ENHANCING CATALYST DURABILITY IN HEAVY DUTY CNG ENGINE THROUGH COLLABORATIVE APPROACH

ECT 2026 TECHNICAL PRESENTATION

New Delhi, October 2026
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CONTENTS

- **EMITEC TECHNOLOGIES**
- CNG APPLICATION CHALLENGES & STRESSORS ON METAL SUBSTRATES
- COLLOBORATIVE APPROACH FOR ENHANCING DURABILITY
- CONCLUSION

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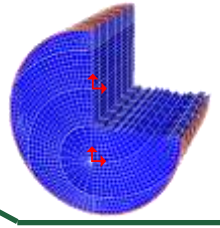
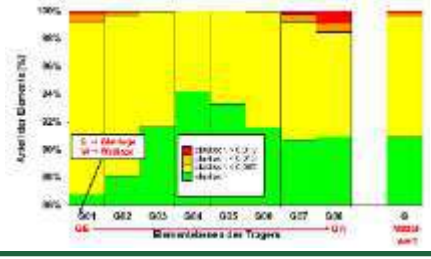
EMITEC DEVELOPMENT

EMITEC DEVELOPMENT CYCLE

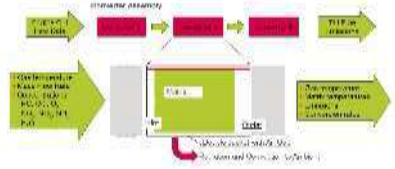
Design Idea

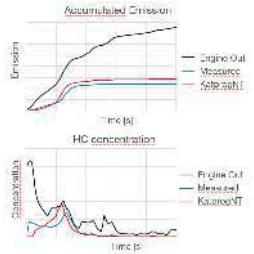


FEM Cal-culation

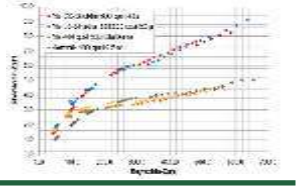


Emission Cal-culation

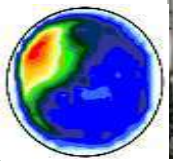


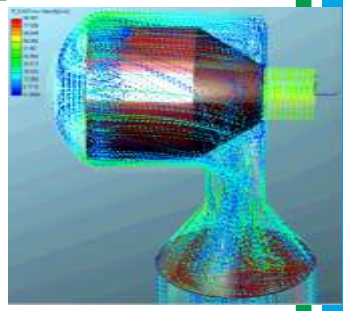


Mass Transfer Analysis

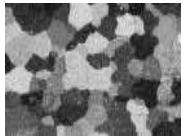


CFD / Flow Measurement

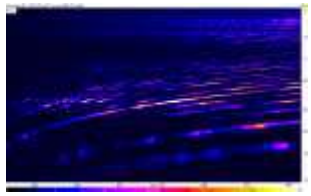


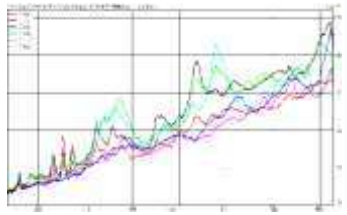


Material Develop-ment



Vibration Analysis

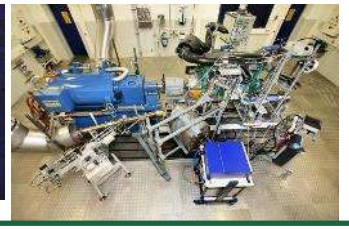




Shape Analyis

KLT Test / Thermal Shock / Hot Vibration

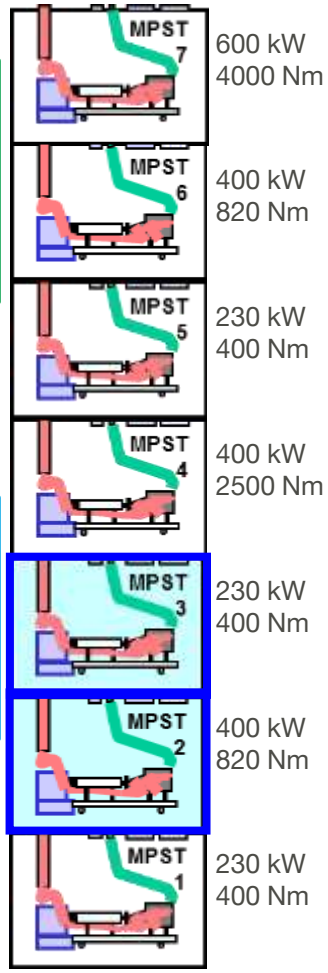
Engine Test Bench

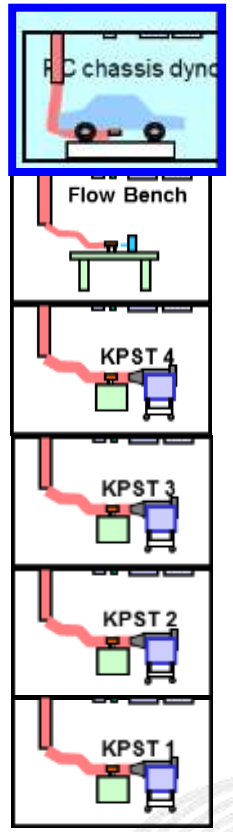


Vehicle Dynamo-menter

PRODUCT AND APPLICATION DEVELOPMENTS SUPPORTED BY A TEST CENTER

VIEW CENTRAL FLOOR





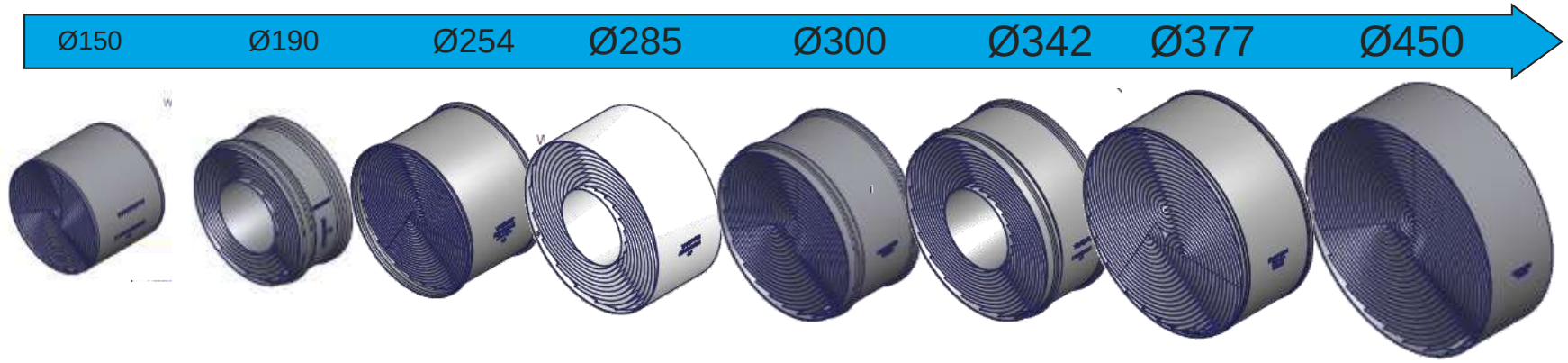
EXAMPLES FROM OUR CUSTOMER PORTFOLIO – HD ON ROAD

FROM LIGHT DUTY CITY VAN TO LONG HAUL HEAVY DUTY TRUCK

Iveco – CNG Light Duty Truck

FIAT – CNG Light Duty Truck

DAF – XF & XG Heavy Duty Trucks



More than 40k substrates supplied till date for CNG Trucks without any issues

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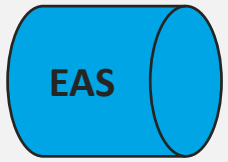
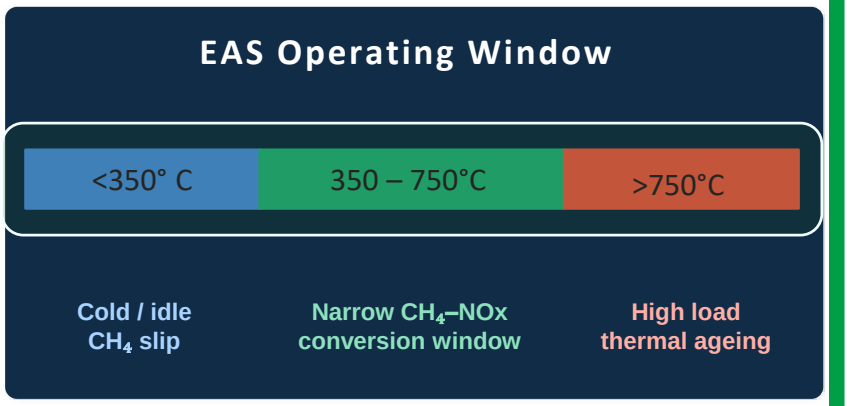
CNG APPLICATION CHALLENGES

- Downsized engine
- ↑ BMEP
- ↑ Power Density

- ↑ Thermal load
- ↑ Mass flow



EAS Performance
- Robust EAS performance required



Operating Demands & EAS impacts

Real World duty severity

- Stop–go traffic and frequent acceleration
- High payload, ambient temperature and altitude
- Repeated lambda and temperature fluctuations

Impact: Degrades catalyst performance and EAS durability

Catalyst Thermal Durability

- High inlet temperature and rapid thermal gradients
- Misfire-induced temperature spikes
- Prolonged full-load operation

Impact : Washcoat ageing, PGM sintering and substrate cracking/damage

Emission impact

- Higher load → Higher engine-out NOx
- Lambda fluctuations → Lower CH_4 and NOx conversion
- Incomplete combustion → Increased methane slip
- Spark retard → Higher Exhaust temp and fuel consumption

Impact : faster catalyst ageing, substrate damage and reduced conversion efficiency

Precise transient lambda, spark, boost and torque control are the critical needs to meet operating demands while protecting EAS performance and durability

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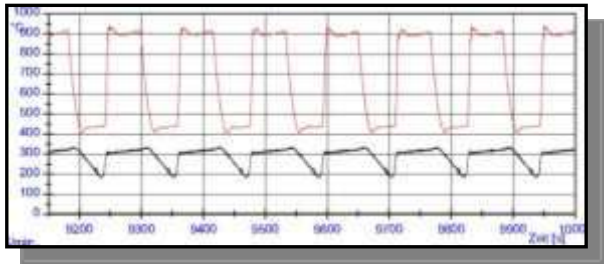
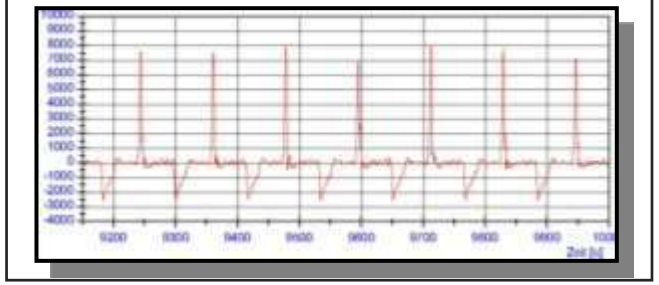
LOADS ON CATALYST SUBSTRATE

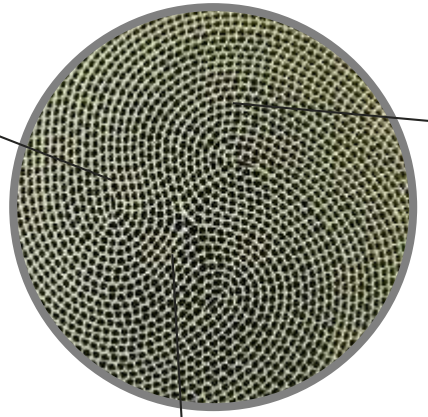
THERMAL & VIBRATION LOAD: MEASURED ON ENGINE TEST BENCH / VEHICLE

Temperatures

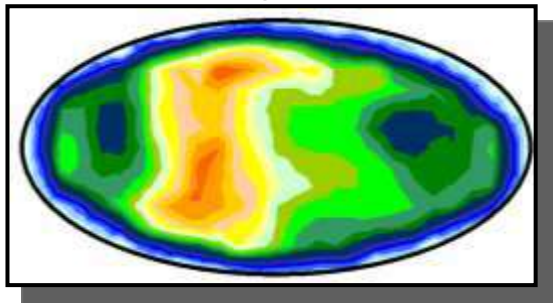


Temperature Transients

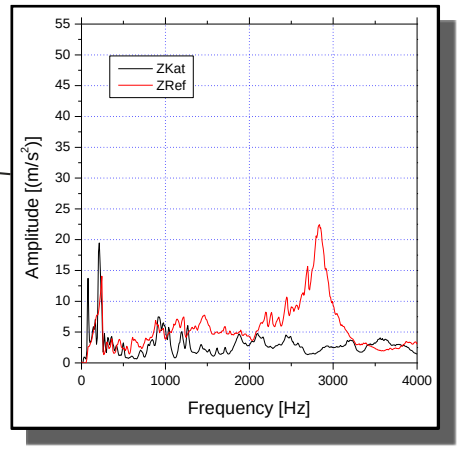




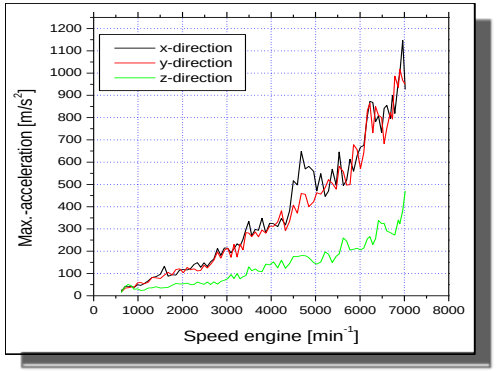
Exhaust gas flow



Frequency



Acceleration



While meeting emission performance, care should be taken for monitoring the loads acting on catalyst substrate to ensure long term durability

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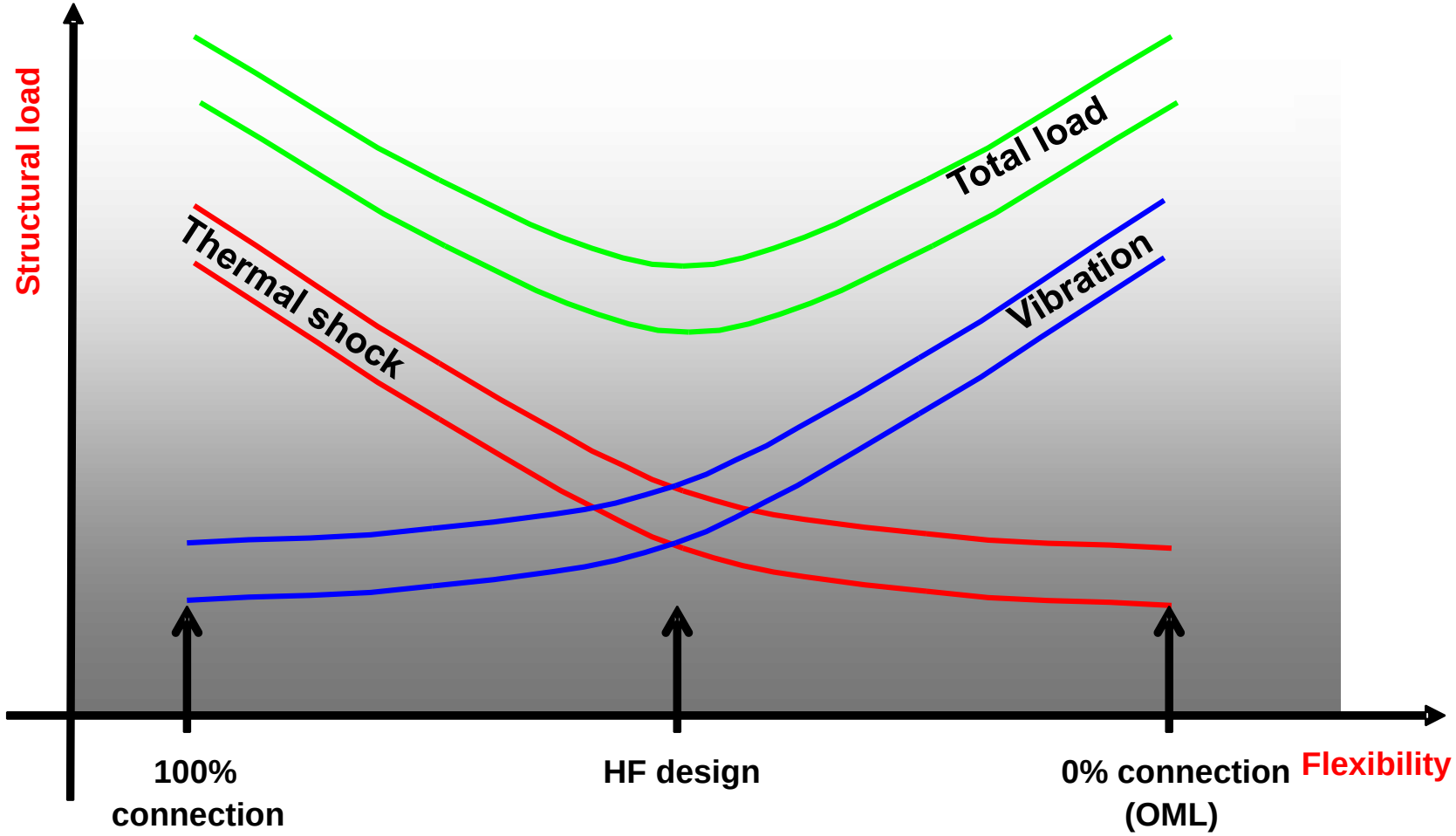
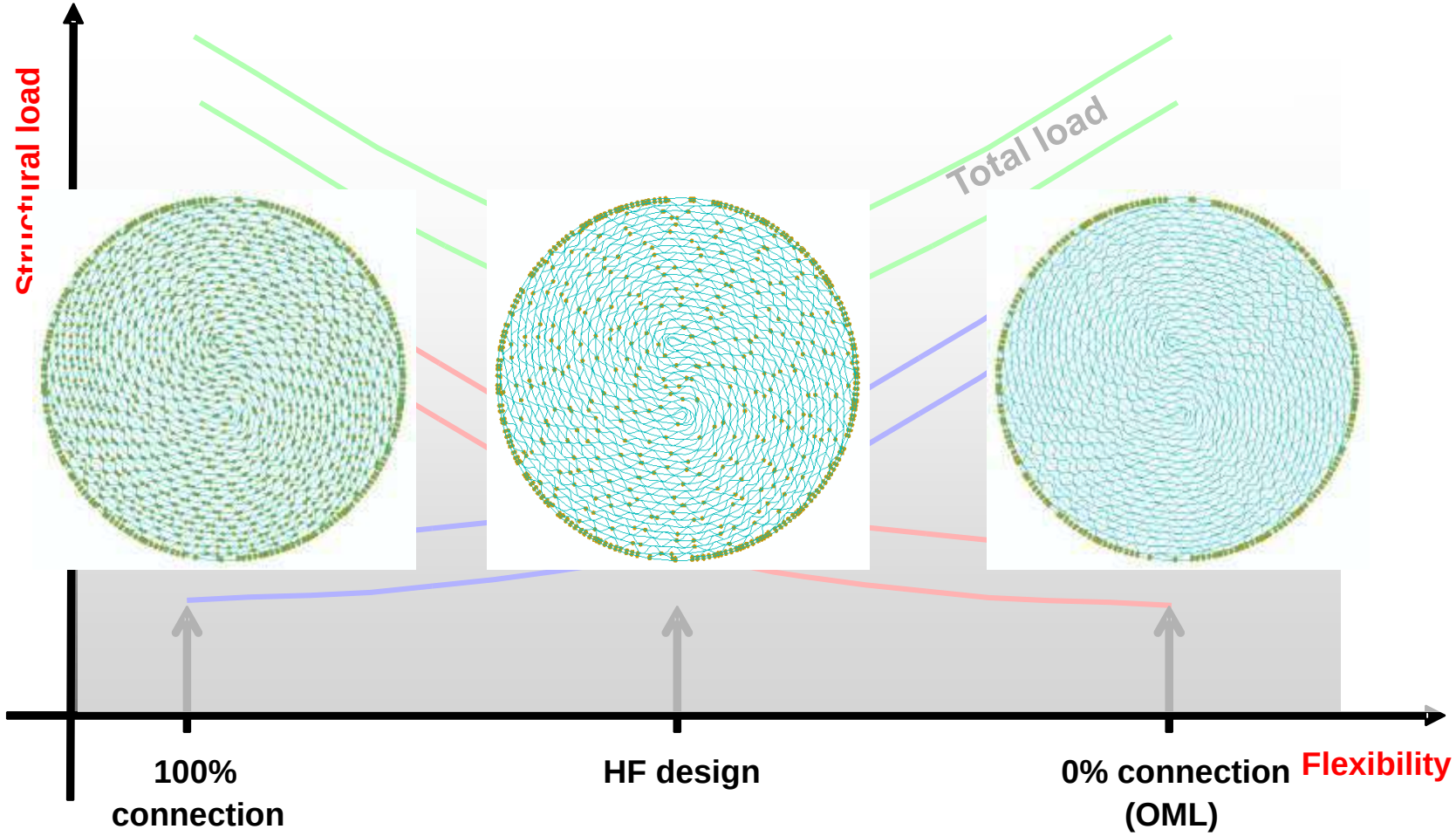
SUBSTRATE DESIGNS FOR ADAPTING TO THE LOADS

THERMAL & VIBRATION LOADS



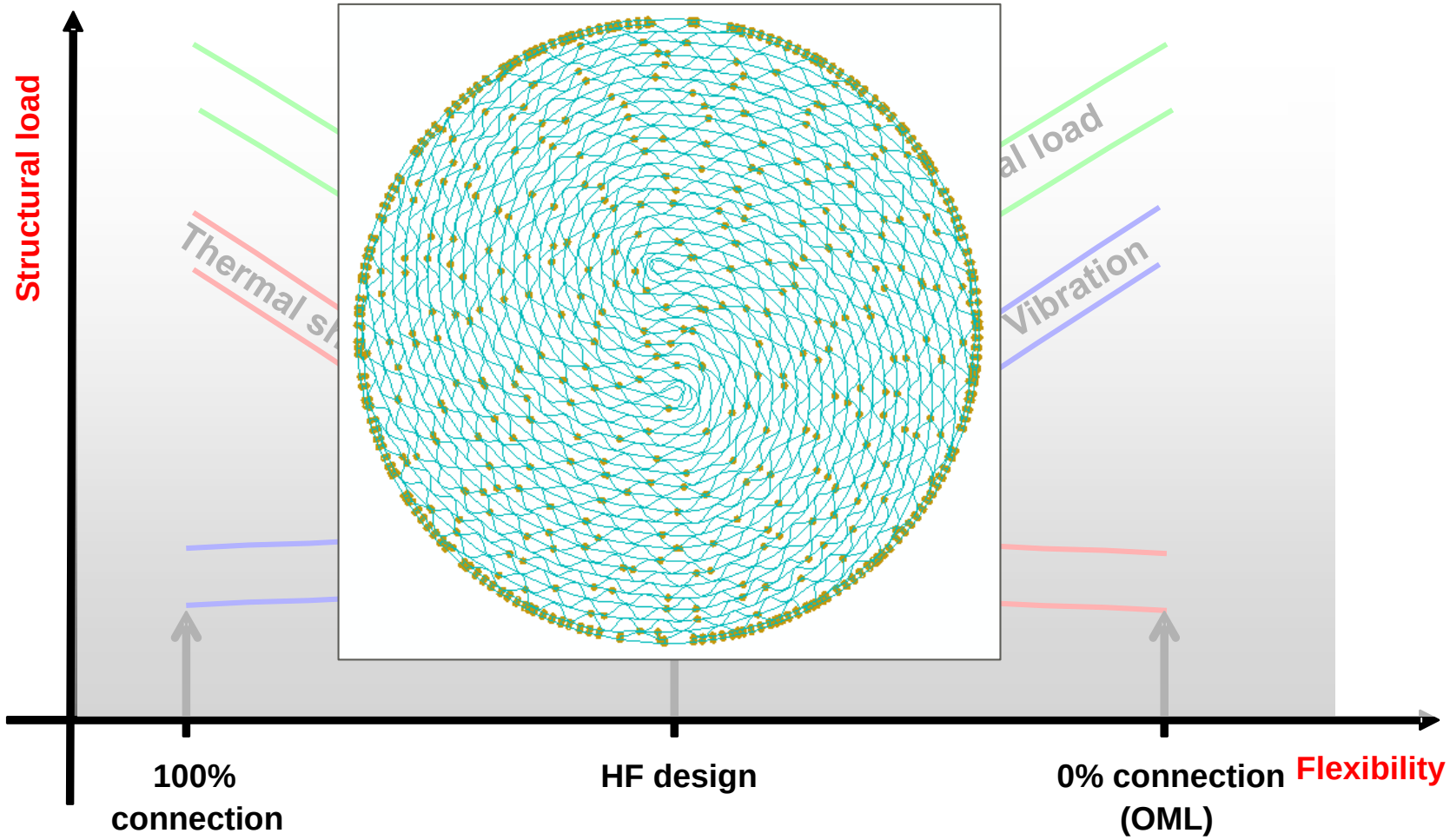
SUBSTRATE DESIGNS FOR ADAPTING TO THE LOADS

THERMAL & VIBRATION LOADS



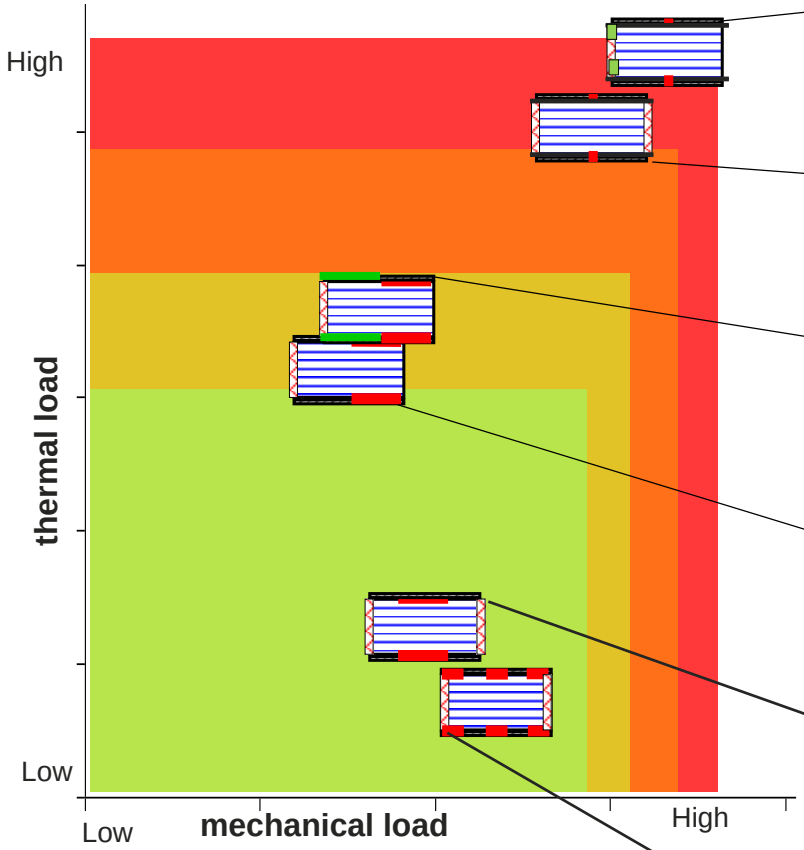
SUBSTRATE DESIGNS FOR ADAPTING TO THE LOADS

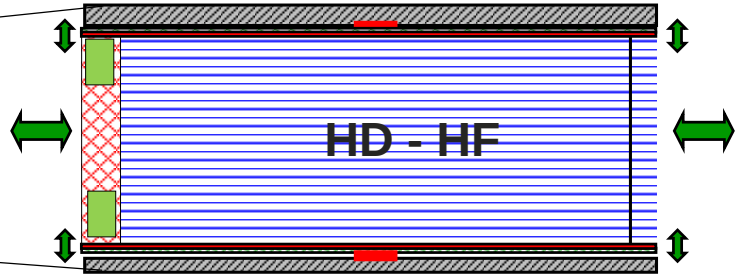
THERMAL & VIBRATION LOADS

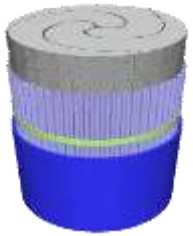


SUBSTRATE DESIGNS FOR ADAPTING TO THE LOADS

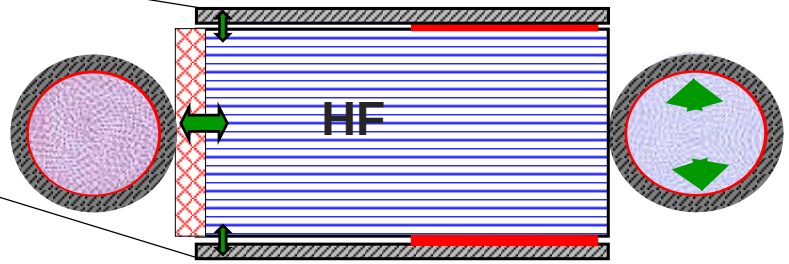
BRAZING DESIGN



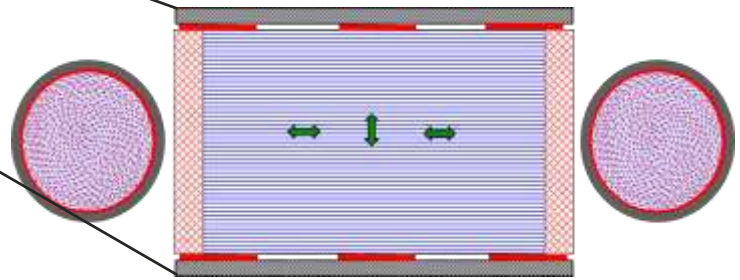




Flexibility:
Bilateral



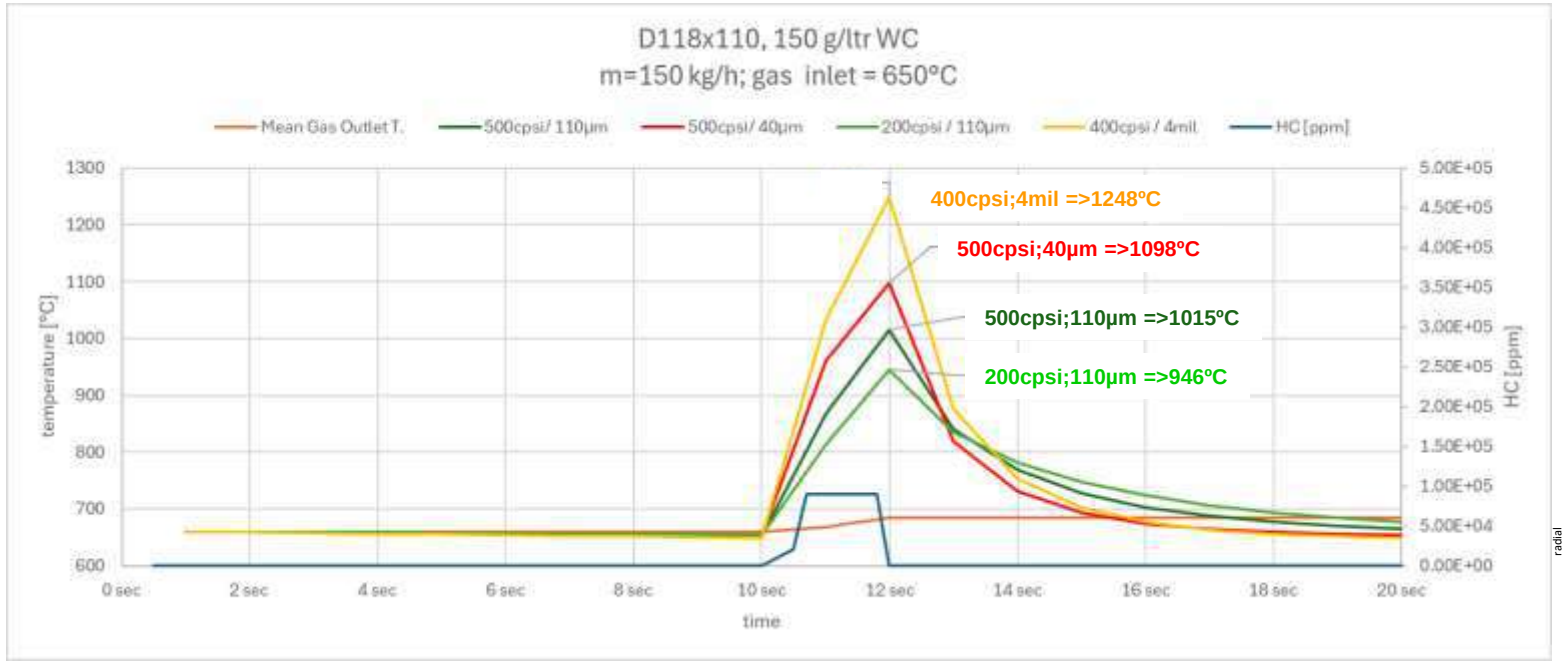
Flexibility:
High



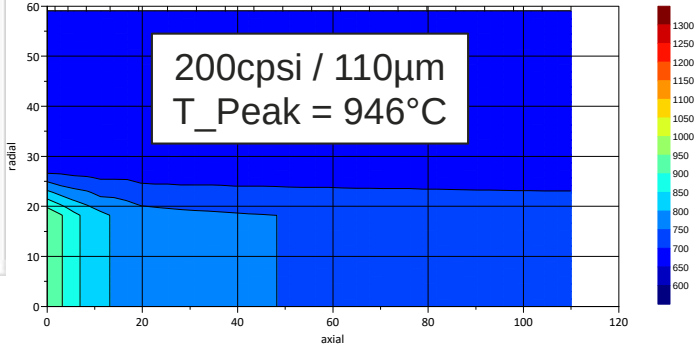
Flexibility:
Low, limited by deep Brazing

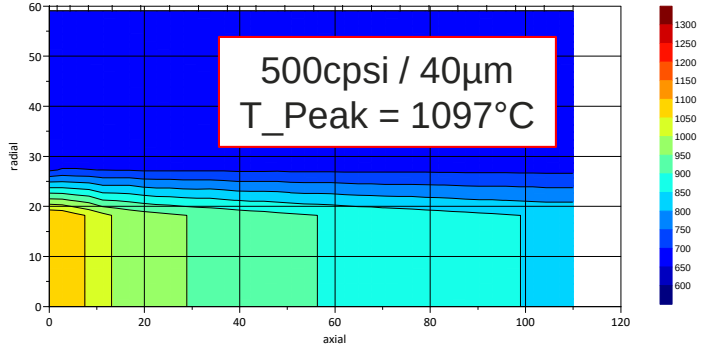
PEAK TEMPERATURE CONTROL WITH FOIL DESIGN

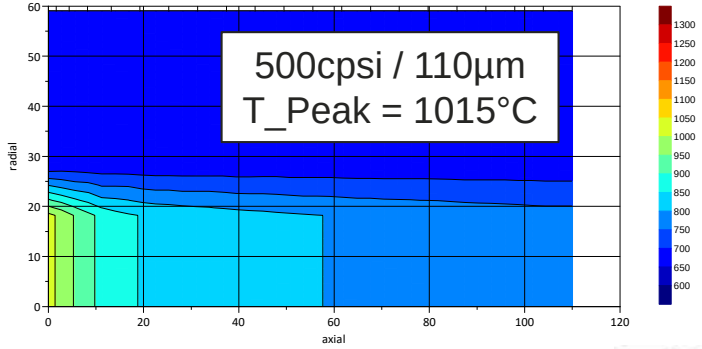
TEMPERATURE FIELD AT 12 SEC AND PEAK TEMPERATURES

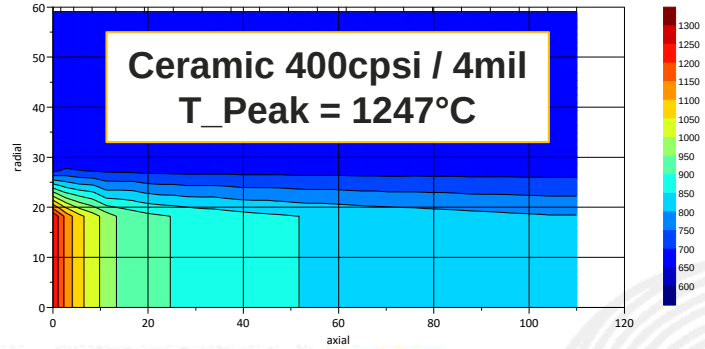


Metallic substrates provide flexibility to control peak temperature through foil design









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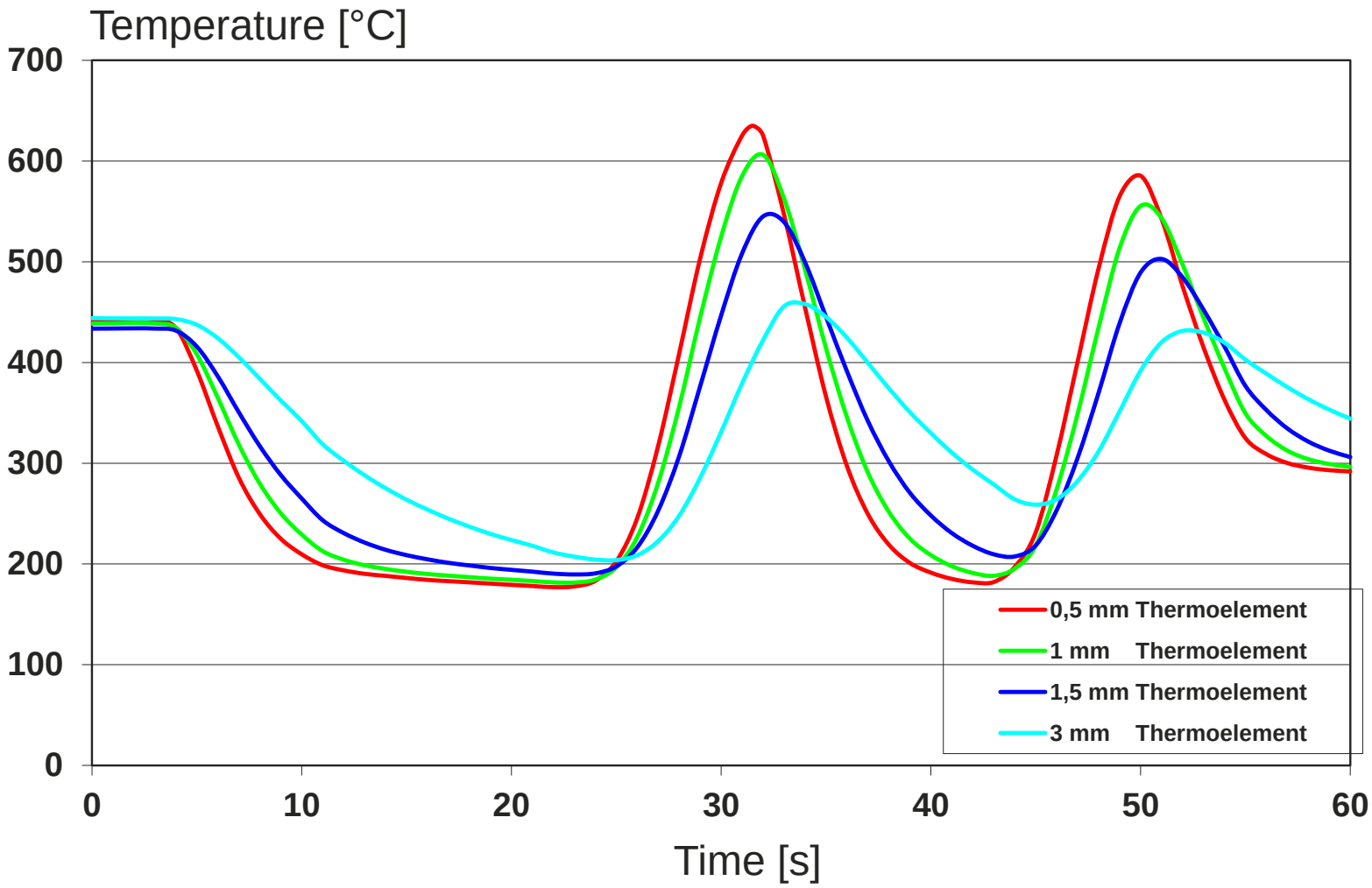
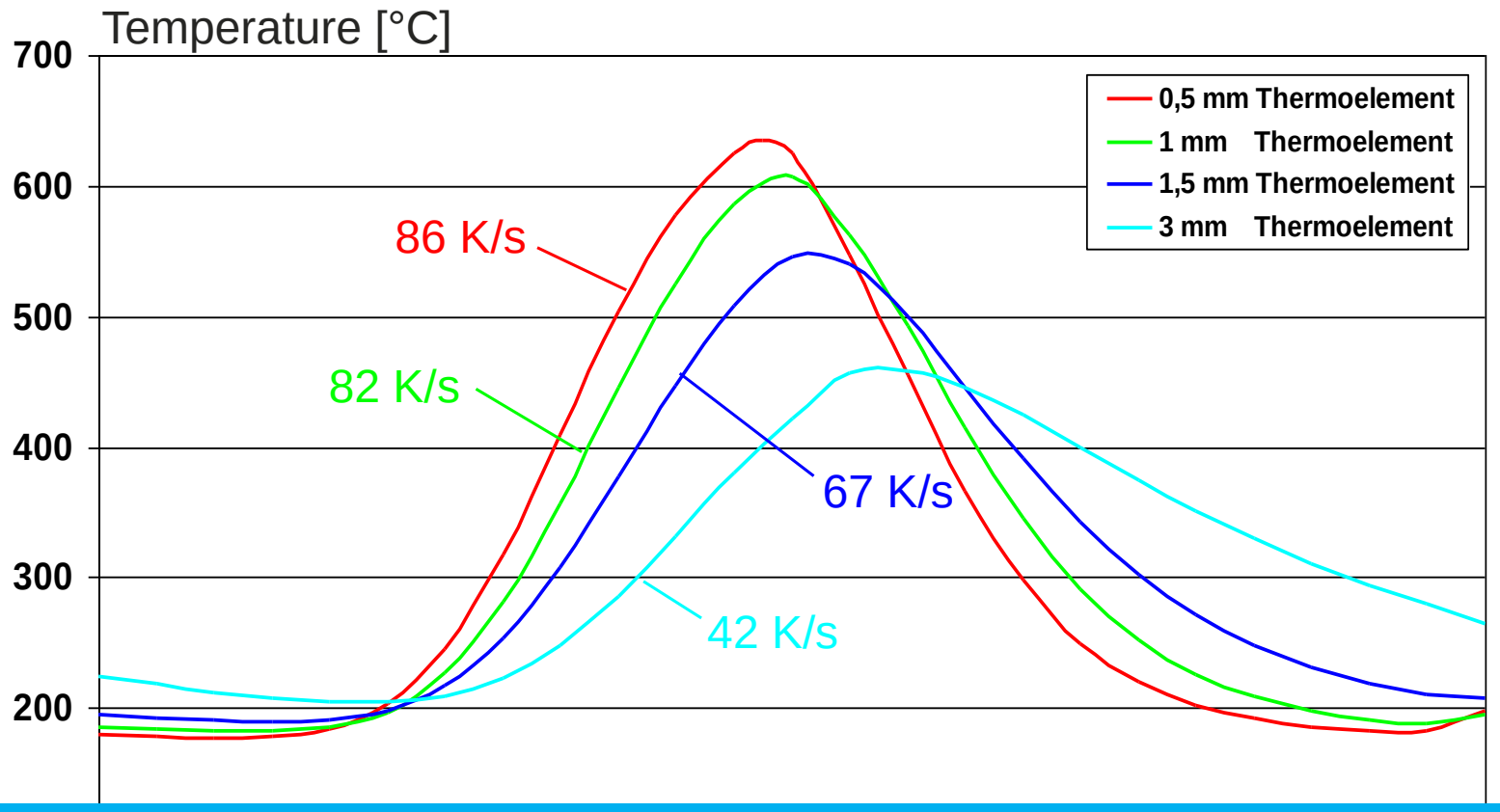
PEAK TEMPERATURE MEASUREMENT

COMPARISON OF THERMOCOUPLE DIAMETERS



TEMPERATURE TRANSIENT MEASUREMENT

COMPARISON OF THERMOCOUPLE DIAMETERS



- **Selection of thermocouple diameter critical to access the realistic thermal loads**
- **Emitec offers instrumented catalysts to assess the application specific thermal stressors**

LOAD DATA COLLECTION BASED ON ACTUAL APPLICATIONS IN FIELD

BOUNDARY CONDITION DEFINITION FOR EMITEC KEY LIFE TIME TEST

	-dT/dt	+dT/dt	Tmin	Tmax	RMS	Time
V6 Turbo, close-coupled	-2600	+8900	380	925	13g	25h
Inline 6 cylinder engine	-3400	+6790	485	945	13g	25h
4 cylinder Turbo close coupled catalyst; manual gearbox	-2800	+8590	410	920	13g	25h
4 cylinder NA, manual gearbox	-1680	+6450	400	95[illegible]	13g	25h
Sportscar >> 400 HP	-4200	+9480	430		16g	10h
4 cylinder Turbo close-coupled Special test track	-5050	+10550	5[illegible]	1010	13g	25h
4 cylinder Turbo close-coupled Highway	-3020	+60[illegible]	490	950	13g	25h
4 cylinder NA 55kW race-track	-2560	[illegible]10	640	940	13g	20h
4 cylinder NA 55kW high-speed track	-18	+6360	570	910	13g	20h
4 cylinder Turbo race-track	-2070	+5770	520	960	13g	25h
4 cylinder Turbo handling track	-2050	+4860	500	640	13g	25h
6 cylinder Turbo Sportscar >> 400HP	-3000	+ 7000	330	1030	16g	10h
Emitec KLT Otto	-2500	6000	330	930	13g	25h
Emitec KLT Diesel PKW	-4000	4000	150	750 (850*)	10g	25h

measured

KLT developed by Emitec represents a long-time proven test procedure to validate substrate durability

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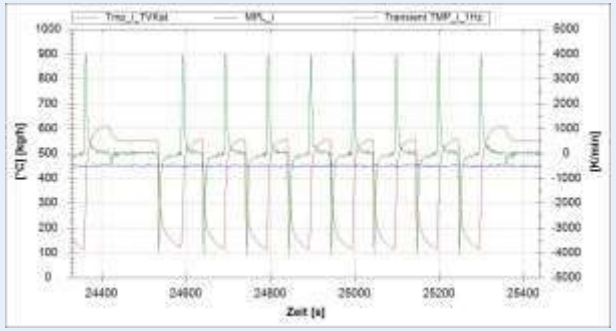
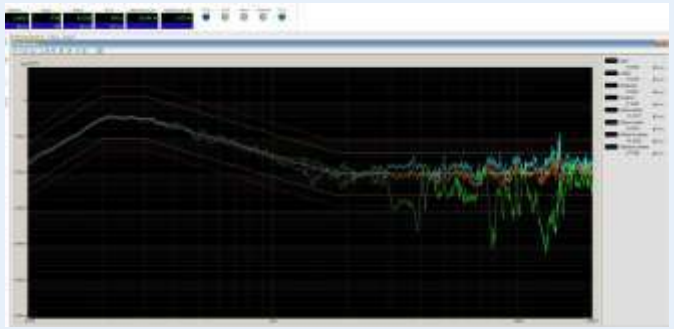
SUBSTRATE VALIDATION ON COMPONENT BENCH

KLT STANDARD BOUNDARY CONDITIONS FOR CNG APPLICATION

Setup:

Parameter		Value
PSD	Acceleration level [g RMS]	6
	Frequency [Hz]	10 - 2000
Gas temperature ºC (Min / Max)		200 / 800
Temperature transients, negative [K/min]		-2500
Temperature transients, positive [K/min]		4000

Mass flow: 450 kg/h

Stressors	Thermal Stressors	Mechanical Stressors
Time plot		
Details	Refer the Table	Refer the Table (PSD)

Vibration profile on KLT more severe compared to vehicle vibration profile

SUBSTRATE VALIDATION ON COMPONENT BENCH

SUBSTRATE CONDITION AT THE END OF ACCELERATED TEST

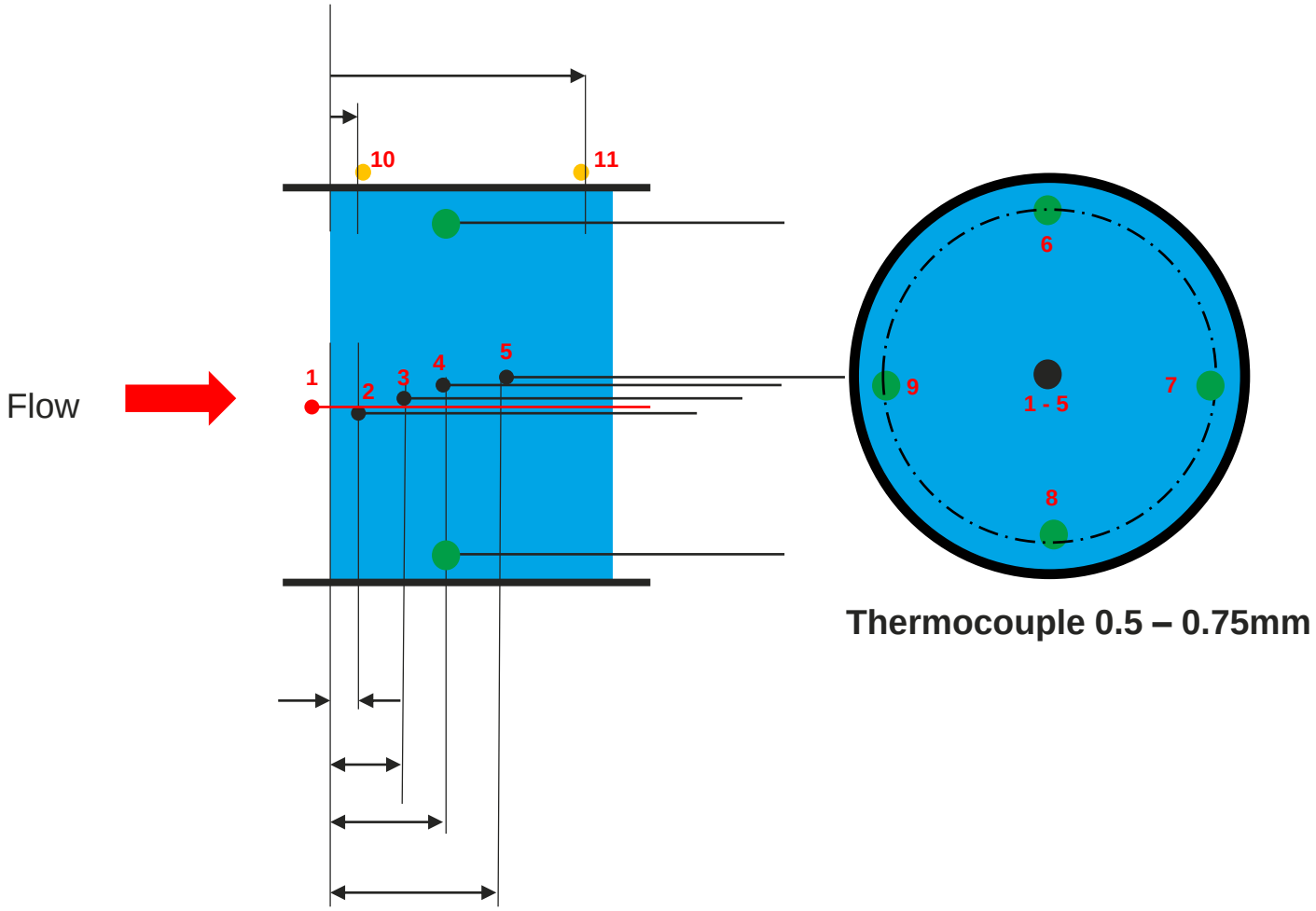
Gas inlet

Gas outlet

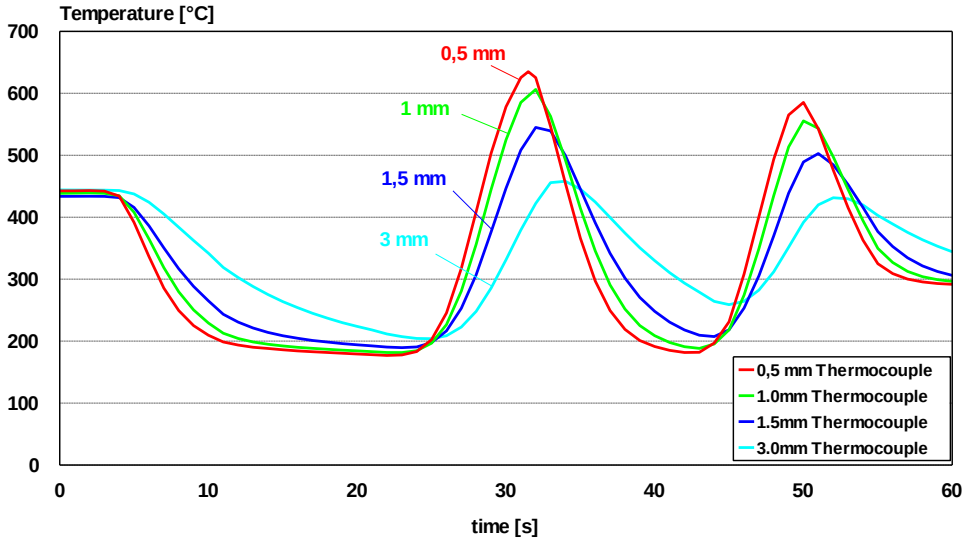
Substrate found in good condition at standard test conditions based on Emitec Key Lifetime Test Cycle

EAS INSTRUMENTATION TO ACCESS THERMAL STRESSORS

THERMOCOUPLES LOCATION ON TWC



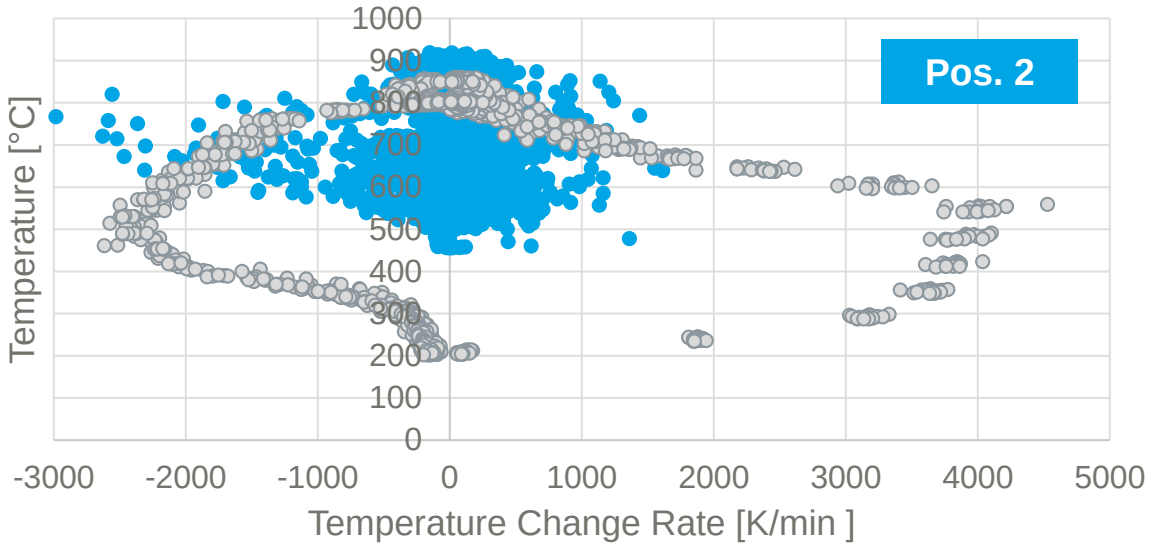
Thermocouple 0.5 – 0.75mm

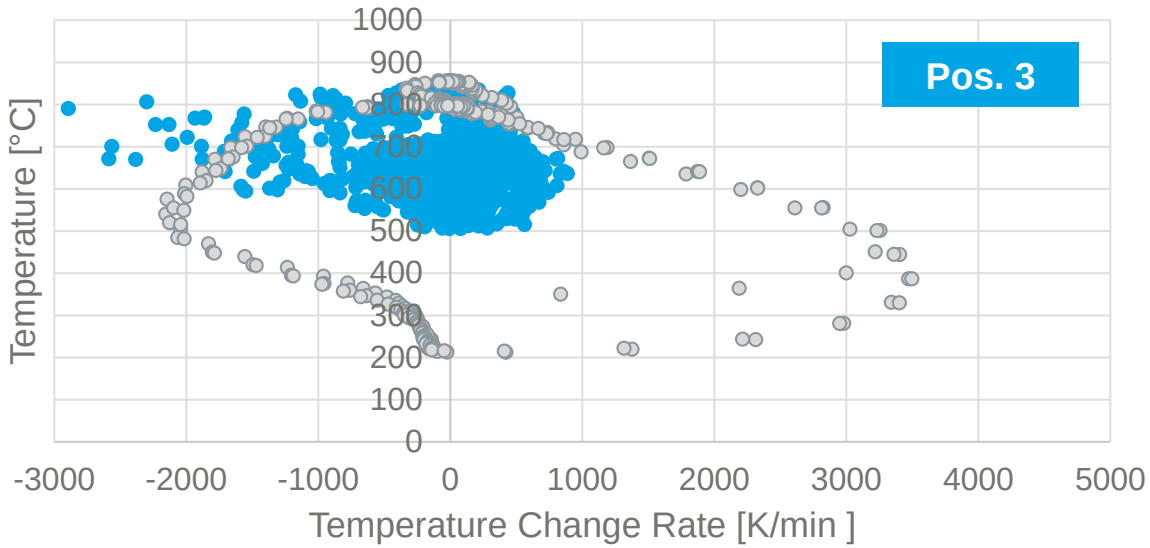


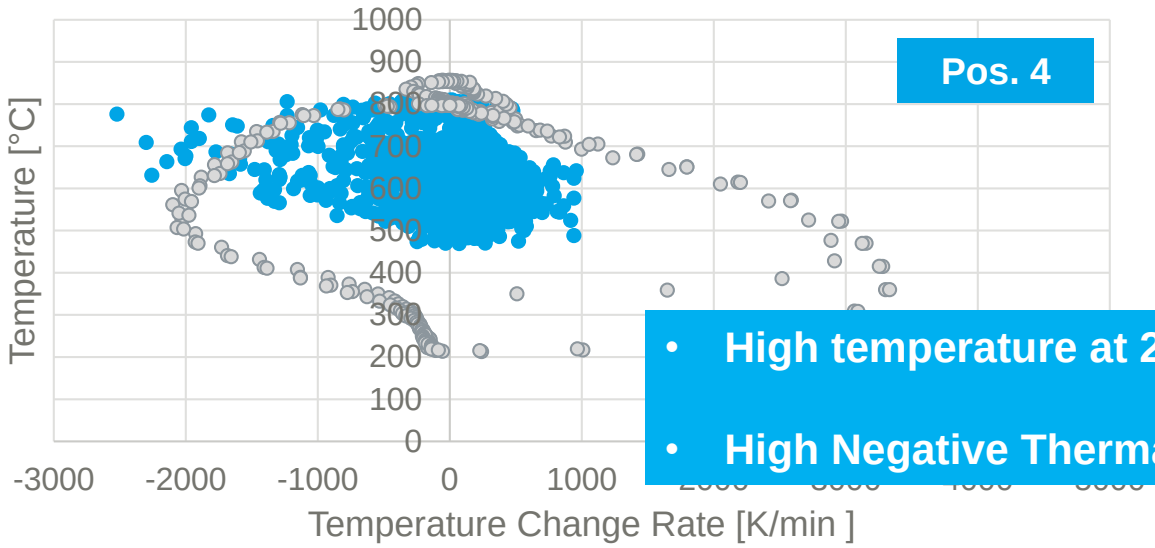
COMPARISON OF THERMAL STRESSORS

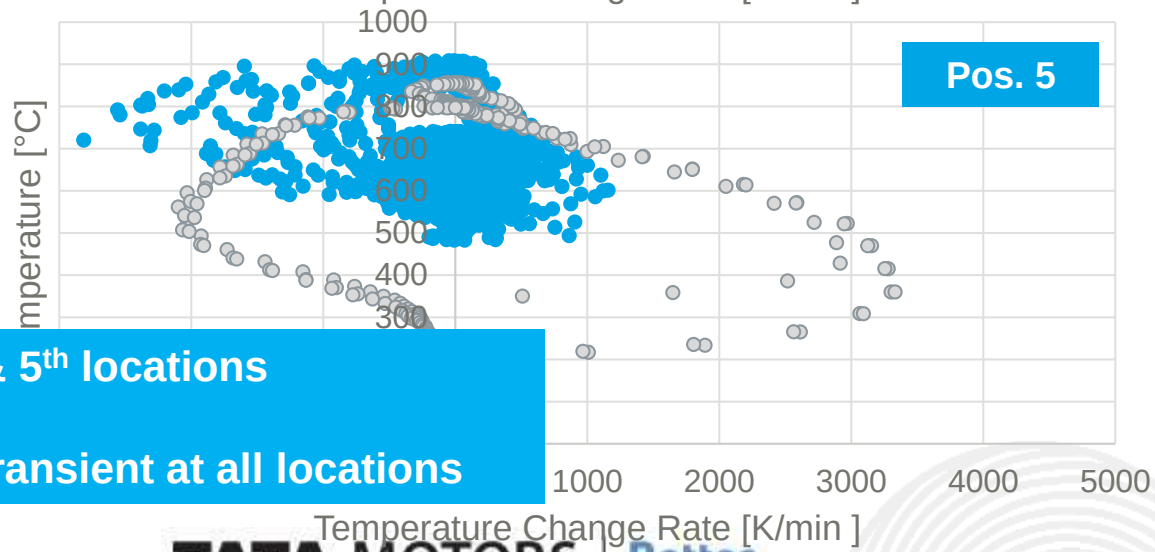
AT VARIOUS LOCATIONS

Emitec KLT Test
Tata Endurance Test









- High temperature at 2nd & 5th locations
- High Negative Thermal Transient at all locations

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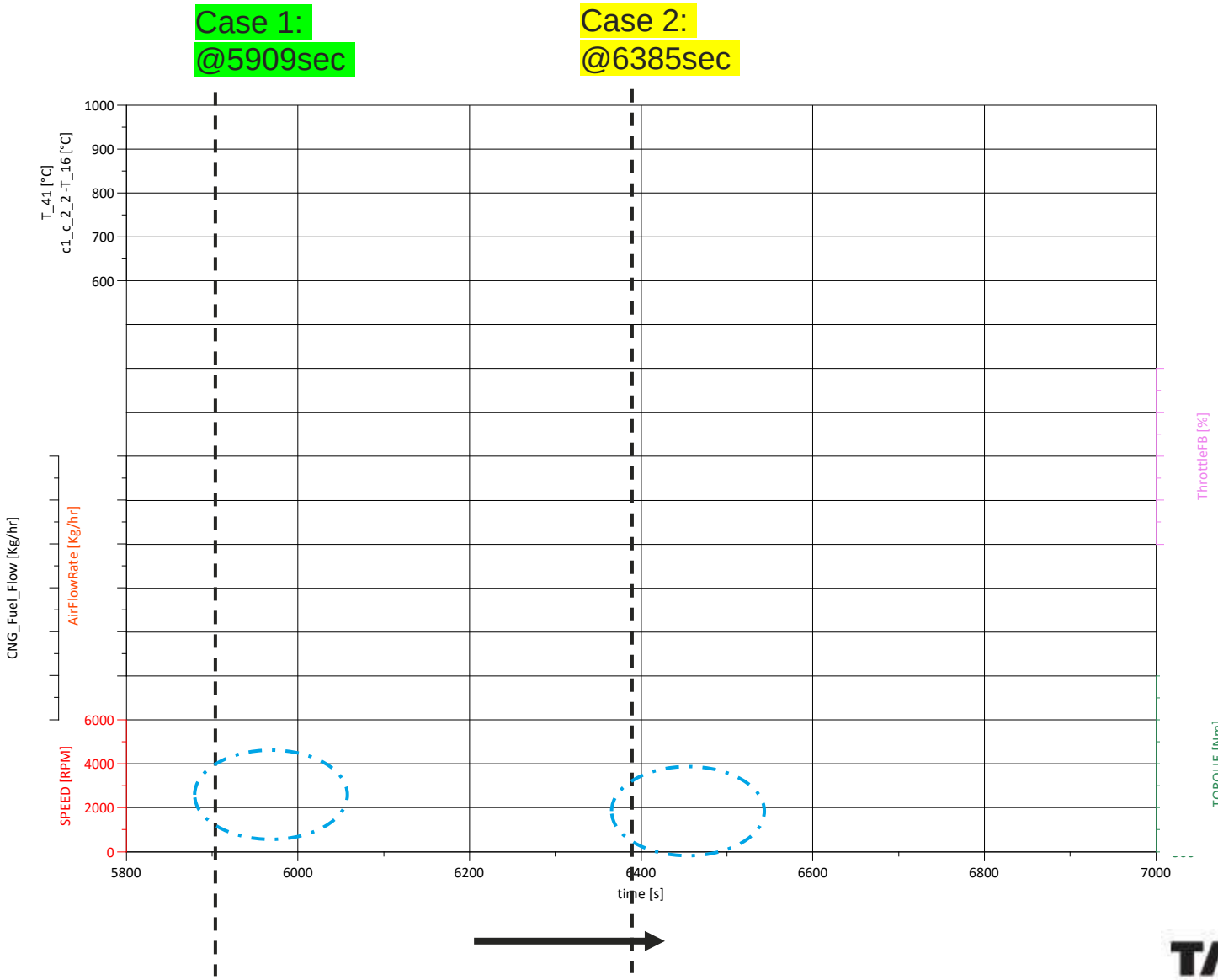
HYPOTHESIS FOR HIGH THERMAL TRANSIENTS

OBSERVATION ENGINE ENDURANCE CYCLE



@5909sec:

Load reduction w/ near zero torque (coasting)

- Engine still firing

@6385sec:

Transition to negative torque (engine braking)

Fuel cut-off (delayed)

Engine becomes an air-pump after delayed fuel cut-off

Result:

- High HC (methane) emissions
- Very low efficiency combustion

At catalyst:

- HC are converted at low gas flow
- Catalyst bed temperature increase
- Convectional heat transfer reduced (low gas flow)

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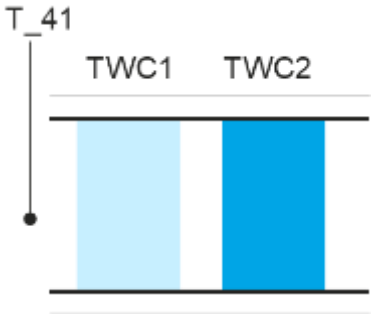
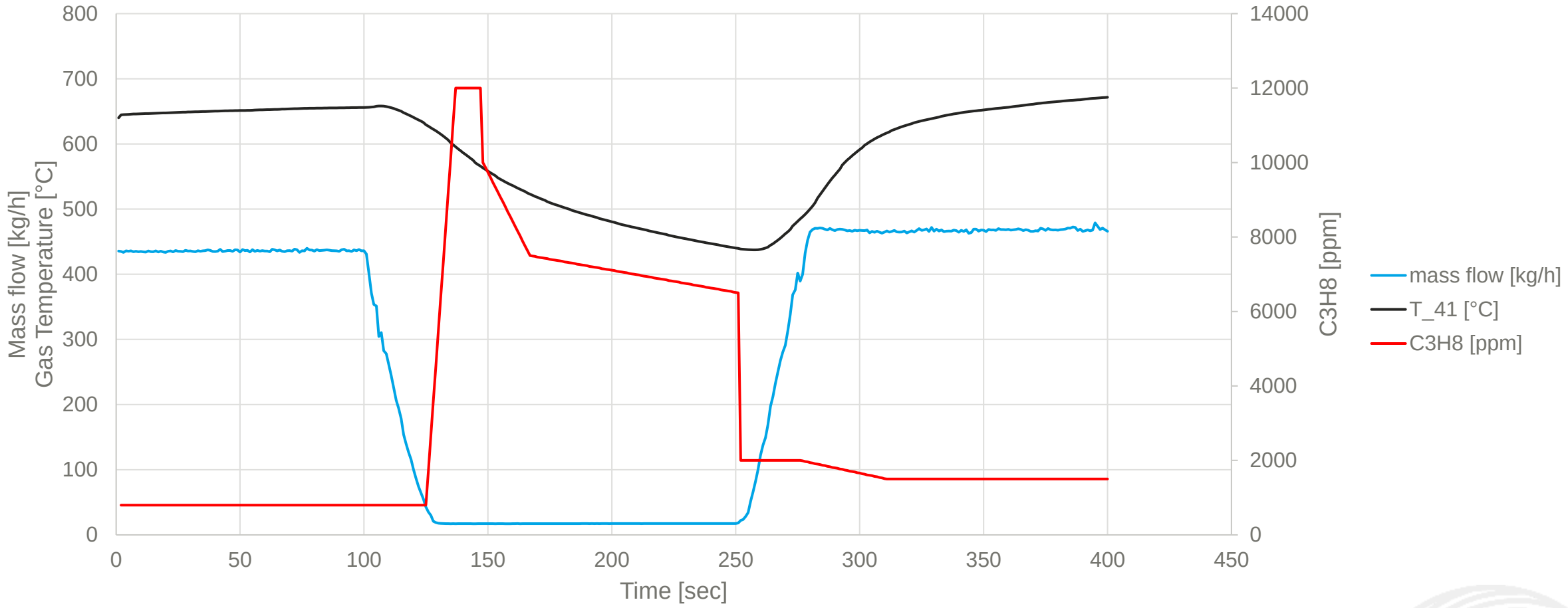
BOUNDARY CONDITIONS FOR KATPROG MODELLING

CASE 2

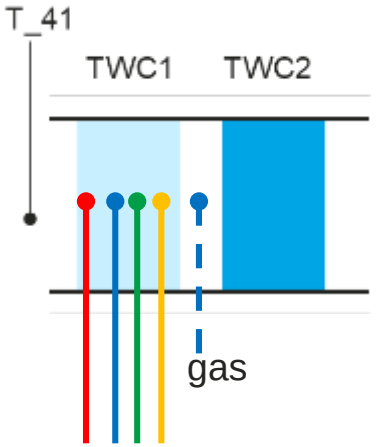


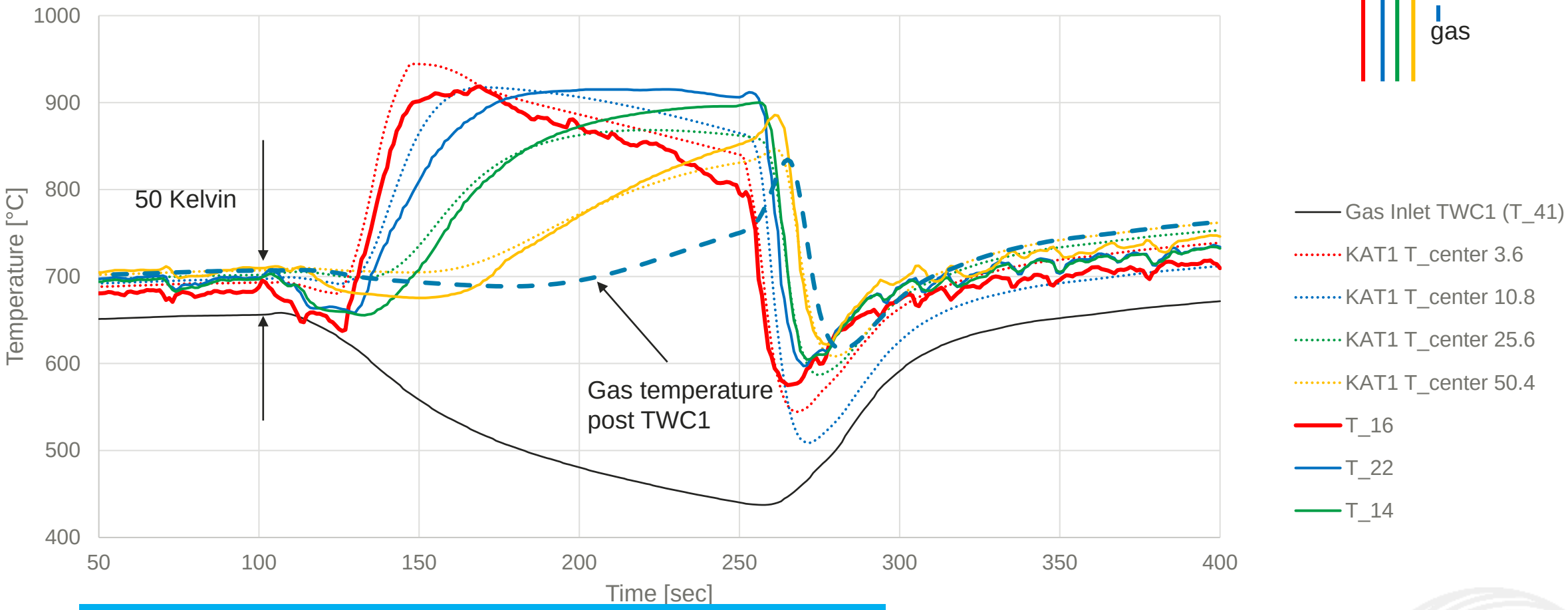


Simulation of high HC slip to correlate thermal behavior

TEMPERATURE AT TWC1 & TWC2 TEST AND KATPROG

C3H8 CONCENTRATION PROFILE TO MATCH TWC CENTER 2MM

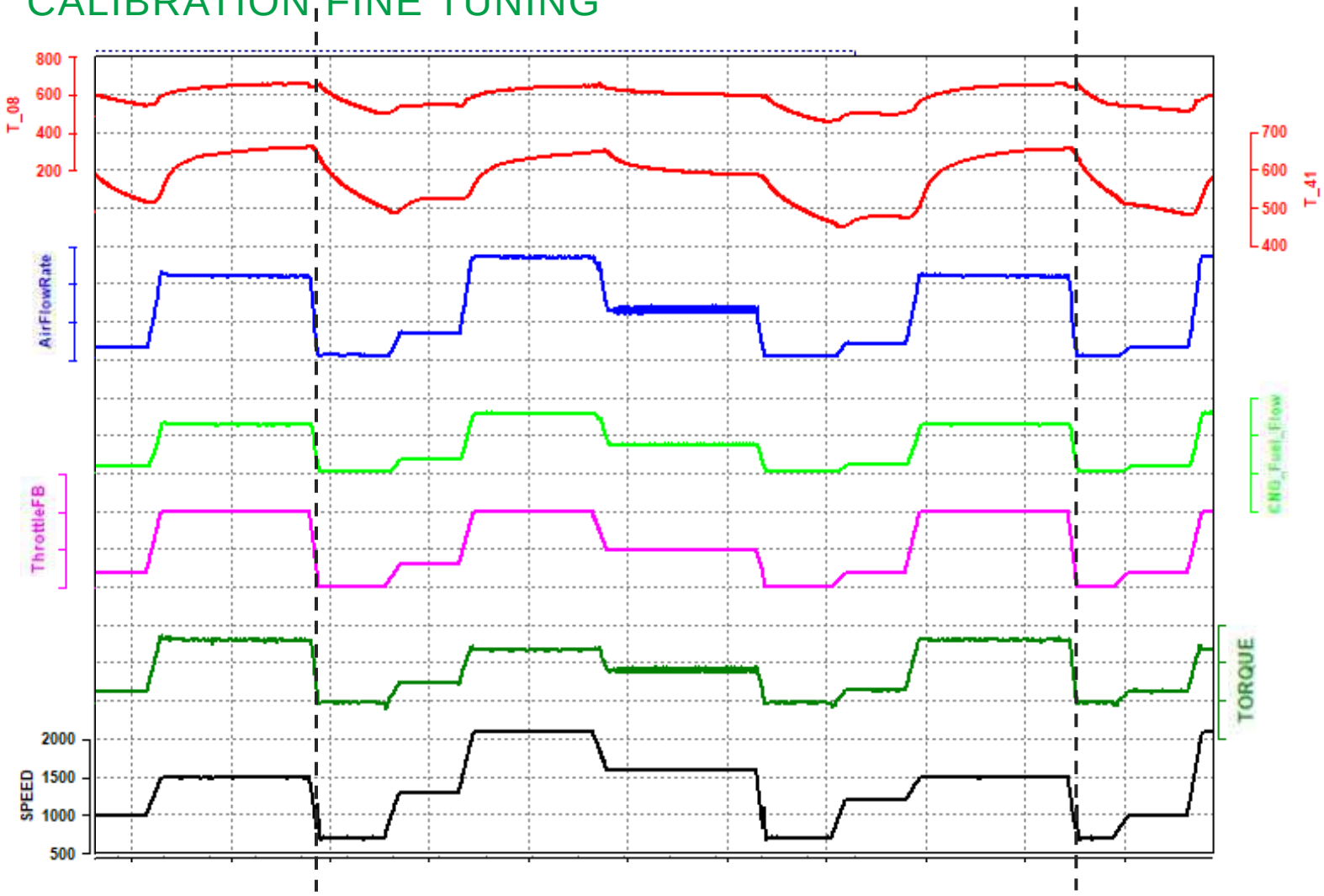




Simulation results correlate well with actual measured temperatures confirming HC slip prediction

MEASURES TAKEN TO CONTROL THERMAL TRANSIENTS

CALIBRATION FINE TUNING



- PGM ratio optimized to control HC oxidation and reduce catalyst bed exotherm.
- Calibration parameters were fine-tuned to minimize methane slip and maintain stable catalyst temperatures during transient and overrun conditions.

Integrated calibration and PGM-ratio optimization reduced catalyst exotherm, improving catalyst thermal robustness

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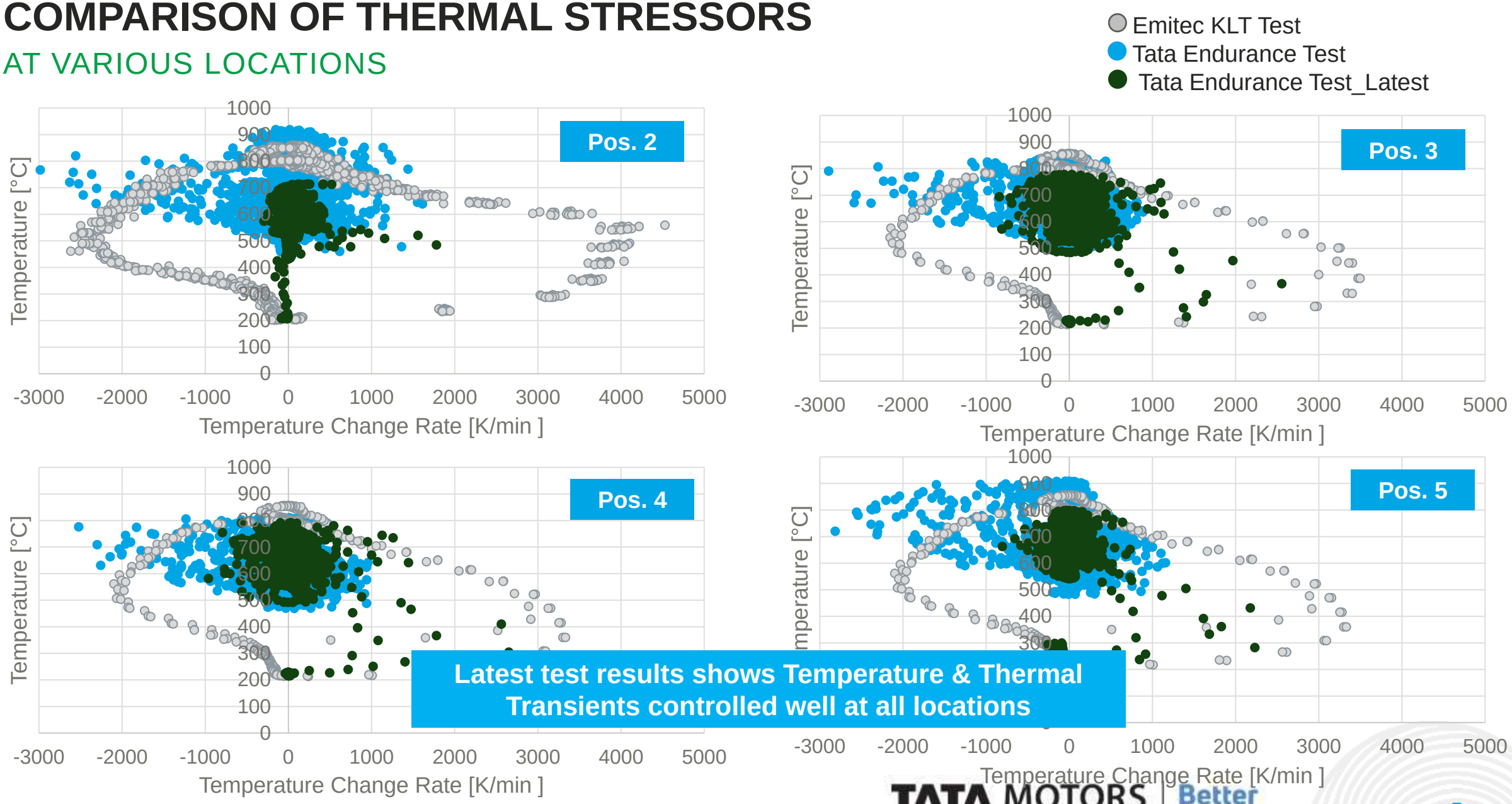
COMPARISON OF THERMAL STRESSORS

AT VARIOUS LOCATIONS



Latest test results shows Temperature & Thermal Transients controlled well at all locations

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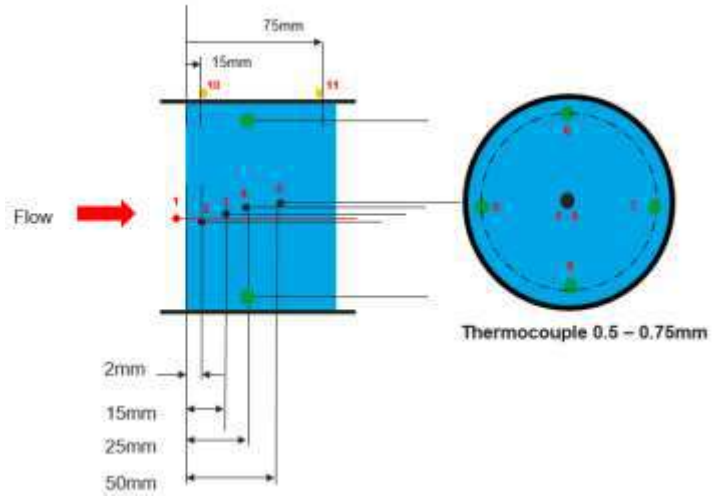
TEMPERATURE ASSESSMENT WITH IMPROVED CALIBRATION

ENGINE ENDURANCE CYCLE

Parameter	Latest results	Previous results
Peak temperature	**800 ºC**	921 ºC
Max. Temperature transient (Positive)	**3200 K/min**	2000 K/min
Max. Temperature transient (Negative)	**1700 K/min**	4000 K/min
Max. Temperature Gradient (Exotherm)	**~ 350°C**	> 500°C



- **Significant reduction in peak temperature, negative temperature transients & exotherm with improved calibration**
- **Positive temperature transient within acceptable limit of 4000 K/min**

Instrumented catalyst aids Application Engineers to get better understanding on what happens inside the catalyst to assure long term durability and fulfillment of the legislative requirements

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COATED SUBSTRATE VALIDATION ON COMPONENT BENCH

AT ELEVATED TEMPERATURE CONDITIONS – APPLICATION SPECIFIC REQUIREMENT

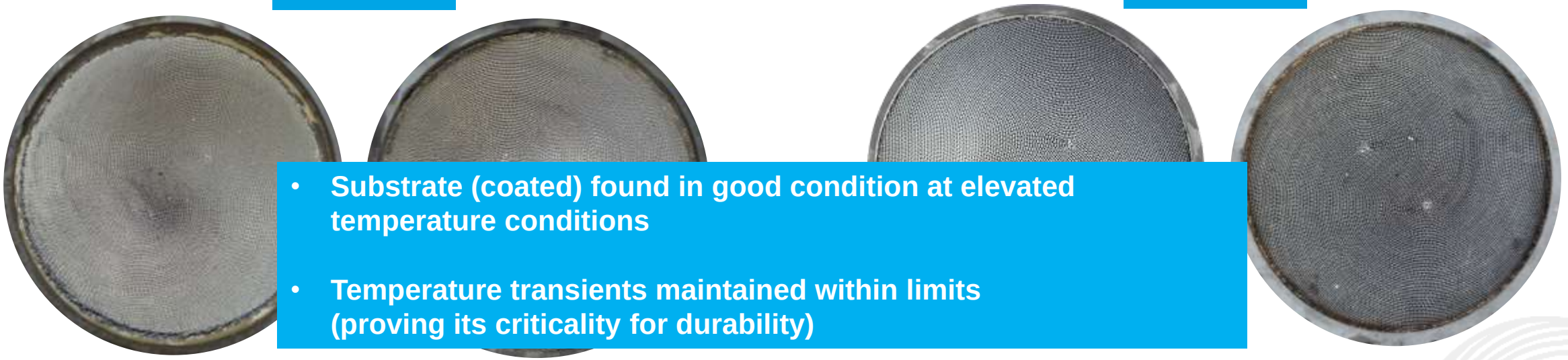
Setup:

Parameter	Value
Gas temperature ºC (Min / Max)	1000 / 1100
Temperature transients, negative [K/min]	-2400
Temperature transients, positive [K/min]	2400

Mass flow: 450 / 550 kg/h

TWC 1

TWC 2



- **Substrate (coated) found in good condition at elevated temperature conditions**
- **Temperature transients maintained within limits (proving its criticality for durability)**

CONTENTS

- EMITEC TECHNOLOGIES
- CNG APPLICATION CHALLENGES & STRESSORS ON METAL SUBSTRATES
- COLLOBORATIVE APPROACH FOR ENHANCING DURABILITY
- **CONCLUSION**

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CONCLUSION

- Emission performance requirements without compromising on the durability to meet the in-service compliance requirements is key objective.
- CNG application poses challenges & accessing thermal stressors is critical to select right substrate design & ensure long term durability performance
- This activity provided a key learning for the need of collaborative approach between OEMs & Catalyst suppliers to ensure a successful application development meeting the stringent emission & durability requirements which becomes even more critical for upcoming BS7 regulation (durability requirements extend by 25% to 875,000 kms for HDVs)

CLOSING SLIDE