Effect of Particle Size Distribution on Filter Lifetime in Three Slurry Pump Systems

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Introduction

- Positive displacement pumps have been widely accepted means of bulk slurry delivery.
- Many slurries are easily damaged by mechanical handling.
- Damage often results in changes in PSD.
- Filtration is often employed to remove large particles.
- Large particles tend to occlude filter causing:
  - Reduced flow rates
  - Increased pressure drops
  - Frequent filter changes
- Frequency of filter changes depends many factors including:
  - Slurry type
  - Filter type
  - Filter pore size rating
- Frequent filter changes can become costly.

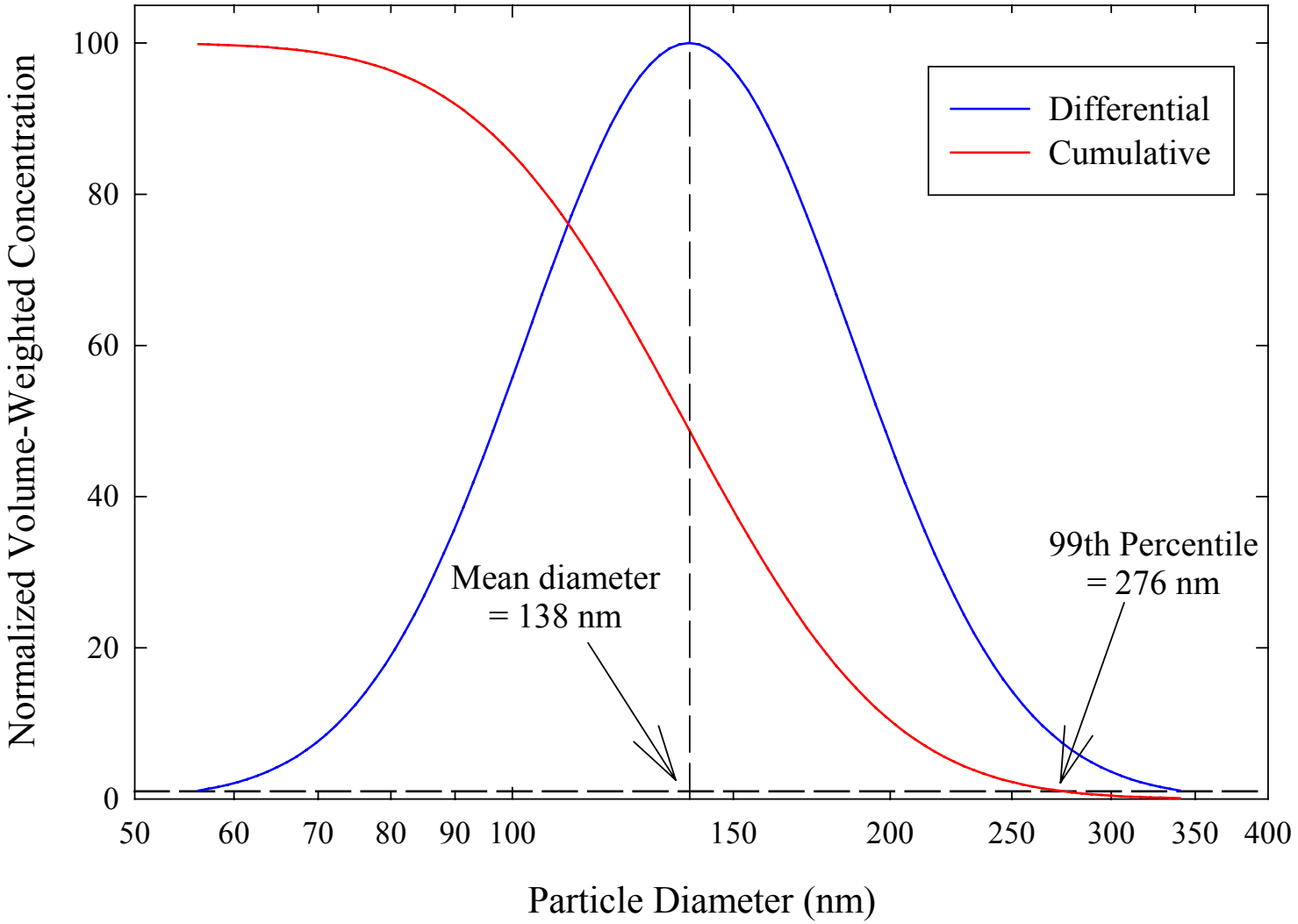
Outline

- Particle measurement procedures
- Effect of pump type on slurry particle size distribution (PSD)
- Effect of pump type on filter lifetime
- Summary

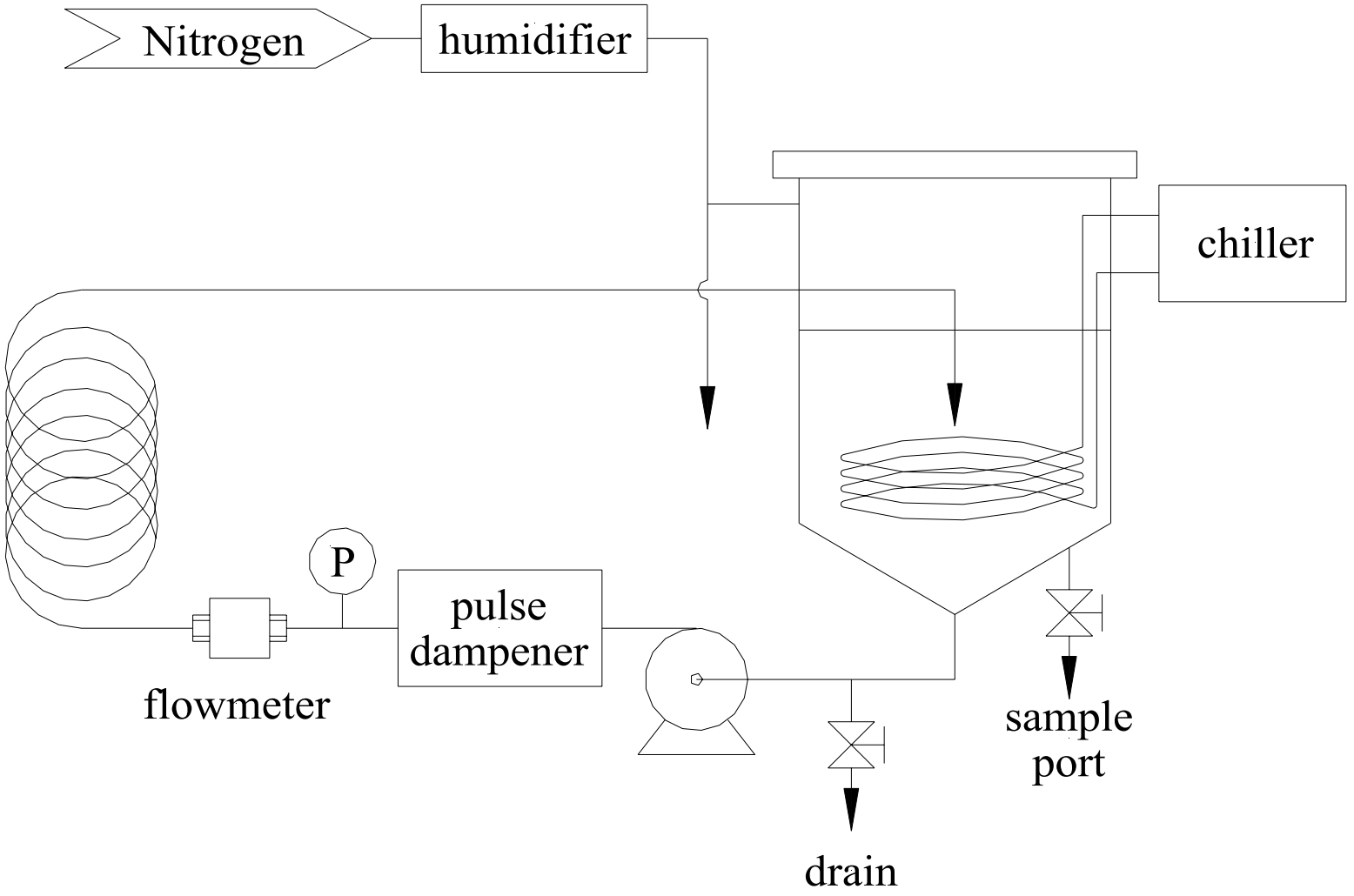
Particle size measurement

- "Working" particle size distribution
  - Instrument used: NICOMP 380ZLS (Particle Sizing Systems)
  - Measured using dynamic light scattering
  - All particles in a defined volume illuminated simultaneously
  - Particles are sized by measuring their diffusion coefficient
  - Measures relative concentrations
  - Sensitive to about 1% by volume
- "Large particle tail" of PSD
  - Instrument used: AccuSizer 780 (Particle Sizing Systems)
    - single optical particle counting technique
  - Requires dilution
    - Slurry contains about 10^{15} working particles/ml
    - The large particle tail contains about 10^{5} particles/ml ($\geq 0.56\mu m$)

Working particle size distribution



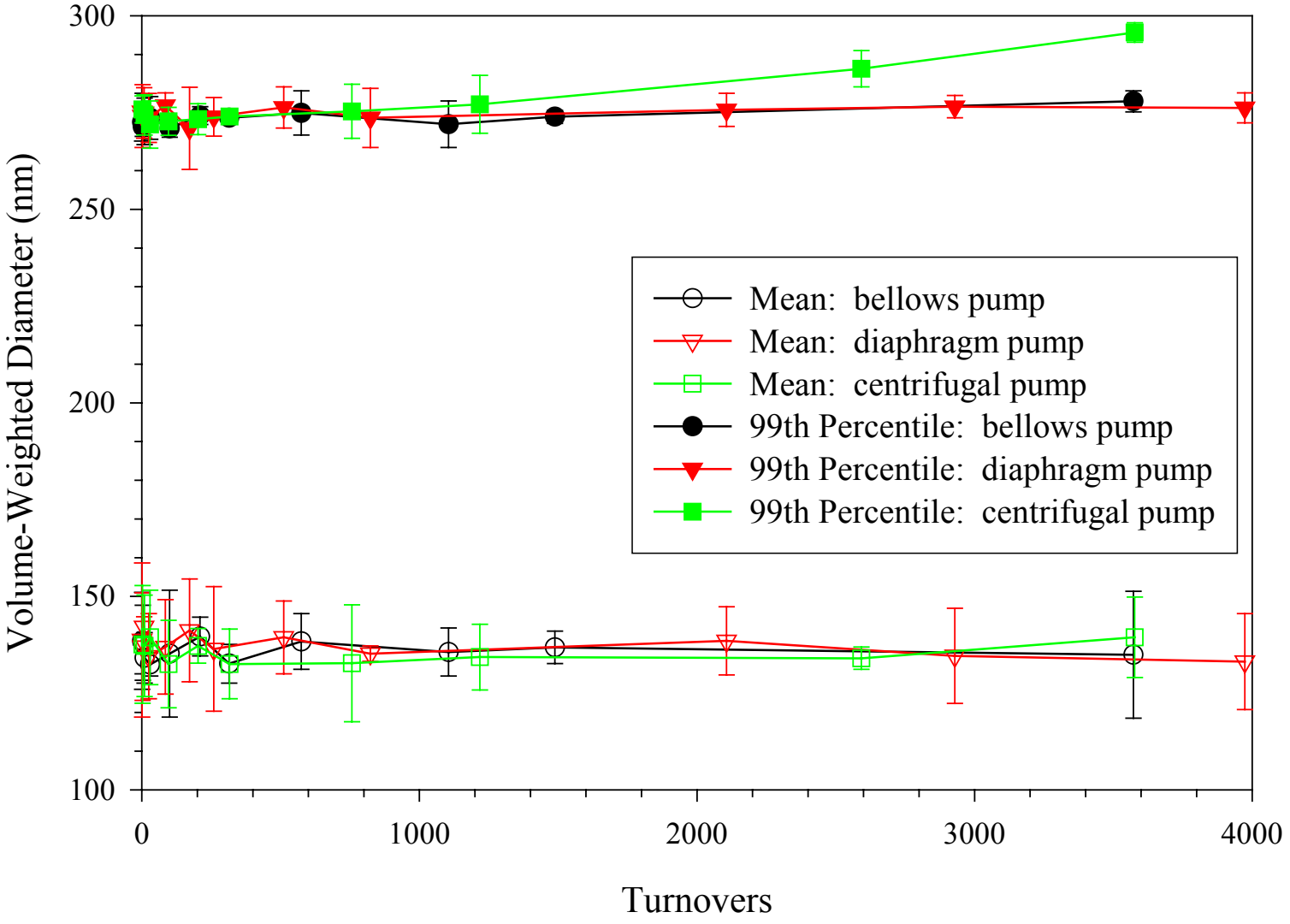
Schematic of system used to measure effect of pumps on slurry PSD



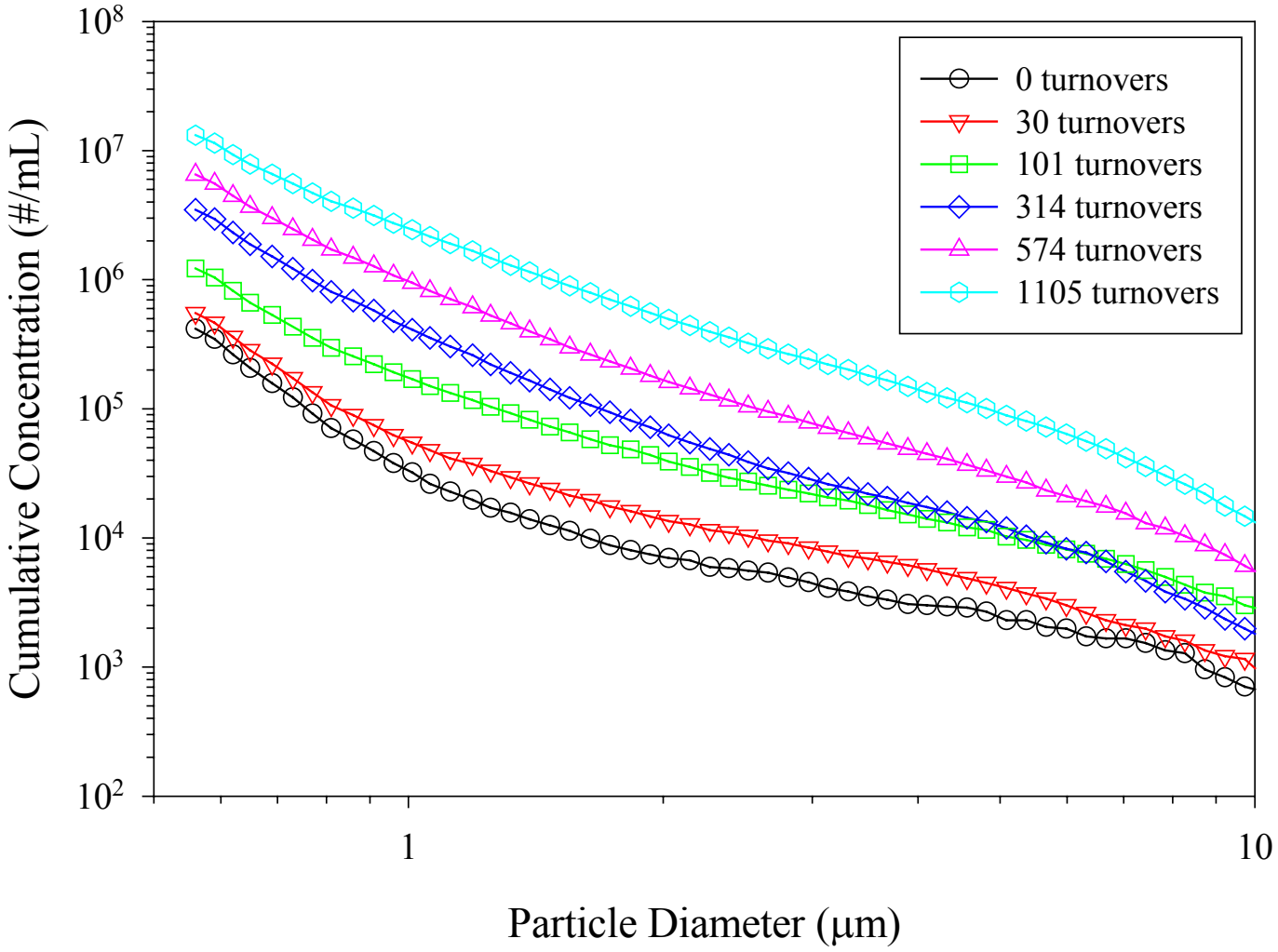
Test conditions

- Pump air supply or speed was adjusted to achieve the following test conditions:
  - Flow rate: 30 Lpm
  - Outlet Pressure: 30 psig (gradual reduction to ambient pressure)
- Tank blanketed with humidified N_2: RH > 90%
- Slurry temperature: 20 ± 2°C

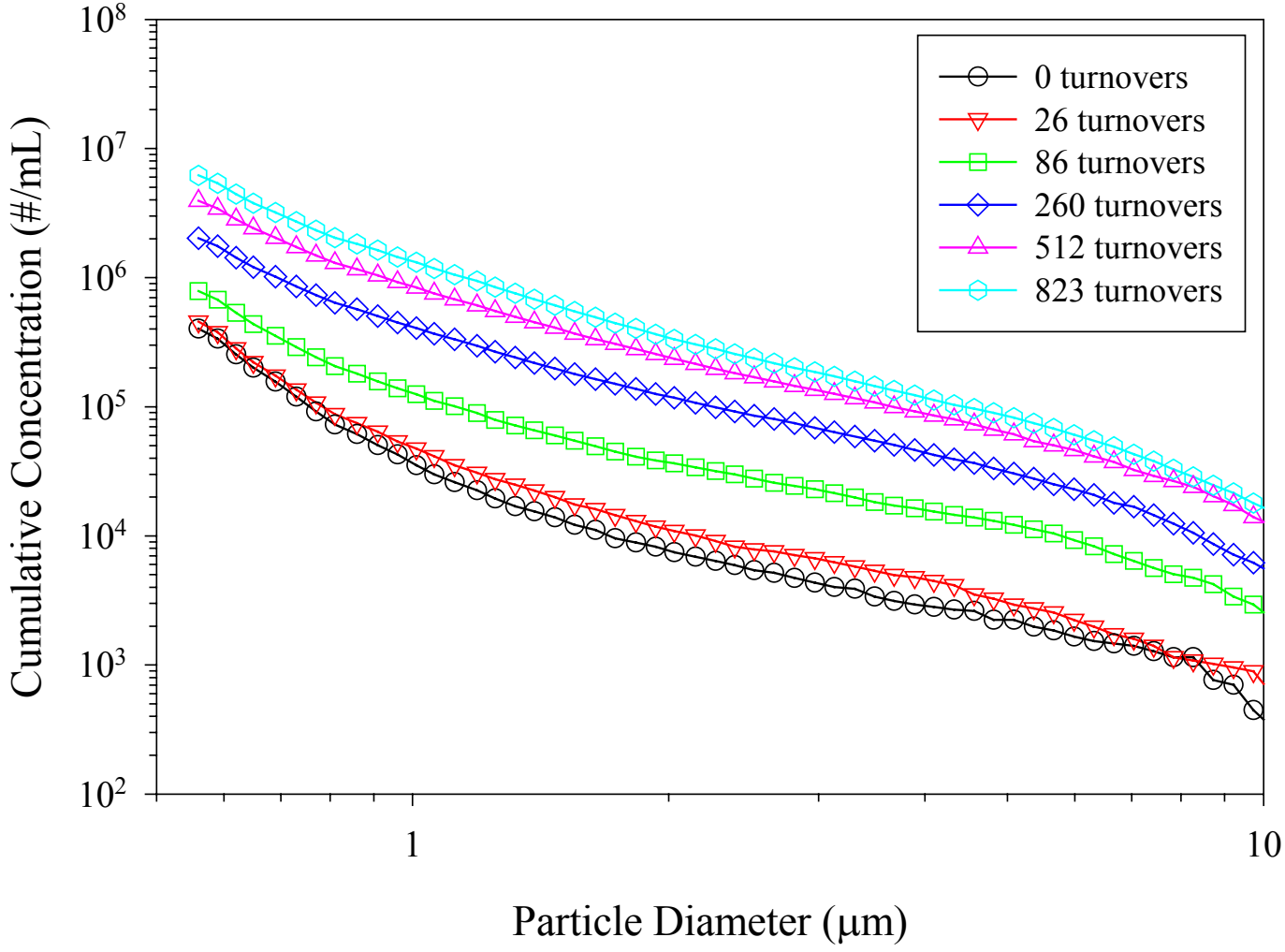
Effect of pumps on the working particle size distribution



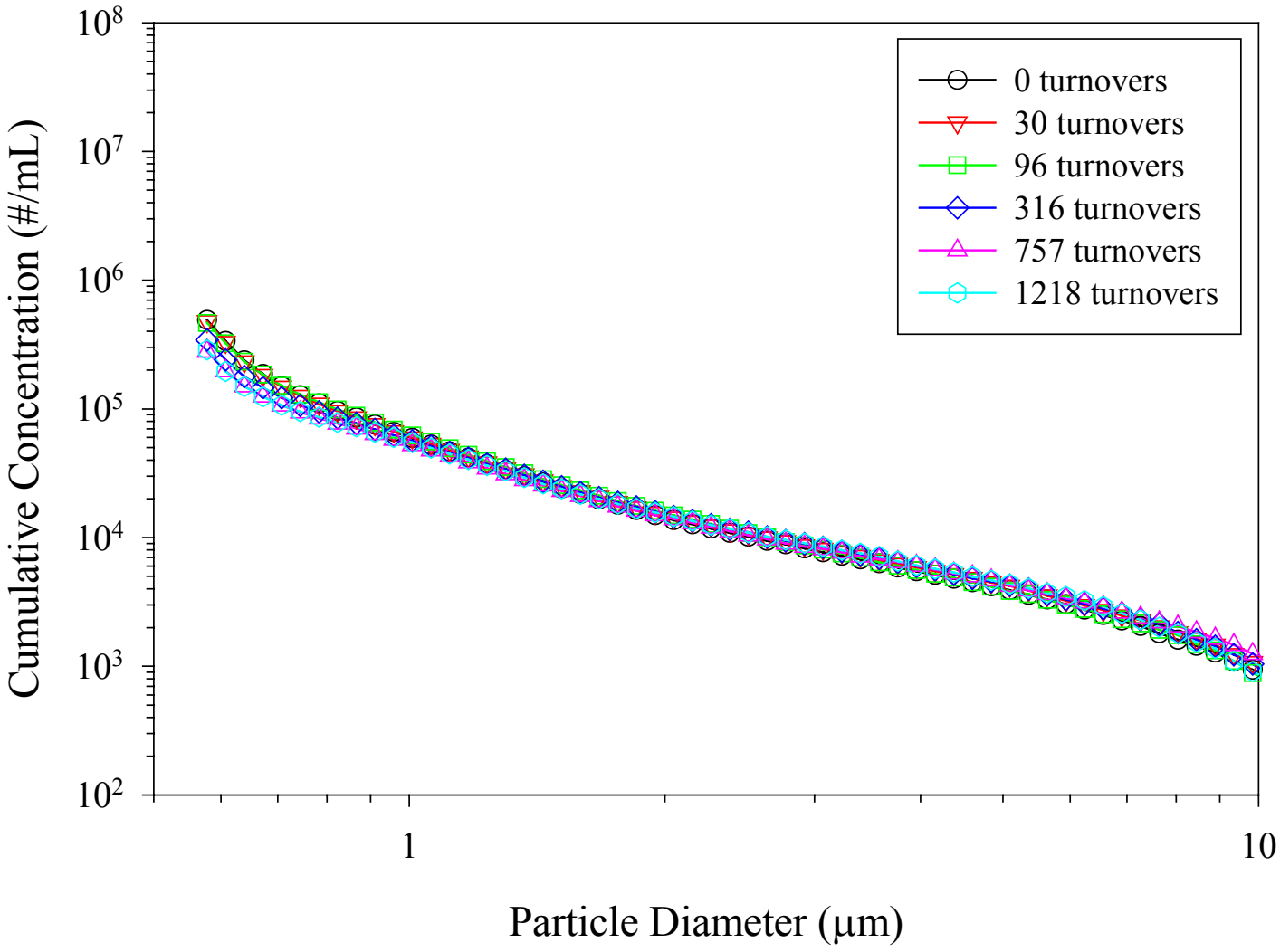
Effect of bellows pumps on the large particle tail



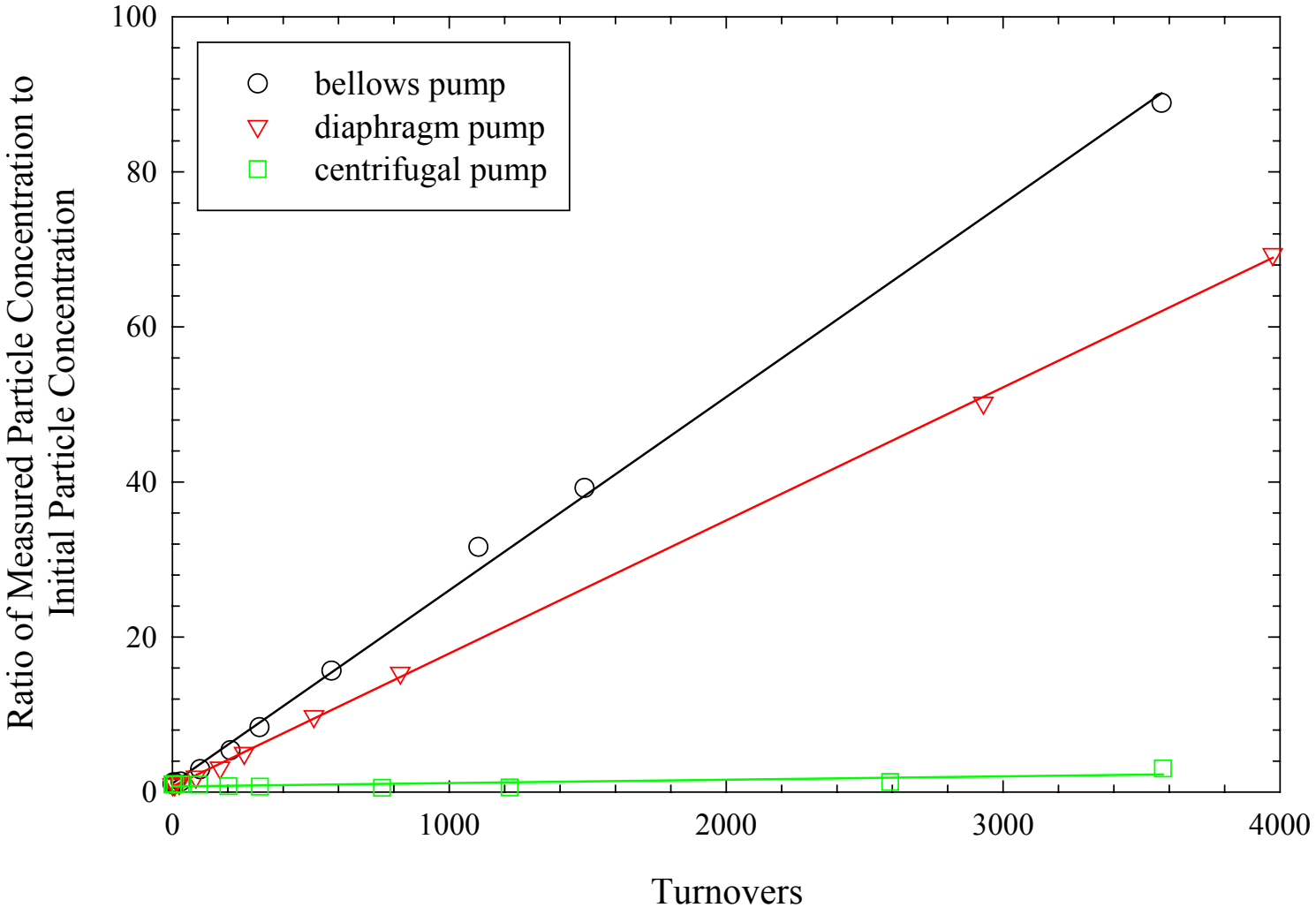
Effect of diaphragm pump on large particle tail



Effect of centrifugal pump on large particle tail



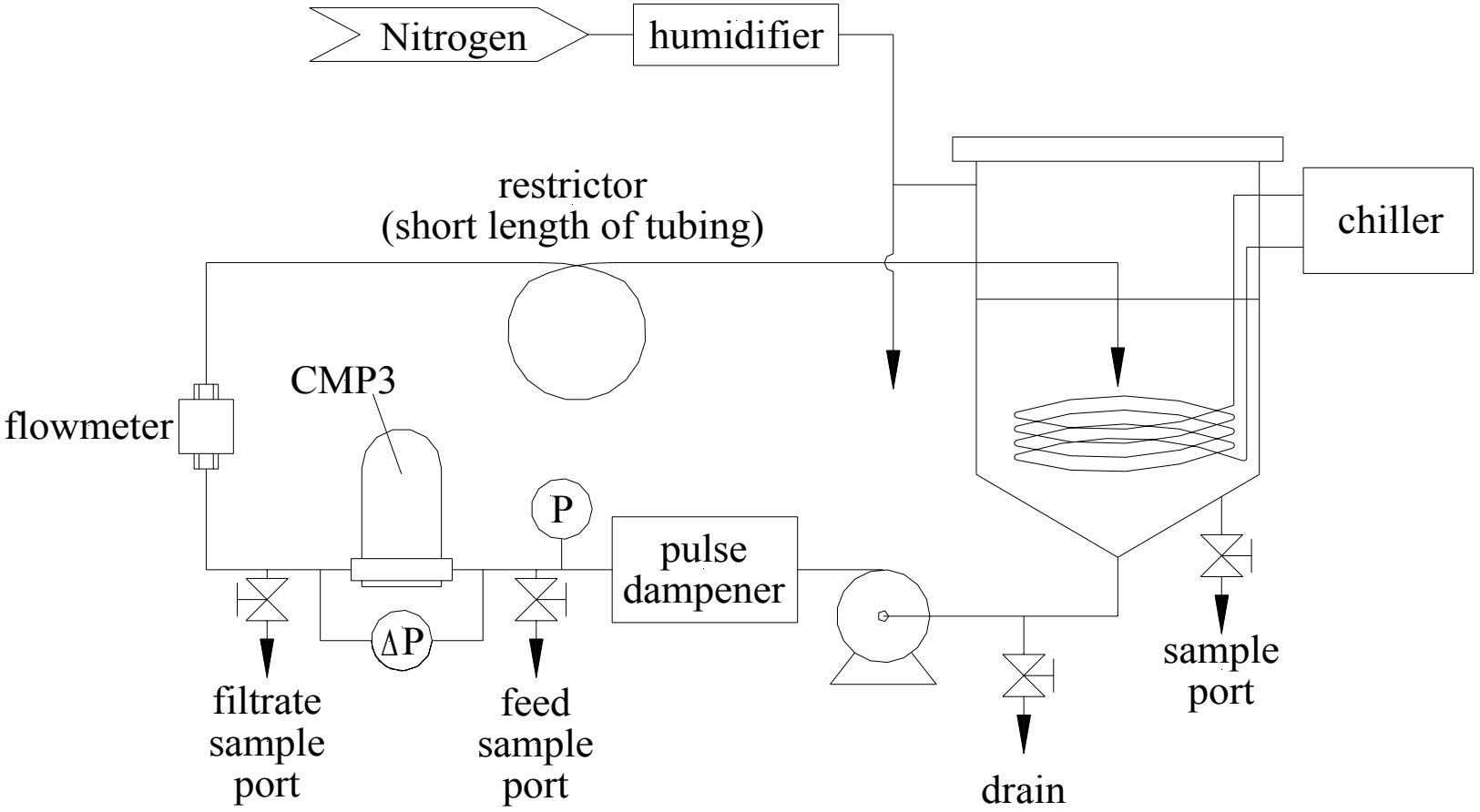
Effect of pumps on particles ≥ 0.56 µm



Effect of pumps on large particle concentrations

Particle Concentrations Relative to the Initial Particle Concentrations (C_T/C_I)						
Particle Size	100 Turnovers			1,000 Turnovers		
	Bellows	Diaphragm	Centrifugal	Bellows	Diaphragm	Centrifugal
≥ 0.56 μm	2.9	2.3	1.0	29	19	0.6
≥ 1.0 μm	5.3	4.1	1.0	69	45	0.9
≥ 2.0 μm	5.6	5.7	1.1	64	54	1.0
≥ 5.0 μm	4.4	6.3	1.0	35	45	1.1
≥ 10 μm	4.3	7.7	0.9	19	49	1.1

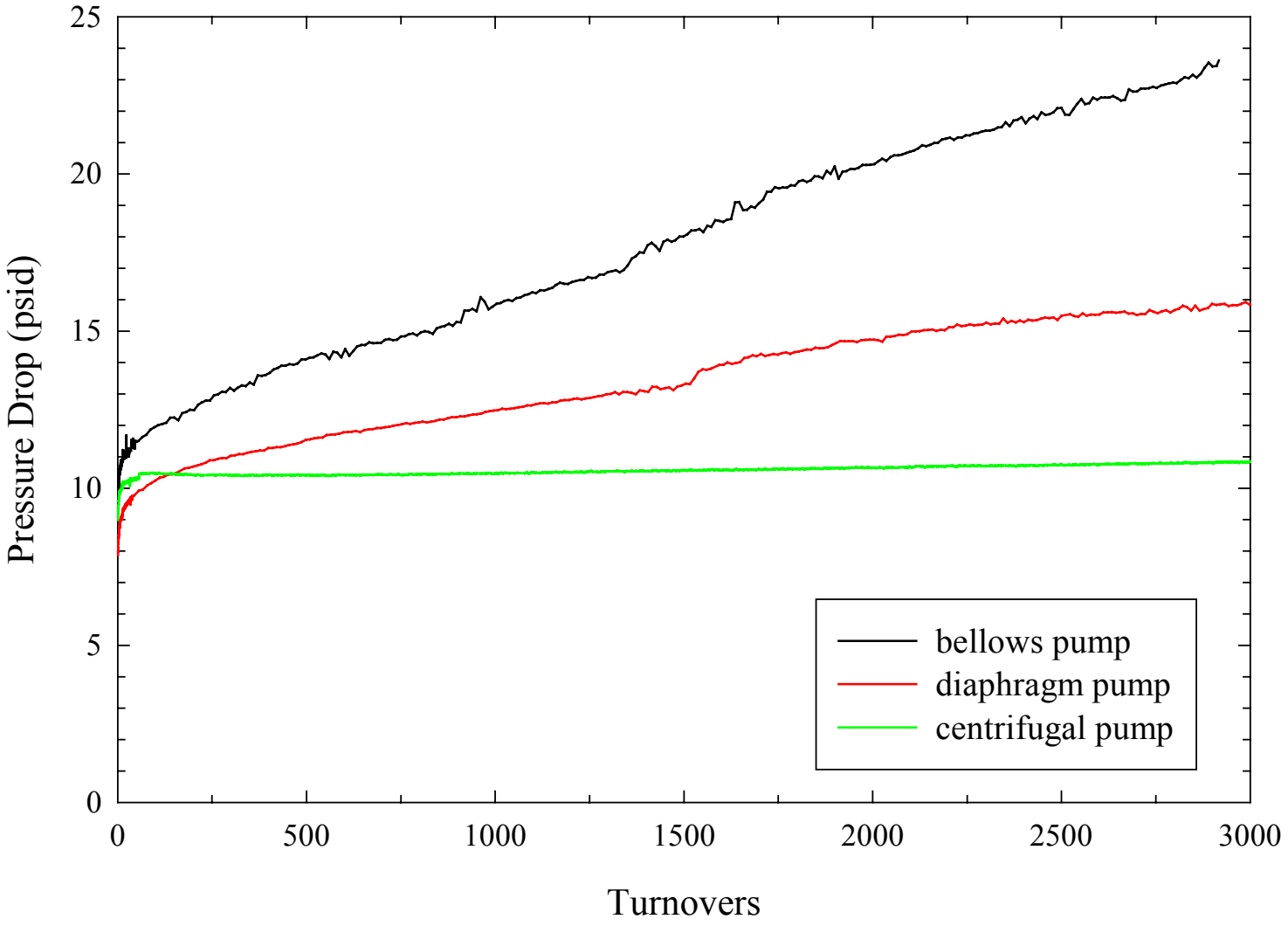
Schematic of system used to measure effect of pump type on filter life



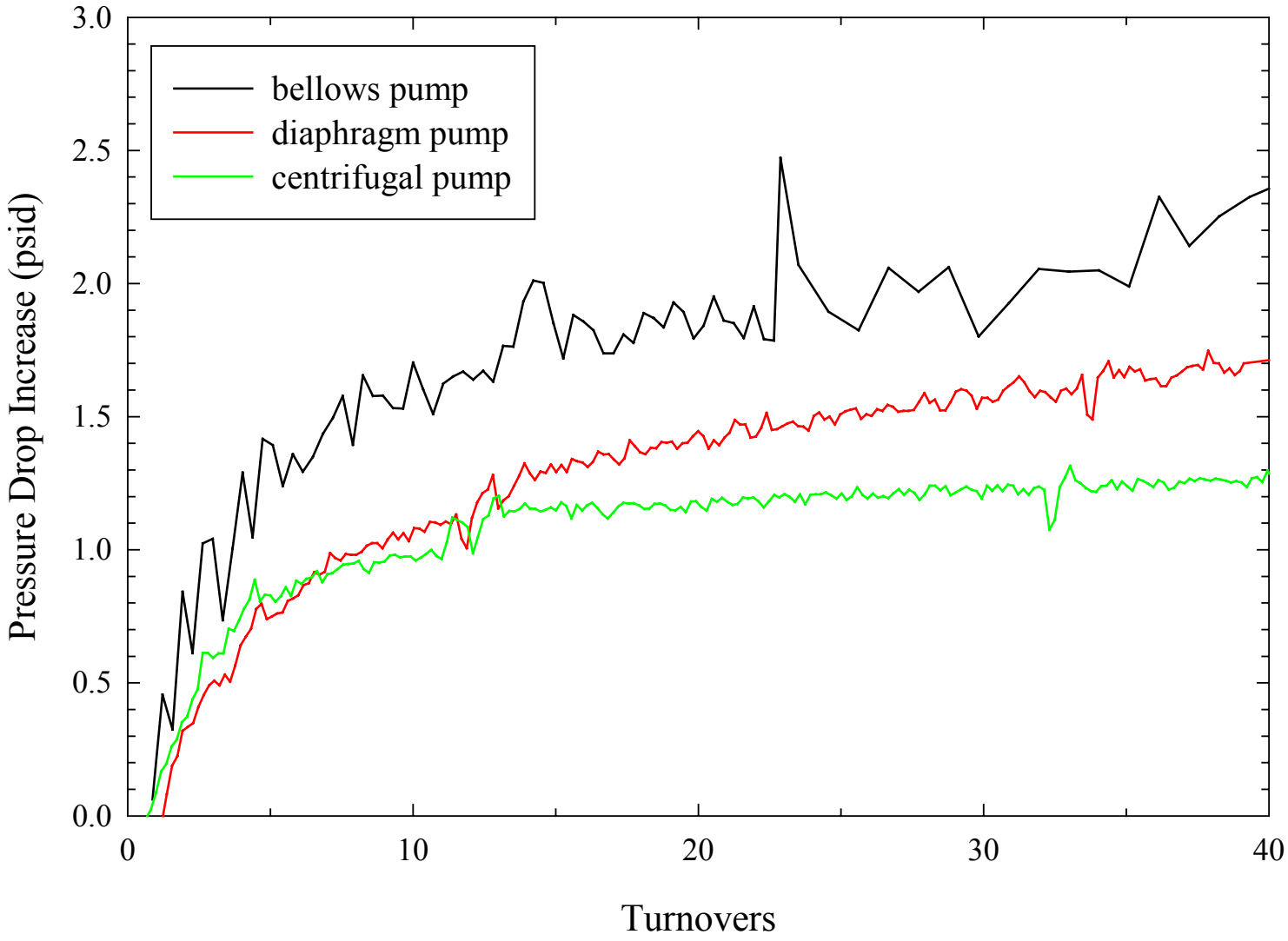
Effect of pump type of filter life

- Test method
  - Pressure drop measured across a new 10” Mykrolis Planargard™ CMP3 filter located downstream of the pump
- Test conditions
  - Pump air supply or speed was adjusted to achieve the following test conditions:
    - Flow rate: 30 Lpm
    - Pump outlet pressure: 22-37 psig (depending on ΔP across filter)
  - Tank blanketed with humidified N_2: RH > 90%
  - Slurry temperature: 20 ± 2°C

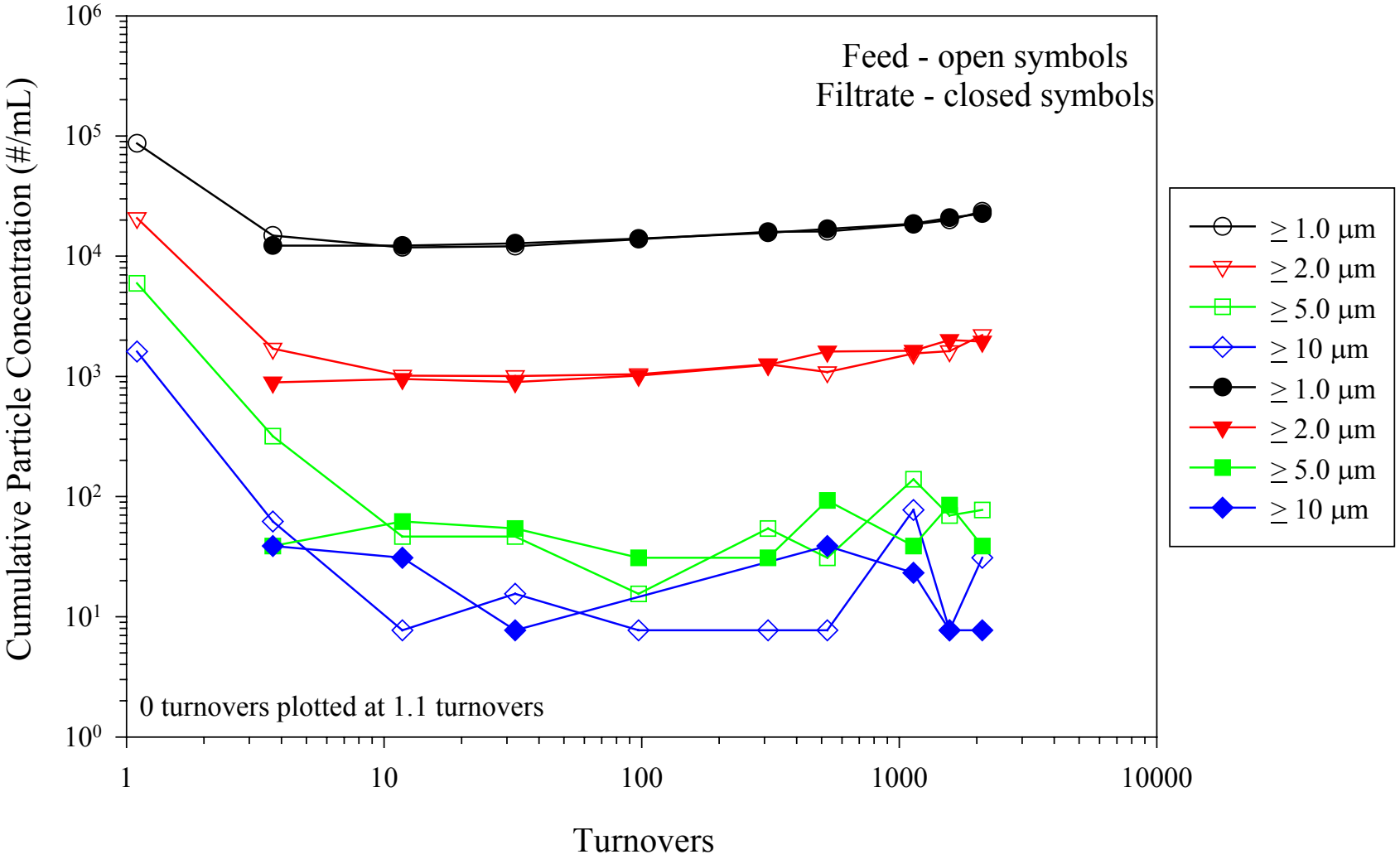
Effect of pumps on filter life



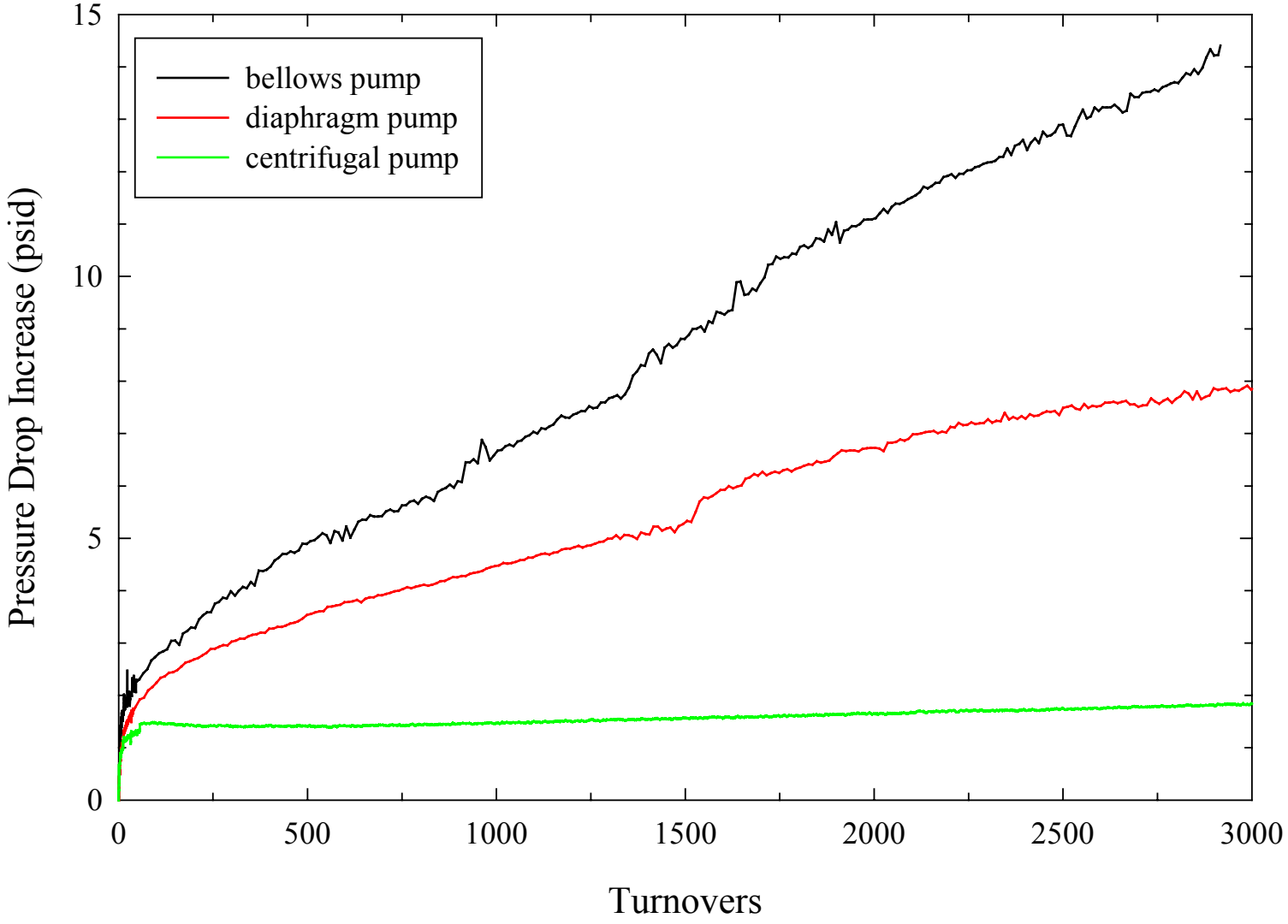
ΔP increase at start of test



Feed and filtrate concentrations measured during centrifugal pump test



ΔP increase during entire test



Summary

Type of Pump	ΔP Increase per 1000 Turnovers (psi/1000 turnovers)	Rate of ΔP Increase (relative to centrifugal pump)
bellows	4.1	23
diaphragm	1.7	9.3
centrifugal	0.18	-

Conclusions

- Pumps can significantly increase large particle concentrations in sensitive slurries.
- Pump type is important; large particle concentrations showed little change with the centrifugal pump; large changes with bellows and diaphragm pumps.
- Filter clogging rates were consistent with changes in large particle concentrations measured in the absence of filtration.