Steam And Condensate Tolerant HEPA filter

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Introduction

A 25+ year old active (C5) vessel ventilation system has suffered a failure of one of its major clean-up components: i.e. one ESP (Electrostatic Precipitator).

Abatement system is complex:

2 off - Primary Off Gas (POG) Systems
- Dust Scrubber Recycle Vessel
- Condenser
- NOx Absorber

1 off - Secondary Off Gas (SOG) System
- ESP (2 x 100%) - G0001 Failed, G0002 Operational - Particulate Removal
- Wet Scrubber (1 x 100%)
- Primary HEPA (2 x 100%) - Particulate Removal
- Secondary HEPA (2 x 100%) - Particulate Removal
- Fans (2 x 100%)
- Stack
Figure 1
Schematic of WVP L1 & L2 Gaseous Abatement Plant

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Perspective View of ESP’s

Failed ESP G0001

10mtrs

1.8m dia

Scaled perspective
ESP Substitute SACT
Metal Filter
500 w x 950 D x 1650 H

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ESP – Key Components

- Support-point (Suspension Tube)
- Insulators
- Bulge
- Oil Seal
- Suspension Tube
- ESP (G001)
- Electrode
- Distributor
- OFF-GAS FLOW OUT (200 dia.)
- OFF-GAS FLOW IN (200 dia.)

10mtrs
1.8m dia

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SOG System DF’s

**Current Plant DF claims**

- **Actual DFs**
  - **ESP Working**: $DF \times 10^3$
  - **WET Scrubber**: $DF \times 10$
  - **1st Stage HEPA**: $DF \times 10^4$
  - **2nd Stage HEPA**: $DF \times 10^4$

- **Total DF**
  - Actual: $10^{13}$
  - Safety: $10^6$

*Note: Pessimistic value of DF10 given for Wet Scrubber.*
Decontamination Factor

Failed ESP - reduces DF from $10^4$ to 10
Can still claim DF 10

• Large diameter vessel = good residence time.

• Significant heat sink that allows the removal of moisture and other non-volatile species by condensation.

• DF of 10 is pessimistically assumed for the passive removal mechanisms of the ESP.
Decontamination Factor

- Failed ESP = Shortfall in DF of $10^3$

- Optioneering studies = Engineered Solution = Tertiary Stage HEPA filter having DF of $>10^3$ for non-volatile releases.

- Initially a conventional Glass Fibre HEPA was considered.

- With respect to volatile releases overall system DF is unchanged.
NEW Filter

- Existing Remote Change Glass Fibre HEPA’s subject to common mode failure e.g. Steam release due to failure of upstream Heater + other moisture injection sources.

- New Filter to maintain its integrity in event of above fault condition. (Now diverse i.e. Metal & Paper)

- Filter is therefore required to be **Steam And Condensate Tolerant** hence the term:

  ‘SACT’ HEPA Filter.

- SACT filter housing / casing 304L and filter media 316L stainless steel sintered metal fibre = 100% metal filter.
Figure 6
Location of Tertiary STAGE HEPA SACT (METAL) HEPA Filter
Typical Candle Filter Element
36m³/h DF 10² SACT Filter Insert

Normally used as a RECLEANABLE unit e.g. Pulse Jet Cleaning
DF100 @ 0.3micron (single media layer filter).
Pressure = 4mbar @ design flow  Media = sintered metal fibre
Gasket = sintered metal fibre  Flow = 36m³/h
Fusion = welded construction  Weight = ~ 0.93 kg

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Square SACT HEPA Filter for remote Change Location.

DF100  < 60kg

DF1000  > 60kg to heavy for remote change application.

1 complete 900m³/h filter unit (600 x 600 x 380 deep) contains 25 inserts.
Decontamination Factor

Existing 200 dia Vessel Vent Pipe.

Section of existing 200 dia pipe to be removed and by-pass installed.

New SACT HEPA Filter housing with 3 ‘plug-in’ metal filters.

Dimensions:
500 W x 950 deep x 1650 H
Weight approx < 400kg

Location of New SACT HEPA Filter Unit.

C3 FAN ROOM
Decontamination Factors

Current Plant DF claims

Plant DF Claims with ESP Failed and 3rd Stage SACT Filter Installed.

Figure 3
Comparison of Actual /Safety DF’s Tertiary Stage DF1000 Filter

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Collection Efficiency of Dust Particles.
Comparison of ESP, Glassfibre HEPA & Metal Filter (2F3 & F3 media)

Collection Efficiency %

0.010 0.100 0.30 1.000 10.000
Particle Size - Microns

ESP
Glassfibre HEPA
Porvair Sinterflo 2F3 media
Porvair Sinterflo F3 media

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Filter Testing

Glass fibre HEPA filters – Current requirements - filters are subjected to sodium flame test and come with a Factory test certificate complete with traceability.

SACT metal filter to be tested to prove:
- Volumetric flow / pressure test.
- Efficiency test (DOP (ONDINA) not Sodium Flame).
- Dust Holding Capacity test (1.8g/min loading, size range 0.05 to 50 micron, Test dust - special mix of ISO 12103 A2 dust and Silica fumes. Original test dust Acetylene Black 50% compressed - no longer available).
- Saturation test (3barg steam (144°C) release 56kg/h).
- Structural Test (150mbar).
- Heat Soak Test (Oven test 500°C) followed by DOP test.
- Filter media - Elevated velocity test.
Differences

Design of the metal Filter insert & Housing brings together two proven technologies.

a) Metal ‘Candle type’ filter technology
b) Glass fibre filter housing technology.

3 Radial metal filters mounted in a traditional ‘EP2’ style filter housing.

New filter dimensions = standard glass fibre 280L/s plug-in filter.

Above imposes additional challenges.
Challenges

Geometric dimensions specific to enable manoeuvrability into final location.

Weight of filter inserts 20kg (~ 4 x heavier than glass fibre equivalent).

Housing pressure capability – much higher than conventional as Metal filter can withstand full fan head pressure 150mbar.

Filter seal subjected to much higher pressure than conventional glass fibre units.

Filter insert PD clean 5mbar compared with 2.5mbar conventional glass fibre HEPA filter.
Section Through SACT Circular Filter Housing

Vacuum Relief to enable filter safe change

3 off SACT Metal HEPA Circular Filters (~ 20kg)

Inlet Spigot complete with bagging ring.

Door

Dirty Filter Drawn out into filter safe-change bag which is heat sealed.

Heat sealed.
View Inside Circular HEPA Filter Housing
Conventional glass fibre filter
296m$^3$/h DF 10$^3$ SACT Filter Insert
Summary

Installing the metal filter is a bespoke solution to a specific problem on a specific system.

Pros - Benefits over glass fibre filter:
• Can handle more onerous gas stream challenge. Will not fail when saturated.
• Higher DF claim when run in series with glass fibre filter rather than two glass fibre filters (diversity in material).
• Can withstand much higher system pressures.
• All metal, Temperature resistant.
• Can be re-cleanable (pulse jet application).

Cons
• Cost typical glass fibre unit £400, Metal filter £15K.
• Weight can be 4 times the weight of glass fibre filter.
• Possible higher disposal costs.
• Higher pressure drop than glass fibre filter.