Optimizing Fume Scrubber Efficiency by the Application of Water Soluble Dispersants

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A manufacturing facility, utilized scrubbers to neutralize and exhaust acidic fumes from metal casting and pickling process applications was experiencing poor removal efficiency and severe scaling upon internal piping and media. A chemical dispersant was added to the scrubber process water to condition dissolved solids and retard carbonate and sulfate deposition. Scrubber efficiencies were increased and waterside deposition of piping, probes, and distribution media was eliminated. By the application of this water-soluble dispersant, maintenance activities were reduced and scrubber efficiency remained within EPA compliance guidelines.

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Background

A manufacturing facility, involved in the casting of bimetal alloys upon a continuous strip steel base, requires a hydrochloric acid pickle to remove oxidation of the steel base before casting. The hydrochloric acid pickle tank is ventilated to assure containment of acid vapors and fumes away from worker exposure.

The ventilation system is exhausted to a roof cross-flow fume scrubber system. The scrubber system incorporates a packing distribution deck which utilizes water droplets to "scrub and neutralize" the acidic fumes. (1) pH control assures efficient acid neutralization with the use of sodium hydroxide (2). (*See figure 1*)

Scrubber Operating Specifications

The cross-flow fume scrubber operates at a pH range of 6 to 10 standard units. 95% efficiency of acid removal is obtained at this pH level of operation. This 95% efficiency is required to meet compliance with USEPA (United States Environmental Protection Agency) regulatory guidelines.

The pH is monitored and controlled via an analyzer/controller; this controller activates a caustic feed pump.

The water scrubbing media is gravity flow returned from the packing to a collection sump. From the collection sump, a circulation pump routes the water back up to the packing media. The make-up water volume is controlled at an average of 2 GPM (gallons per minute.)

A blow-down conductivity controller adjusts the total dissolved solids (TDS) of the water to a specific level. Water TDS is a critical factor in the absorption of acidic gas fumes. As a general guideline, the scrubber water TDS should not exceed 15,000 mg/l, or 22,500 mmhos of conductivity.

The characteristics of the make-up water are an important factor that affect the ability of the recycle water to remain soluble without creating hardness deposition by-products of calcium and magnesium salts (3). In this case, the make-up water hardness contained 120 ppm of calcium hardness and 40 ppm of magnesium hardness, (160 ppm of total hardness).

A water make-up meter/controller sends a 4-20mA (milliamp) signal to a chemical feed pump, which activates a chemical dispersant. The chemical dispersant is utilized to inhibit hardness deposition by-products. In this specific case, calcium carbonate salt build-up was excessive at the desired recirculation rate conductivity of 15,000 TDS. (*See figure 2*)

Scrubber Operation Without The Dispersant Additive

As a typical operation, most fume scrubbers are installed without a chemical additive (dispersant.) Make-up water quality, i.e. the level of alkalinity and hardness in the make-up water, as well as the required pH level to meet the required acid scrubbing efficiency, will vary from application to application, and in fact, will vary in different regions of the country (4).

In many locales, water alkalinity/hardness induced deposition is a constant battle, reducing scrubber equipment removal efficiencies. In addition to poor operating efficiency, hardness induced deposition will foul the packing media, internal piping, pump seals and gaskets, conductivity probes, and pH probes.

In this specific case, deposition of calcium carbonate would seize ball valves on the circulation lines, and the recirculation pump would "lock-up" about once per quarter (every three months). Annually, the scrubber would have to be removed from service and drained. Maintenance workers, usually two men, would remove and dispose of all media using a five-gallon bucket to manually remove the media (plastic ½ moon circular shells.) All "broken-off" scale solids would then have to be removed from the sump basin of the scrubber.

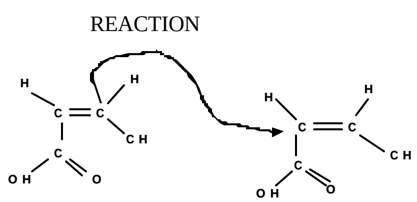
On a monthly basis, an acid cleaning was required to dissolve calcium carbonate from the conductivity and pH probes.

In summary, the scrubber became a maintenance burden and an on-going air discharge compliance concern. (*See figure 3*)

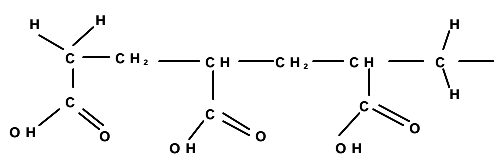
Scrubber Operating With Dispersant Program Implemented

Polyacrylate based dispersants have been widely used by the water treatment industry to inhibit hardness deposition (5). An acrylic base is reacted to form a polyacrylate chain a specific molecular weight.

Base Acrylic Acid Reaction



Polyacrylate Formation

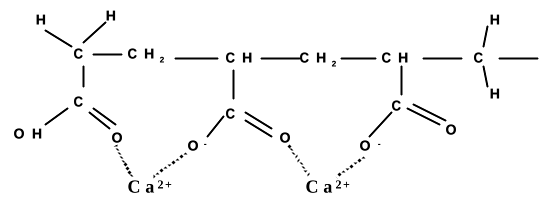


Polyacrylates react with calcium ions to inhibit calcium carbonate formation. A tight bond is created between the polyacrylate molecules and the calcium ion.

> This polyacrylate-calcium bond is stronger than the affinity of calcium ions to precipitate, as calcium carbonate, at alkaline pH levels of 9 to 10 standard units.

In the scrubber recirculation water, provided the calcium ion and the polyacrylate molecule concentration are at the proper ratio, calcium carbonate formation is negligible.

Polyacrylate-Calcium Reaction



A polyacrylate dispersant treatment program was implemented on the scrubber system in November of 1999. Water analysis testing indicated a calcium hardness of 2000 ppm in the scrubber recirculation water. A dosage of 300 ppm, as dispersant, was determined to meet the calcium hardness demand in this system. As the make-up water flow was two gallons per minute (2880 gallons per day,) a total daily dispersant dosage of 0.8 gallons (or 3000 milliliters) was set for administration by the chemical feed pump. (*See figure #4*)

Operating Results: A One-Year Evaluation

The dispersant application demonstrated improvement within 30 days after implementation. After 30 days, the pH and conductivity probes no longer required extensive cleaning of calcium scale formation. Scrubber efficiency maintained 95%+ as compliance was routine versus the previous erratic operation.

Chemical demand for the dispersant was minimal, at a dosage of 0.8 gallons per day. The 55-gallon dispersant drum was located below the penthouse level of the roof scrubber, and pumped up to the roof via a liquid metering pump.

Each dispersant drum lasts for 68 factory operation days. The cost associated with utilizing a dispersant was justified, based upon reduced maintenance and on-going compliance.

After one full year of operation the full benefit of the dispersant application was noted, as follows:

- No visible scale was observed upon the plastic distribution media.
- Internal water piping ball valves were working free from occlusion by scale formation.
- The recirculation pump rebuilds were reduced to annual maintenance versus the previous quarterly re-builds of the ceramic seals. This maintenance alone saved $2,400 in pump seal costs.
- The Scrubber manual clean-out, a previous annual requirement, utilizing two men, was eliminated.
- Media replacement was no longer required. No deposition was observed upon the internal media or distribution piping of the scrubber unit.

Summary

The use of polyacrylate dispersants to assist fume scrubbers is not common for most facilities in the metal casting and finishing markets.

Dispersant chemistries are available to improve fume scrubber efficiency, reduce or eliminate hardness deposition, minimize routine maintenance, and reduce a facilities overall cost of meeting air compliance concerns.

References

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3. *The Nalco Water Handbook*, 2nd edition, Kemmer, Frank N., Ed., McGraw-Hill, New York, N.Y., pp. 4.1-4.7; 1988

4. *The Nalco Water Handbook*, 2nd edition, Kemmer, Frank N., Ed., McGraw-Hill, New York, N.Y., pp. 4.8-4.20; 1988

5. *Betz Handbook of Industrial Water Conditioning*, 7th edition, pp. 179–181, Betz Laboratories, Trevose, PA.; 1976

FIGURE #1

SCHEMATIC OF A CROSS-FLOW FUME SCRUBBER

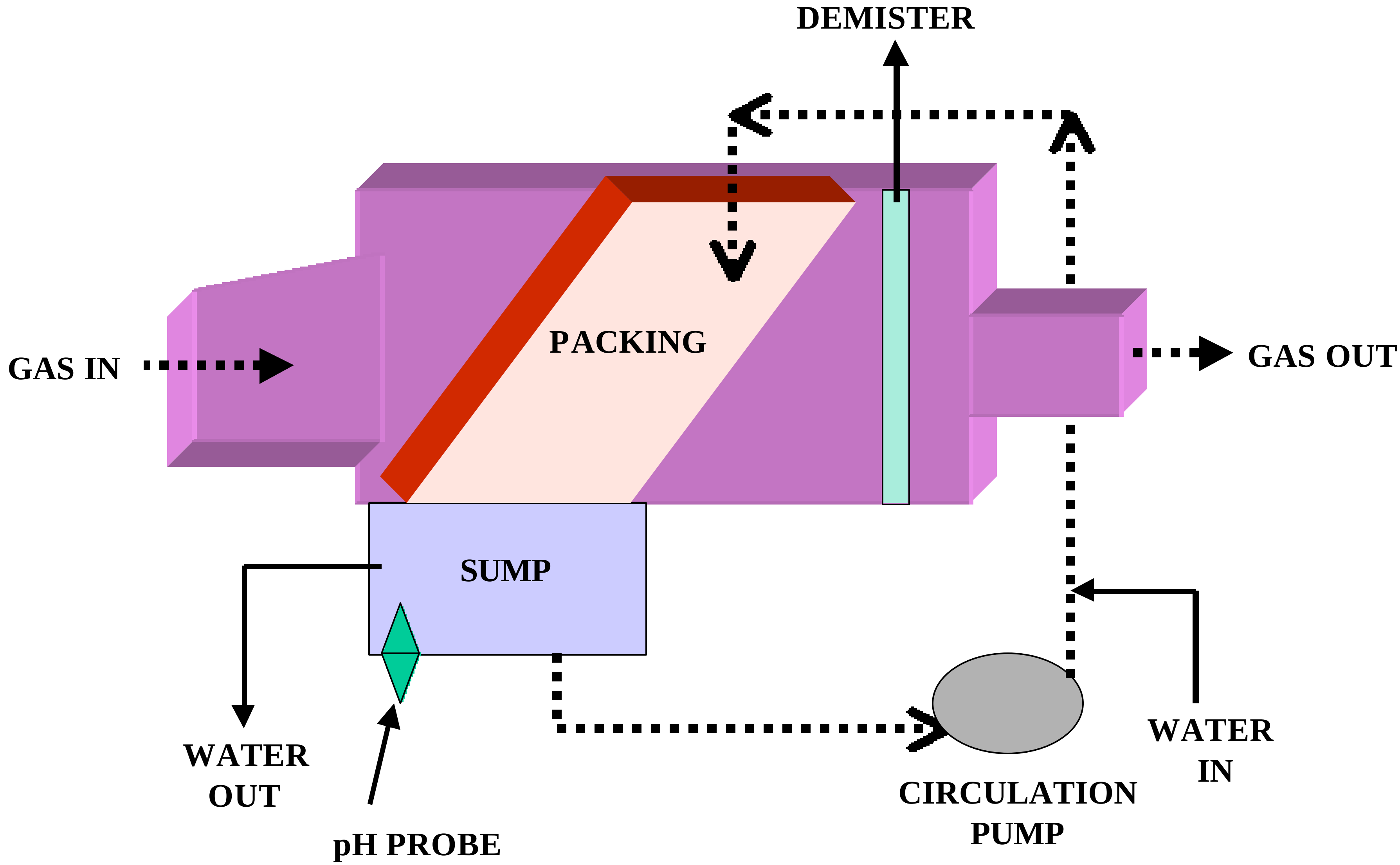

FIGURE #2

CROSS-FLOW FUME SCRUBBER WITH CHEMICAL TREATMENT DISPERSANT

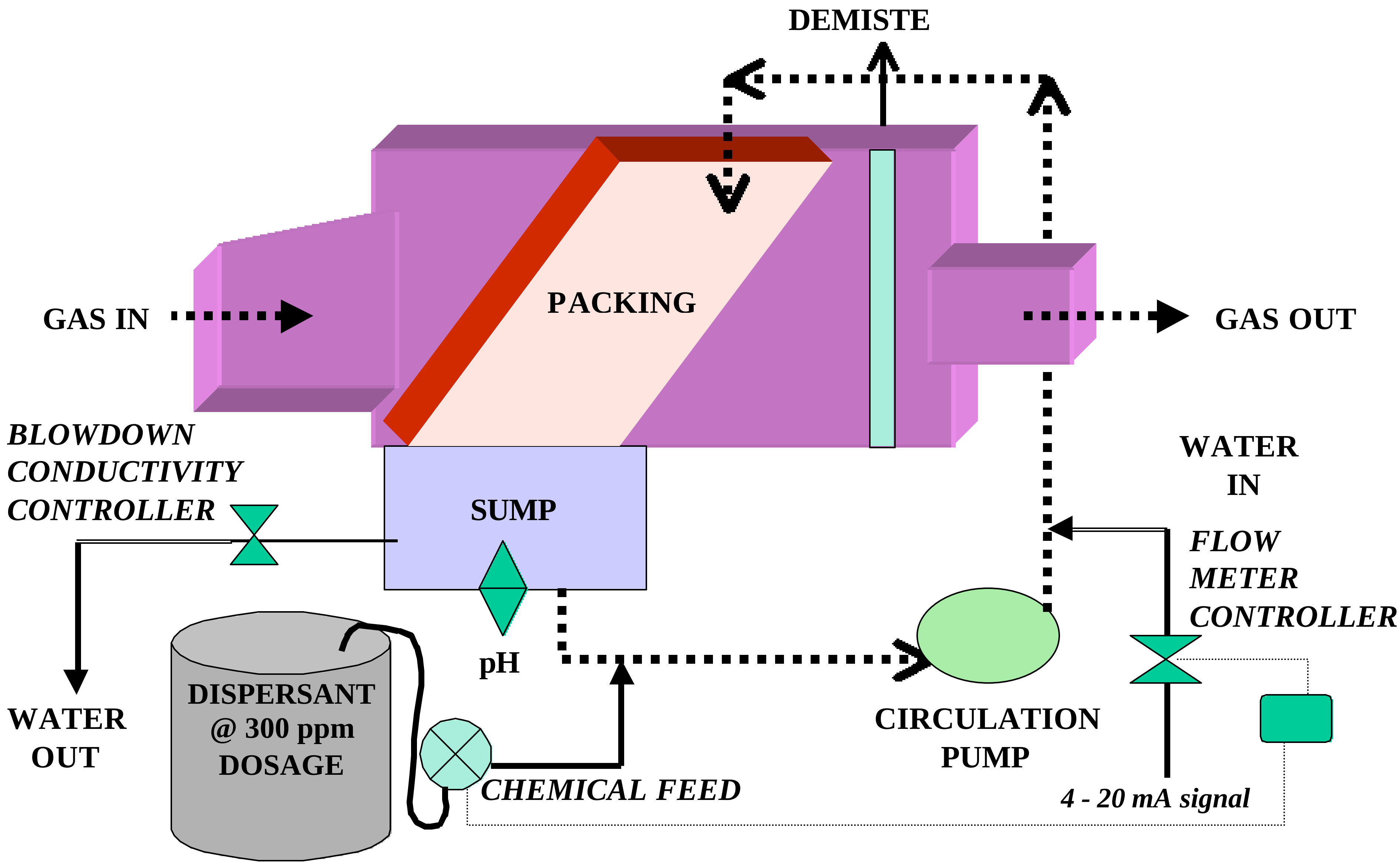

FIGURE #3

CROSS-FLOW FUME SCRUBBER: SCALE/FOULING LOCATIONS

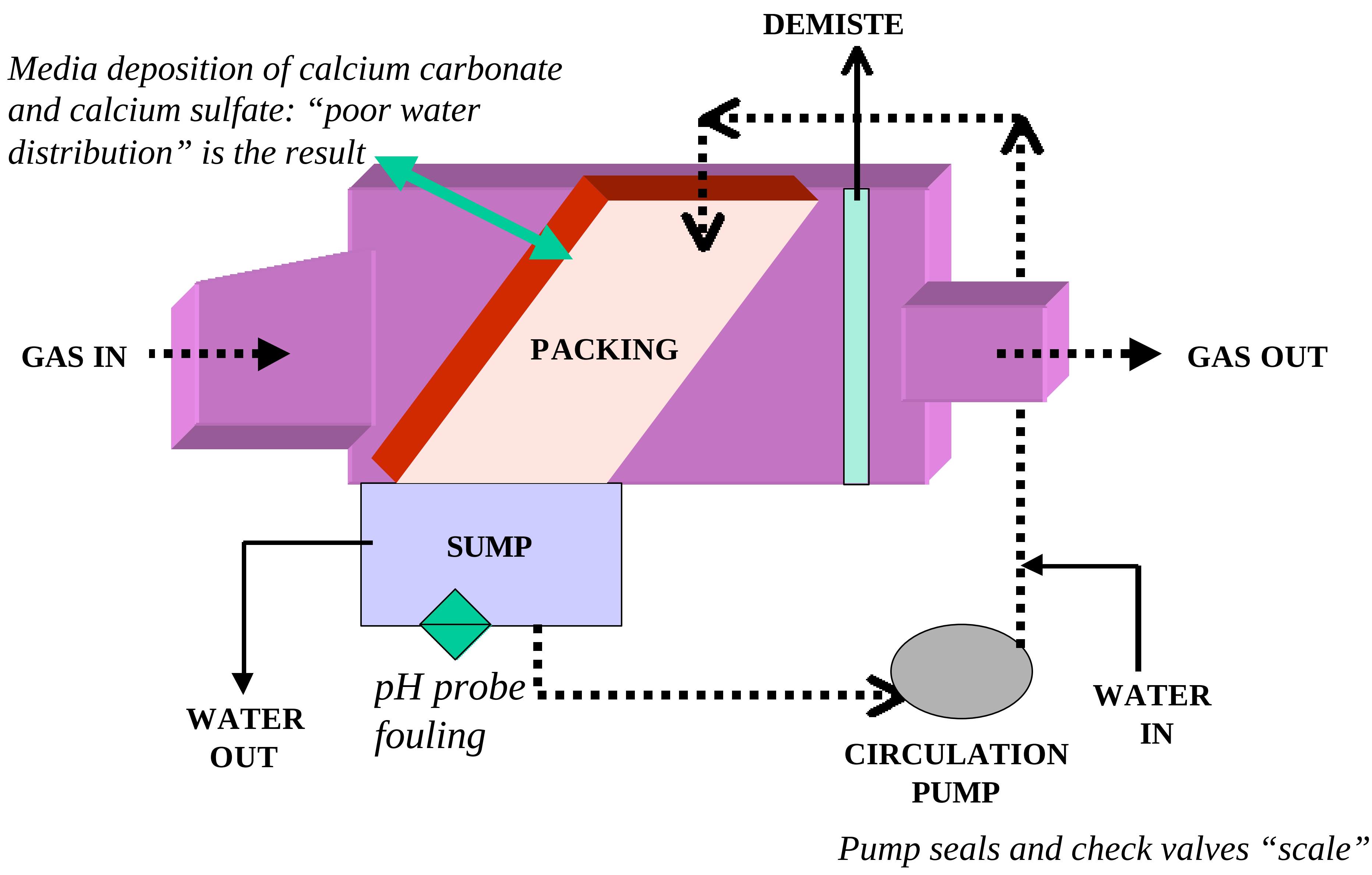

FIGURE #4

CROSS-FLOW FUME SCRUBBER WITH CHEMICAL TREATMENT DISPERSANT - ***OPERATING SPECIFICATIONS***