CPCB IV+ Emission Upgrade Challenges
Air Cooled Engines

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Introduction

Manoj Kusumba
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Engine R & D, TMTL
Alwar, Rajasthan

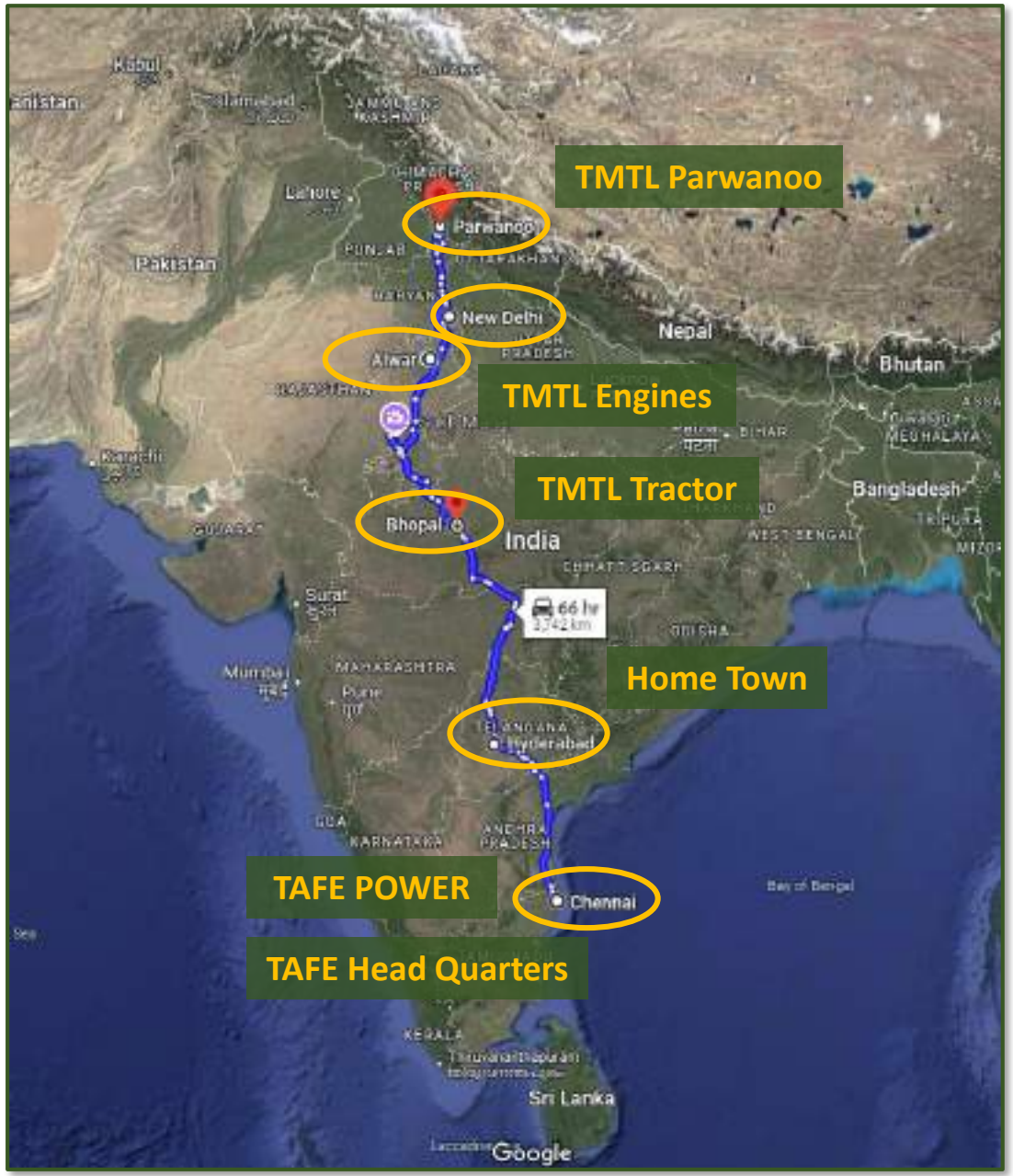
From : Hyderabad, Telangana

Education :
M .Tech (Masters in Technology)
Design & Production of I.C engines (NIT/REC, Warangal)

Work Experience :
Diesel engine design & development. – 30 years
AVL Technical Centre, Gurgaon, India
Skill team leader, Diesel engine development : 18 years
Earlier work experience : 10 years

- Punjab Tractors Ltd (Mahindra Swaraj) Engine R & D
- GE Transportation Systems, Engine R & D
- Automotive Research Institute (ARAI), Engine R & D

Hobbies:
Music (Indian classical, learning to play violin)
Sports (Cricket, table tennis)



Contents

- Product portfolio
- Emission limits
- Design & Development methodology
  - Power ratings : 8 < P < 19 kW
  - Power ratings : 19 < P < 56 kW
- Critical design & development activities
- OBD – NOx Control Diagnostics (NCD)
- Engine emission certification (TA)






Product portfolio

Tractors

Power Generators

Agro Engines

Industrial Engines

Product portfolio

De-Watering Pump

Air Compressor
Application for India Army

Gensets for Defense Application

Transit Mixture

Customised genset for COVID VACCINATION BUS

Emission Limits

Emission limits for Genset engines up to 800 kW Gross Mechanical Powered by 1) All CI engines and 2) PI engines > 800 cc engine displacement.

Power Category, kW	NOx	HC*	NOx +HC*	CO	PM		Smoke (light absorption coefficient)	
	CI/PI	CI/PI	CI/PI	CI/PI	CI	PI	CI	PI
	g/kWh						m^{-1}	
P ≤ 8	-	-	7.5	3.5	0.30	-	0.7	-
8 < P ≤ 19	-	-	4.7	3.5	0.30	-	0.7	-
19 < P ≤ 56	-	-	4.7	3.5	0.03		0.7	
56 < P ≤ 560	0.40	0.19	-	3.5	0.02	-	0.7	-
560 <P ≤ 800	0.67	0.19	-	3.5	0.03	-	0.7	-

Category (Power Band)	Emission durability period (hours)	Engine Category
>19 ≤ 56 kW (constant speed Engines)	3000	PI and CI
>19 ≤ 56 kW (Variable speed Engines)	5000	PI and CI
> 56 kW (All engines)	8000	PI and CI

(b) As an alternative to use a service accumulation schedule to determine deterioration factors, engine manufacturers may select to use the assigned multiplicative deterioration factors as per Table 4 given below for engine families using exhaust After-treatment system.

Engine Category	CO	HC	NOx	PM
CI	1.3	1.3	1.15	1.05
PI	1.3	1.3	1.15	-

Emission Limits

Genset application	Emission limits		
Power P (kW)	Emission	CPCB II	CPCB IV+
8 < P < 19	NOx + THC	7.5	4.7
	PM	0.3	0.3
19 < P < 56	NOx + THC	4.7	4.7
	PM	0.3	0.03

38 % NOx reduction

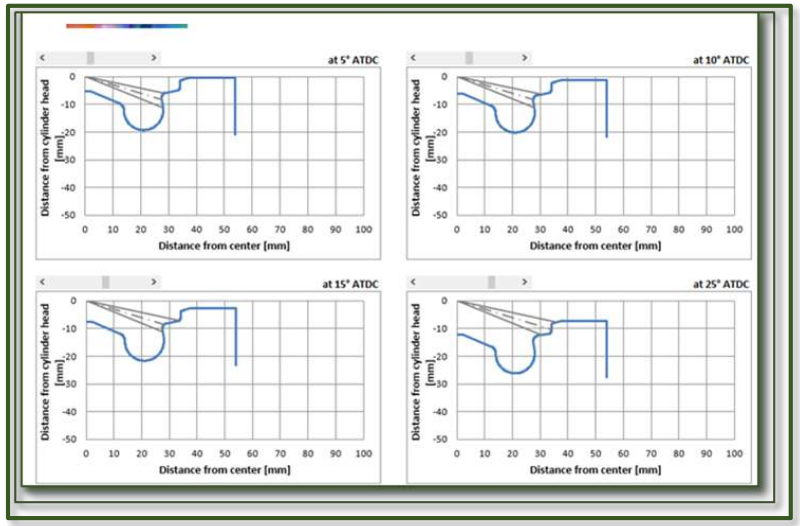
90 % PM reduction

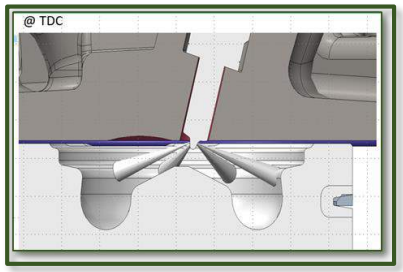
Significant NOx and PM reduction from CPCB II to CPCB IV+ Emission Upgrade

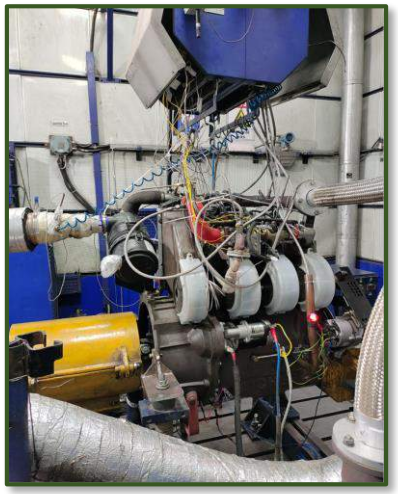
Power ratings : 8 < P < 19 kW

Single/multi cylinder air cooled engine series

- Mechanical fuel injection system
- Naturally Aspirated (NA)
- Hot EGR
- Progressive EGR valve
- EGR control strategy / controller
- NCD controller (OBD compliance)







Phase 01 : Design and simulation

- Introduction of EGR
  - Progressive EGR valve
  - EGR distribution / mixing optimisation
  - EGR control strategy / controller
- Combustion system optimisation
  - Swirl ratio
  - Fuel injection nozzle spray configuration
  - Combustion chamber
  - Compression ratio
- NCD controller (OBD compliance)

Phase 02 : Performance & Emission development

- P & E development
  - EGR, Swirl ratio
  - Fuel nozzle (No. of sprays, flow, cone angle)
  - Combustion chamber
  - Fuel injection timing
  - High altitude & cold start verification

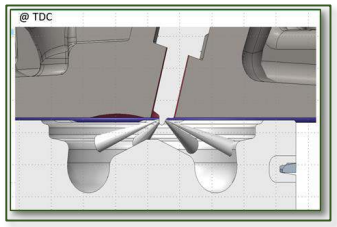
Phase 03 : Emission consistency & durability

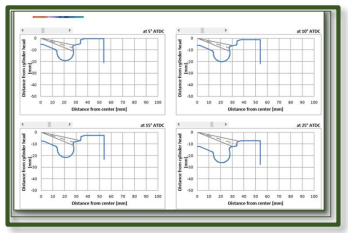
Systematic, methodology based design and development

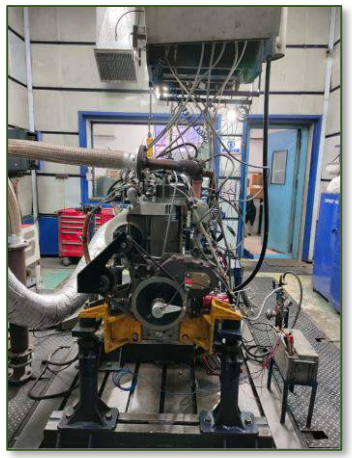
Power ratings : 19 < P < 56 kW

Multi cylinder air cooled engine series

- Electronic fuel injection system
- Naturally Aspirated / Turbocharged / Intercooled (TCIC)
- Hot EGR / Cooled EGR
- EGR control strategy / controller
- Diesel Oxidation Catalyst
- ECU functionality – air cooled engines







Phase 01 : Design and simulation

- Introduction of EGR
  - Progressive EGR valve
  - EGR distribution / mixing optimisation
- Combustion system optimisation
  - Swirl ratio
  - Fuel injection nozzle spray configuration
  - Combustion chamber
  - Compression ratio

Phase 02 : Performance & Emission development

- P & E development & Calibration
  - EGR, Swirl ratio, Fuel nozzle (No. of sprays, flow, cone angle). Combustion chamber
  - Main, pilot, post injections, Rail pressure,
  - Base engine calibration
  - Engine protection calibration
  - High altitude & cold start calibration
  - OBD calibration

Phase 03 : Emission consistency & durability

Systematic, methodology based design and development

Critical design & development activities

- Liner temperature : Main injection timing, EGR, ambient temperature
- Hot side EGR valve : Oil cooled EGR valve
- Particulate matter : bore distortion, oil consumption, piston pack optimisation
- High temperature operating condition in canopy : Liner temperature
- High Altitude capability : Liner temperature
- NCD control strategy (OBD compliance) : Mechanical fuel injection systems
- Base CRDI engine software and corrections compatibility : More precise corrections (lube oil based)

Methodology and experienced based development & calibration

CPCB IV+ Applications with
- Single Cylinder
- Air cooled
- Mechanical fuel injection systems
- Mechanical speed governing

USP

CPCB IV+ Applications with
- Multi Cylinder Engines
- Air cooled
- NA, TC, TCIC
- Electronic fuel injection systems

Patent Filed

Systematic, methodology based design and development : Efficient, robust and unique applications

OBD – NOx Control Diagnostics (NCD)

EGR is used to control NOx, For any error related to EGR valve:
Warning will be indicated by MIL lamp blinking and buzzer in the control panel
As per regulations, following strategies are used for NCD (NOx Control Diagnostics):

Strategy – A

- Warning- up to 36 hours
- Low level inducement- 36 to 72 hours
- Severe inducement- beyond 72 hours & Engine shut off reaction.

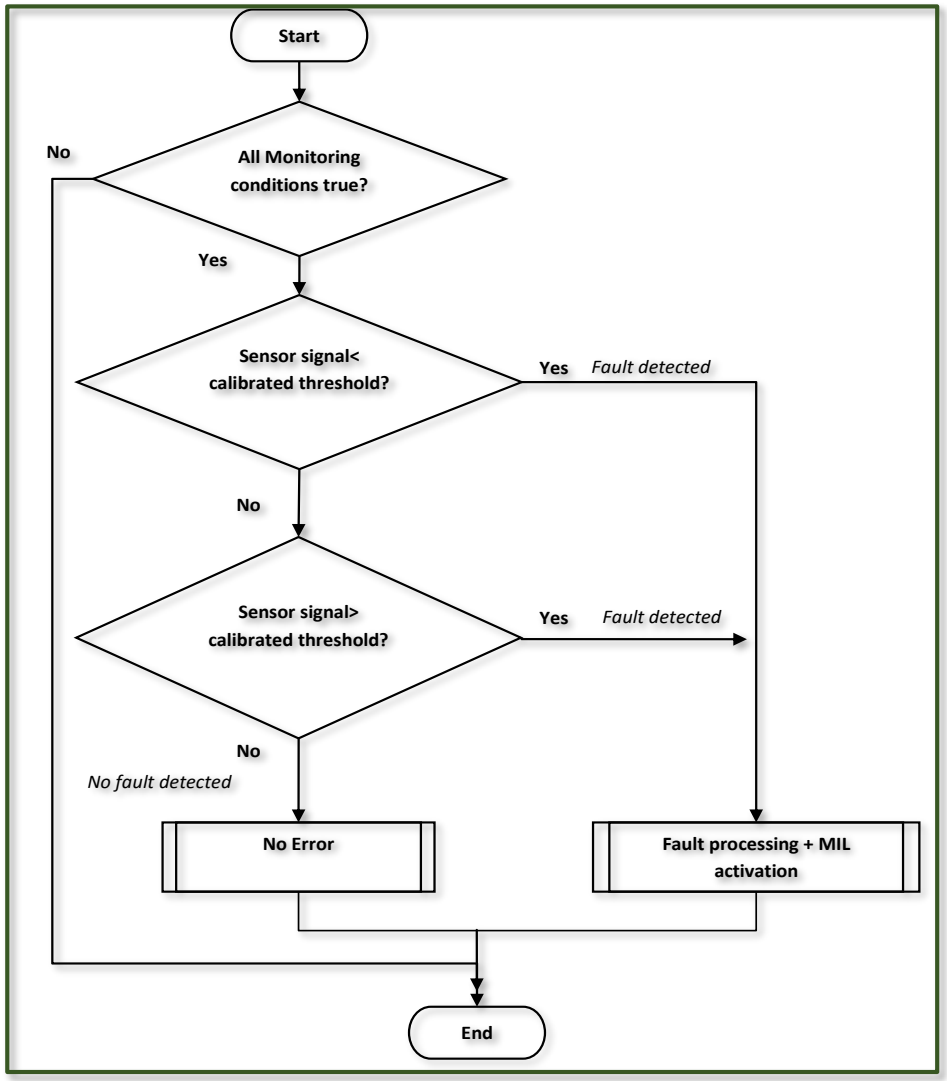
Inducement group	NCD Inducement level	Lamp Behaviour	Buzzer pattern	Lamp pattern	Engine behaviour (Torque inducement)	Time (as per legislation)
EGR category	Warning stage	MIL ON	NIL	Continuous ON	No reaction	first 36 hours
	Low level Inducement	MIL Blink	2 sec ON - 5 sec OFF	2 sec ON - 3 sec OFF	No reaction	36th to 72nd hour
	Severe Inducement	MIL Blink	2 sec ON - 2 sec OFF	2 sec ON - 2 sec OFF	Engine shut off	at 72nd Hour

Strategy – B

- Warning- up to 36 hours
- Low level inducement- 36 to 120 hours with 50% reduce torque.
- Severe inducement- beyond 120 hours & Engine shut off reaction.

Inducement group	NCD Inducement level	Lamp Behaviour	Buzzer pattern	Lamp pattern	Engine behaviour (Torque inducement)	Time (as per legislation)
EGR category	Warning stage	MIL ON	NIL	Continuous ON	No reaction	first 36 hours
	Low level Inducement	MIL Blink	2 sec ON - 5 sec OFF	2 sec ON - 3 sec OFF	50%	36th to 120th hour
	Severe Inducement	MIL Blink	2 sec ON - 2 sec OFF	2 sec ON - 2 sec OFF	Engine shut off	Beyond 120th Hour

OBD – NOx Control Diagnostics (NCD)



Operator warning

0 to 36 hrs ➔ Only visual error, Immediately Fault should display and counter start for engine operating hours. Also, error should be non-erasable by end user for analysis purpose, till authorized person reset / clear it after rectification.

Low Level Inducement

36 to 72 hrs ➔ Visual error & Audio buzzer once in 5 sec

Severe Inducement

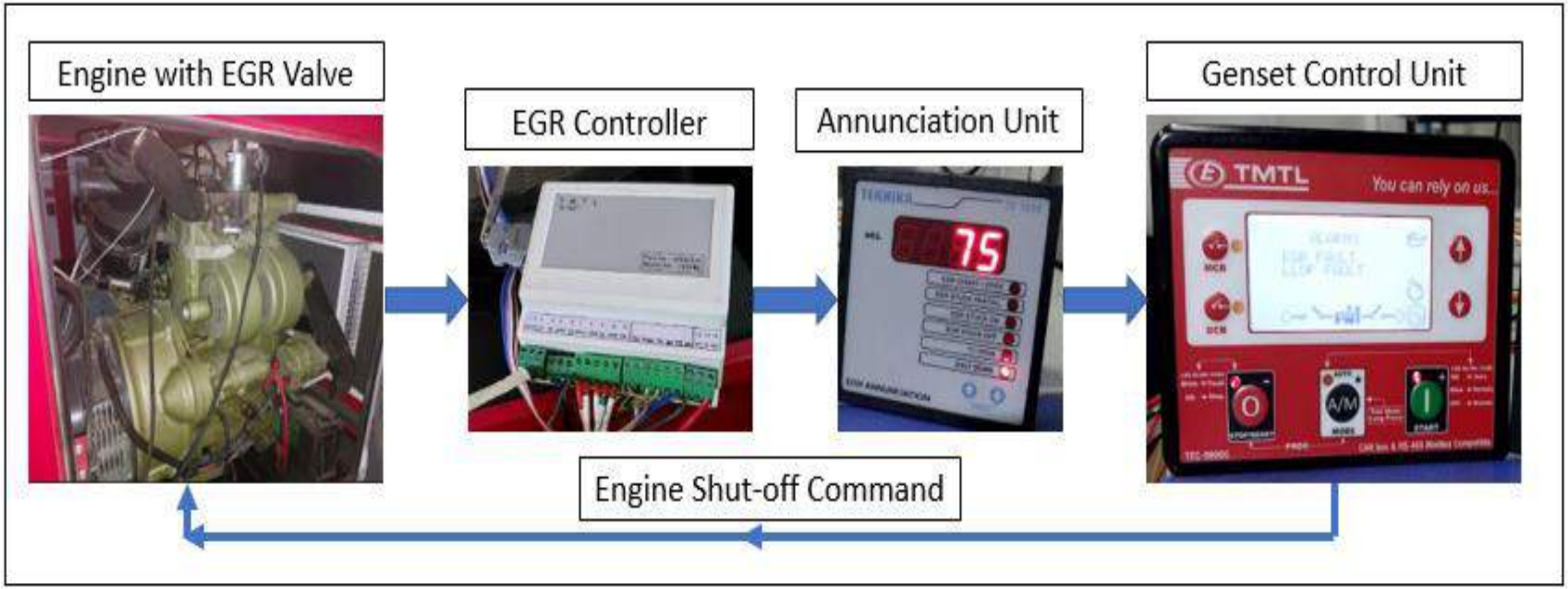
72 hrs onwards ➔ Visual error & Audio buzzer every in 2 sec with 2 sec long beep.

Secondary action at 36 hrs ➔

Strategy 1: If Genset load is > 50% at 36hrs, then it should continue with full load capacity till 72 hrs., followed by shut down and then not allow to start till rectification done by authorized person.

Strategy 2: If Genset load is < 50%, then it should continue running with part load limitation from 36 hrs. till 120 hrs., followed by shut down and then not allow to start till rectification done by authorized person.

Block diagram



Engine emission certification (TA)

Major activities :

- Design update : EGR , CRDI and Exhaust aftertreatment (DOC).
- Engine test bed development : Performance & emission development
- Engine performance, emission, high altitude, cold start and OBD calibration
- Engine emission Type Approval certification
- Emission consistency verification.
- Min/Max tolerance investigation (combustion sensitivity/calibration robustness)
- Beta engine calibration update and validation.
- Engine Type Test certification.

CPCB IV+ emission upgrade activity executed as a complete in house design, development and calibration project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Thanks