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A Portable, Automated, Integrity Tester for Large Filters and Filter Systems

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Background

Problem : Current filter leak detection systems that use a Freon probe gas are not accurate at elevated RH.

Reason : Freons are too weakly adsorbed on activated carbons when the water loading is high resulting in false positives.

Approach : Develop a leak detection system capable of operating when the activated carbon is nearly saturated with adsorbed water (high humidity environments).

Design Challenge

- Select a suitable probe gas
  - Non-toxic
  - Non-reactive
  - Weakly adsorbed enough to not adversely affect filter performance, but strongly adsorbed enough (especially at elevated humidity conditions) to produce a reliable result
- Select a chemical and detector pair capable of identifying a $1x10^{-5}$ leak
- Minimize the mass of chemical needed to conduct the test
- Provide a fully automated system, including chemical injection as well as detection

Chemical and Detector Selection

- Acetone was identified as the best probe gas
  - Not toxic
  - Adsorbed water does not adversely affect the adsorption capacity of acetone
  - Acetone is not reactive on ASZM-TEDA carbon and it will eventually elute through the filter.
- A photo-ionization detector (PID) was selected because it is very sensitive to acetone and it does not require any resources except power

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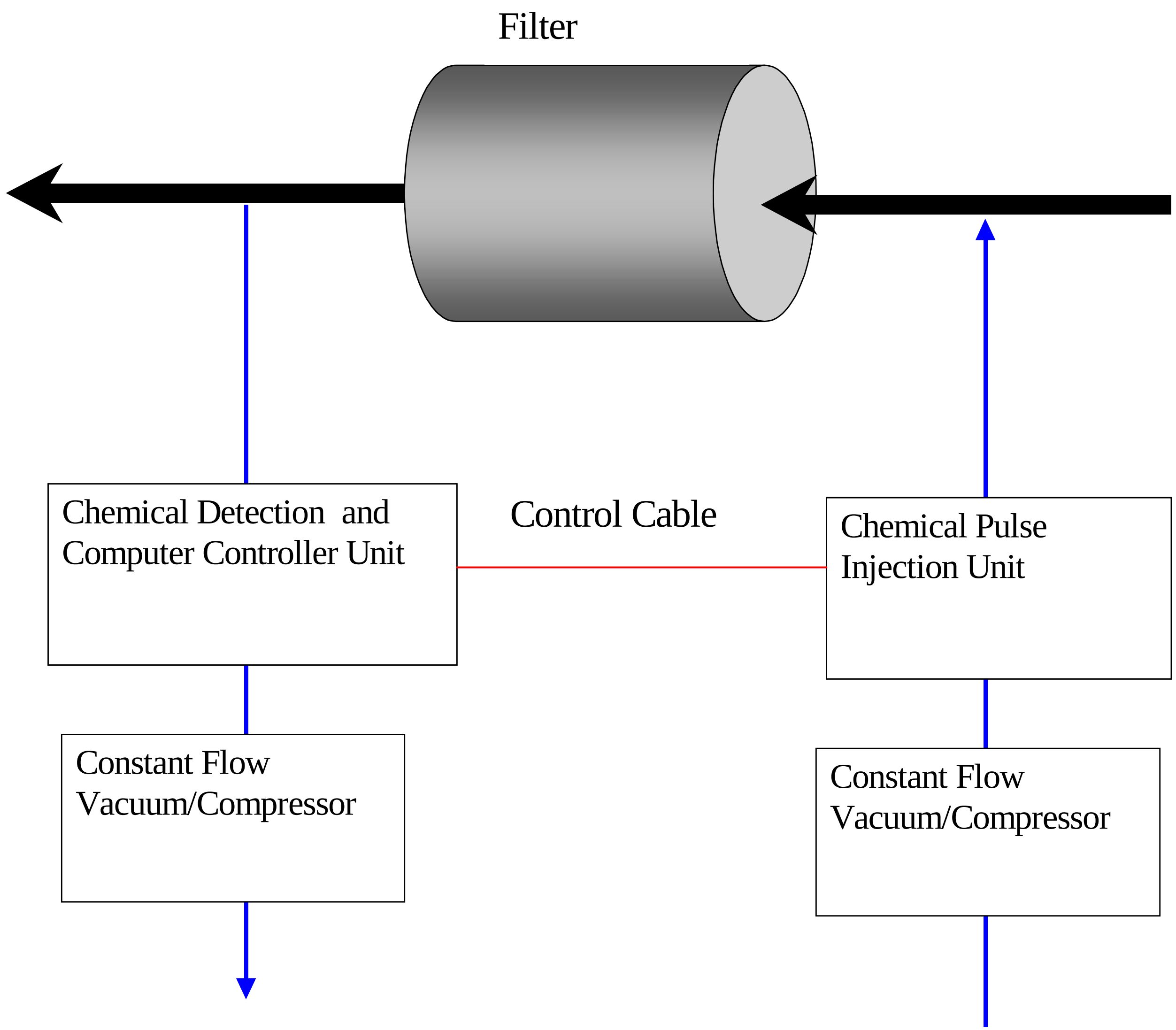

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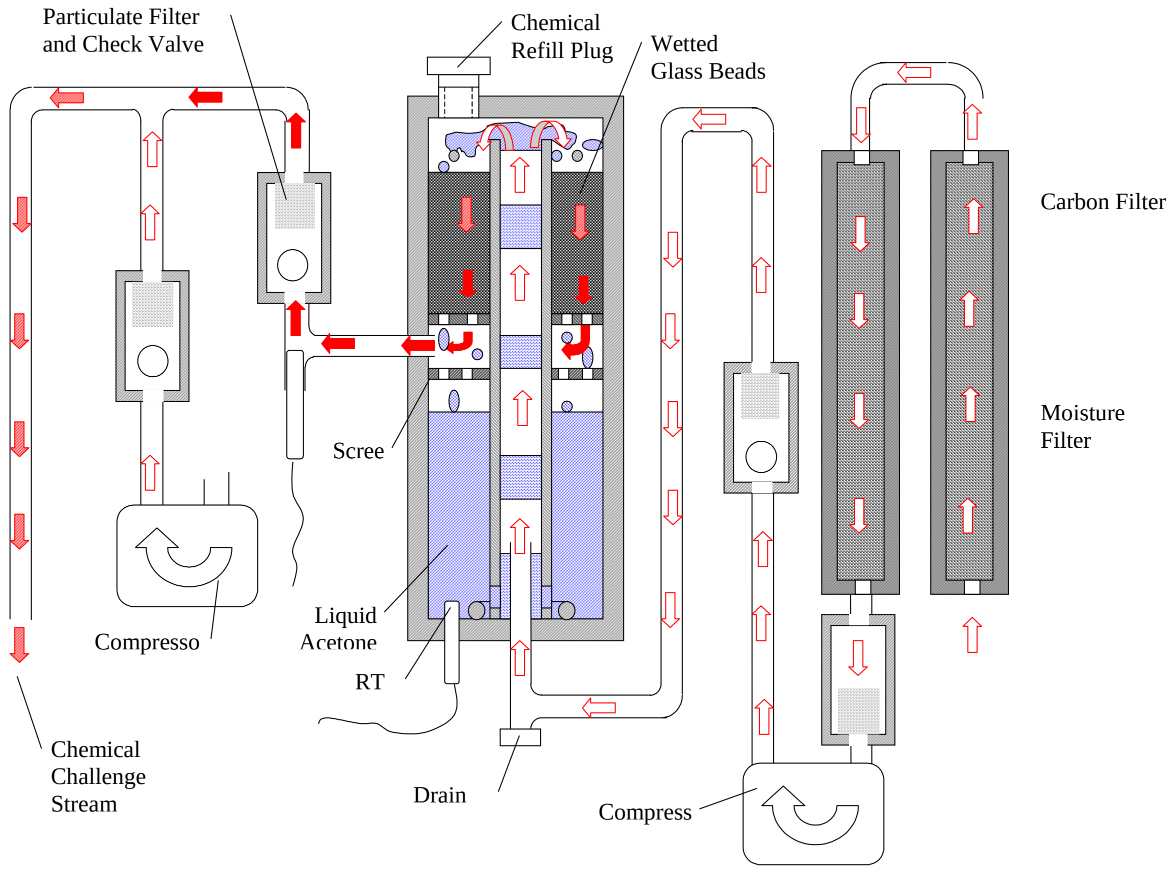
Chemical Injection System



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Injection Unit

- Generates a constant output concentration using a unique co-current sparger concept
  - Air flow pulls liquid up
  - Liquid falls down through glass beads, coating the glass beads. Excess liquid returns to the bottom reservoir
- A dilution air stream eliminates injection line condensation
- Currently sized for a 2,000 CFM system

  (9” x 10.5” x 16”)
- Injection mass is about 5 g per 1,000 CFM of filter air flow

Detection System Overview

- PID detector capable of measuring acetone concentrations of about 50 ppb
- Chemical enriching mechanism increases system detection capability to 500 ppt (with 35 ppm feed concentration, effluent/feed concentration ratio is about $6x10^{-5}$)
- Automated zeroing
- Automated operation

Detection System Operation Steps

- Sampling Step: effluent filter air is drawn through the enriching tube for a specified period of time
- Purging/Detecting Step: high concentration acetone vapor is purged slowly through the detector
- Cleaning Step: enriching tube heated and cleaned with purified, dried air
- Cooling Step: enriching tube cooled with fresh, purified air

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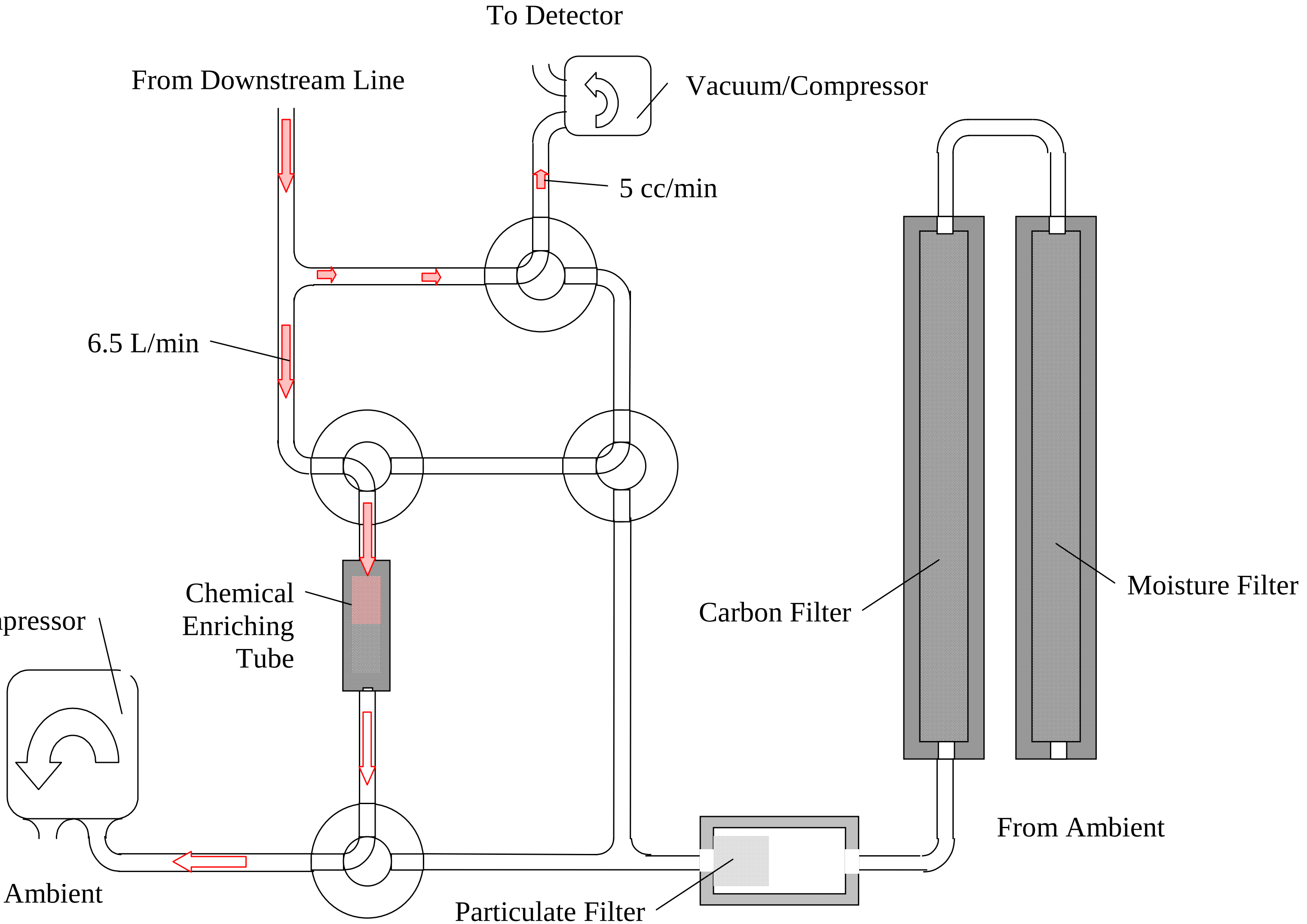
Sampling Step



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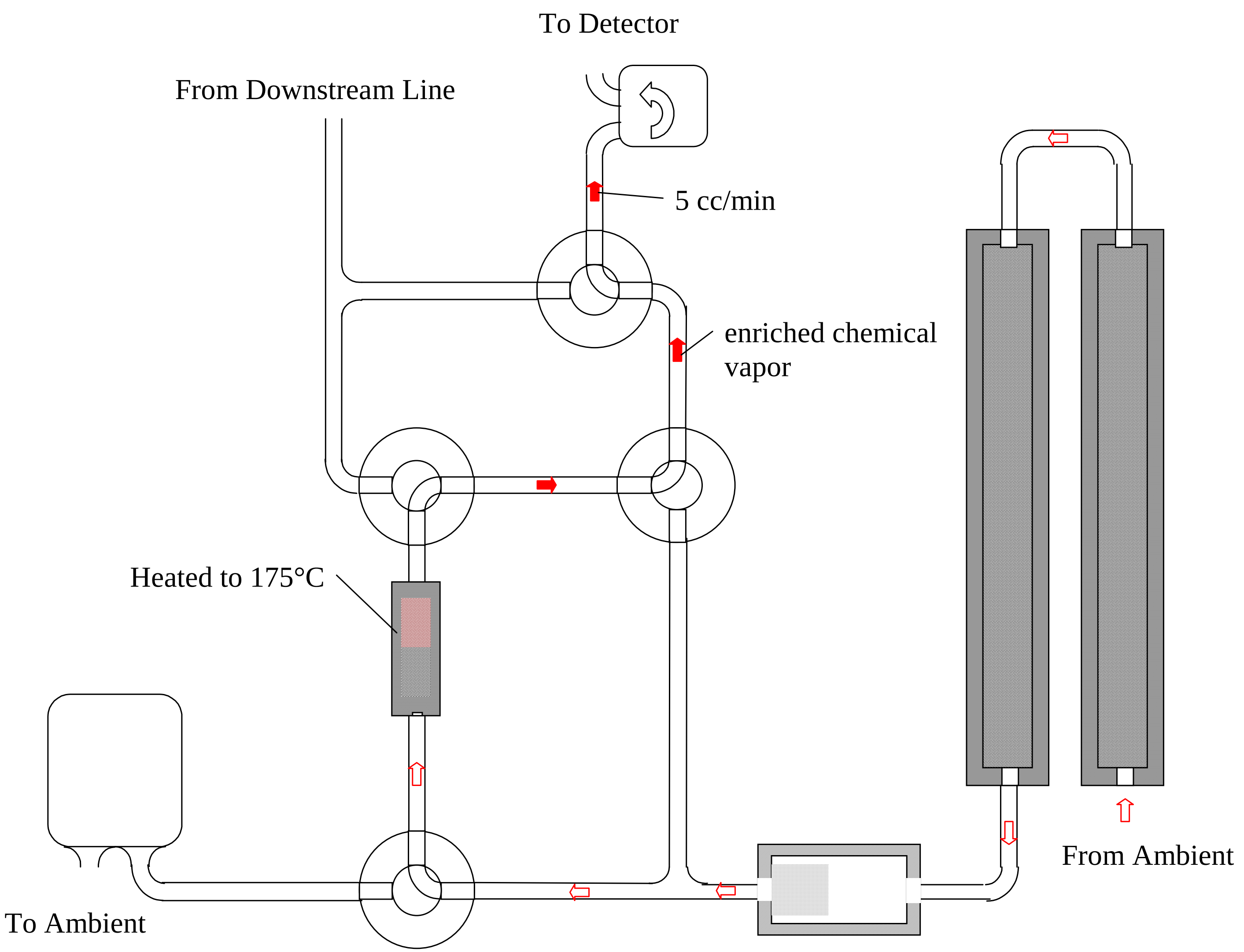
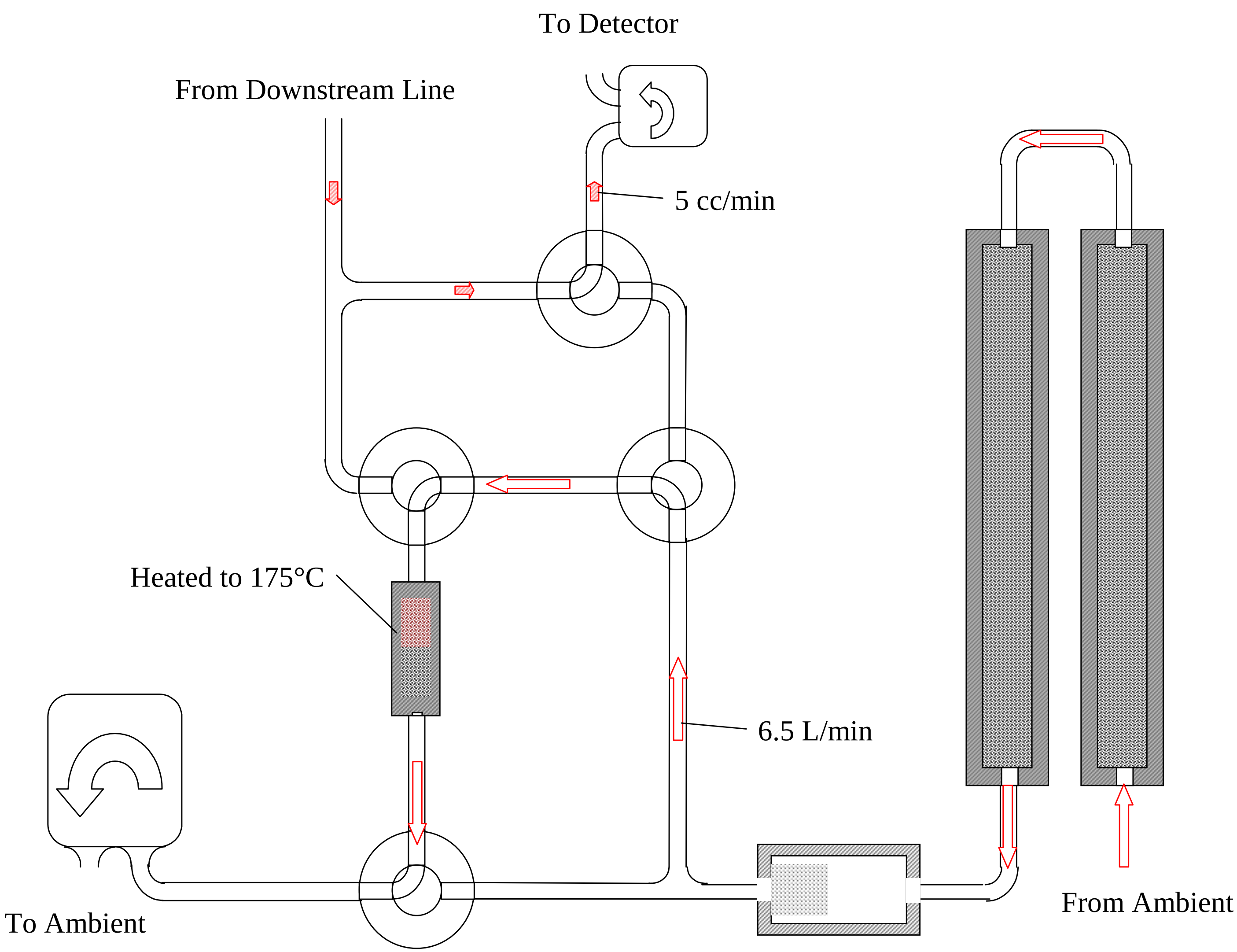
Purging/ Detecting Step



Cleaning Step



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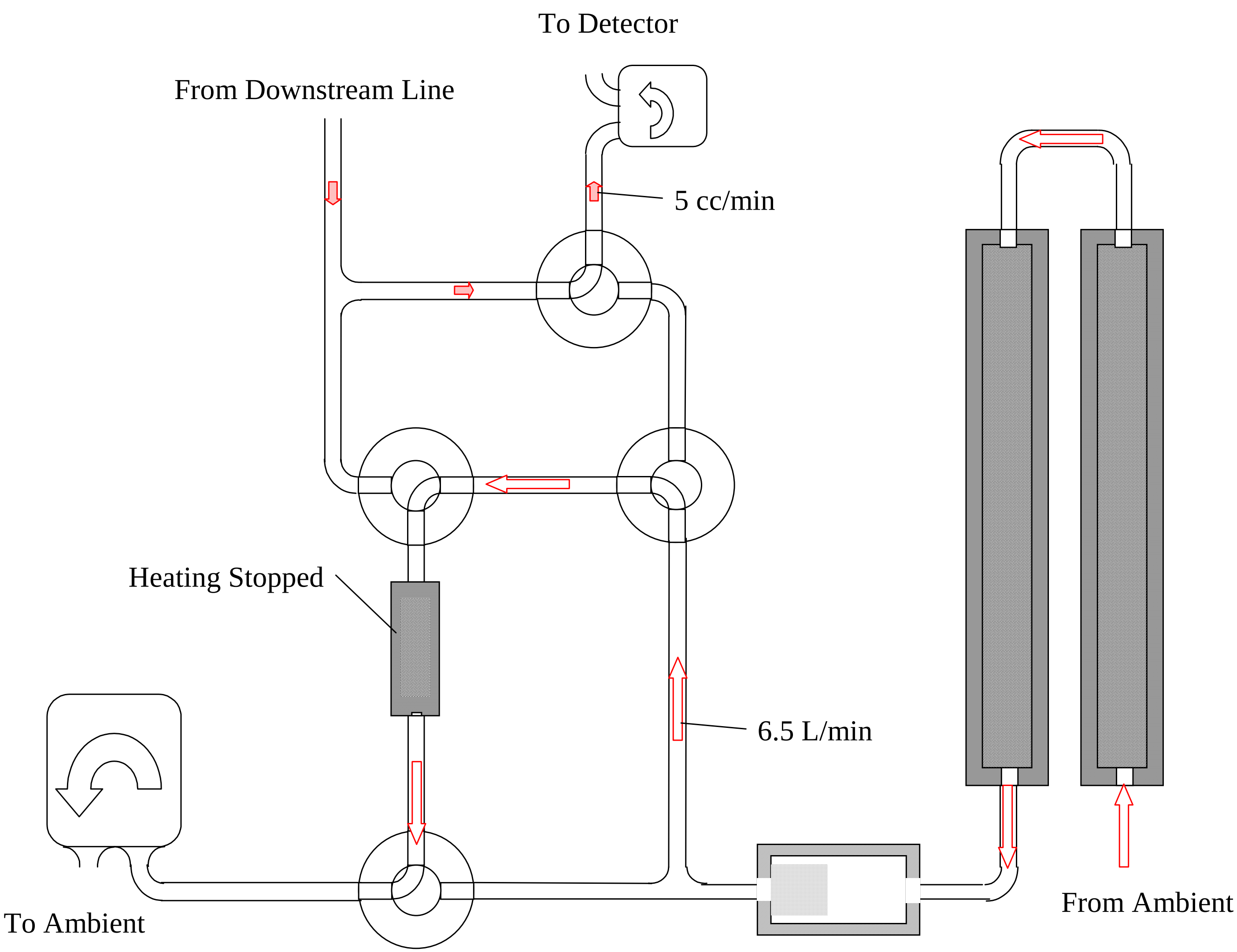
Cooling Step



FIT Operation Overview

- Inject a known concentration of acetone (approx. 35 ppm) into the inlet stream for a specified time (fix the total mass injected)
- Feed time is calculated and set based on the temperature of the chemical reservoir
- Use a chemical enriching step to raise the effluent concentration 100-fold
- Use a Photo Ionization Detector to measure the resulting acetone concentration, then provide a Yes/No to the user.

Summary of FIT Capabilities and Features

- Detects leaks below 10^{-5}
- Functions properly at elevated RH
- Fully automated operation, including chemical injection
- Portable and light-weight
- LCD display / Keypad input
- Internal flash memory to memorize up to 1,000 test results