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Sanitaire TotalCare: Fine Bubble Diffuser Maintenance & Diffuser Cleaning Methods

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Introducing…

The Sanitaire TotalCare Team

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Sanitaire TotalCare – what do we do?

- Key offerings:
- Replacement Parts and Fixed Parts Agreements
- System Inspections & Condition Audits
- Diffuser Evaluations and Replacement
- Preventative Maintenance Agreements (PMAs)
- Diffuser Liquid Cleaning System (LCS) Contracts
- Aeration System Retrofits & Upgrades
- Aeration Controls Upgrades (OSCAR)
- Process Audits
- Operator Training & Technical Support

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Recommended Maintenance for Fine Bubble Aeration Systems

Annual System Inspection

- Frequency: Recommended once per year

  1) Drain basin

  2) Remove excess solids

  3) Inspect system line by line and make repairs

  – Look for:

    - Loose supports
    - Tilted air distributors
    - Loose tubing or clamps
    - Loose retainer rings on diffusers, spline joints, expansion joints

Annual System Inspection, continued

- Following pipe breakage or leaks:
  - Remove air distributor end caps and diffusers and check for sludge intrusion and air side fouling
  - Clean out piping and diffusers (both sides) if found

4) Perform leak & level test

- Look for:
  - Coarse bubbling around joints, connections, diffuser retainer rings, anywhere else!
  - Tighten joints and replace o-rings as needed

5) Clean diffusers – more on that to come!

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Diffuser Fouling

Fouling Locations

- Diffuser surface – water side
- Diffuser surface – air side
- Diffuser pores/slits

Fouling Types

- Biological
- Organic
- Inorganic/Mineral scaling

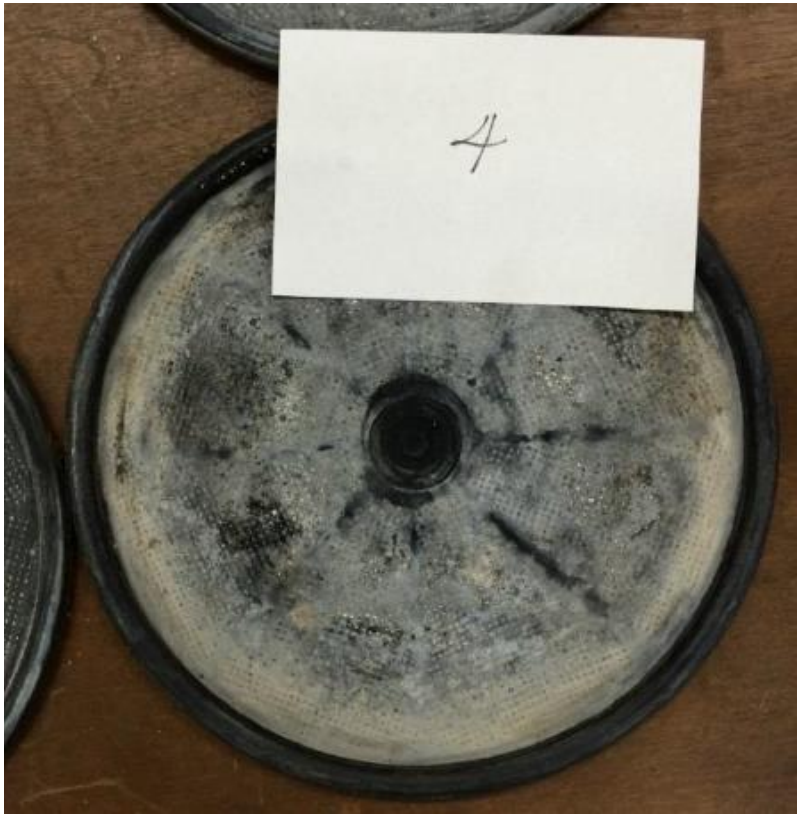
- Biological fouling: biofilm growth ("slime")
  - Location: primarily diffuser surface, water side
  - Consists of: Microscopic ecosystem that grows on the diffuser surface
    - Cells excrete "sticky" polysaccharides to trap nutrients from wastewater
    - Can be very well adapted and resilient
  - Impacts on aeration
    - May or may not reduce airflow or increase pressure
    - Increases bubble size, reducing oxgen transfer efficiency (OTE)
      - Air passages develop across biofilm layers, where air coalesces; bubble size increases with biofilm thickness
    - Reduced uniformity

- Organic fouling
  - Primarily diffuser surface, water side
  - May consist of:
    - Oils and greases in the wastewater
    - Fibrous material
    - Accumulation of settled solids; may be trapped in biofilm
  - Exacerbated by power outages
  - Impact:
    - May increase pressure
    - Reduced uniformity
    - Thick layers may block diffusers entirely
      - Dead zones

- **Inorganic Fouling/Mineral Scaling**
  - Location: Air side, water side, and/or diffuser pores
  - Consists of: Mineral precipitates
    - Most common: Calcium carbonate
  - Varies by region – water hardness
  - Process addition of lime
  - Impacts on aeration:
    - Blocking of diffuser pores → Increased DWP
    - Increased energy use
    - Decreased uniformity
    - Increased air flux through open pores
      - Larger bubbles
      - Reduced OTE
    - Reduced ability to maintain DO

Air Side Fouling

- Larger material may accumulate on air side surface; smaller particles may block diffuser pores
- Sources:
  - Construction debris: installation, repair work
  - Dirt/dust from poorly filtered air
  - Rust/corrosion products from air main piping and coatings
  - Mixed liquor solids
    - Pipe breakages, leaks
    - Power loss (primarily ceramic diffusers)
  - Contaminants from foul air used for aeration
- Impacts on aeration:
  - Increased DWP and energy requirements
  - Decreased uniformity



Fouling Rates

- Variable due to
  - Diffuser type
  - Wastewater characteristics
  - Process factors and operational history
    - Air on/air off operation
    - Batch/continuous/stepwise addition
    - Airflow rate of operation per diffuser
    - Power loss events
    - Diffuser cleaning/maintenance history
  - Diffuser/grid location
    - Influent vs. effluent end
    - Dead zones

Monitoring for Diffuser Fouling

- Pressure Monitoring System
  - Grid-specific
  - Monthly or quarterly
- Blower discharge pressure
- Laboratory diffuser evaluation
- Other indications:
  - Continuously increasing over time:
    - Operating pressure
    - Air demand without changes in tank loadings
    - Air demand along with decrease in DO

Impacts on Energy & Efficiency of Aeration

- Increased headloss/DWP
- Increased air flow rates
- Reduced OTE
- Difficulty maintaining tank DO
- Increased operational energy costs for aeration
- Reduced diffuser life span
  - Irreversible fouling

Five signs that it's time to clean your diffusers

1. More air is required to maintain process performance.
2. Residual DO levels are decreasing or are too low.
3. The back pressure at the blowers is increasing.
4. There is a year-on-year increase in the energy consumption of your blowers.
5. Your blowers are unable to produce enough air to meet DO requirements.

If any of the above applies it is time to consider cleaning your diffusers.

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Combating Diffuser Fouling: Diffuser Cleaning Methods

1) Hosing

- Method: Low or high pressure hosing from tank top or bottom
- Applications: Membranes or ceramics
- Operational impact:
  - Requires draining tank – perform during regular inspection
- Effectiveness
  - Removes surface biological/organic fouling layer buildup
  - Poorly effective on mineral scaling
  - Not effective on air side fouling
  - High pressure spray may lodge foulant deeper in diffuser pores
- User-friendliness: simple, easy
- Safety: low level concerns
- Costs
  - Minimal equipment and labor costs

2) “Modified Milwaukee Method”

- Method
  - Drain tank
  - Hose diffusers with water
  - Apply acid spray of 50% by volume 30% HCl to diffusers
  - Let sit for 30 minutes
  - Hose again

- Standard recommended method in Sanitaire O&M
  - May be performed in conjunction with in-situ methods

- Operational impact:
  - Requires draining tank – perform during regular inspection

"Modified Milwaukee Method", continued

- Effectiveness
  - Proven! Quite effective in dissolving mineral scaling
  - Partially active in killing biological fouling
  - Good surface contact
  - Particularly good for ceramic diffusers
- User-friendliness
  - Simple method but very labor intensive and time-consuming
- Safety concerns:
  - Handling of liquid HCl
  - Working in bottom of tank
- Costs
  - Low chemical and equipment costs
  - High labor costs

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3) HCl Gas Cleaning

- History
  - Patented by Sanitaire in the 1980s
  - First in-situ diffuser cleaning method
  - Mostly applied to ceramic diffusers
- Method
  - Anyhdrous HCl gas injected into the aeration grid dropleg
  - Air stream transports gaseous acid to the diffuser bottom surface
  - Condenses to liquid and carried through diffuser, dissolving scaling and killing some organics
- Operational Impact: Does not interrupt aeration

HCl Gas Cleaning, continued.

- Effectiveness:
  - Very effective in dissolving mineral scaling and reducing DWP
  - Uniformity of diffuser contact may be unpredictable
- User friendliness
  - Requires special training
  - Often contracted out
    - Few providers
  - Availability and DOT requirements for HCl gas
- Safety concerns
  - Significant: Compressed HCl gas on site
  - May require planning for gas leak
- Costs: High
  - High costs for panel, injection piping, valves at each grid
  - High cost of replacement components
  - High cost of HCl gas compared to liquid
  - Labor

4) Other Methods

- Acid Atomization System
  - Method
    - Atomized acid injected into the air stream, where it is carried to the diffuser
  - Operational Impact: In situ; high air rate required
  - Effectiveness:
    - Very questionable
    - Difficulty of keeping liquid in suspension
    - Potential for low diffuser contact across grid/short-circuiting
    - Little data available

- Complete Fill Acid Immersion
  - Method
    - Dilute acid pumped to completely fill aeration grid piping
  - Operational impact:
    - Tank out of operation for 1+ days
  - Somewhat effective
  - Cons:
    - High volume of solution and acid required but low acid concentration
      - » Higher cost, lower effectiveness
    - Takes a long time to work

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New Diffuser Cleaning Method Development Project

- **History**
  - Launched in 2011 by Sanitaire R&D
  - Patent for new system applied for in 2014

- **Project Goal:**
  - Develop new in-situ cleaning method for ceramic and membrane diffusers

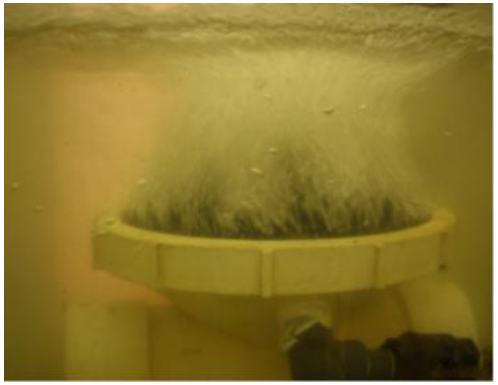
- **Product Requirements**
  - Reduce operating pressure & energy costs
  - Indirectly extend diffuser life
  - Maintain OTE
  - Not harmful to the biology of the system
    - In-situ; no interruption of aeration
    - Cleaning agent must be
      - » Low pressure, low cost
      - » Readily available
      - » Low risk factors for storage, safety, handling
    - Effective against mineral scaling and to a lesser extent biological fouling
    - Low cost vs other methods
    - Simple to operate and maintain

The Result: New Patent-Pending Sanitaire Liquid Cleaning System

The Method (in situ)

1. Dilute liquid acid (HCl or formic acid) is pumped into the aeration grid lower dropleg or manifold, filling the manifold and air distributors to a depth of 0.5”.
2. Acid fumes gradually rise to the bottom surface of the diffusers and recondense.
3. Air draws the liquid acid up through the diffuser pores, dissolving mineral scaling.
4. Passage of air restored to partially or fully blocked diffuser pores/slits, resulting in reduction of DWP across the diffusers.
5. The process continues for 2-3 days as the full volume of injected acid is drawn across the diffusers.

Before

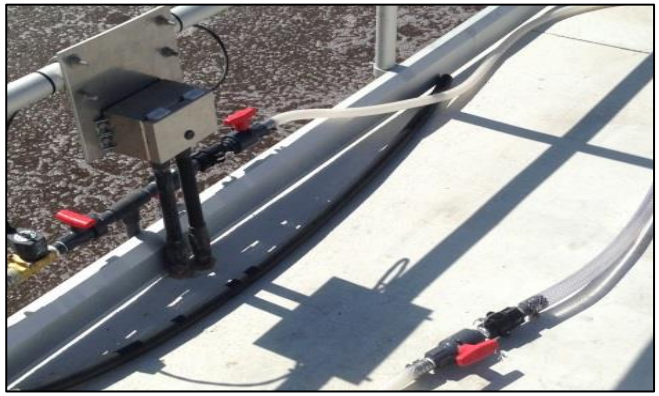


After

Sanitaire Liquid Cleaning System

Applications

- Diffuser types:
  - EPDM membrane ceramic, and Gold Series diffusers
- Compatible with PVC or stainless steel manifolds
  - PVC: Hydrochloric acid
  - Stainless steel: Formic acid
- Acid injection point options
  - Dedicated Monel drop pipe at each grid
  - Manual purge droplegs with purge extension valve kit
- Not compatible with continuous purge
  - Continuous purges may be plugged if already present



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Liquid Cleaning System Advantages

- **Operational impact**
  - No need to drain tanks
  - Cleans while diffusers are operating—no disruption
- **Improved safety & user-friendliness**
  - Avoids safety concerns related to having HCl gas on site; user-friendly skid
- **Effectiveness**
  - Liquid HCl: improved contact area with diffusers vs. HCl gas method
  - Proven results through numerous lab and field trials and commercial sales
- **Lower Costs**
  - Lower chemical costs for liquid HCl or Formic acid vs. HCl gas
  - Short payback time in reduced energy costs

Sanitaire TotalCare: What we can offer

- **Contract cleaning service**
  - Included with Silver and Gold PMA contracts
  - Also available as standalone service by Sanitaire
- **LCS system capital purchase**
  - 60, 90, and 120 gallon sizes available
  - Includes Operator Training

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Sanitaire TotalCare Preventative Maintenance Agreements (PMAs)

Included:	Gold Package	Silver Package	Bronze Package
Annual on-site Fine Bubble Aeration System Inspection	✓	✓	✓
Annual Liquid Acid Diffuser Cleaning Service	✓	✓	✗
Annual on-site Operator Training	✓	✗	✗
Cleaning and calibration of Xylem-provided instrumentation sensors	✓	✓	✓
Discount on all Genuine Sanitaire Parts associated with aeration system	20%	15%	10%
Discount on labor rates for unscheduled callouts	15%	10%	5%
Field or laboratory diffuser testing/evaluation	✓	✓	✓
Annual data review	✓	✓	✓

Diffuser Performance Evaluations

- **Testing of up to 5 diffusers available at no cost**
  - $50/diffuser for quantities beyond 5
- **Performed at Sanitaire R&D lab in Brown Deer, WI**
- **Used to determine condition and remaining life**
- **Written report provides results and recommendations for diffuser replacement and cleaning methods**
- **Physical characteristics tested**
  - DWP at 1.0, 2.0 and 3.0 scfm/diffuser.
  - Uniformity
  - Hardness
  - Thickness in center and edge
  - Diameter
  - Permanent set
  - Weight
- **Diffuser cleaning methods**
  - Can estimate energy savings and DWP reduction potential for liquid acid cleaning

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Sample Energy Savings Estimate
After testing submitted used diffusers

Figure 6. Estimated annual operating cost per diffuser based on 17 feet of submergence and $0.10/kWh, based on pre- and post-cleaning DWP, compared to a new Sanitaire ceramic diffuser.

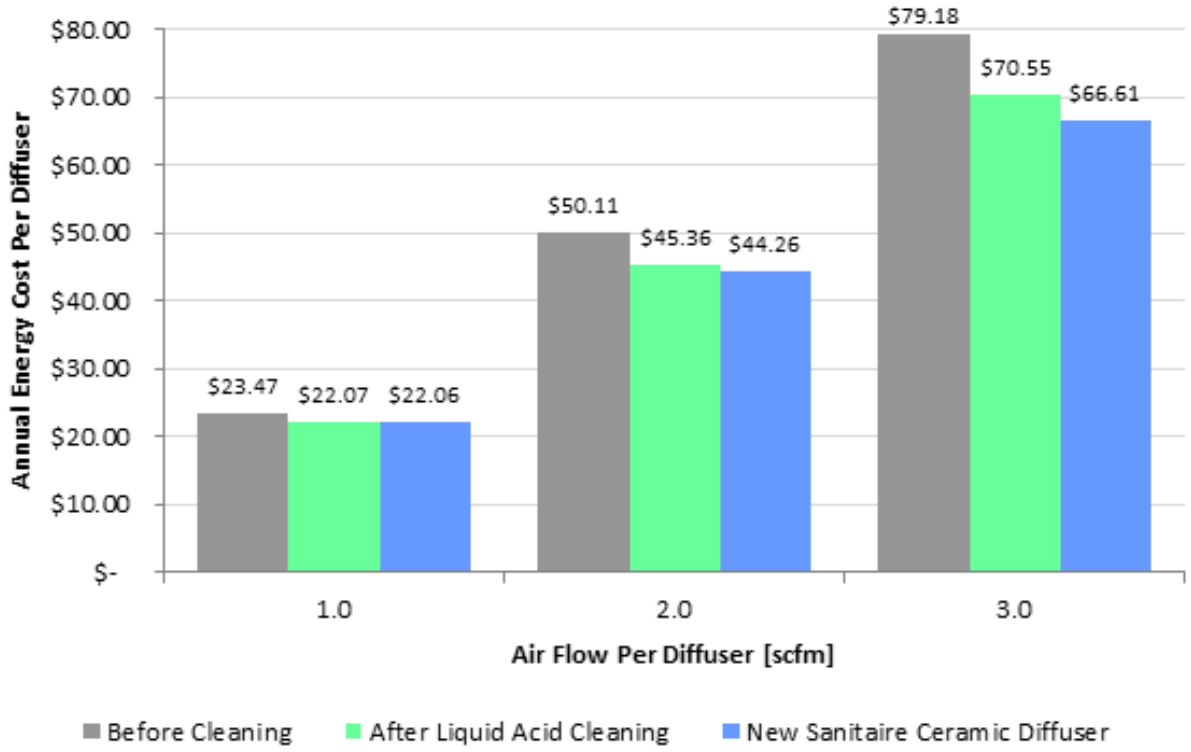

Table 3. Estimated energy cost reductions by air rate

Air rate	Estimated energy cost reduction from DWP decrease achieved through liquid acid cleaning
1.0 scfm	$1.40 per diffuser per year
2.0 scfm	$4.75 per diffuser per year
3.0 scfm	$8.63 per diffuser per year

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Thank you! Questions?