	Pipe Class	
Nominal Diameter	300 mm	Inside Diameter	300 mm
Outside Diameter	324 mm	Pipe Length	888 m
Pipe Roughness	0.071 mm	Allowable Press.	2780 kPa
Orifice Plate Dia	-	Non Return Valve	No
Total Fittings k	0	Total Fittings kf	0
Flow Rate	141.4 l/s	Velocity	2 m/s
Friction Loss	20.104 m	Fitting Losses	0 m
Slurry Losses	0 m	Orifice Losses	0 m
Fixed Head Loss	0 m	Booster Pump Head	0 m
Total Head Loss	20.104 m	Total Pressure Drop	327.765 kPa
Entry Total Head	0 m	Exit Total Head	-20.104 m
Entry Gauge Head	0 m	Exit Gauge Head	-20.104 m
Reynolds No.	1922.52	Friction Factor	0.03329 (Darcy f)

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Pipe No	8	From node to node	6 - 7
Description		Equipment No	
Slurry Type	Bingham Plastic		
Slurry Description	Raw Portland Cement Slurry	Slurry Reference	Warman Manual Sect.9 pg15
SG Carrier Liquid Sl	1	Liquid Viscosity	1 cP
SG of Dry Solids	2.65	SG of Mixture	1.662
Conc. by Mass Cw	64 % w/w	Concentration by Vol	1.662 % v/v
Solids Flow Rate	188.028 kg/s	Particle Size d50	0.04 mm
Grading	Closely Graded		
Yield Stress	20.11 Pa	Co-eff of Rigidity n	0.0163 Pa-s
Critical Velocity Vc	2.906 m/s	Critical Flow Rate	205.404 l/s
Pump Wear Factor Pw	1	Pump Head Ratio HR	0.968
Pipe Description	Steel Pipes AS1836 (ANSI B36.10)	Pipe Class	
Nominal Diameter	300 mm	Inside Diameter	300 mm
Outside Diameter	324 mm	Pipe Length	888 m
Pipe Roughness	0.071 mm	Allowable Press.	2780 kPa
Orifice Plate Dia	-	Non Return Valve	No
Total Fittings k	0	Total Fittings kf	0
Flow Rate	176.72 l/s	Velocity	2.5 m/s
Friction Loss	20.262 m	Fitting Losses	0 m
Slurry Losses	0 m	Orifice Losses	0 m
Fixed Head Loss	0 m	Booster Pump Head	0 m
Total Head Loss	20.262 m	Total Pressure Drop	330.337 kPa
Entry Total Head	0 m	Exit Total Head	-20.262 m
Entry Gauge Head	0 m	Exit Gauge Head	-20.262 m
Reynolds No.	2979.541	Friction Factor	0.02148 (Darcy f)

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Pipe No	11	From node to node	9 - 10
Description		Equipment No	
Slurry Type	Bingham Plastic		
Slurry Description	Raw Portland Cement Slurry	Slurry Reference	Warman Manual Sect.9 pg15
SG Carrier Liquid Sl	1	Liquid Viscosity	1 cP
SG of Dry Solids	2.65	SG of Mixture	1.662
Conc. by Mass Cw	64 % w/w	Concentration by Vol	1.662 % v/v
Solids Flow Rate	225.63 kg/s	Particle Size d50	0.04 mm
Grading	Closely Graded		
Yield Stress	20.11 Pa	Co-eff of Rigidity n	0.0163 Pa-s
Critical Velocity Vc	2.906 m/s	Critical Flow Rate	205.404 l/s
Pump Wear Factor Pw	1	Pump Head Ratio HR	0.968
Pipe Description	Steel Pipes AS1836 (ANSI B36.10)	Pipe Class	
Nominal Diameter	300 mm	Inside Diameter	300 mm
Outside Diameter	324 mm	Pipe Length	888 m
Pipe Roughness	0.071 mm	Allowable Press.	2780 kPa
Orifice Plate Dia	-	Non Return Valve	No
Total Fittings k	0	Total Fittings kf	0
Flow Rate	212.06 l/s	Velocity	3 m/s
Friction Loss	20.112 m	Fitting Losses	0 m
Slurry Losses	0 m	Orifice Losses	0 m
Fixed Head Loss	0 m	Booster Pump Head	0 m
Total Head Loss	20.112 m	Total Pressure Drop	327.901 kPa
Entry Total Head	0 m	Exit Total Head	-20.112 m
Entry Gauge Head	0 m	Exit Gauge Head	-20.112 m
Reynolds No.	4257.216	Friction Factor	0.014805 (Darcy f)

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Pipe No	14	From node to node	12 - 13
Description		Equipment No	
Slurry Type	Bingham Plastic		
Slurry Description	Raw Portland Cement Slurry	Slurry Reference	Warman Manual Sect.9 pg15
SG Carrier Liquid Sl	1	Liquid Viscosity	1 cP
SG of Dry Solids	2.65	SG of Mixture	1.662
Conc. by Mass Cw	64 % w/w	Concentration by Vol	1.662 % v/v
Solids Flow Rate	263.231 kg/s	Particle Size d50	0.04 mm
Grading	Closely Graded		
Yield Stress	20.11 Pa	Co-eff of Rigidity n	0.0163 Pa-s
Critical Velocity Vc	2.906 m/s	Critical Flow Rate	205.404 l/s
Pump Wear Factor Pw	1	Pump Head Ratio HR	0.968
Pipe Description	Steel Pipes AS1836 (ANSI B36.10)	Pipe Class	
Nominal Diameter	300 mm	Inside Diameter	300 mm
Outside Diameter	324 mm	Pipe Length	888 m
Pipe Roughness	0.071 mm	Allowable Press.	2780 kPa
Orifice Plate Dia	-	Non Return Valve	No
Total Fittings k	0	Total Fittings kf	0
Flow Rate	247.4 l/s	Velocity	3.5 m/s
Friction Loss	27.229 m	Fitting Losses	0 m
Slurry Losses	0 m	Orifice Losses	0 m
Fixed Head Loss	0 m	Booster Pump Head	0 m
Total Head Loss	27.229 m	Total Pressure Drop	443.92 kPa
Entry Total Head	0 m	Exit Total Head	-27.229 m
Entry Gauge Head	0 m	Exit Gauge Head	-27.229 m
Reynolds No.	5749.946	Friction Factor	0.014726 (Darcy f)

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Pipe No	17	From node to node	15 - 16
Description		Equipment No	
Slurry Type	Bingham Plastic		
Slurry Description	Raw Portland Cement Slurry	Slurry Reference	Warman Manual Sect.9 pg15
SG Carrier Liquid Sl	1	Liquid Viscosity	1 cP
SG of Dry Solids	2.65	SG of Mixture	1.662
Conc. by Mass Cw	64 % w/w	Concentration by Vol	1.662 % v/v
Solids Flow Rate	300.832 kg/s	Particle Size d50	0.04 mm
Grading	Closely Graded		
Yield Stress	20.11 Pa	Co-eff of Rigidity n	0.0163 Pa-s
Critical Velocity Vc	2.906 m/s	Critical Flow Rate	205.404 l/s
Pump Wear Factor Pw	1	Pump Head Ratio HR	0.968
Pipe Description	Steel Pipes AS1836 (ANSI B36.10)	Pipe Class	
Nominal Diameter	300 mm	Inside Diameter	300 mm
Outside Diameter	324 mm	Pipe Length	888 m
Pipe Roughness	0.071 mm	Allowable Press.	2780 kPa
Orifice Plate Dia	-	Non Return Valve	No
Total Fittings k	0	Total Fittings kf	0
Flow Rate	282.74 l/s	Velocity	4 m/s
Friction Loss	35.417 m	Fitting Losses	0 m
Slurry Losses	0 m	Orifice Losses	0 m
Fixed Head Loss	0 m	Booster Pump Head	0 m
Total Head Loss	35.417 m	Total Pressure Drop	577.426 kPa
Entry Total Head	0 m	Exit Total Head	-35.417 m
Entry Gauge Head	0 m	Exit Gauge Head	-35.417 m
Reynolds No.	7452.822	Friction Factor	0.014666 (Darcy f)

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Pipe No	20	From node to node	18 - 19
Description		Equipment No	
Slurry Type	Bingham Plastic		
Slurry Description	Raw Portland Cement Slurry	Slurry Reference	Warman Manual Sect.9 pg15
SG Carrier Liquid Sl	1	Liquid Viscosity	1 cP
SG of Dry Solids	2.65	SG of Mixture	1.662
Conc. by Mass Cw	64 % w/w	Concentration by Vol	1.662 % v/v
Solids Flow Rate	376.046 kg/s	Particle Size d50	0.04 mm
Grading	Closely Graded		
Yield Stress	20.11 Pa	Co-eff of Rigidity n	0.0163 Pa-s
Critical Velocity Vc	2.906 m/s	Critical Flow Rate	205.404 l/s
Pump Wear Factor Pw	1	Pump Head Ratio HR	0.968
Pipe Description	Steel Pipes AS1836 (ANSI B36.10)	Pipe Class	
Nominal Diameter	300 mm	Inside Diameter	300 mm
Outside Diameter	324 mm	Pipe Length	888 m
Pipe Roughness	0.071 mm	Allowable Press.	2780 kPa
Orifice Plate Dia	-	Non Return Valve	No
Total Fittings k	0	Total Fittings kf	0
Flow Rate	353.43 l/s	Velocity	5 m/s
Friction Loss	55.016 m	Fitting Losses	0 m
Slurry Losses	0 m	Orifice Losses	0 m
Fixed Head Loss	0 m	Booster Pump Head	0 m
Total Head Loss	55.016 m	Total Pressure Drop	896.944 kPa
Entry Total Head	0 m	Exit Total Head	-55.016 m
Entry Gauge Head	0 m	Exit Gauge Head	-55.016 m
Reynolds No.	11470.725	Friction Factor	0.01458 (Darcy f)

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	0	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	-	Ext Flow (+In/-Out)	-
Int.(Gauge) Head	-	Int.(Gauge) Pressure	-
Total Node Head	0 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	1	Node Type	Nozzle
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	0	Ext Flow (+In/-Out)	-70.7 l/s
Int.(Gauge) Head	-19.788 m	Int.(Gauge) Pressure	-322.617 kPa
Total Node Head	-19.788 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	3	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	-	Ext Flow (+In/-Out)	-
Int.(Gauge) Head	-	Int.(Gauge) Pressure	-
Total Node Head	0 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	4	Node Type	Nozzle
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	0	Ext Flow (+In/-Out)	-141.4 l/s
Int.(Gauge) Head	-20.104 m	Int.(Gauge) Pressure	-327.765 kPa
Total Node Head	-20.104 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	6	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	-	Ext Flow (+In/-Out)	-
Int.(Gauge) Head	-	Int.(Gauge) Pressure	-
Total Node Head	0 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	7	Node Type	Nozzle
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	0	Ext Flow (+In/-Out)	-176.72 l/s
Int.(Gauge) Head	-20.262 m	Int.(Gauge) Pressure	-330.337 kPa
Total Node Head	-20.262 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	9	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	-	Ext Flow (+In/-Out)	-
Int.(Gauge) Head	-	Int.(Gauge) Pressure	-
Total Node Head	0 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	10	Node Type	Nozzle
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	0	Ext Flow (+In/-Out)	-212.06 l/s
Int.(Gauge) Head	-20.112 m	Int.(Gauge) Pressure	-327.901 kPa
Total Node Head	-20.112 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	12	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	-	Ext Flow (+In/-Out)	-
Int.(Gauge) Head	-	Int.(Gauge) Pressure	-
Total Node Head	0 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	13	Node Type	Nozzle
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	0	Ext Flow (+In/-Out)	-247.4 l/s
Int.(Gauge) Head	-27.229 m	Int.(Gauge) Pressure	-443.92 kPa
Total Node Head	-27.229 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	15	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	-	Ext Flow (+In/-Out)	-
Int.(Gauge) Head	-	Int.(Gauge) Pressure	-
Total Node Head	0 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	16	Node Type	Nozzle
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	0	Ext Flow (+In/-Out)	-282.74 l/s
Int.(Gauge) Head	-35.417 m	Int.(Gauge) Pressure	-577.426 kPa
Total Node Head	-35.417 m		

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Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	18	Node Type	Tank
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	-	Ext Flow (+In/-Out)	-
Int.(Gauge) Head	-	Int.(Gauge) Pressure	-
Total Node Head	0 m		

Helix Technologies Pty Ltd

Project	Demo QA	Client	Helix Demo
Project No.	4567	Design Date	12/06/2017
Category	Demo Bingham Slurry	Atmos. Press	100.19 kPa
Description	Raw Portland Cement Slurry (Warman Example)		

Node No	19	Node Type	Nozzle
Description		Equipment No	
Rel. Level (RL)	0 m	Pressure Input	0 kPa
Nozzle K value	0	Ext Flow (+In/-Out)	-353.43 l/s
Int.(Gauge) Head	-55.016 m	Int.(Gauge) Pressure	-896.944 kPa
Total Node Head	-55.016 m		