

Helix Technologies Pty Ltd

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| Project | Demo QA | Client | Helix QA |
| Project No. | 4567 | Design Date | 11/07/2017 |
| Category | Demo Gas 14 mile pipeline | Atmos. Press | 101.33 psi |
| Network Type | Gas | Calc. Method | Modified Darcy |
| Description | Gas flow in 78 mile pipeline Fluid Flow Handbook Ex 9.5 pg 9.14 | | |

Fluid Flow Handbook, 2002, McGraw-Hill, Jamal Saleh, Ex 9.5 pg 9.14

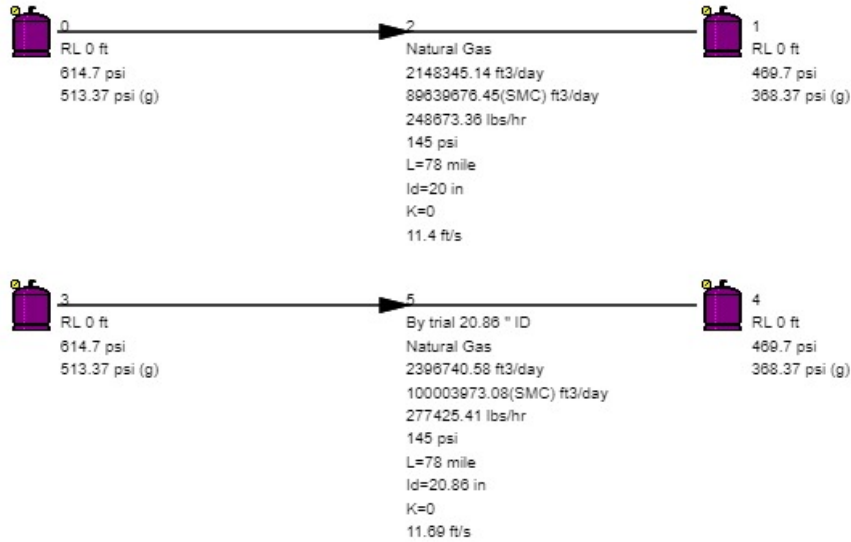
Find the inside diameter to transport 100 MMSCFD of natural gas with SG 0.87 a distance of 78 miles. The maximum pressure drop is 145 psi, inlet pressure is 600 psig.

| Calculation results. | Publication | Helix |
|---|-------------|--------------------------------|
| Calculated flow rate at SMC | 100 MMSCFD | 100 MMSCFD |
| Panhandle B Equation pipe Dia req. | 18.8" | -- |
| AGA Equation pipe Dia req. | 20.4" | -- |
| Helix pipe Dia req. | | 20.86" - Modified Darcy method |
| Helix pipe Dia req. | | 20.75" - Isothermal method |
| Published results vary quite widely depending on method used. | | |

Helix results are close to the AGA method.

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| Pipe No | 2 | From node to node | 0 - 1 |
| Description | | Equipment No | |
| Gas | Natural Gas | Molecular Mass | 25.2039 kg/kmol |
| Ratio Cp/Cv | 1.27 | Viscosity | 0.012 cP |
| Temperature | 15.56 C | Density | 44.5 kg/m ³ |
| Gas SG to Air | 0.87 | Gas Specific Vol | 0.02 m ³ /kg |
| Gas Constant R | 329.89 | Abs. Gas Temp. | 0.02 deg K |
| Flow Condition | Free Flow | Net Exp.Factor Y | 0.93 |
| Pipe Description | Steel Pipes 12" AS1836 (ANSI B36.10) | Pipe Class | Sch 40 |
| Nominal Diameter | 20 in | Inside Diameter | 20 in |
| Outside Diameter | 21 in | Pipe Length | 78 mile |
| Pipe Roughness | 0.003 in | Allowable Press. | 999 psi |
| Orifice Plate Dia | - | Non Return Valve | No |
| Total Fittings k | 0 | Total Fittings kf | 0 |
| Flow Rate | 2148345.14 ft ³ /day | Flow at SMC | 89639676.45 ft ³ /day |
| Mass Flow Rate | 248673.36 lbs/hr | Velocity | 11.4 ft/s |
| Mach number | 0.66 | | |
| Friction Loss | 145 psi | Fitting Losses | 0 psi |
| Orifice Losses | 0 psi | Fixed Pressure Drop | 0 psi |
| Total Pressure Drop | 145 psi | | |
| Entry Total Pressure | 614.7 psi | Exit Total Pressure | 469.7 psi |
| Reynolds No. | 291216362.8 | Friction Factor | 0.01296 (Darcy f) |

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| Pipe No | 5 | From node to node | 3 - 4 |
| Description | By trial 20.86 " ID | Equipment No | |
| Gas | Natural Gas | Molecular Mass | 25.2039 kg/kmol |
| Ratio Cp/Cv | 1.27 | Viscosity | 0.012 cP |
| Temperature | 15.56 C | Density | 44.5 kg/m3 |
| Gas SG to Air | 0.87 | Gas Specific Vol | 0.02 m3/kg |
| Gas Constant R | 329.89 | Abs. Gas Temp. | 0.02 deg K |
| Flow Condition | Free Flow | Net Exp.Factor Y | 0.93 |
| Pipe Description | Steel Pipes 12" AS1836 (ANSI B36.10) | Pipe Class | Sch 40 |
| Nominal Diameter | 22 in | Inside Diameter | 20.86 in |
| Outside Diameter | 23 in | Pipe Length | 78 mile |
| Pipe Roughness | 0.003 in | Allowable Press. | 999 psi |
| Orifice Plate Dia | - | Non Return Valve | No |
| Total Fittings k | 0 | Total Fittings kf | 0 |
| Flow Rate | 2396740.58 ft3/day | Flow at SMC | 100003973.08 ft3/day |
| Mass Flow Rate | 277425.41 lbs/hr | Velocity | 11.69 ft/s |
| Mach number | 0.66 | | |
| Friction Loss | 145 psi | Fitting Losses | 0 psi |
| Orifice Losses | 0 psi | Fixed Pressure Drop | 0 psi |
| Total Pressure Drop | 145 psi | | |
| Entry Total Pressure | 614.7 psi | Exit Total Pressure | 469.7 psi |
| Reynolds No. | 311493105.93 | Friction Factor | 0.01286 (Darcy f) |

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| Node No | 0 | Node Type | Tank |
| Description | | Equipment No | |
| Rel. Level (RL) | 0 mile | Pressure Input | 614.7 psi |
| Ext Flow (+In/-Out) | - | Abs. Node Pressure | 614.7 psi |
| Int.(Gauge) Head | 0 psi | | |

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| Node No | 1 | Node Type | Tank |
| Description | | Equipment No | |
| Rel. Level (RL) | 0 mile | Pressure Input | 469.7 psi |
| Ext Flow (+In/-Out) | - | Abs. Node Pressure | 469.7 psi |
| Int.(Gauge) Head | 0 psi | | |

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| Node No | 3 | Node Type | Tank |
| Description | | Equipment No | |
| Rel. Level (RL) | 0 mile | Pressure Input | 614.7 psi |
| Ext Flow (+In/-Out) | - | Abs. Node Pressure | 614.7 psi |
| Int.(Gauge) Head | 0 psi | | |

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| Node No | 4 | Node Type | Tank |
| Description | | Equipment No | |
| Rel. Level (RL) | 0 mile | Pressure Input | 469.7 psi |
| Ext Flow (+In/-Out) | - | Abs. Node Pressure | 469.7 psi |
| Int.(Gauge) Head | 0 psi | | |