

Robust DPF system considering Indian market condition

IND	'18	'19	'20	'21	'22	'23	'24	'25	'26	'27	'28
On Road	BS IV (No PN)	BS VI Phase1 PN regulated					BSVI Phase2 PN Regulated under RDE				
Non Road	TREM III (No PN regulation)					TREM IV (No PN regulation)				TREM V PN Regulated	
	CEV III (No PN regulation)				CEV IV (No PN regulation)				CEV V PN Regulated		

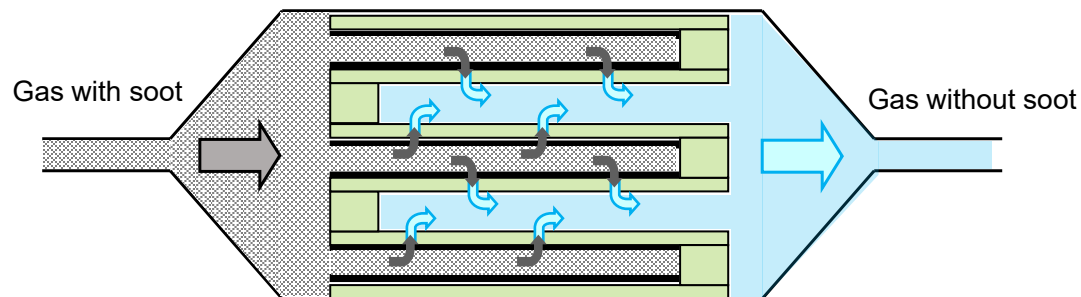


Table Comparison of PM/PN regulations and ATS layout in Trem/CEV IV and Trem/CEV V

	PM	PN	main ATS layout	
TREM/CEV IV (No PN regulated)	0.025	-	E/G	DOC
TREM/CEV V (PN regulated)	0.015	1.0×10^{12}	E/G	DOC
			DPF	
			DPF added to meet PM/PN regulation	

❑ Diesel car needs DPF system

PN/PM filtration by DPF



Steps to regeneration

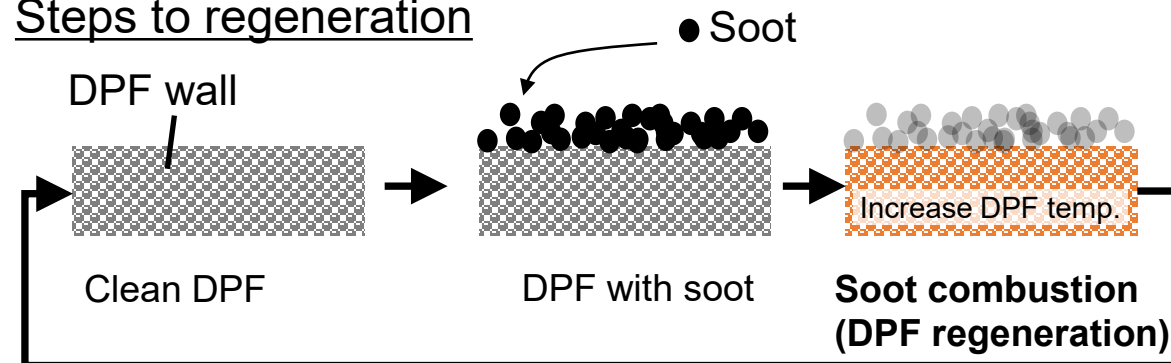
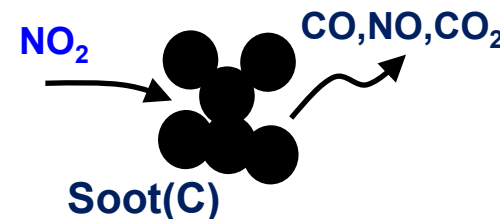
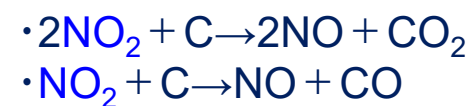


Table Different from Passive regeneration and active regeneration

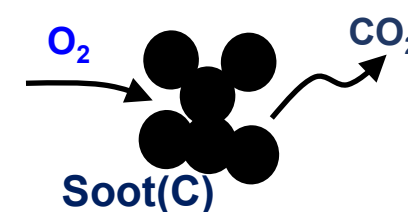
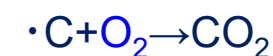
	Passive	Active	
Timing	During driving	During driving	Parked regeneration (Reset regularly)
Temperature	250°C~	550°C~	550°C~
Additive fuel	-	If needed	If needed
Regeneration speed	Low	High	High
workability	Non-stop	Non-stop	Stop
System risk	-	Abnormal regeneration /Product fail	Abnormal regeneration /Product fail

Soot combustion type

■ NO₂ regeneration (250°C~)



■ O₂ regeneration (550°C~)



DPF fail on Tractor in global market(i.e., EU, US, JPN, China)

Causes

- EGR : Soot much exhaust due to EGR fail
- Too much soot deposition due operator ignoring RG indicator
- **Transient driving (High load/speed + stop/parking)**

High load/speed working
: Emit much soot under high temp condition.
: DPF temp increased under low O2 condition
(No burning and soot remaining in the filter)

↕

Stop for rest or parking suddenly
O2 intaking to high temp DPF
➡ **Soot burn explosively(Abnormal RG ; DTI)**

Plowing
& Rest(Idle/Parking)



Uphill transportation with over load
& Parking

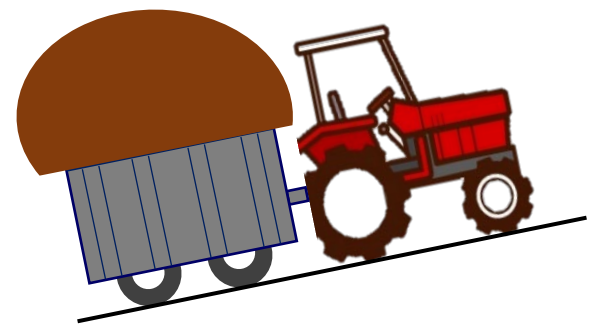


Table Engine character

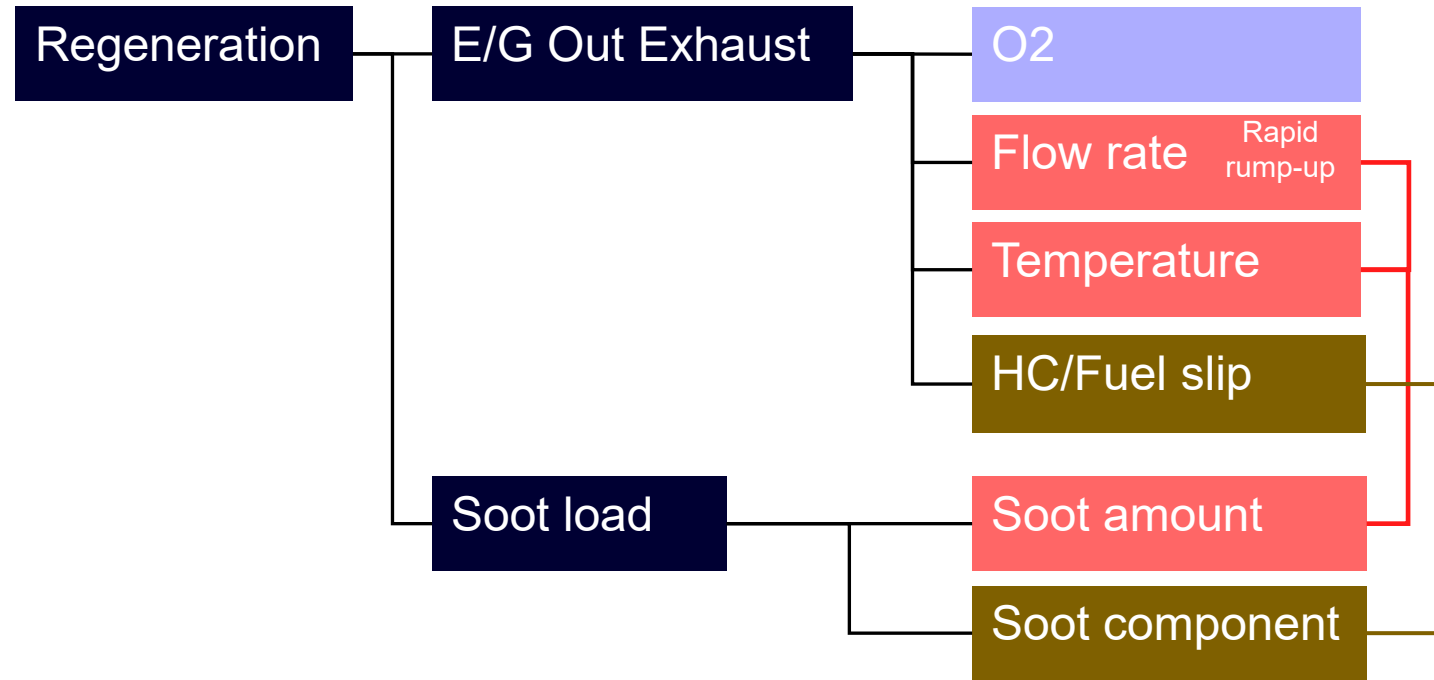
	TC : Turbo charged engine	NA : Natural Aspiration engine
	TC-E/G	NA-E/G
Trend in IND	High grade (Minority)	Standard grade (Majority)
Maximum exhaust Temp. @full load/full speed	550degC	620degC
DPF temp.(Estimation)	580degC	650degC

IBIDEN investigated this on internal bench (Today's report)
➔ This can contribute to making robust ATS

➡ NA engine is majority in India , but ATS development for NA engines(high exhaust temp.) is not mainstream in other markets. Furthermore, to check risk under more severe regeneration condition is needed.

Parameters influence to abnormal regeneration

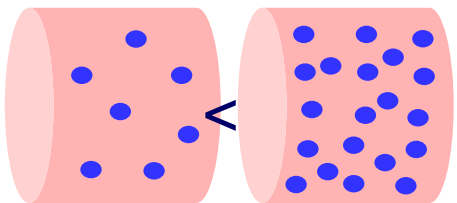
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Investigation A
This report shows
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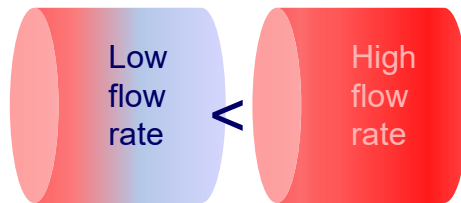
Investigation B
(2023-ECMA report from IBIDEN)

O2 amount



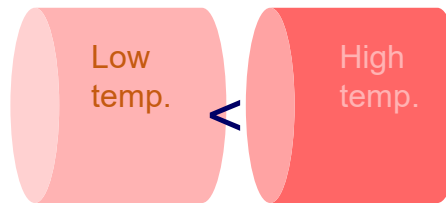
DTI(Drop-To-Idle) condition

Flow rate(rapid rump-up)



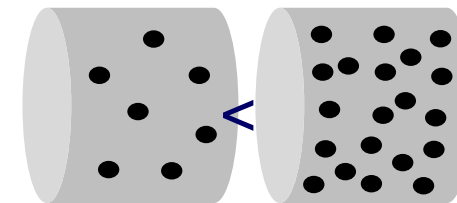
Full load condition

Temperature



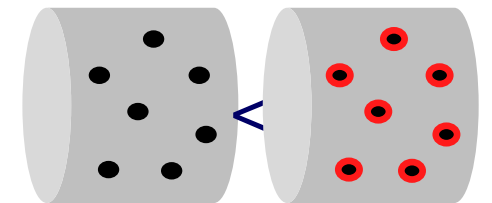
TC < NA engine

Soot amount



**Detection deviation
/End-user ignoring indicator**

Soot component(with HC)



Long idle/DOC aged

Main Tractor use condition in India

Noise and deterioration during use cycle

~Investigation A~

- Flow rate(Rapid increasing temperature homogeneously)
- Gas temperature
- Soot amount

Impact for regeneration behavior(DTI test)

■ Demonstrates Abnormal Regeneration(DTI)

Table Engine and DPF sample information

Item	Value
Engine	1.6L
DPF size	D5.66x6”L
Substrate*	R-SiC Cord

*Similar Cell structure

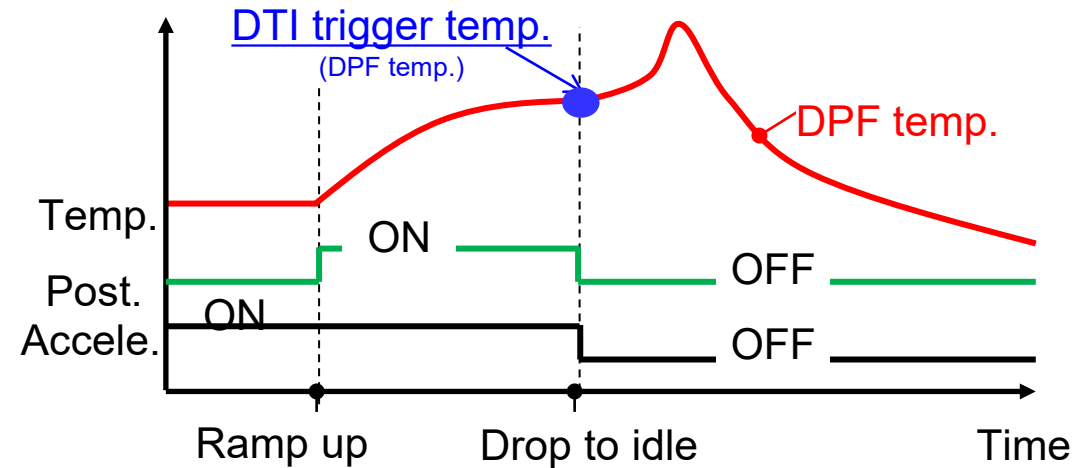
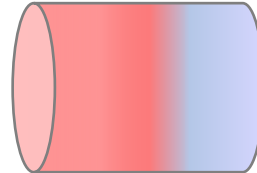
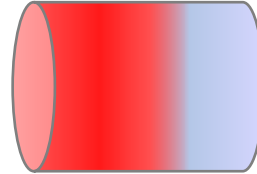


Fig. DTI test protocol

Table DTI test condition

Condition	Exhaust gas temp	Flow rate	Rump up	DPF temp. Image
1	550degC (TC engine Max)	Standard	1min	 A part hot
2	620degC (NA engine Max)	Standard	1min	 A part hot
3	620degC (NA engine Max)	High (Full rpm/full load during driving)	1min	 Whole hot

DTI evaluation results

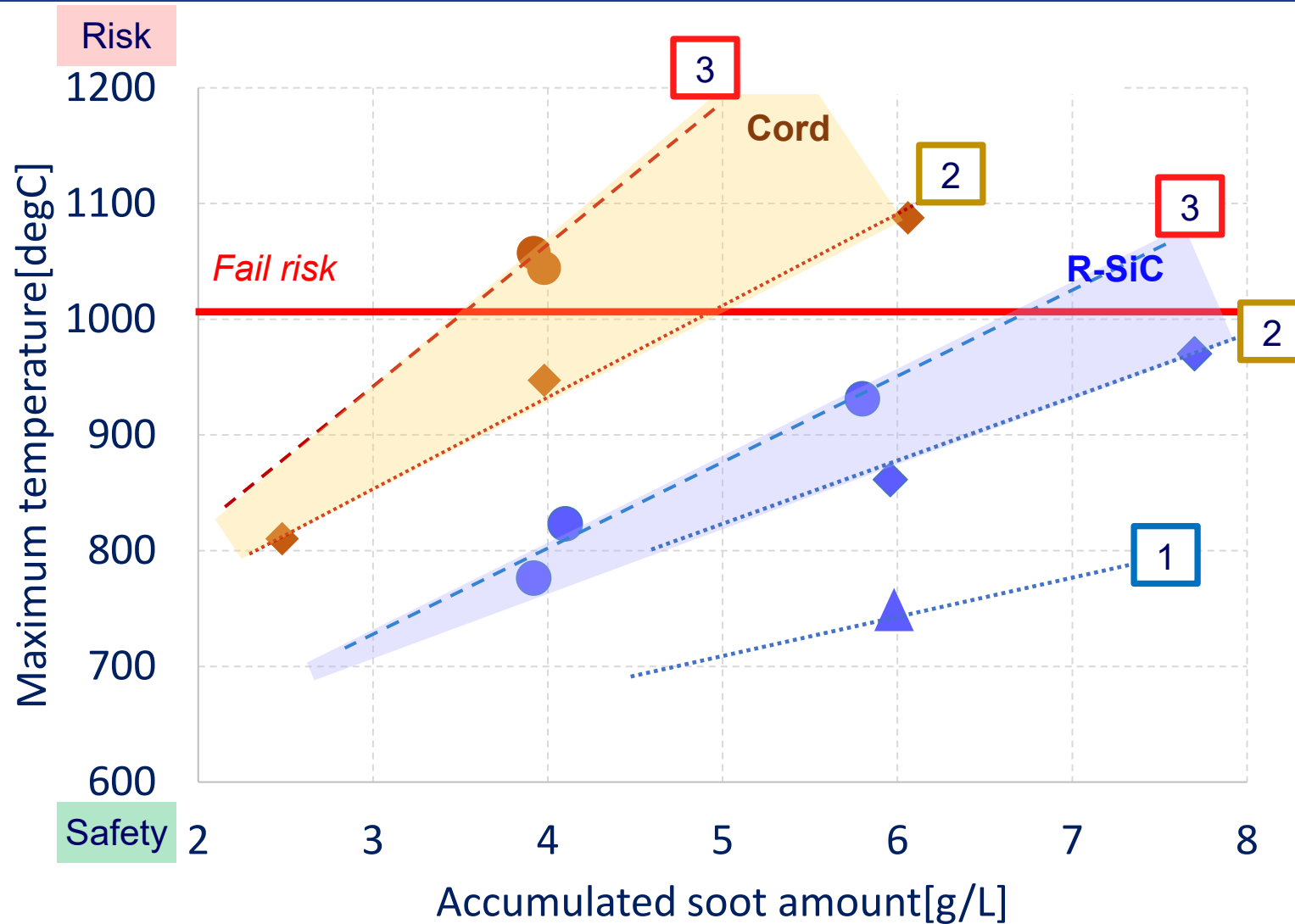
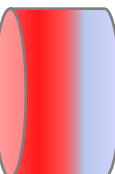


Fig. Maximum temperature in the DPF when DTI occurred

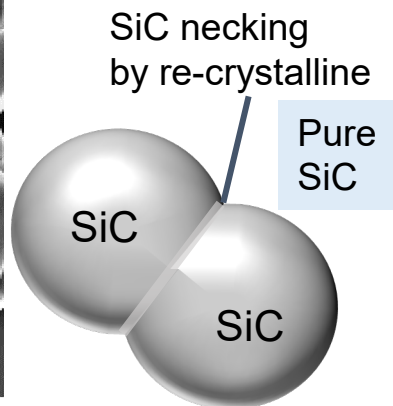
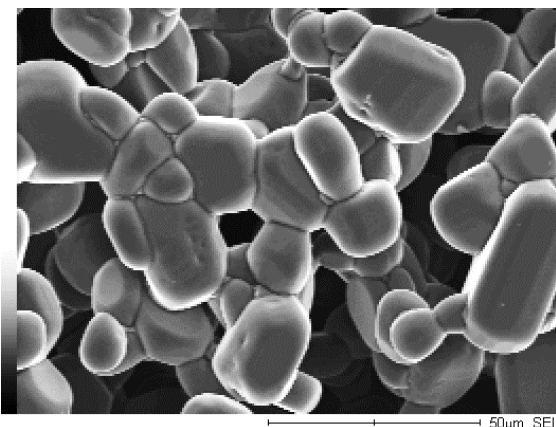
Table condition

Rump up : 1min

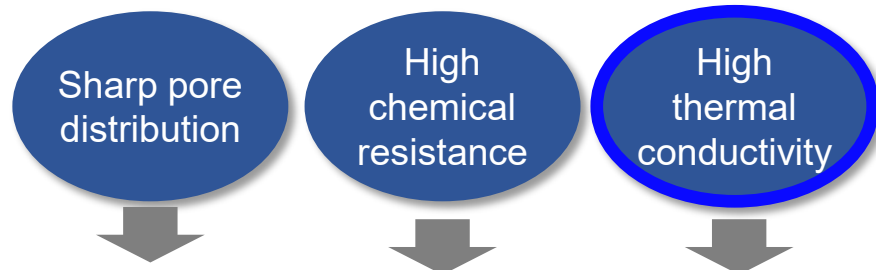
	Exhaust gas temp@DPFin	Flow Rate	DPF thermal image@DTI
1	550degC (TC engine Max)	Standard	 A part hot
2	620degC (NA engine Max)	Standard	 A part hot
3	620degC (NA engine Max)	High	 Whole hot

- ✓ DTI of NA engine and rump-up with high flow rate is more severe regeneration
- ✓ R-SiC DPF can suppress temperature increasing even if such condition

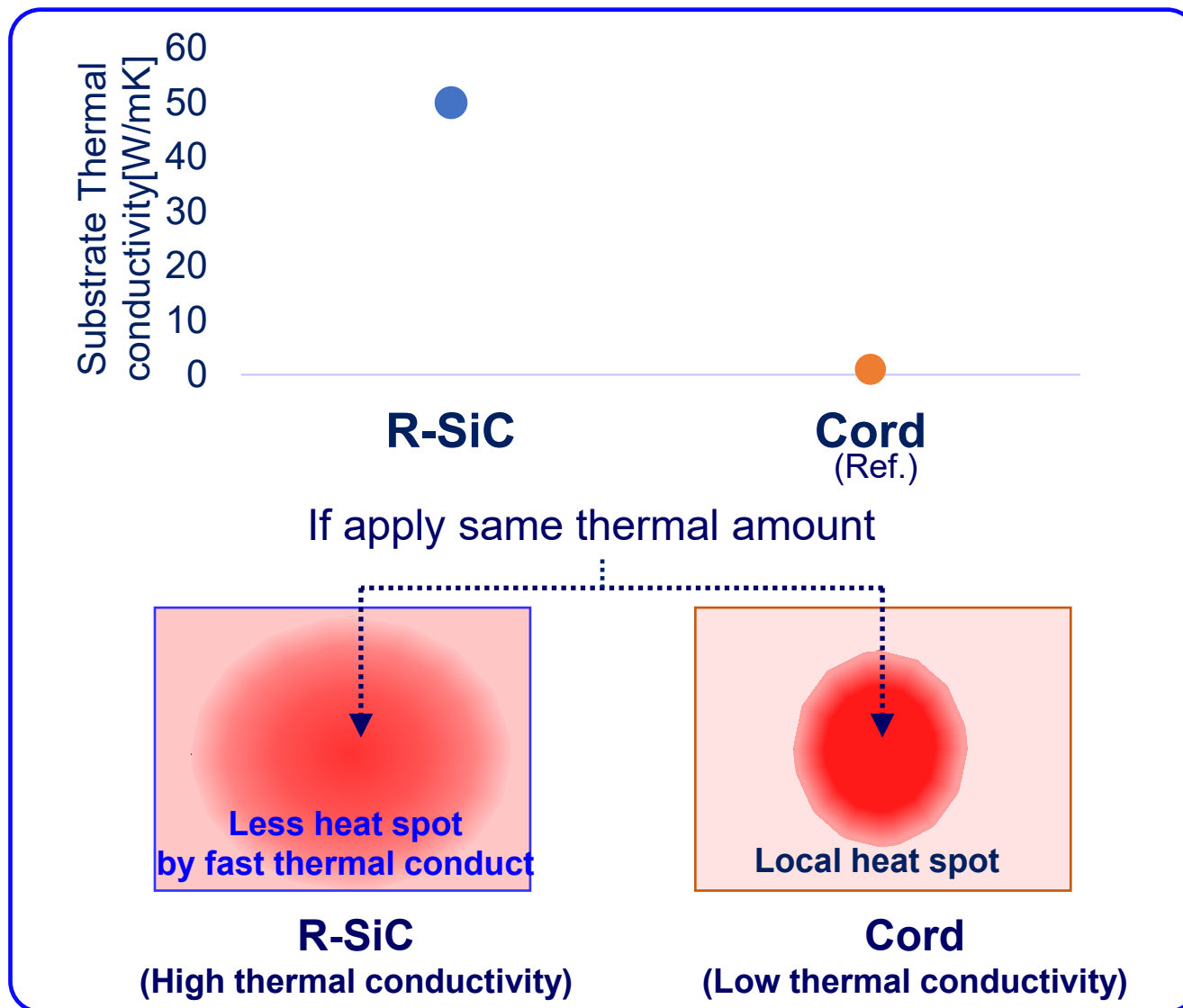
- ✓ R-SiC's high thermal conductivity allows to accumulate more soot in DPF in comparison with that of Cordierite.



R-SiC character



Contribution for DPF

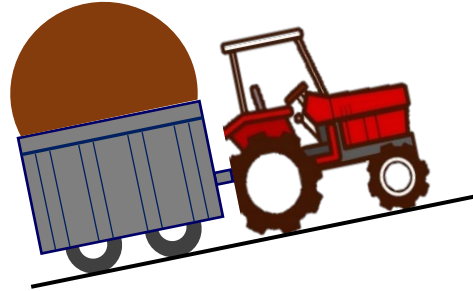


Tractor use severe condition

Plowing
& Rest



Uphill transportation
With over load & Parking



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Engine character(TC.NA)

TC : Turbo charged engine
NA : Natural Aspiration engine

	TC-E/G	NA-E/G
Stream in IND	High grade	Main
Maximum exhaust Temp. @full load/full speed	550degC	620degC
DPF temp.(Est.)	580degC	650degC

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“Making more severe regeneration condition as possibility in India market”

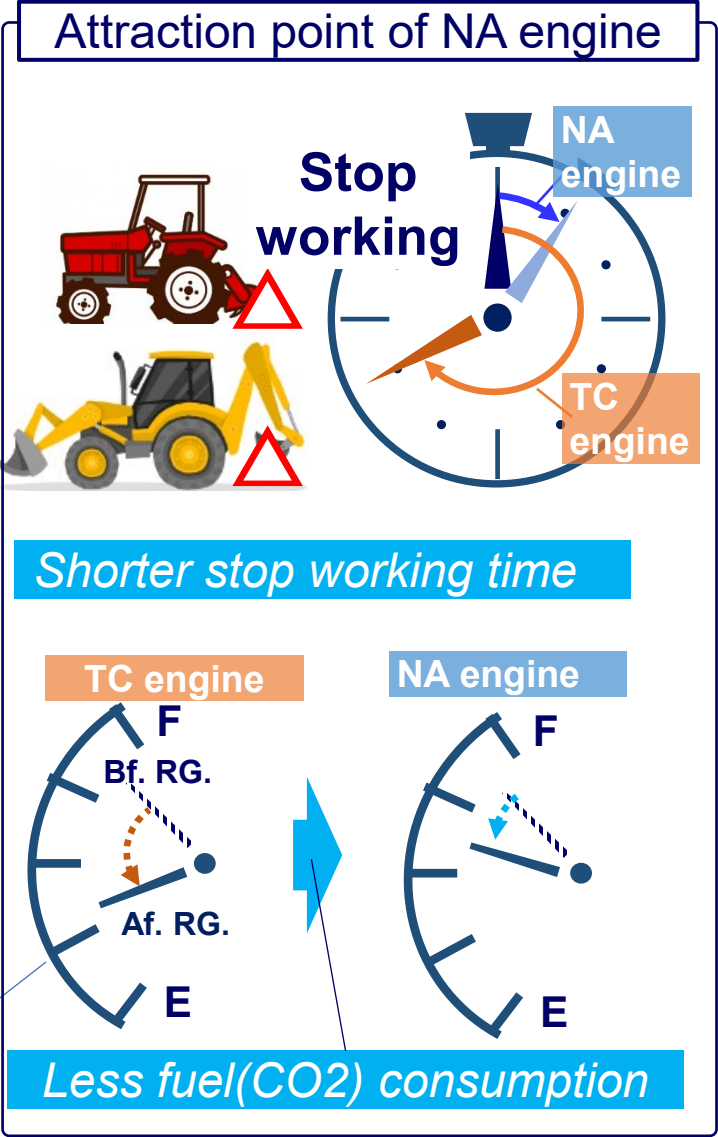
Proposal : To evaluate worst condition DTI

- Exhaust gas temp up considered with deviation due to injection/DOC error : **Max + 30~50deg C**
- High speed rump up (Remaining soot / Almost filter hot until DTI) : **Full load/Full speed**
- Soot amount up considered with deviation due to detection error : **+1~2g/L**

R-SiC robustness advantage can cover such severe regeneration situation

■ Additional benefit by R-SiC DPF for NA engine

	TC-E/G	NA-E/G
Trend in IND	High grade (Minority)	Standard grade (Majority)
Vehicle cost	Expensive	Standard
Maximum Exhaust Temp. @full load/full speed	550degC	600degC
DPF temp. (Estimation)	570~600degC	620~650degC
If Abnormal Regeneration happen	(Severe)	More severe ↕ R-SiC (Robust DPF) can cover
Soot Regeneration time	Long	Short



**NA engine
(High temp.)**

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**IBIDEN R-SiC
(Robust DPF)**

II

- Maximize vehicle attraction
- Leads to sales up in other market by NA engine
- compositable for TC engine
- Increase OEM brand & value