NPP Containment Vent Protection
Why There Is No One-size-fits-all Solution

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Purpose of the Paper

This presentation is a simplified overview of more complex problems, some of which my colleagues will review in more detail later

Its purpose is to -

- provoke debate
- Illustrate the complexity of the application(s)
- Illustrate importance of proper understanding of the filtration aspects of the application(s)
- review key factors influencing filter type selection
- to invite bigger, and better informed, organisation to answer our concerns

Later papers will show some of these slides again in order to reinforce the point

Why is an accurate evaluation of the process conditions important?

- Porvair is concerned solely with the issues around the design and offering of dry filtration solutions to the Containment Venting problem

- To design a dry filter solution properly, the problem it is trying to solve must be Understood properly

- If the problem cannot be defined, the filter cannot be defined

- From the enquiries we have seen at Porvair, it would appear that the general implications of a LOCA include high gas production rates possibly needing to be vented to reduce pressure inside the containment, a large quantity of apparently very fine solids, which, once deposited on the filter, can generate “decay heat”, together with the possible presence of liquid water (condensate), Iodine and Hydrogen.

Establishing an accurate set of process conditions

Porvair makes no claim to be Nuclear science experts, but we are an expert filtration company engineering very specialised filtration equipment across the nuclear sector, in fuel production, power generation, waste treatment and storage and decommissioning, we would like to share our observations and concerns, based on what we have seen from the applications we have been asked to revue in the field

In short we see

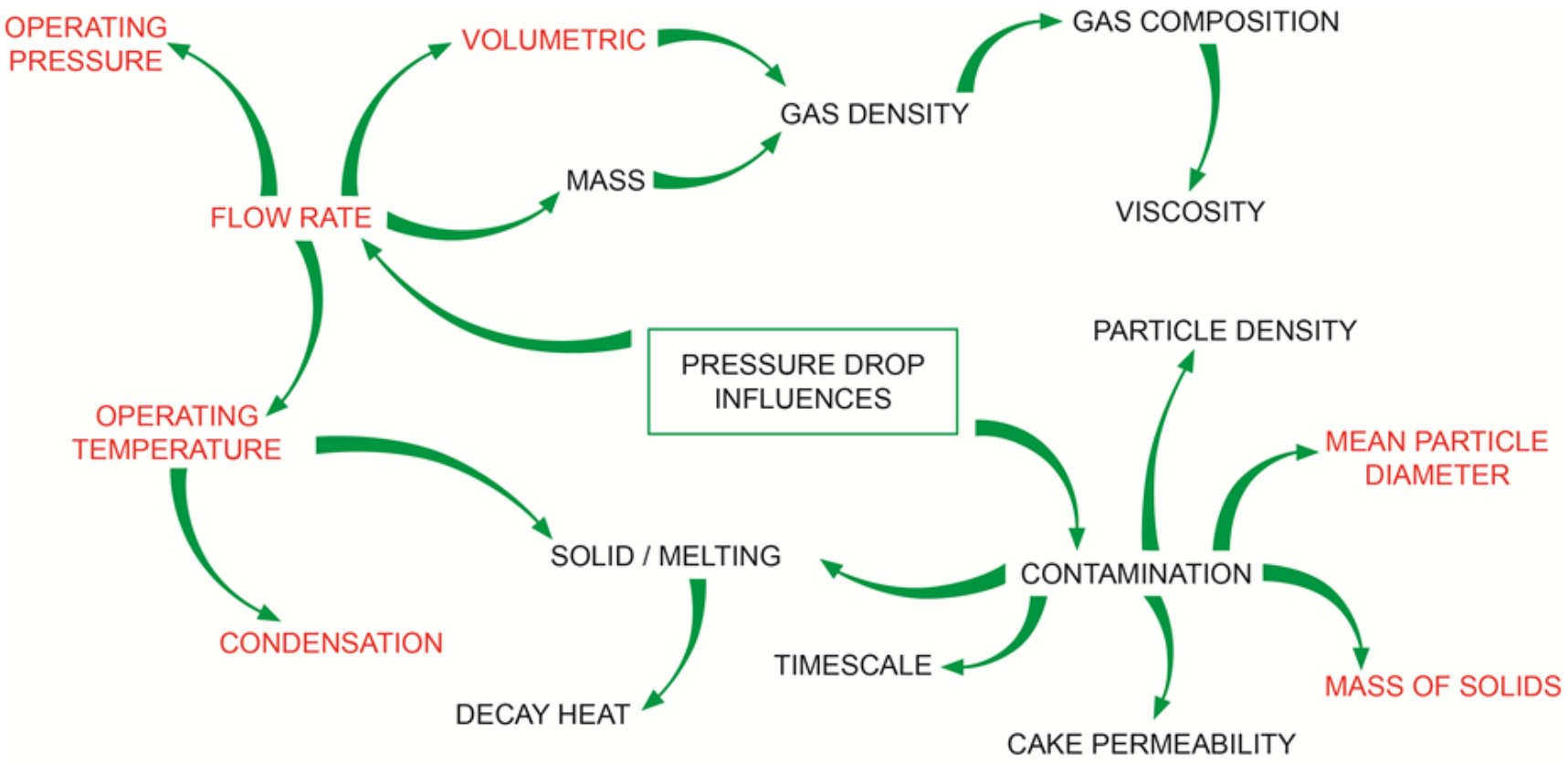
- An arduous set of process conditions
- A range of different operating philosophies
- Often conflicting process conditions for seemingly “similar” sites

Establishing an accurate source term

The Problem In Brief

An incomplete list of relevant parameters needing definition to enable filter design

- Gas composition ?
- Flow ?
- Pressure ?
- Temperature ?
- Solids load ?
- Solids type ?
- Particle size ?
- Moisture content ?
- Decay heat ?
- Allowable DP ?
- Down stream pipework ?
- Closed vessel, open system ?
- Pressure resistance
- Caesium hydroxide melting ?
- Temperature capability of the filter medium/system ?
- Iodine absorption ?
- Hydrogen recombination ?



The effect of condensate

- Liquid aerosol must be removed before solids can be dealt with
- Liquid aerosol can effectively blind the filter medium
- Liquid aerosol/coalesced water can cause the carryover of larger solids in a HEPA filter
- Generally requires a separate removal system

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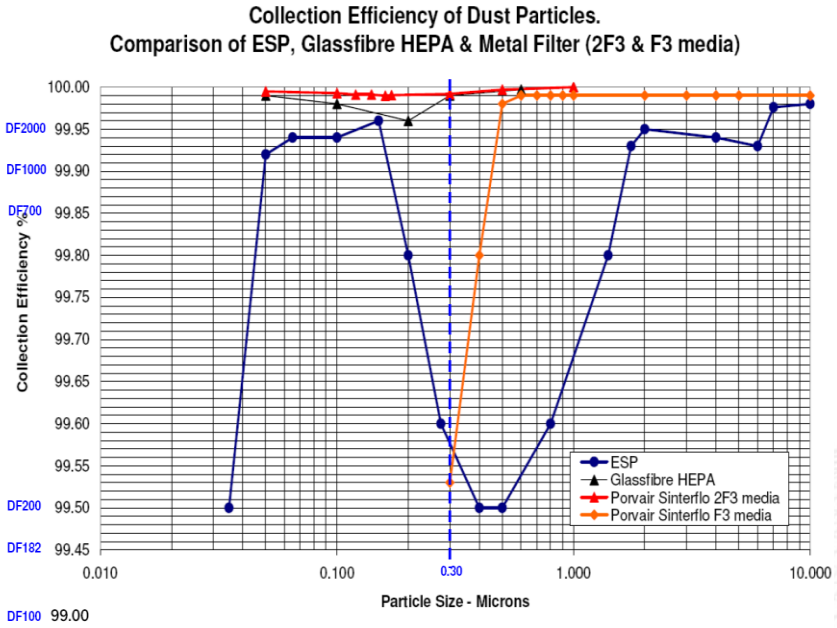
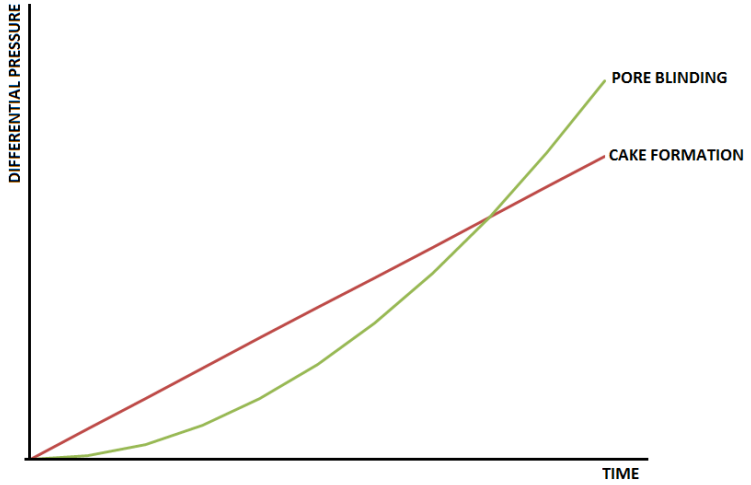
The effect of particle size

- 0.2 microns MPPS appears to have been assumed as the mean particle size
- Using a normal sized filter element using standard test dust data and a mean particle size of 5 microns gives a DP of 130 mbar and a cake thickness of 0.5 mm, retaining 470 grams per element
- Using the same conditions as the above but changing the mean particle size to 0.2 microns reaches 130 mbar DP with a cake thickness of 0.8 microns (if cake evolution is the capture mechanism) the same filter retains just 0.7 grams per element
- It should also be noted that the most likely collection mechanisms differ between the two particle sizes. At 0.2 microns, the most likely mechanism would be depth capture within the medium, leading to pore blinding, whilst at 5 micron there is a higher probability of cake formation

The effect of particle size





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The effect of decay heat

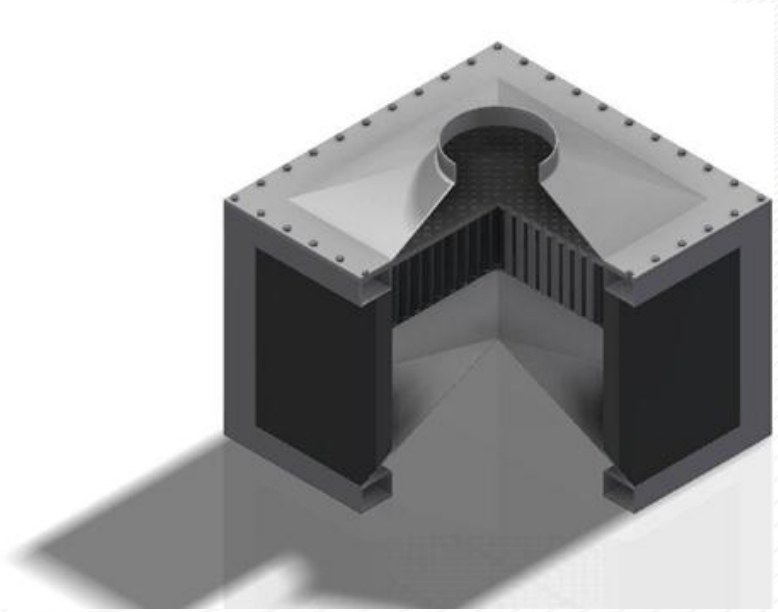
- Total burdens experienced to date in the several applications we have been asked to look at have ranged from 2 kW to hundreds of kW

- At whatever the kW loading, if the system is to be designed for zero intervention for some period (72 hours is often noted), then the system would be subject to a number of accumulating joules, which effectively means continuous temperature rise if the energy is not shed in some other way.

- Continuous temperature rise can not only compromise the structural strength of components, but also give rise to melting/re-melting of solids (for instance CsOH) on the filter medium, leading to a liquid blinding of the medium

A Porvair proposed solution

- In-containment solution. Out-of-containment requires pressure resistant housing if 8 bars (120 psi) operation is to be contemplated
- Smaller diameter tubes in multiples provides complete flexibility to accommodate flow and solids loading, whilst maximising metal content to accommodate decay heat
- Coalescing stage for liquid aerosol removal can be installed easily
- Flat plate presence minimised
- Smaller diameter tubes maximises resistance to collapse
- Flexible design allows key parameters to be fine tuned



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Why Is Core Collapse Important ?

The importance of core collapse in containment venting applications is similar to its importance in AGR SRV protection (where this work originates). As ably indicted by the image on the right
a collapsed core can seriously compromise the ability of a filter element to pass flow.

That makes core collapse a primary concern, not a secondary or tertiary issue

Smaller filter elements provide better resistance to collapse, but still collapse. A collapsed core can effectively prevent all flow through the filter, preventing venting.

Containment Venting Filtration - General conclusions

- Porvair Filtration Group, through its applications work in this field finds itself unconvinced as to the applicability of current models of LOCA source terms and the adaptability of existing offerings to meet, what to the company appears to be, a widely varying series of applications.

- Bear in mind that this paper and presentation is quite deliberately intended to be provocative and, we hope, to generate debate

- Porvair considers that if the problem is not understood a solution cannot be designed

- Porvair Filtration Group would be quite happy to be proven wrong in this. We would much rather be proven wrong, than be proven right if something very bad happens.

The Consequences Of Failure are unthinkable to society at large and to our industry in particular