



CASE STUDY COLLECTION

Industrial Fan System Effects

Six real-world installations where the fan wasn't the problem

Every fan in these six cases was properly built, properly rated, and AMCA certified. Every one of them still underperformed, vibrated, overheated, or failed early — because of the system around it.

Inside: what happened at each installation, what caused it, and the lesson worth carrying into your next specification — across manufacturing, wastewater treatment, correctional facilities, and pulp-and-paper production.

6

installations reviewed across four industries

0

failures caused by the fan's rated performance

3

practices that would have prevented most of them

WHAT'S INSIDE

01 Commissioning before the system was complete

02 75% of the airflow through a single quadrant

03 A 24.5% free-area loss nobody calculated

04 When a closed damper cooks a fan

05 When footprint constraints override design

06 18 months of staged startups, no balancing

A fan is only as good as the system around it

At AMCA International's conference, the engineering team at Hartzell Air Movement — a manufacturer JEPCO represents — presented six case studies on advanced system effects, drawn from real installations across four industries.

The pattern held across all six. The engineering looked sound on paper. But unaccounted system effects — inlet conditions, duct layouts, dampers, commissioning practices — drove up operating and maintenance costs in the field. If a design ignores those conditions, even a well-built, properly specified fan can vibrate, overheat, or fail early.

SYMPTOM

Oscillating vibration

Airflow below design

Harsh noise, system pulses

Heat damage, cooked coating

WHAT TO LOOK AT FIRST

Asymmetric inlet air — a tee, elbow, or duct split too close to the wheel

Uncalculated free-area losses, or a system commissioned before it was complete

An unbalanced system, or dampering right at the fan inlet

Dead-head operation behind a closed damper

CASE 01 • MANUFACTURING

Commissioning before the system was complete

A large manufacturing facility ran a general exhaust system built around multiple centrifugal fans, each on a VFD, with a control sequence holding constant pressure inside a shared header and branch dampers setting the airflow rates. During commissioning, the team reported inadequate airflow and elevated vibration.

The cause came down to timing. Construction schedules forced the team to commission the fans before crews finished the full system. To compensate, they partially blocked the main headers and added smaller dampers to create “false loads.” Header pressure read correctly, but airflow stayed low. The first two or three fans had enough air. The last one or two ran starved, near stall.

THE LESSON

Pressure readings alone don't tell you what a fan is actually doing. A fan in stall can produce the right static pressure while moving the wrong amount of air — and the wear it builds stays invisible until something fails.

CASE 02 • WASTEWATER TREATMENT

75% of the airflow through a single quadrant

An odor-control application used two Arrangement 8 centrifugal fans in parallel — one running, one on standby — each handling 30,000 cfm at 18 inches w.c. Within six months the running fan developed oscillating vibration severe enough to trip the high-vibration switch regularly. Fan 1 eventually failed outright.

CFD analysis found the root cause: the duct split immediately upstream of the fans, so 75% of Fan 1's airflow entered through a single quadrant of the wheel. Fan 2 had a similar, slightly milder problem. The resulting oscillation caused shaft turndown at the bearing seat. The air permit compounded it — it required exact airflow on a 24-hour rolling average, so the VFDs were programmed for constant real-time speed corrections and the fans never settled at a stable operating point.

The fix came in three parts: P-traps to handle water buildup in the duct, a rewritten air permit that dropped the real-time speed corrections, and targeted Unistrut reinforcement to cut air-induced vibration.

THE LESSON

Asymmetric inlet air creates vibration the wheel can't handle. Straight duct between elbows, tees, and fan inlets isn't a nice-to-have — it's what protects the bearings and shaft.

CASE 03 • CORRECTIONAL FACILITIES

A 24.5% free-area loss nobody calculated

A correctional facility with roughly 200 cells couldn't deliver the required airflow to each cell. Every cell had a 6-by-6-inch ventilation opening, and code required a 0.75-inch hardened steel security bar running both horizontally and vertically across each one.

Comparing as-built drawings to design drawings, then AMCA-certified fan performance data to the on-site test-and-balance reports, made the picture clear: the system effect calculation left out the security bars. Across 200 openings, those bars reduced free area by 24.5%. The original fan already ran near maximum RPM, so it had no headroom to compensate. The facility ultimately replaced it with a larger fan sized for the actual losses.

THE LESSON

Every component in the airflow path counts, even the ones added for non-mechanical reasons. When a system repeats a feature 200 times, small per-unit losses compound fast.

CASE 04 • PULP & PAPER

When a closed damper cooks a fan

A process exhaust application used a 316 stainless steel centrifugal fan designed for ambient air, roughly 75°F. After three months, vibration exceeded 0.8 inches per second and inspection found the epoxy coating cooked off the housing.

Maintenance records explained it. During an emergency breakdown elsewhere in the plant, crews held a butterfly damper — sitting directly upstream of the fan — closed for six to eight hours while the fan kept running. Air recirculating inside the housing generated enough heat to push temperatures over 500°F, warping the wheel and destroying the coating. The wheel was redesigned with high-strength stainless components, including Inconel in critical structural areas, and the maximum operating temperature spec for similar applications was raised to 550°F.

THE LESSON

A fan that can't move air can't cool itself. Operating procedures and mechanical design both have to account for a fan running into a closed system — because eventually it will happen.

CASE 05 • POOR LAYOUTS ACROSS APPLICATIONS

When footprint constraints override good design

In the first of two installations, a tee and a control damper sat directly upstream of a centrifugal fan with no straight duct between them. The customer reported a loud, harsh-sounding fan, then adjusted the damper to a 45-degree angle to try to manage the airflow. Within two weeks the turbulent inlet conditions had cracked welds on the centrifugal wheel. The recommendation: a VFD to control airflow instead of dampering that close to the inlet.

The second was more extreme. To fit the fan into a tight footprint, the contractor installed a hard inlet bend of roughly 135 to 180 degrees, then put an inlet box on the fan outlet. The fan ran with severe vibration. A different arrangement — a square design rather than Arrangement 01 — would have eliminated the system effects entirely.

THE LESSON

When footprint forces compromises near the fan inlet or outlet, change the fan arrangement — don't bend the duct harder. Talk to the manufacturer before the duct routing is final.

CASE 06 • COMPLEX WASTEWATER SYSTEMS

18 months of staged startups without air balancing

This system was complex from the start: six supply fans, twelve area exhaust fans, and three odor-control fans, operating in combinations of series and parallel and feeding a common odor-control duct from six branches, with a 91,000 cfm target. The fans were belt-driven centrifugals, the odor-control units on VFDs, all factory balanced and AMCA tested before shipment.

But the system came online in stages over 18 months, and each time a new fan went in the contractor declined to balance the system, preferring to wait until everything was in place. The result was predictable in hindsight: erratic airflow, extremely noisy operation, frequent vibration trips, and oscillating vibration severe enough to cause shaft turndown on the odor-control fans.

Once the full system was finally air-balanced, the vibration resolved. The odor-control bearings were replaced with concentric bearings to handle residual oscillation, and two shafts already ruined by turndown damage were replaced.

THE LESSON

Air balancing isn't a final step. It has to happen every time you bring a fan online in a connected system. System pulses are a strong sign the air isn't balanced — ignore them and those pulses do real mechanical damage.

What ties these six cases together

AMCA certification confirms performance in lab conditions — but lab conditions don't include an elbow two duct diameters from the inlet, security bars across 200 openings, or a damper held closed for six hours during a plant emergency. Those are system effects, and they fall on the system designer, the installer, and the commissioning team, not on the fan. Three practices prevent most of what these cases show:

- 1 Account for system effects during design.** AMCA Publication 201 and the Fan and Air System Applications Handbook are good starting points. Every elbow, tee, damper, and obstruction near the fan inlet has a cost.
- 2 Maintain straight duct between components.** Air entering a fan wheel needs to stay as laminar and symmetrical as possible — the straight-duct rules keep the bearings and shaft alive.
- 3 Air-balance every time you bring a fan online.** Not just at final commissioning. Every stage.

Quick answers

What is a fan system effect?

Any performance loss created by the installation conditions rather than the fan. Elbows, tees, dampers, security bars, and transitions near the inlet or outlet disrupt the laminar airflow the fan needs — reducing airflow and adding vibration, noise, and wear.

How much straight duct should I leave between a fan and the nearest fitting?

AMCA Publication 201 calls for at least three duct diameters upstream of the inlet and two to three downstream of the outlet. Elbows, tees, and dampers call for more. When in doubt, get the manufacturer's input before finalizing duct routing.

When should I involve a fan manufacturer?

As early as possible, and certainly before anyone finalizes the duct routing. Most of these cases stem from decisions made after the fan was specified but before installation was complete.

READ THE FULL WRITE-UP

The complete case studies, straight from the manufacturer

Hartzell Air Movement's engineering team published all six cases in full — including the AMCA conference session detail and an extended FAQ on straight-duct requirements, dead-head operation, and when to bring a manufacturer into the design process.

INDUSTRIAL FAN SYSTEM EFFECTS →

Designing a system — or troubleshooting one already in trouble?

JEPCO represents the industry's best air movement equipment for OEM, industrial, contracting, and engineering needs. Bring us the layout, the airflow targets, and the constraints, and we'll help you catch the system effects before they become failures.

TALK TO US

Contact your JEPCO representative

WHAT WE COVER

Industrial fans & blowers • dampers • vacuum systems

Case studies presented by the Hartzell Air Movement team at AMCA International's 2026 conference, session "Advanced System Effects: Causes and Remedies," and published by David Long, Vice President Sales. Summarized and distributed by JEPCO. Read the original in full at hartzellairmovement.com/blog/industrial-fan-system-effects.