# Fans for Plating, Pickling and Paint-Booth Exhaust

## Specifying against acid corrosion, solvent ignition and deposit build-up on a surface-finishing line

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**Abstract.** The fans on a surface-finishing line rarely fail for want of airflow. They fail because the air is a saturated acid aerosol that condenses on bare metal, a solvent vapour that can ignite, or a stream of overspray and plating salt that builds unevenly on the wheel. A fan engineered for the duty point alone typically corrodes through, sparks or shakes itself apart within 6 to 18 months; one engineered for the air it actually moves runs 8 to 10 years and more. This paper sets out the three failure mechanisms, the material, spark-resistance and balancing choices that answer them, two worked calculations a project engineer can reuse, a field case, and a specification checklist that can be copied into an RFQ.

## 1. The air on a finishing line is not ordinary air

A plating, pickling or paint shop runs a family of fan duties rather than one. Lip and hood extraction pulls hydrochloric, sulphuric, chromic and nitric acid mist off the tanks. Booth exhaust moves solvent-laden air from liquid-paint, dip-coat and powder-coat booths. A booster fan pulls the combined acid stream through a wet scrubber, commonly against 150 to 600 mmWC of packed-bed resistance. Around them sit fume extraction on buffing and grinding stations, general dilution ventilation and bath-laboratory fume hoods.

None of these fans is hot. That is the trap. Hot-gas duties in cement or power announce their severity and get specified accordingly; a plating exhaust at 35 to 45 °C looks like a ventilation job and gets bought like one. The gas, however, leaves the tank close to 100 % saturated, so it sits at or below its acid dew point all the way to the scrubber. Every cold surface becomes a condensing surface, and the condensate is acid.

The cost of getting it wrong is not the fan. When a booth exhaust or scrubber booster stops, the line stops, and work in progress inside a booth or a plating sequence does not wait for a spare. On a conveyorised line that is lost output per hour of downtime, rework on part-coated components, and an emissions exceedance if the scrubber loses draught while the tanks are still fuming.

## 2. Three failure mechanisms

### 2.1 Acid corrosion

Saturated acid aerosol attacks wetted metal from the inside out. Mild steel is consumed; 304 stainless pits and perforates in chloride service; even a sound casing fails if the wheel is thinned unevenly, because material loss on one blade is imbalance long before it is a hole. The usual history is a wheel that corrodes out of balance within a single season of 6 to 12 months. Condensate pooling at the volute low point and at the shaft penetration accelerates it.

### 2.2 Flammable solvent vapour

Booth and dip-coat exhaust can carry solvent vapour within the flammable range, particularly in flash-off zones and curing-oven exhaust where air change is kept low to hold heat. A wheel rubbing its inlet cone, a static discharge from an unbonded assembly, or a tramp part drawn into the wheel is an ignition source inside a duct full of fuel and air. Powder-coat booths add a combustible dust atmosphere.

### 2.3 Paint and salt build-up

Overspray solids and crystallised plating salts deposit on the wheel and casing. The deposit is never uniform, so the rotor drifts out of balance, vibration climbs, and a bearing or a seal fails. On a belt-driven fan the symptom often appears first as noise at the bearings, which is easily misread as a lubrication problem.

## 3. Engineering the answer

### 3.1 Metallurgy matched to the bath chemistry

There is no single corrosion-resistant fan. The right material for chloride is the wrong one for chromic, so the wetted material has to be chosen from the bath chemistry, concentration, temperature and saturation of each stream. The principle is simple: no bare steel in the airstream, and a material whose weakness the stream cannot reach.

| Stream | Wetted construction | Watch-point |
|---|---|---|
| Hydrochloric pickling, mixed-acid and chloride-bearing exhaust | PP casing and wetted parts, with your choice of SS 316L or FRP-coated impeller; or FRP-lined carbon steel | We state the expected impeller life on your duty in the offer, and supply the standby. Thermoplastics lose stiffness as temperature rises: confirm the maximum gas temperature, including upset. |
| Sulphuric (anodising), chromic (hard chrome), nitric (passivation, bright dip) | SS 316L, or a higher alloy against your specification | Stainless suitability depends on concentration and temperature; decided per stream, never by default. |
| Solvent-laden paint and dip-coat booth exhaust | Coated carbon steel (IS 2062) with non-sparking wheel-to-inlet construction | Corrosion is mild; the governing requirement is ignition control (section 3.2). |
| Powder-coat booth and recovery | Coated carbon steel, bonded and earthed | Combustible dust; classify the zone and build to it. |

Whatever the material, three details decide service life: internals fully coated or lined with no bare steel exposed, a drain at the volute low point so condensate never pools, and a wash-down connection so the casing can be flushed in place. On a belt-driven arrangement the motor and bearings stay outside the airstream, and the shaft penetration carries a seal rated for the gas.

### 3.2 Spark-resistant construction for booth exhaust

Where the area classification is ATEX Zone 2 (gas) or Zone 22 (dust), the fan is built spark-resistant to the AMCA Type B/C rubbing-clearance approach: non-sparking materials where the wheel could contact the inlet, adequate running clearance, the whole assembly bonded and earthed against static, and a motor rated to the classified zone. Jitamitra self-declares this construction to 2014/34/EU, Category 3, for Zone 2/22. It is a self-declaration of conformity, not a third-party certificate, and it does not cover Zone 1 or Zone 21, which require Category 2 equipment. The zone is the plant owner's classification; the fan is built to it, not the other way round.

### 3.3 A rotor that tolerates deposit

A non-stick coated wheel and casing lets deposit shed rather than key on. Access and cleanout doors and an optional wash-down spray allow cleaning without dismantling. The rotor is dynamically balanced to ISO 21940 grade G 6.3 as standard, with G 2.5 on application, so it keeps running inside the vibration limits between wash cycles. In service, vibration is judged against ISO 14694: for a rigidly mounted fan in

category BV-3, 4.5 mm/s is acceptable, 7.1 mm/s is the alarm and 9.0 mm/s the shutdown level (6.3, 11.8 and 12.5 mm/s on flexible mounts).

### 3.4 Wheel choice

A backward-curved plate wheel is the workhorse for booth exhaust and scrubber boosters: best efficiency on clean, higher-pressure air. An aerofoil wheel suits general and local exhaust ventilation where the air is largely clean and noise matters. A radial wheel is the rugged choice where scrubber carry-over or wet solids are in the stream, because it sheds solids that would load a backward-curved blade. Considered and rejected for acid duty: forward-curved wheels, whose many shallow blades are hard to coat completely and harder to clean.

## 4. Two worked calculations

### 4.1 Booth exhaust: capture velocity, then a flammability check

Booth airflow is set by the capture velocity across the open face, and the flammability limit is then checked against it. Take a booth with a 3.0 m × 2.5 m open face, a design face velocity of 0.5 m/s, and a spray rate that evaporates 10 kg/h of xylene (molar mass about 106 kg/kmol, lower flammable limit about 1.0 % by volume).

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Booth airflow  Q = 3.0 × 2.5 × 0.5 = 3.75 m³/s = 13,500 m³/h
Vapour released  = (10 ÷ 106) kmol/h × 24.45 m³/kmol = 2.31 m³/h at 25 °C
Concentration  = 2.31 ÷ 13,500 = 0.017 % by volume = 1.7 % of LFL
Air needed to hold 25 % of LFL  = 2.31 ÷ 0.0025 = 924 m³/h
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In an open spray booth the capture-velocity airflow is roughly fifteen times the flammability requirement, so the booth fan is sized by capture, and the ATEX build is protection against local pockets, upsets and the duct, not against the bulk mixture. The picture reverses in a curing oven or an enclosed flash-off tunnel, where air change is minimised to save heat and the same solvent load can approach the limit. There the exhaust fan is a safety device, sized to the flammability calculation with margin, and interlocked with the burner.

### 4.2 Scrubber booster: specify the fouled pressure drop

A booster draws 40,000 m³/h of saturated acid fume through hoods and ducting (100 mmWC), a packed-bed scrubber (150 mmWC when clean) and a mist eliminator and stack (50 mmWC): 300 mmWC in total. Fan static efficiency is taken as 70 % for illustration.

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Q = 40,000 ÷ 3,600 = 11.11 m³/s   Δp = 300 mmWC × 9.807 = 2,942 Pa
Air power = 11.11 × 2,942 = 32.7 kW   Shaft power = 32.7 ÷ 0.70 = 46.7 kW
Packing fouls: scrubber 150 to 200 mmWC, system 300 to 350 mmWC
To hold flow, fan laws: n2/n1 = √(350 ÷ 300) = 1.080   P2/P1 = 1.080³ = 1.26
Fouled shaft power = 46.7 × 1.26 = 58.8 kW
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Sized on the clean pressure drop, a 55 kW motor looks comfortable and runs out of power the month the packing loads. Sized on the fouled figure, the motor is 75 kW and the fan runs on a variable-frequency drive that adds speed as the bed loads. Density works in the same direction: saturated gas at about 40 °C is near 1.10 kg/m³ against 1.20 kg/m³ for standard air, so a fan tested on standard air at the same volume flow develops about 9 % more pressure and absorbs about 9 % more power than it will on the line. Specify the duty at site gas conditions and state which condition the motor must cover, including a cold start on dry ambient air.

## 5. From the field: vibration and noise on a coating-line blower

A surface-coating systems provider in western India reported abnormal vibration and noise on a blower serving an engineering customer's line: 15,500 m³/h at 60 mmWC on a 10 HP motor, several years into

service. The site's diagnosis was imbalance and the order raised was for balancing.

Vibration together with noise pointed past imbalance to the rotating assembly. Process and aerodynamic causes were ruled out first, since the line was still making its air; the motor and drive were ruled out next. Our technician attended with two bearings to fit if required. Both halves of the job were needed: the bearings were replaced and the rotor was then balanced in situ, in that order, because a rotor re-bearinged after balancing is no longer the rotor that was balanced. Reported 29 December; offer issued the next working day; technician on site 4 January.

What the record does not show is as instructive. The file carries a balancing record and a site report, but no signed post-repair vibration figure and no customer acceptance rating, so we claim neither. Since this job every field-balancing visit records before-and-after readings against ISO 14694, with bearing designation, position and failure mode logged, so a fan population can be trended. The preventive lesson for a finishing line: the fan that has run faultlessly for years is the fan nobody measures, and a scheduled five-minute vibration reading would have shown this drift months earlier.

## 6. What to specify

The checklist below can be copied into a tender or RFQ as it stands.

- Duty at site conditions: volume flow ($m^3/h$), static pressure (mmWC), gas temperature (normal and upset), and whether the gas is saturated.
- Pressure drop across the scrubber stated clean and fouled; motor to cover the fouled case and a cold start on ambient air.
- Stream chemistry for every acid exhaust: acid, concentration, bath temperature. Wetted material chosen per stream and stated on the GA drawing.
- No bare steel in the airstream: internals coated or lined; volute drain at the low point; wash-down connection.
- Area classification from the plant owner (Zone 1, 2, 21 or 22). For Zone 2/22, spark-resistant AMCA Type B/C construction, bonded and earthed, motor rated to the zone, declaration of conformity supplied. Zone 1/21 requires Category 2 equipment.
- Drive arrangement that keeps motor and bearings out of the airstream, with a shaft seal rated for the gas.
- Anti-build provisions where overspray or salt is present: non-stick coating, access and cleanout doors, optional wash-down spray.
- Dynamic balance to ISO 21940 G 6.3 (G 2.5 where specified), with the balancing record supplied.
- Vibration acceptance to ISO 14694 at commissioning, with readings recorded and handed over.
- Performance tested to the IS 4894 / ISO 5801 / AMCA 210 method, with the test curve supplied against the duty point.
- Variable-frequency drive where the system resistance changes with fouling or the line runs at part load.
- For replacement fans: existing duty point, bearing centres, inlet and outlet orientation and foundation bolt pattern, so the unit drops onto the existing base and ducting.

## 7. Conclusion

On a finishing line, the fan is specified by the air it moves, not by the duty point alone. Match the wetted material to each acid, build the booth fan to the zone the plant has classified, design the rotor to tolerate deposit, and size the scrubber booster on its fouled resistance. For acid chemistry you cannot pin to a single material, or a booth or oven where the flammability margin is tight, send the stream data to Jitamitra's design team before the fan is bought.

## About Jitamitra Electro Engineering

Jitamitra designs and builds centrifugal fans and blowers in Ahilyanagar, Maharashtra, and has built more than 15,000 fans since 2011, including 405 fans for surface coating and plating across 34 customers. Each fan is engineered to its own duty across an envelope of up to 2,25,000 m³/h, 2,000 mmWC, 425 HP and 500 °C, performance-tested in-house on a 200 HP VFD test rig to the IS 4894 / ISO 5801 / AMCA 210 method (fans above the rig's 200 HP are run at derated speed and scaled to the specified duty by the fan laws), and balanced to ISO 21940 G 6.3. The company's third-party certification is ISO 9001:2015; CE and ATEX Zone 2/22 are self-declared. *Engineered for Every Application.*

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**Meet the design team** at the CII Surface Coating Show 2026, Hall B, Stall C08, Auto Cluster Exhibition Centre, Chinchwad, Pune, 19 to 21 November 2026. This paper online: jitamitrablowers.com/insights/plating-pickling-paint-booth-fans/

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