

Sintered Metal Technology provide excellent performance in passive and active regeneration modes







Mission Statement

Genuine Maintenance Inc.



To provide reliable support and resources to clients seeking solutions to Diesel emission maintenance excellence.

- Diesel emission solutions, Upgrades to aftertreatments, installs, training, and service support
- Mining Equipment Heavy Duty Diagnostics and Evaluation
- Maintenance Strategic planning consulting Fleet evaluation and CMMS to reach best-in-class
- Onsite installation, repair, and support resource
- Over 32 years experience in mining maintenance.







Allied Reliability/TFH History

- TFH Founded in 1947, headquartered in Houston, Texas
- Merger with Allied Reliability Group enhanced asset reliability capabilities.
- Rebranded to Allied Reliability 2019
- ~350 employees with locations in Texas (HQ), Louisiana, South Carolina, and Venezuela
- Shell Lubricants acquired Allied Reliability in December 2022







HJS Emission Technology

- Founded 1976 by Herman Josef Schulte (HJS)
- Headquarters Menden, Central Germany
- Number of employees 450
- Family owned company









Filter Types









SMF[®] Variations in Design



DPF Selection Challenges & Criteria

- Regeneration of DPFs is a critical aspect of successful operation over it's longevity
- The probability of success of each regeneration system depends on several factors:
- Engine maintenance
- Excessive idling of equipment
- Proper filter sizing
- Operator and maintenance responsiveness

Most of the DPF failures reported in the field result from inadequate filter regeneration.









Filter Regeneration is Critical to DPF Performance

- Main component of PM is oxidizable soot
- Regeneration efficiency factors: filter temperature, inlet flow, exhaust and PM composition, soot/ash load, oxygen concentration, catalyst loading, and other factors.
- Filter temperature is the decisive factor for regeneration
 - soot can be oxidized **only** when the ignition temperature is reached (Fang et al. 2017) (Lapuerta et al. 2020) (Lisi et al. 2020).
- Engine exhaust temperature (200-400 °C) not enough to oxidize the captured soot
- Effective oxidation temperature with O₂ as the reaction gas needs to be maintained above 600 °C.
- It's necessary to increase the exhaust temperature or use a catalyst to reduce the ignition temperature to achieve regeneration.
- Exhaust NOx:PM ratio: 20:1 25:1 (by weight, minimum)
- The importance of the NOx:PM ratio is straightforward; NOx is the source of NO₂ needed for CRT regeneration (Vernikovskaya et al. <u>2015</u>) (Fino et al. <u>2016</u>)



The three kinds of common passive regeneration:

- There are catalyzed diesel particulate filter (CDPF)
- CRT or catalyzed continuously regenerating trap (CCRT)
- Fuel-borne catalysts (FBC)







Sintered Metal Filters (SMF) We are different

- Exceptional filtration efficiency (99%)
- Extended range of applications (wide temperature window allowing for lower horsepower engines)
- Lower exhaust gas backpressure
- · Long service life due to large ash storage capacity
- Easy to clean (open structure) power wash
- Excellent heat conductivity for uniform filter regeneration
- Lifetime sintered metal filter element
- Robust: hot-shake test; 10M cycles, 160 Hz, 250°C
- NO2 neutral
- VERT and MSHA listed









5 Product Types



• SMF-AR and SMF-FBC

AR- Active Regeneration using fuel additive FBC-Passive regeneration using fuel additive



SMF-CRT Passive filter with DOC

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• SMF-ER Soot capture for low exhaust temperatures



SMF-SCRT State-of-the-art employing selective catalytic reduction









Regeneration of SMF® Filters

- The SMF-AR DPF system can adapt to and thus work in different operating modes: If needed, the active electrical regeneration occurs; if not, the system regenerates passively (without electrical heating). In all cases, the dosage of the FBC is moderated to optimize performance against cost.
- Besides the obvious benefits of clean exhaust and no downtime during operation, the system is compact, demonstrably robust, and has long service intervals between 800 and 2,000 h.









HJS SMF[®]- AR actively regenerated system

- These systems are built around filter elements made of sintered metal plates.
- The electrical heater mounted at the back of the filter element can regenerate the system when needed.
- Iron-based fuel additives supplied by the onboard dosing system are essential in the regeneration process and system operation.











SMF Regeneration Real-time



Abgas-Systeme • Katalysatoren inter-Metall-Filter SMF Jet 4 ,1.8m²,20gRuß/m² Thermoelektrische Regeneration 2500/min 40Nm Elektrische Leistung: 1.1kW Heizdauer: 2 Minuten TAbgas vor SMF = 250°C

Full regeneration In 2 minutes No equipment Downtime

Exhaust Flow

Application advantages and range of applications



⇒ SMF has a much higher soot loading capacity

- Lower Back Pressure
- Greater ash-holding capacity
- Reduced regen temperatures
- Regeneration takes minutes to complete

SMF® ash storage capacity is 3 to 4 times higher than ceramic wall flow



HJS on NIOSH / MSHA List

• Approved by US Mine Safety and Health Administration (MSHA)

HJS Filters have the highest Filtration Efficiency of all the MSHA Listed DPF filters

Non-Catalyzed Particulate Filters, Base Metal Particulate Filters, Specially Catalyzed Particulate Filters, and High Temperature Disposable Filters	Manufacturer	DPM Filtration Efficiency*
HJS Emission Technology GmbH & Co. KG, SMF®-ER: Sintered Metal Filter External regeneration, can be cleaned with water and reused	HJS Emission Technology Germany 312-757-2553 mmazzuca@tfhudgins.com +49-2373-987-282 hubertus.borgmeier@hjs.com	99%
HJS Emission Technology GmbH & Co. KG, SMF®-AR: Sintered Metal Filter Automatic thermoelectrical on board, active self- regeneration and FBC	HJS Emission Technology Germany 312-757-2553 mmazzuca@tfhudgins.com +49-2373-987-282 hubertus.borgmeier@hjs.com	99%

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N.		[®] -Cortificato
4 N		
No.	B 195/12.06	
Product	Particle-Filter System:	SMF®-AR
	Filter Module:	HJS sintered metal filter
	Regeneration 1:	Active (thermo electrical) FBC Innospec Satacen® 1 Active (thermo electrical) FBC Innospec Satacen® 2
8	Regeneration 2:	Active (thermo electrical) FBC Innospec Satacen® 3 (plus) Active (thermo electrical) FBC Solvay Eolys
	Regeneration 3:	Passive FBC Innospec Satacen® 1 Passive FBC Innospec Satacen® 2
	Receptoration 4:	Passive FBC Innospec Satacen® 3 (plus)
1	Flashes's Ossial Usit	
Manufacturer	HJS Emission Technolo Dieselweg 12	gy GmbH & Co. KG
	D-58706 Menden (Germ	any)
We herewith	apply to be listed in th	ne VERT [®] filter-list and accept the rules and condit
		N 10
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Manufacture		Date
	Sembel & Co. KG	Trate by tere
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Tel. 02373/987-0 • 5	Fax 02373/987-259 09.	09.2014 i.A. 100% WE
	he VERT [®] Scientific (Committee
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Product	HJS SCR BK: Exhaust Aftertreatment Sy	stem DPF+SCR Non	road+Onroad		
Manufacturer	HJS Emission Technology GmbH & Co. KG Dieselweg 12; D-58706 Menden				
VERT- Test-Number	R017/11.21 DPF (HJS-CRT, HJS-SMF)+SCR (200-400 cpsi, V2O5/Cu-Z)+DEF 32,5%+ASC				
Properties		Test	Reduction		
-	Reduction of SPN 20nm-500nm/ NRTC	VERT 4Pt, regen.	98.7% / 5 x10 ¹⁰		
	Reduction of Particle Mass PM (EC) Reduction of Opacity	Full Load B097 Free acceleration	98.5% 99%		
	Reduction of NOx	RDE (datalogger)	83-94%		
	Reduction of NOx	NRSC/NRTCw	105/99 ma/kWh		
	Slip of Ammonia	NRTC	0.7 ppm		
	Reduction of HC	RDE	<10 mg/km		
	Reduction of PAH	VSET B111	<95%		
	NOx Reduction by SCR	onset below 200°C			
	Endurance Test 10'000 km	no aging observed			
Assessment	is fully suitable for any application as long tested limits and Diesel fuel EN 590 is us been investigated by the Swiss exhaust g line with the Swiss technical standard SN VERT Test-Number R017/11.21 must sho	as space velocity rer ed. The properties of jas emission laborator 277206 and certified ow up at the system s	nains within this system have ry AFHB/Biel in by VERT. The pecification plate.		
Effects	The particle reduction effect corresponds above independent on the particle genera of any engine will be reduced by at least the system nearly eliminates the emissio NO _x is reduced by up to >90% to >100 m CO ₂ and fuel consumption are slightly inc pressure build-up if fully soot loaded, while by the VERT-certified onboard control HJ	to the penetration fact ation of the engine e.g 98%. In of HC, CO, NO ₂ , N ₂ g/kWh with minimum reased by about 1% c ch however is electron S-ACU and limited to	tor mentioned particle emission O and PAH; slip of NH ₃ Jue to back- nically controlled 200 mbar.		
Benefit/Cost	This device is not only eliminating carcino but also other toxic substances like carcin will be at least 10 x higher than to actual and place of usage. In addition the global	ogenic nanosize soot hogenic PAH. Thus th cost of the device dep warming effect due to	particles and NOx e health benefit ending on time o black carbon		

Soot only Capture

SMF-ER

- Underground vehicles cause considerable air pollution on mine sites. As a result, there is an ever-increasing demand for particulate filters when regeneration is poor due to the temperature limitations of diesel engines and the DPF.
- HJS offers a flexible, robust, and effective alternative to DPFs that do not regenerate properly. The SMF®-ER is quick and easy to install and can be interchanged with several other machines. Regeneration or cleansing can be performed on-site while the machine runs with a second filter unit.





Advantages

- · Quick and easy installation
- Cost efficient
- Individual usage and interchangeable
- · Simple handling short changeover times via quick-release clamps
- · High soot capacity compared to other conventional filter systems
- Pressure monitored for easy inspection
- Regeneration or cleansing apart from the machine
- · Easily cleanable with water
- Extra durable design
- Built for rough construction site conditions
- · In-house development and manufacturing





HJS interchangeable filter system SMF[®]-ER:

- The HJS SMF®-ER is designed for quick and easy installation on the machine on-site.
- All necessary components from our modular system portfolio can be constellated according to the intended use, enabling the individual configuration of each filter on all of the fitted equipment.
- The filter is fixed to the machine-mounted base plate via quick-release clamps.
- Advantage: Using identical base plates on multiple machines allows you to quickly and easily switch the filter unit from one machine to the other.
- The inlet and outlet cones have been designed for an optimal exhaust gas flow, resulting in the complete utilization of the filter unit. The soot level can be easily monitored with the affixed pressure manometer.
- Cleaning intervals depend on the engine condition, operation, and driving conditions. The filter should be cleaned in an enclosed container with pure water. Waste water must be properly disposed of according to waste codes.









SMF-ER (lifetime filter solution)



- 1 Mounts for manometer
- 2 Clamp for hose
- 3 Pressure hose incl. martens protection
- 4 Inlet Module
- 5 SMF Filter
- 6 Gasket
- 7 Connection clamp
- 8 Outlet cone
- 9 Monometer
- 10 Exhaust hose
- 11 Fastening console
- 12 Fixing clamp
- 13 Holder (optional)
- 14 Rubber Damper







Toyota Landcruiser Experience







Think about tomorrow.



(MDEC 2015)

Toyota Landcruiser

Toyota Land Cruisers provide good cost/performance at Vale. Their versatility offers a wide range of configurations for a variety of applications.

The engines are non-tiered and contribute to high levels of pollutants in the mine environment:

Diesel Particulate Matter Carbon Monoxide

NOX

NO2

Hydrocarbons

Let CE Jubition reconnect

Past efforts to significantly reduce emissions of these vehicles have not been successful.

Allied Reliability/T.F. Hudgins provided an SMF-AR 3.8 filter system for trial.

Installation was completed on 10/1/2014







(MDEC 2015)

Toyota Landcruiser



The HZJ79L/1HZ6 engine is non-tiered, with no emission controls beyond a muffler and a scrubber for CO reduction.

Vale chose a 60-day trial period, and the test included emissions data as well as data from the HJS ECU.

The CO scrubber was removed prior to the installation of the

SMF-AR 3.8 system.

- There was a significant reduction in backpressure when CO scrubber was removed.
- A Steel Heat deflector was installed as per Vale's request.
- Unit enclosed in Ferwin 3A-9Z heat wrap was required by Vale. (not shown)
- Additional exhaust noise reduction was achieved with DPF replacing the exhaust muffler.









Temperature distribution over the 60-day test program



(MDEC 2015)

Back pressure was under 100 mbar 98.4% of the duration of the trial





Toyota

Conclusions

System performance achieved the objectives of the test:

Soot has been reduced by over 95%.

The filter system is NOX neutral.

The filter achieved passive and active regeneration and maintained low back pressure.

The filter exceeded 500 hours of operation without requiring cleaning.







Cleaning DPF Filters

Ceramic/Cordierite Filters

- Cleaning is a 7–12-hour process
- Cleaning Ceramic Filters range between \$250-\$700
 - Most mines target 200-hour filter cleaning intervals
- · Ceramic filters can suffer breakage due to handling
- After successive cleanings, the filter will be at the end of its useful life, requiring replacement.





SMF Filters

- SMF Filter elements do not require replacement
- Cleaning process with water 20 minutes
- Local cleaning costs \$25-\$50







Cleaning SMF Filters



Cleaning equipment

- Cleaning cabinet for mobile and stationary use
- Wasted water will be captured and refurbished
- Seperation of soot and water
- Dimensions: 1.550x490x490mm
- Weight: 37 kg













Maintenance & Commitment - The Achilles Heel Of Success

- Commitment to providing optimal maintenance of DPFs.
- Improved Diesel engine maintenance training to diagnose, repair, and adjust components.
- Baseline engine emissions and create a threshold for maintenance activities.
- Data logging engine temperature to assess the correct regen strategy
- Installation of the correct design after treatment to application selection. Use of engineering practice, science-based, and application specifics.
- Integration of best-in-class systems only to be upheld for guidance to installation /maintenance.









Conclusion

- The underground mining environment presents some of the most severe operating conditions found anywhere, and maintaining mobile equipment in a mine requires highly skilled people, facilities, tools, and support.
- The maintenance of diesel engines and emissions control systems is the most critical factor in any mine's emissions control strategy.
- DPFs There is no magic bullet.
- DPFs are not set it and forget it







