From:	Raymond Caparas
To:	Glass, Ruth
Cc:	Christenson, Patrick L
Subject:	RE: Emission Certification Cummins Engine
Date:	Monday, December 22, 2025 12:01:46 PM
Attachments:	image001.png image002.png JM Letter for Intel Corporation - Hillsboro, JM DPF Performance 11-14-2025.pdf DPF reduction of heavy metals.pdf

Ruth,

Attached is the letter for some chemical species for the Johnson Mattey T4 aftertreatment option. Also on heavy metals, some data has been verified, and some has not. In general, they can state that these metals are typically trapped in both the DOC and the DPF element sections of a JM DPF. Overall, the reduction of many forms and types is very good, but some (especially in a gaseous form) are moderate. Please see the 2nd attachment for some additional info about how their ceramic filter (which is not a SiC type) element (inside JM DPF) can reduce heavy metals (check out the Summary Table towards the end of this attachment).

Let me know if you have any questions. Happy holidays!

Thank you,

Ray Caparas
Territory Manager, Power Generation
Cummins Sales and Services
Mobile (425)977-5327
Raymond.Caparas@cummins.com

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From: Glass, Ruth <ruth.glass@intel.com>
Sent: Monday, December 22, 2025 8:11 AM
To: Raymond Caparas <raymond.caparas@cummins.com>
Cc: Christenson, Patrick L <patrick.l.christenson@intel.com>
Subject: RE: Emission Certification Cummins Engine

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verify the sender and know the content is safe.

Just checking on the status…

From: Glass, Ruth
Sent: Thursday, December 11, 2025 10:09 PM
To: 'Raymond Caparas' <raymond.caparas@cummins.com>
Cc: Christenson, Patrick L <patrick.l.christenson@intel.com>
Subject: RE: Emission Certification Cummins Engine

Hi Ray

Can I get the control efficiencies for the following metals:

Antimony and Compounds
Arsenic and Compounds
Barium and Compounds
Beryllium and compounds
Cadmium and Compounds
Chromium VI
Copper and Compounds
Cobalt and compounds
Lead and Compounds
Manganese and Compounds
Mercury and Compounds
Nickel and Compounds
Phosphorus and compounds
Selenium and Compounds
Silver and compounds
Thallium and compounds
Zinc and compounds

Thanks.

Ruth

From: Raymond Caparas <raymond.caparas@cummins.com>
Sent: Thursday, August 28, 2025 8:04 AM
To: Glass, Ruth <ruth.glass@intel.com>
Cc: Christenson, Patrick L <patrick.l.christenson@intel.com>
Subject: RE: Emission Certification Cummins Engine

Ruth,

Attached is the letter from Johnson Matthey. Also, the second letter is a White Paper by EPA, which provides the information about PM control efficiency.

Please let me know if you need anything else.

Thank you,

Ray Caparas
Territory Manager, Power Generation
Cummins Sales and Services
Mobile (425)977-5327
Raymond.Caparas@cummins.com

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From: Glass, Ruth <ruth.glass@intel.com>
Sent: Wednesday, August 20, 2025 2:59 PM
To: Raymond Caparas <raymond.caparas@cummins.com>
Cc: Christenson, Patrick L <patrick.l.christenson@intel.com>
Subject: RE: Emission Certification Cummins Engine

EXTERNAL SENDER: This email originated outside of Cummins. Do not click links or open attachments unless you verify the sender and know the content is safe.

Hi Ray

We are looking for something similar to the attached for the Johnson Mathey units we have currently at Ronler Acres.

Please let me know if you need more information or want to discuss further.

Ruth

From: Christenson, Patrick L <patrick.l.christenson@intel.com>
Sent: Wednesday, August 20, 2025 10:39 AM

To: Raymond Caparas <raymond.caparas@cummins.com>
Cc: Glass, Ruth <ruth.glass@intel.com>
Subject: Emission Certification Cummins Engine

Ray wanted to follow up on the request for poly aromatic values. You mentioned sending in an engineering request for this info. I added Ruth from our EHS team and she can also call out more specifically what is needed.

Sounds like the DPF we have will affect these but may need to see if Cummins has a method to get it from Johnson Mathey who makes ours. We have tried contacting them but since we have not relationship with them we don't get a response.

Thx Pat

Johnson Matthey – Clean Air Solutions
1397 King Rd., West Chester, PA 19380

Johnson Matthey
Inspiring science, enhancing life

To Whom It May Concern November 14, 2025

Re: Summary of Performance using Johnson Matthey's (JM) CARB Verified Diesel Particulate Filter

Johnson Matthey is a leading worldwide manufacturer and research company involved in all types of catalyst applications. We pioneered Diesel Particulate Filters (DPFs) over thirty years ago, receiving both patents and the first approval by CARB for PM reduction. Today millions of Johnson Matthey DPFs are used worldwide on diesel cars, automobiles, trucks, and buses, and several thousand installed on stationary diesel engine/generators of all sizes and types. NOTE: The performance shown below is only for our CARB Verified DPF. We also have a non-CARB Verified DPF that can achieve higher reduction values (especially regarding CO, HAPS, and HC), and if you would like more information on this version, please let me know.

JM DPF (Diesel Particulate Filter):

A JM DPF is an absolute filter which has been tested and reported by the EPA as being highly efficient at removing PM (See Appendix A – EPA 2015 White Paper). Because it is an absolute filter, PM is removed/reduced regardless of engine load, exhaust gas conditions, and whether unit is regenerating or not. A DPF creates more engine backpressure than some other emission devices (ex. Diesel Oxidation Catalyst), and thus each JM DPF is supplied with a Datalogger/Monitor called the JM SootAlert, which monitors and alarms to alert operations of any issue.

Our CARB-Verified DPF

PM Reduction: Minimum 93% and typically exceeds 95%. The Soluble Organic Fraction (SOF) of PM is reduced, but the primary reduction is in removal of carbon soot.

CO; greater than 80%. If required, the JM DPF can be formulated* to be greater than 95% CO reduction when engine exhaust temperature goes above 650F.

HC/HAPS: greater than 70% of many HCs and for many HAPS (including formaldehyde). Breakdown of some specific and more resistant HAPS shown in Table #1 attachment. If required, our DPF can be formulated to further improve overall HAPS reduction by 10%-20%.

Johnson Matthey – Clean Air Solutions
1397 King Rd., West Chester, PA 19380

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Table 1

(Some variations of the values in this table are possible, and actual reduction values at a particular engine load are dependent on exhaust gas temperature at that load. In addition, there is some inherent +/- associated with testing and test methods, as well as actual testing variation in the field. Since our standard CARB-Verified product is represented in this table, there might be some benefit in pursuing more custom DPF recommendations by Johnson Matthey . . . if desired or required)

Pollutant	**Expected Reduction Efficiency at hottest engine exhaust temp.**
Filterable PM	93
VOC	85
CO	90
Benzene	65
Butadiene	70
Formaldehyde	65
Naphthalene	65
PAHs (excluding Naphthalene)	63
Benzo[a]pyrene	65
Acetaldehyde	63
Acrolein	70
Ethyl benzene	67
Hexane	60
Toluene	73
Xylene	66
Acenaphthene	66
Acenaphthylene	63
Anthracene	65
Benz[a)anthracene	63
Benzo[b)fluoranthene	63
Benzo[e]pyrene	65
Benzo[g,h,i)perylene	63
Benzo[k)fluoranthene	63
Chrysene	65
Dibenz[a,h)anthracene	65
Fluoranthene	68

Table 1 - continued

Fluorene	68
Indeno[1,2,3-cd]pyrene	70
2-Methyl naphthalene	65
Perylene	63
Phenanthrene	63
Pyrene	63

Thank you for taking the time to review this information on the significant reductions of particulate matter (PM) and hazardous air pollutants (HAPS) achieved using the Diesel Particulate Filters by Johnson Matthey. Please don't hesitate to reach out with any questions or to continue the conversation.

Sincerely,

Robert Bono

Robert Bono
Western Sales Manager
Johnson Matthey – Clean Air Solutions
TEL: 949-307-1265 mobile, E-mail: bonorp@matthey.com

Filtering efficiency of a **ceramic honeycomb diesel particulate filter (DPF)** varies by **metal species mainly because different metals partition differently between solid particles, semi-volatile compounds, and gas-phase species** in diesel exhaust. Since a DPF is a **physical PM filter**, it removes metals **in proportion to how strongly they associate with particles**.

Below is a practical, species-by-species breakdown.

1. Metals strongly bound to solid particles

High removal efficiency (≈90–99%+)

These metals are largely present as **oxides, sulfates, or wear debris embedded in soot or ash**, so they are trapped very efficiently.

Examples

- **Iron (Fe)** – engine wear, brake wear
- **Chromium (Cr)** – engine materials
- **Nickel (Ni)** – fuel/oil impurities
- **Copper (Cu)** – bearings, brake wear
- **Manganese (Mn)** – fuel additives (e.g., MMT)
- **Barium (Ba), Calcium (Ca), Magnesium (Mg)** – lubricant additives

Why high efficiency?

- Exist primarily in **coarse and fine PM**
- Low volatility
- Incorporated into the soot cake and ash layer

👉 Their reduction closely tracks total PM reduction.

2. Metals associated with ash and lubricant additives

Very high capture, but permanent accumulation

Examples

- **Zinc (Zn)** – anti-wear oil additive (ZDDP)
- **Phosphorus (P)** – oil additives
- **Calcium (Ca), Magnesium (Mg)**

Efficiency

- **>95% capture**, but these metals **do not burn off during regeneration**
- Accumulate as ash and eventually limit filter lifetime

👉 These metals are effectively removed from exhaust but remain in the DPF.

3. Semi-volatile metals

Moderate to high efficiency (≈50–90%, condition-dependent)

These metals may partially vaporize at exhaust temperatures and then **re-condense downstream**, sometimes after the filter.

Examples

- **Lead (Pb)** – legacy fuel contamination
- **Cadmium (Cd)**
- **Zinc (Zn)** (partly volatile at high temperatures)

Why efficiency varies

- Temperature-dependent phase changes
- During regeneration, some metals may:
    - Vaporize
    - Re-nucleate as ultrafine particles
    - Bypass the filter as metal vapor

👉 Capture efficiency improves at **lower exhaust temperatures** and with a well-developed soot cake.

4. Metals with significant gas-phase fraction

Low efficiency (<30–50%)

These metals or metal compounds can exist partly as **true vapors or extremely small clusters** that are not easily intercepted.

Examples

- **Mercury (Hg)** (rare in diesel, but illustrative)
- Some **organometallic compounds**

Why poor capture

- Gas-phase species pass through porous ceramic walls

- No chemical adsorption mechanism in standard DPFs

👉 These metals require **sorbents or catalysts**, not plain ceramic filtration.

5. Effect of operating conditions

Filtering efficiency for *all* metals is influenced by:

🔥 Regeneration events

- High temperatures can:
    - Volatilize semi-volatile metals
    - Redistribute metals deeper into the filter
    - Cause downstream re-emission as ultrafine PM

🧱 Soot cake formation

- A loaded DPF often captures **ultrafine metal particles more efficiently** than a freshly regenerated one.

⚙️ Filter material

- **Silicon carbide (SiC)** DPFs tolerate higher temperatures but do not chemically bind metals.
- **Catalyzed DPFs** may alter metal speciation but still rely on physical capture.

Summary table

Metal type	Examples	Typical DPF removal
Particle-bound wear metals	Fe, Cr, Ni, Cu	**90–99%+**
Lubricant additive metals	Zn, Ca, Mg, P	**>95% (ash)**
Semi-volatile metals	Pb, Cd, Zn	**50–90%**
Gas-phase metals	Hg (rare)	**<30–50%**

Bottom line

A ceramic honeycomb DPF **removes heavy metals extremely well when they are particle-bound**, moderately well when they are semi-volatile, and poorly when they exist in the gas phase.