

FREE TECHNICAL GUIDE

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# HF, HCl and nitric acid fume: a scrubber design guide

How each acid behaves in a scrubber, choosing liquor and materials, handling NOx and acid mist, keeping incompatible streams apart, and the data your permit will ask for.

For process and plant engineers

EHS and permitting leads

UK and Europe



**Wet scrubbers for acid and chemical fume**

Designed, fabricated and commissioned in the UK

[caldera-technologies.com](https://caldera-technologies.com)

# Start from what is in the extract

Acid fume scrubbers fail for predictable reasons. The scrubber was sized for one acid and the line runs another. The liquor removes the gas but not the mist. Two streams that should never meet end up in one sump. Or the permit asks for figures nobody calculated. This guide walks through each of those, in the order an engineer meets them.

## Who it is for

Process and plant engineers specifying extract for pickling, etching, plating, wet bench and process lines, and the EHS leads who sign off the permit.

## How to use it

Read it before you write a specification or ask for quotes. The checklist on the back page lists the data a supplier needs to size a scrubber properly.

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## Five things to get right

1. **Name every acid**, with its concentration and temperature, not just "acid fume".
2. **Separate gas from mist**. A packed bed absorbs gases; fine mist needs its own collection stage.
3. **Treat NO as its own problem**. Caustic alone will not remove it.
4. **Map the streams** before they share a duct, a sump or a liquor.
5. **Ask for predicted outlet figures** per acid, in writing, before you buy.

# Five acids, five different problems

Some acids arrive as a soluble gas that a packed bed absorbs easily. Others arrive as a fine mist that passes straight through it. Knowing which you have decides the whole train.

## HCl

Soluble gas

**Behaviour:** highly soluble in water and absorbs readily. In damp air it forms a visible white fume, so a dirty discharge is easy to see.

**Design response:** packed tower with water or dilute caustic. Polypropylene suits most duties.

## HF

Soluble gas

**Behaviour:** absorbs well, but attacks glass, silica and silicate-based materials. Fluoride in the liquor can also react with calcium in hard make-up water and scale the packing.

**Design response:** caustic packed tower in polypropylene or PVDF, with nothing glass or ceramic in the wetted path. Consider softened make-up water.

## Nitric

Gas, mist and NOx

**Behaviour:** pickling and etching with nitric acid release acid mist plus nitrogen oxides. NO<sub>2</sub> is the brown plume; NO is colourless and barely soluble.

**Design response:** caustic removes the acid and NO<sub>2</sub>. Where the permit limits NOx, add an oxidising stage (section 03).

## Sulphuric

Fine mist

**Behaviour:** very little vapour; the load is fine mist thrown off heated and electrolytic baths. Much of it is too small to be caught by a packed bed alone.

**Design response:** a high-efficiency mist eliminator, sized for the droplet size, with a packed bed where gases are also present.

## Chromic

Fine mist, Cr(VI)

**Behaviour:** chrome plating releases chromic acid mist containing hexavalent chromium, a carcinogen, so capture efficiency matters for people as well as the permit.

**Design response:** mist elimination, with the collected liquor kept separate so it can be returned to the process or treated.

**Mixed acids?** Size for the most demanding acid, choose materials for the most aggressive one, and check section 04 before any streams are combined.

# The liquor does the chemistry. The materials have to survive it.

## Scrubbing liquor

| LIQUOR                  | REMOVES                                                      | WATCH FOR                                                                                     |
|-------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| <b>Water</b>            | Highly soluble gases such as HCl at modest loads             | Liquor turns acidic and loses capacity; needs a steady bleed and make-up                      |
| <b>Caustic (NaOH)</b>   | HCl, HF, NO <sub>2</sub> , acid vapour and soluble acid mist | Dosed to a pH setpoint; salt build-up sets the bleed rate; does not remove NO or solvent VOCs |
| <b>Oxidising agents</b> | NO, by converting it to NO <sub>2</sub>                      | Usually hydrogen peroxide, persulfate                                                         |

## Materials

### Polypropylene (PP)

The workhorse for most acid duties, including HF, at moderate temperatures.

### PVDF

Higher temperature and more aggressive or oxidising duties where PP runs out of margin.

### GRP / FRP

Large vessels and stacks; the resin and corrosion liner must be matched to the acid.

### PVC / CPVC

Ductwork and smaller units on cooler duties.

### 316L stainless

Structure and dry parts; not for wetted service with chlorides or HF.

### Rubber-lined steel

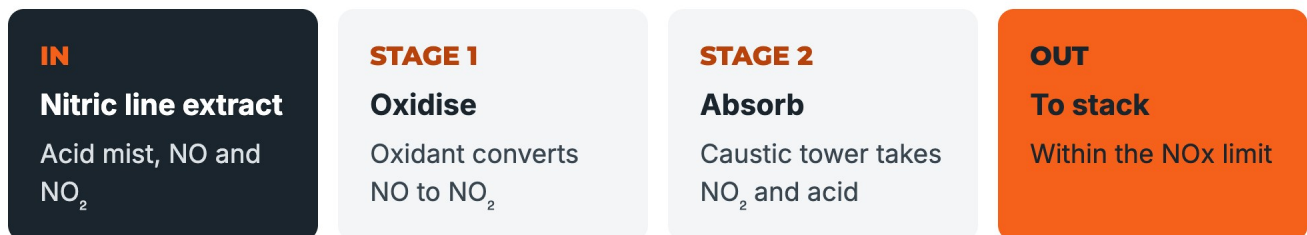
Large or high-strength vessels where plastic alone is not practical.

**Temperature sets the limit.** Every thermoplastic has a temperature ceiling. On hot extract, a quench comes first so the packed tower, packing and fan stay inside their rating.

# The two loads a single packed bed will miss

## NOx from nitric acid

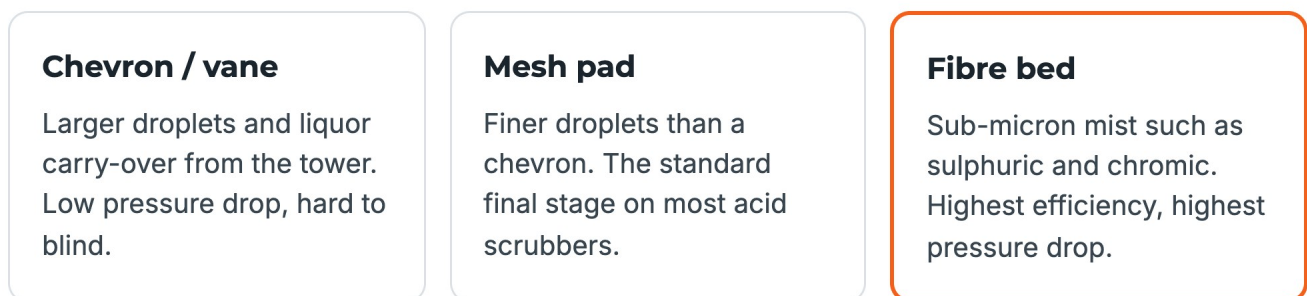
NO<sub>2</sub> dissolves in caustic. NO hardly dissolves at all, so a caustic tower can clear the brown plume and still miss most of the NOx. The fix is to oxidise NO to NO<sub>2</sub> first, then absorb it. EU best available technique for nitric acid pickling names wet scrubbing with an oxidising agent such as hydrogen peroxide as one option.



Stage order, reagent and control are set per duty. If your permit has no NOx limit, a single caustic stage may be enough; say so in the enquiry.

## Acid mist

Mist is liquid, not gas, so it is collected by impaction and filtration rather than absorbed. Smaller droplets need finer media and accept a higher pressure drop. Match the eliminator to the droplet size, not to the scrubber catalogue.



### What the published data says

The US EPA fact sheet on fibre-bed mist eliminators reports removal of 70 to over 99 percent depending on droplet size and design, and notes plastic fibre beds are limited to below 60°C. A quench or cooling step ahead of the bed protects it and grows the droplets.

## A shared sump can make a new hazard

Combining extract saves a scrubber, but only when the chemistry allows it. Ducts, sumps and recirculated liquor are where incompatible streams meet. Map every source before any of them share a scrubber.

| IF THESE MEET                              | YOU CAN GET                                                          | SO                                                          |
|--------------------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------|
| <b>Acid fume + cyanide plating extract</b> | Hydrogen cyanide gas                                                 | Always separate extract and scrubbers                       |
| <b>Acid + hypochlorite</b>                 | Chlorine gas                                                         | Separate vents and liquors                                  |
| <b>Acid + sulphide-bearing streams</b>     | Hydrogen sulphide                                                    | Separate, or treat as an odour duty in its own right        |
| <b>Nitric or other acid fume + ammonia</b> | Ammonium salt deposits in ducts and fans, including ammonium nitrate | Separate extract; scrub ammonia in an acid stage of its own |
| <b>Perchloric acid + anything shared</b>   | Perchlorate deposits that can be shock-sensitive                     | Dedicated extract with wash-down, never manifolded          |

### Before you combine streams

#### List every source

Each tank, bench and vent, with what is in it and when it runs. Occasional processes count.

#### Check pairs, not lists

Test each combination against the table above and your safety data sheets.

#### Think about upsets

Spills, maintenance and cleaning chemicals can put the wrong thing in a duct.

#### Record the decision

Write down which streams share a scrubber and why, for the risk assessment and the next change.

# Numbers, in writing, before you buy

Regulators judge a scrubber on what leaves the stack. Make sure the supplier's figures line up with the limits your site answers to, whether that is a UK environmental permit, a local authority permit or an EU permit under the Industrial Emissions Directive.

## Example: EU BAT conclusions for pickling

The BAT conclusions for ferrous metals processing name wet scrubbing followed by a demister for acid fume from pickling, with these associated emission levels:

HCl

**<2 to 10**

mg/Nm<sup>3</sup>

HF

**<1**

mg/Nm<sup>3</sup>

NOx (nitric pickling)

**10 to 200**

mg/Nm<sup>3</sup>

Source: Commission Implementing Decision (EU) 2022/2110. Other sectors have their own BAT conclusions; your permit conditions take precedence.

### Ask for this on the datasheet

- Design flow and temperature
- Inlet concentration for each acid
- Predicted outlet concentration for each acid
- Liquor flow, reagent use and bleed rate
- Pressure drop and fan duty
- Materials of every wetted part

### Keep it working, and prove it

- Liquor pH held at setpoint
- Recirculation flow and sump level
- Pressure drop across bed and eliminator
- Periodic stack emission testing
- Signed commissioning record on file
- In the UK, LEV thoroughly examined at least every 14 months under COSHH

**A warning sign:** a quote that gives a removal percentage but no outlet figure for each acid. Percentages depend on the inlet; your permit is written in mg/Nm<sup>3</sup>.

## The checklist for a quote you can trust

Send what you have; an engineer can fill gaps on a call or a site visit. The more of this list you can answer, the tighter the sizing and the fewer surprises at commissioning.

☐ **Acids and processes:** each acid, concentration and bath temperature

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☐ **Extract flow** in m<sup>3</sup>/h, and the extract temperature

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☐ **Emission limits** or the permit conditions you must meet

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☐ **Any gas analysis** or stack test results you already hold

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☐ **Every extract source** that might share the scrubber

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☐ **Site space**, indoor or outdoor, and access

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☐ **Utilities:** power, water quality and effluent route

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☐ **Drawings:** P&ID, layout or photos of the line

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### TALK TO AN ENGINEER

## Tell us which acids are in your extract

Send the acids, the flow and the limit you have to meet. A process engineer will reply within 4 working hours and tell you what will work, and what will not, before anyone talks about price.

[caldera-technologies.com/acid-fume-scrubbers](https://caldera-technologies.com/acid-fume-scrubbers)

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