Pipe Flow Simulation Report — Water Distribution System

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Pipe Flow Simulation Report – Project 1

Summary

A steady-state hydraulic simulation of a simple water distribution network was performed using Pipe Flow Expert. The working fluid is water at 20°C. The model contains eight pipe runs (P1–P8), several fittings (tees, bends, globe valves, pipe entries/exits) and nine nodes (N1–N9). Results include node pressures, per-pipe flow rates and velocities, pressure losses (dP), fitting K-values, and an energy loss breakdown by pipe. Key findings: (1) the network delivers the simulated volumetric flows shown in Table 1 while maintaining positive pressures at most nodes; (2) certain pipes and fittings contribute disproportionately to head/energy losses; and (3) the output contains some unexpected entries (e.g., unusually large “length” values recorded in inches) that should be checked in the model input. All numerical values in this report are taken from the Pipe Flow Expert simulation output.

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2. Objectives

* Document and summarize the hydraulic simulation results produced by Pipe Flow Expert.

* Identify pipes and fittings responsible for high friction and minor losses.

* Provide observations and practical recommendations to reduce head loss and improve hydraulic efficiency.

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3. Fluid Properties (from model)

* Fluid: Water (H_2O)

* Temperature: 20.0 °C

* Density: 998 kg/m^3

* Kinematic viscosity: 1.000 cSt (dynamic viscosity ≈ 1.002 cP reported).

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4. Pump / Driving Element

The specific pump data fields in the Pipe Flow Expert printout were not populated in the PDF extract (pump table headings are present but values are blank). Therefore this report focuses on the pipe network, node pressures, fittings and energy losses as reported by the simulation. If pump head/curve and operating point are available elsewhere (or in the model file), include them to complete an energy balance and to assess pump efficiency.

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5. Pipe Network — Key Results

Table 1 — Pipe summary (extracted from simulation output)

(Units as reported by the software: diameters in mm; lengths shown in the file in inches; flows in m³/s; dP in bar; pressures in bar.g.)

Pipe Id	Pipe Name and Notes	Fluid Zone	Material	Inner Diam mm	Length m	Mass Flow kg/sec	Vol Flow m³/sec	Velocity m/sec	Friction Los m.hd	Entry Fitt. l m.hd	Exit Fitt. Lo m.hd	Comp. Loss m.hd	Ctrl Valve L m.hd	Pump Heac m.hd	dP Total Lo bar	Entry Press bar.g	Exit Pressure bar.g
1	P1	Water (20°	80 mm Ste	80.2	10	5.4463	0.0055	1.08	0.156	0.03	0	none	none		0.0182	0.1468	0.1286
2	P2	Water (20°	80 mm Ste	80.2	7.5	5.4463	0.0055	1.08	0.117	0.032	0	none	none		-0.2301	0.1286	0.3588
3	P3	Water (20°	40 mm Ste	43.3	3.4	2.1636	0.0022	1.472	0.204	0.139	0	none	none		0.0336	0.3588	0.3252
4	P4	Water (20°	40 mm Ste	43.3	5.3	2.1636	0.0022	1.472	0.317	0.055	0.348	none	none		0.1684	0.3252	0.1568
5	P5	Water (20°	50 mm Ste	52.5	2.2	3.2827	0.0033	1.519	0.11	0.134	0	none	none		0.0239	0.3588	0.3349
6	P6	Water (20°	40 mm Ste	43.3	12.7	1.7386	0.0017	1.183	0.505	0.09	0.225	none	none		0.1781	0.3349	0.1568
7	P7	Water (20°	40 mm Ste	43.3	9.4	1.5441	0.0015	1.051	0.3	0.024	0	none	none		0.0316	0.3349	0.3033
8	P8	Water (20°	40 mm Ste	43.3	8.9	1.5441	0.0015	1.051	0.284	0.035	0.177	none	none		0.1465	0.3033	0.1568

> Notes:

> • The simulation file lists pipe lengths in **inches** in the Pipe Data table (e.g., 393.701), which is unusually large compared to typical project lengths; verify whether the intended unit was metres or another unit when reviewing the model.

> • P2 shows a **negative** dP entry (−0.2301 bar) in the table — this likely indicates a sign convention (energy gain from a pump or a junction effect) or data-entry/interpretation issue; examine the model set-up and pump placement.

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6. Fittings and Minor Losses

The simulation lists K-values for the major fittings present. Representative items from the fittings table:

* P1: Pipe entry (sharp) — K = 0.50.

* P2: Standard bend — K = 0.53.

* P3: Branch tee — K = 1.26.

* P4: Entry (sharp) K = 0.50; Globe valve (angled) K = 3.15.

* P5: Branch tee — K = 1.14.

* P6: Branch tee K = 1.26; Globe valve K = 3.15.

* P7: Through tee — K = 0.42.

* P8: Standard bend K = 0.63; Globe valve K = 3.15 (total K shown ≈ 3.78).

Observation: Globe valves (K ≈ 3.15) and branch tees (K ≈ 1.1–1.26) are major contributors to minor losses. Where several high-K elements are present in series (e.g., tee + globe valve), the cumulative minor loss can exceed the pipe friction loss and dominate the total head loss for that run.

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7. Node Pressure Summary

Selected node results (from Node Data):

Node	Type	Elevation (m)	Pressure at Node (bar.g)	HGL (m.hd)
N1	Tank	2.5	0.1468	4.000
N2	Join	2.5	0.1286	3.814

N3	Join	0.0	0.3588	3.666
N4	Join	0.0	0.3252	3.323
N5	Demand pressure node	1.0	0.1568	2.602
N6	Join	0.0	0.3349	3.422
N7	Demand pressure node	1.0	0.1568	2.602
N8	Join	0.0	0.3033	3.099
N9	Demand pressure node	1.0	0.1568	2.602

> The model shows multiple demand nodes (N5, N7, N9) with the same required pressure (0.1568 bar.g). Most nodes remain at positive gauge pressures, indicating the network can satisfy the applied demands under simulated conditions.

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8. Energy Loss Breakdown (kW)

Extracted energy loss subtotals per pipe (friction + fittings) from the Energy Data table:

Pipe	Friction Loss (kW)	Fitting Loss (kW)	Subtotal (kW)	Additional Notes
P1	0.008327	0.001589	0.009916	Lowest subtotal
P2	0.006245	0.001684	0.007930	Negative elevation term reported (see file)
P3	0.004321	0.002955	0.007276	Moderate fittings loss
P4	0.006736	0.008559	0.015295	High fitting losses (globe valve)

P5	0.003540	0.004320	0.007860	Moderate
P6	0.008608	0.005366	0.013974	High friction & fittings
P7	0.004536	0.000358	0.004894	Low fittings K, friction-dominated
P8	0.004295	0.003222	0.007516	Moderate

> P4 and P6 show the largest combined losses in kW; P1 and P7 have the smallest subtotals. Energy loss to discharge pressure and changes in elevation are reported elsewhere in the output and should be included when preparing a full system energy balance.

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9. Discussion & Interpretation

1. **Fittings dominate in several runs** — especially where globe valves or multiple fittings are present (P4, P6, P8). Replacing high-loss valves or reducing number of restrictive fittings can substantially reduce energy loss.

2. **Apparent data/units anomalies** — the “Length” column in the pipe table is in inches and contains large numbers (e.g., 393.701). Confirm the intended length units (m vs in) and verify that equivalent lengths for fittings were not inadvertently summed into pipe length fields. Also investigate the negative dP recorded for P2. These issues affect hydraulic head calculations and must be clarified.

3. **Node pressures are acceptable** — the network maintains positive gauge pressure at most nodes, and the demand nodes show the target pressure (0.1568 bar.g). However, several pipes (P4, P6) show comparatively large drop from entry to exit pressures and should be evaluated for serviceability under peak conditions.

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10. Conclusions

* The Pipe Flow Expert simulation provides a full hydraulic picture of the network: flows, velocities, pressures, and energy losses.

* Major contributors to head loss are globe valves and long equivalent pipe lengths (possibly inflated by unit mismatch).

* The network, as simulated, supplies the demanded pressure at all demand nodes; nevertheless, energy inefficiencies exist and can be reduced.

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11. Recommendations

1. **Verify model units and geometry input**: confirm whether the pipe lengths are in inches or were intended to be in metres; correct unit/entry errors before taking design actions.

2. **Review pump data and include pump curve**: the PDF printout did not include pump operating data. Add pump head/curve and operating point to check system head and pump efficiency.

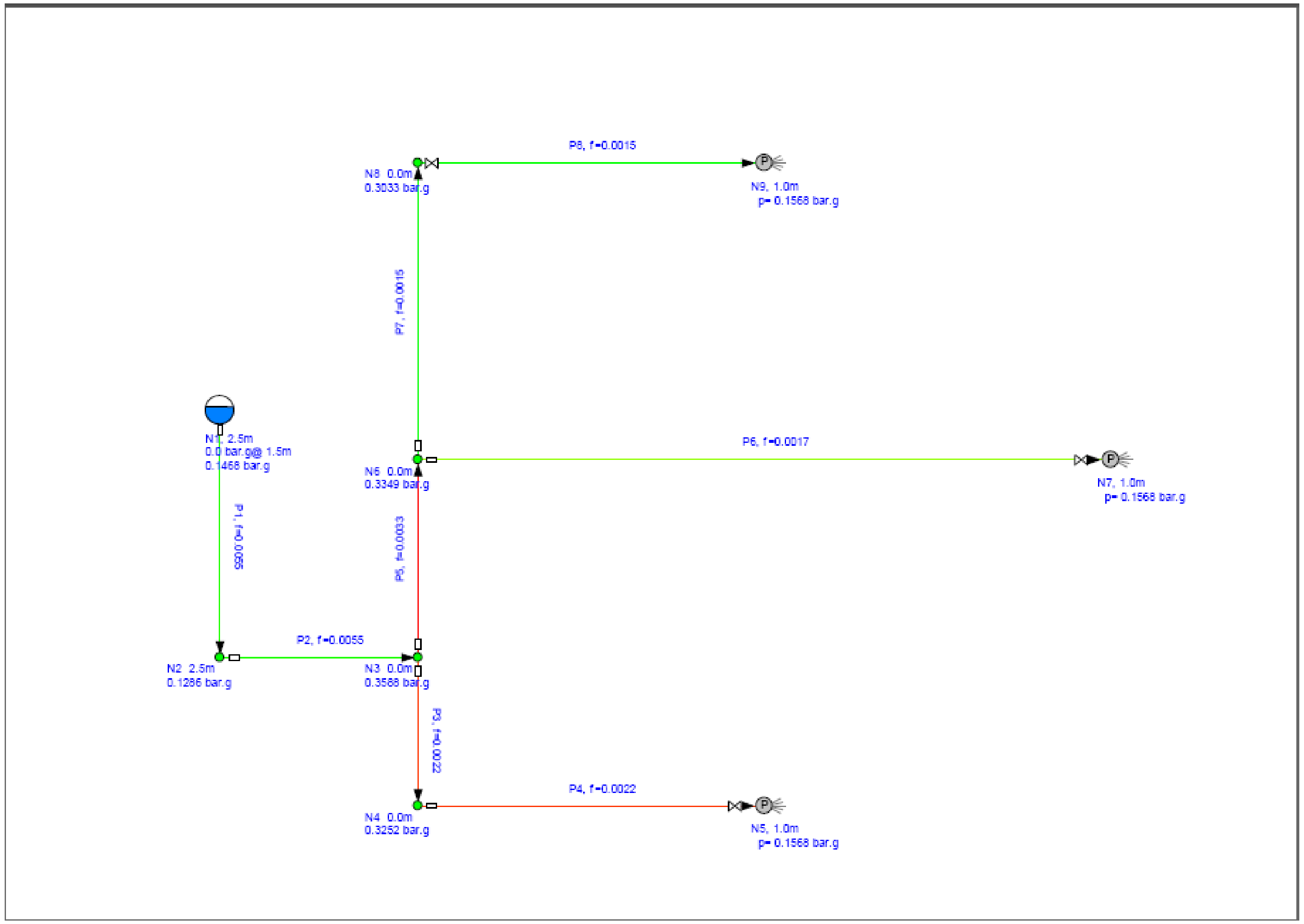
3. **Reduce high minor losses**: replace globe valves ($K \approx 3.15$) with lower-loss alternatives (e.g., full-bore ball valves) where throttling performance is not required, or relocate valves to reduce series losses.

4. **Reconsider pipe sizing on high-loss runs**: for pipes with high friction or velocity (if velocities approach undesirable levels), increase diameter to lower Reynolds number/velocity and reduce frictional loss—perform a sensitivity run in Pipe Flow Expert to quantify savings.

5. **Perform a full energy balance**: include pump input power, discharge work, and elevation changes (the energy table shows both positive and negative elevation terms) to ensure consistent accounting of energy sources and sinks.

6. **Validate negative dP and elevation terms**: investigate the cause of negative pressure drop entries (P2) and negative elevation energy terms in the energy table—these may indicate sign convention differences, pump head additions, or data-entry errors.

SYSTEM



P8, f=0.0015
N8 0.0m
0.3033 bar.g
N9, 1.0m
p= 0.1568 bar.g
P7, f=0.0015
N1, 2.5m
0.0 bar.g@ 1.5m
0.1468 bar.g
P6, f=0.0017
N6 0.0m
0.3349 bar.g
N7, 1.0m
p= 0.1568 bar.g
P1, f=0.0055
P5, f=0.0033
P2, f=0.0055
N2 2.5m
0.1286 bar.g
N3 0.0m
0.3588 bar.g
P3, f=0.0022
P4, f=0.0022
N4 0.0m
0.3252 bar.g
N5, 1.0m
p= 0.1568 bar.g

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Pipe Flow Simulation Report – Project 2

1. Summary

A piping system simulation was conducted using **Pipe Flow Expert** to analyze fluid flow, pressure distribution, and energy losses. The system consists of **7 pipes** with associated fittings and a centrifugal pump. The working fluid is **water at 20°C**.

This report integrates the **design data** (planned pipe lengths and fixtures) with the **simulated results** (pressures, flows, losses). Key findings show the pump operates below its best efficiency point, and several pipes, particularly **P7**, exhibit high energy losses due to velocity and multiple restrictive fittings.

2. Fluid Properties

Property	**Value**
Fluid	Water (H_2O)
Temperature	20°C
Density	998.000 kg/m³
Viscosity	1.002 cP

3. Pump Performance

Parameter	**Value**
Pump Name	Pump (Generic)

Parameter	Value
Speed	2950 rpm
Flow Rate	0.0226 m^3/sec
Head	47.633 m
Efficiency	61.70%
Power	17.05 kW

The pump operates at **61.70% efficiency**, which is below its Best Efficiency Point (BEP) of **64.0%**.

4. Pipe Network: Design vs. Simulated Results

The following table contrasts the **design input** (from the provided image) with the **simulated output** (from Pipe Flow Expert).

Pipe Id	Pipe Name and Notes	Fluid Zone	Material	Inner Diamete mm	Length inch	Mass Flow kg/sec	Vol Flow m^3/sec	Velocity m/sec	Friction Loss m.hd	Entry Fitt. Loss m.hd	Exit Fitt. Loss m.hd	Comp. Loss m.hd	Ctrl Valve L m.hd	Pump Head(+) m.hd	dP Total Lo bar	Entry Pressure bar.g	Exit Pressure bar.g
1	P1	Water (20°C at	100 mm Steel Sch. 40	102.26	590.551	22.5177	0.0226	2.747	1.017	0.192	0	none	none	47.633	-4.5436	0.2936	4.8372
2	P2	Water (20°C at	100 mm Steel Sch. 40	102.26	944.882	22.5177	0.0226	2.747	1.627	0.196	0	none	none		0.9614	4.8372	3.8758
3	P3	Water (20°C at	80 mm Steel (ANSI) Sch. 40	77.927	3149.606	12.7873	0.0128	2.686	7.251	0.132	0	none	none		0.7226	3.8758	3.1532
4	P4	Water (20°C at	80 mm Steel (ANSI) Sch. 40	77.927	8110.236	9.5937	0.0096	2.016	10.782	0.11	0	none	none		1.2618	3.1532	1.8915
5	P5	Water (20°C at	90 mm Steel (ANSI) Sch. 40	90.119	5314.961	9.7304	0.0097	1.529	3.498	0.125	0	none	none		0.3546	3.8758	3.5212
6	P6	Water (20°C at	50 mm Steel (ANSI) Sch. 40	52.502	3937.008	5.7384	0.0057	2.656	14.447	0.205	0	none	none		1.6297	3.5212	1.8915
7	P7	Water (20°C at	65 mm Steel (ANSI) Sch. 40	62.713	590.551	15.3321	0.0154	4.974	5.844	1.816	4.666	none	none		1.8915	1.8915	0

Note on Lengths: There is a significant discrepancy between the design and simulated pipe lengths. The simulated model likely includes equivalent lengths for fittings, elevation changes, and other complexities, resulting in much larger values.

5. Fittings Analysis & Losses

The design data correctly identifies the critical fixtures. The simulation confirms that **P7**, which includes a **Globe Valve (K=2.70)**, **Branch Tee (K=1.08)**, and a **pipe exit (K=1.00)**, has the highest combined fitting loss (**0.975 kW**), contributing significantly to its total pressure drop.

6. Node Pressure Summary

Node ID	**Type**	**Elevation (m)**	**Pressure (bar.g)**
N1 (Tank)	Inlet	0.000	0.2936
N2	After Pump	0.000	4.8372
N7 (Tank)	Outlet	17.000	0.0000
System Total Pressure Loss (N1 to N7)			**~4.837 bar**

7. Energy Loss Breakdown

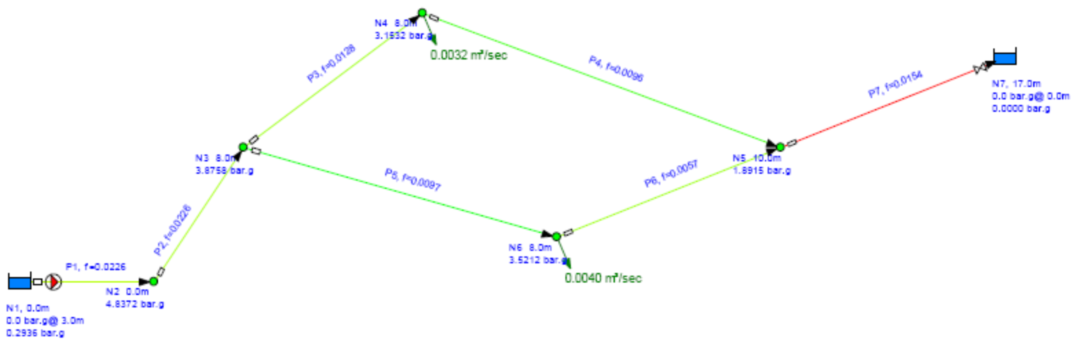
Pipe ID	**Friction Loss (kW)**	**Fitting Loss (kW)**	**Total Loss (kW)**	**Key Contributing Factor**
P1	0.224	0.042	6.797	Pump Inefficiency
P2	0.359	0.043	2.169	Friction in long pipe
P3	0.909	0.017	0.926	Friction
P4	1.014	0.010	1.122	Friction
P5	0.334	0.012	0.346	Low

Pipe ID	Friction Loss (kW)	Fitting Loss (kW)	Total Loss (kW)	Key Contributing Factor
P6	0.813	0.012	0.937	High velocity (2.656 m/s)
P7	0.879	**0.975**	2.906	**Multiple Fittings & High Velocity (4.974 m/s)**

8. Conclusions and Recommendations

1. **Pump Operation:** The pump is operating slightly below its BEP. Consider impeller trimming or speed adjustment to improve efficiency and reduce energy costs.
2. **Critical Line (P7):** This line has the highest velocity and fitting-related energy losses.
    - **Recommendation:** Investigate if the pipe diameter can be increased to reduce velocity.
    - Consider replacing the high-loss **Globe Valve** with a more efficient valve type (e.g., a ball valve) if feasible for the application.
3. **High Friction Losses:** Pipes **P3, P4, and P6** show significant friction losses. The simulated lengths are extremely long, suggesting a significant pressure drop due to pipe run and elevation gain. Verify the routing and overall system layout.
4. **System Balance:** The pressure distribution shows the system is hydraulically functional, but energy optimization is possible.

SYSTEM



N4 8.0m
3.1532 bar.g
0.0032 m³/sec
P3, f=0.0128
P4, f=0.0096
P7, f=0.0154
N7, 17.0m
0.0 bar.g@ 0.0m
0.0000 bar.g
N3 8.0m
3.8758 bar.g
P5, f=0.0097
P6, f=0.0057
N5 10.0m
1.8915 bar.g
P2, f=0.0226
N6 8.0m
3.5212 bar.g
0.0040 m³/sec
P1, f=0.0226
N2 0.0m
4.8372 bar.g
N1, 0.0m
0.0 bar.g@ 3.0m
0.2936 bar.g