Truckflow

质量流量传感器

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Systec Controls
Puchheim, Germany

Welcome to systec

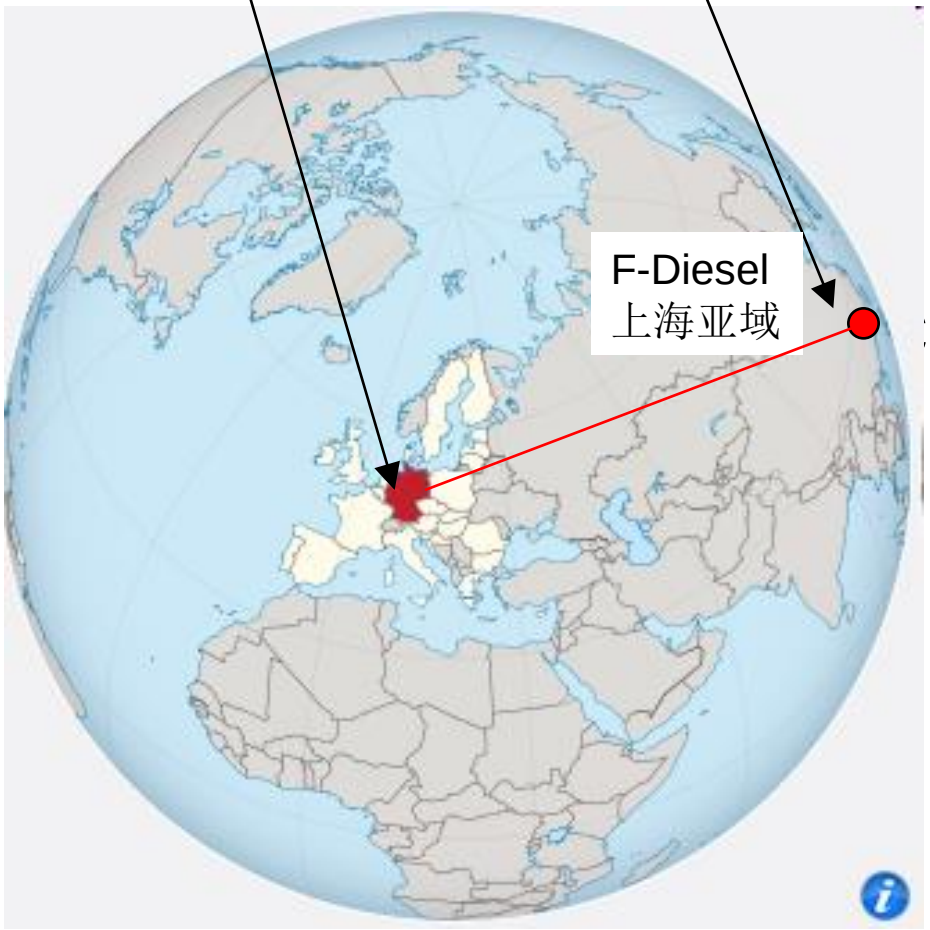
Systec 总部
Puchheim, Germany
开发和生产部门总共约220员工

Where we are 我们是谁

Germany

China

Free State Bavaria



Systec 25km from Munich

Systec距慕尼黑25公里

Systec Group， Systec集团

- 1974 systec Ausbausysteme
- Engineering Company for Building Autom.
- Engineering for Lightsystems
- 1981 systec POS

- 1994 systec Controls

- 1999 Ungurean Service GmbH
- 2000 Wieth Racing

- systec Group approx. 220 Employees

Systec Controls 目标

Systec Controls = 流量传感器专家

- **Development** and **Production** of **Best available technology products** 开发生产最优秀的产品
- „**Niche**“-products with a **high value for customer** 定制高附加值产品
- **Extension** of the national and **international sales** 扩张本国和国际市场销量

In China 中国:

2001: Co-operation with Maxonic, 合作深圳 Maxonic (Industrial工业产品)

2014: Co-operation with F-Diesel, 合作上海亚域 (Automotive汽车产品)

Some systec Controls Customer 部分客户

Flow Meter for Gas, Liquid and Steam deltaflow
燃气、液体、蒸汽流量测量计

Application应用: Stack gas
Customer客户: Aventis
Certificates证书: 13 und 17. BImSchV
Advantage优势:
- **venturi 400% more expensive**
- **thermals mass flow meters drift**
- **precise multipoint**

Application应用: high pressure gas
Customer客户: Gaz de France
Certificates证书: PED / Ex
Advantages优势:
- **orifices get flooded**
- **vortex did not work**
- **insensitivity on condensates and particles**

Deltawave Ultrasonic Flow Meter / deltaflowC
Deltawave超声流量计 / DeltaflowC

Clamp-on ultrasonic Flow meter 超声流量计

deltaflowC Low-cost gas mass flow meter 低成本流量计

Automotive Products汽车产品: Truckflow

Application 应用:

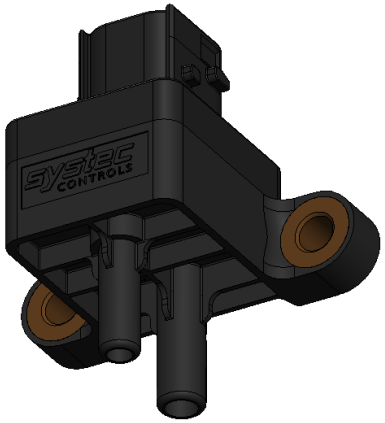
Air-, EGR-, Exhaust Massflow for Trucks / Off-Road

卡车和非道路的新鲜空气、EGR、废气流量测量

Advantages 优势:

- **Robust, 1.000.000 miles 耐用**
- **High Accuracy 精度高**
- **Low calibration effort 标定简单**

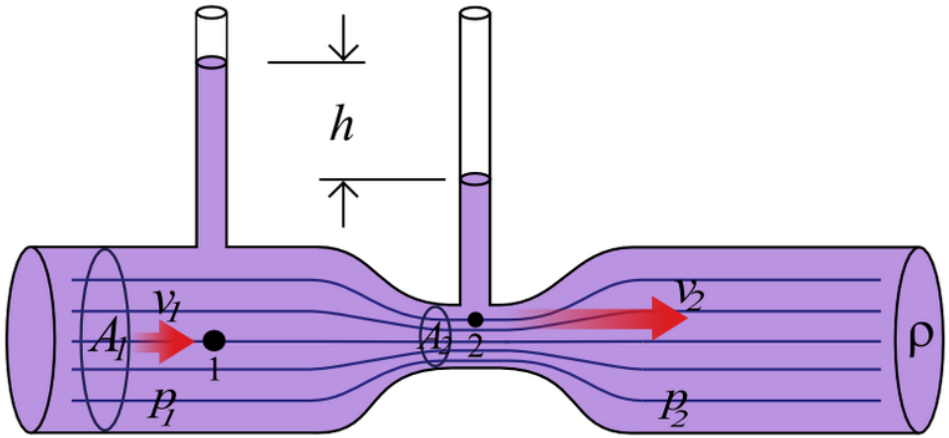
TFI4



TFI4-2P

Venturi principle

Daniel Bernouli, 1700-1782



Bernouli:
An increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid‘s potential energy.
(energy conservation)

Bernouli´s Law

$$\frac{1}{2}\rho V u_1^2 + p_1 V = const. = \frac{1}{2}\rho V u_2^2 + p_2 V$$

Kinetic energy

Pressure energy

Pitot tube: $u_2=0$ $\quad dp = p_2 - p_1 = \frac{\rho u_1^{\,2}}{2}$

Mass flow equation:

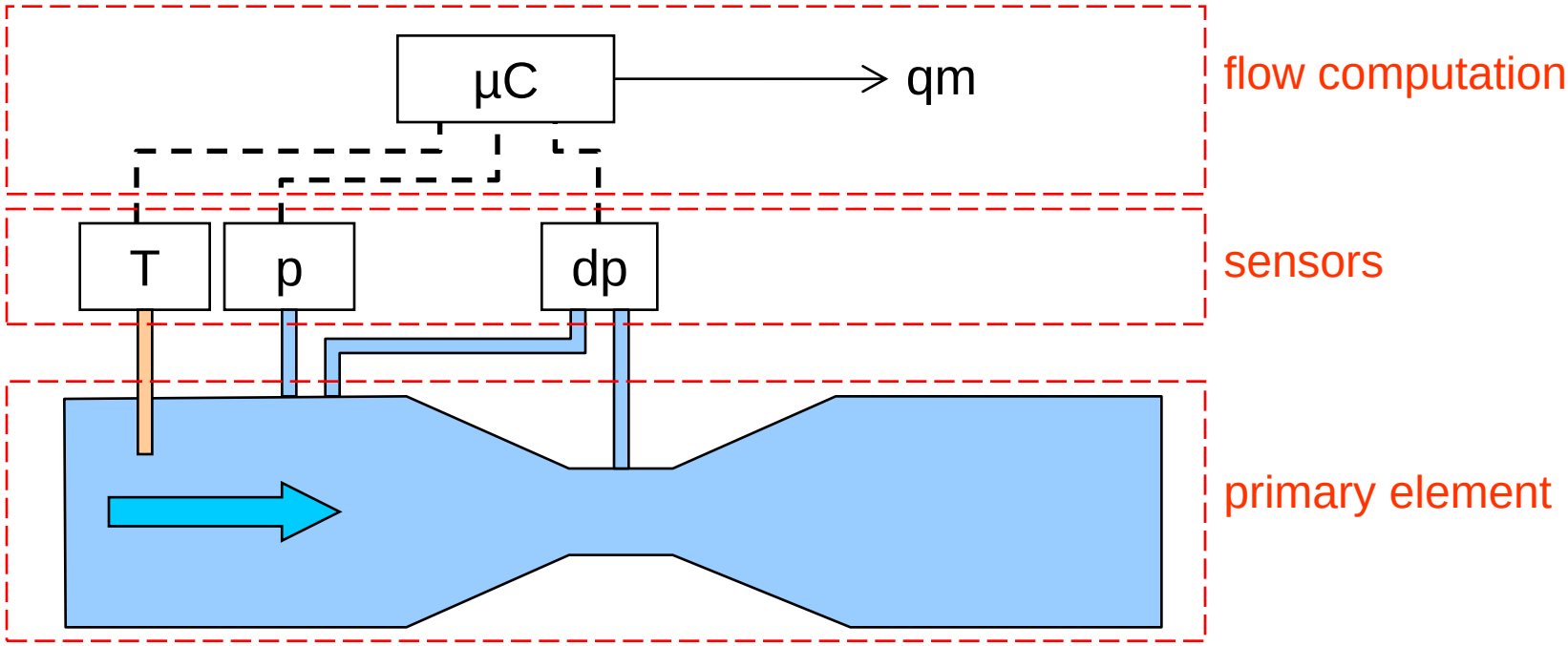
$$q_m = \boxed{K_S \frac{\pi D^2}{4}} \cdot \boxed{\varepsilon \sqrt{2\, dp\, \rho(p,T)}}$$

constant

to be masured and calculated

(ISO 5167)

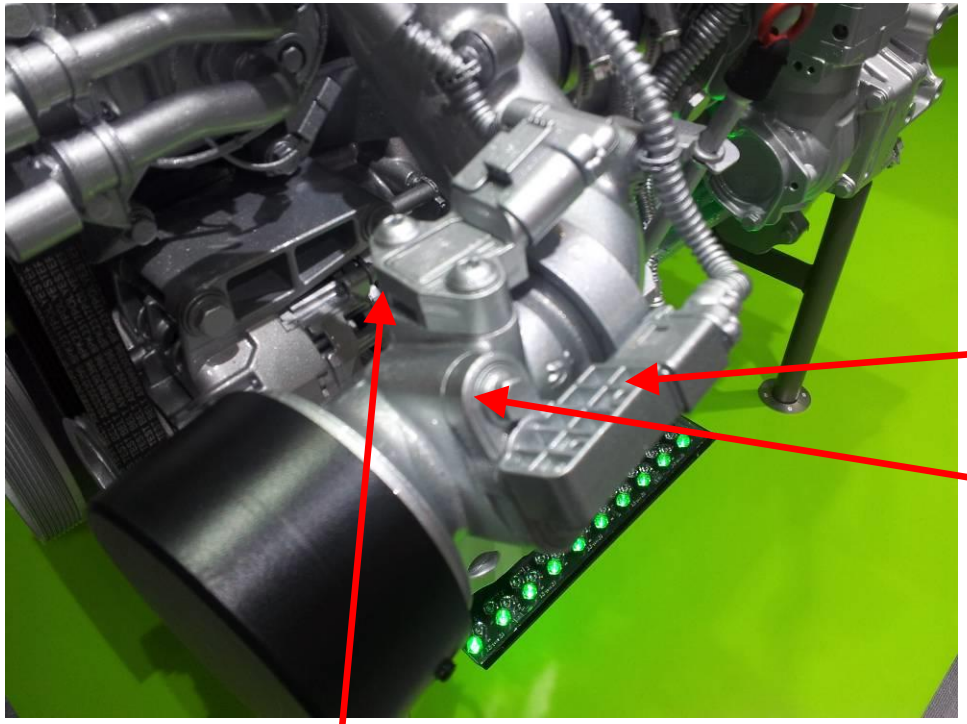
Schematic of Venturi mass flow meter



- primary element: mechanical device to create dp
- sensors: p & T-sensor for density calculation, dp-sensor for flow (can be separated from primary element)
- flow computation to solve flow equation

$$q_m = K_S \frac{\pi D^2}{4} \cdot \varepsilon \sqrt{2\, dp\, \rho(p,T)}$$

Systec pitot sensors for Daimler truck engines



Analog
dp sensor

Pitot probe

Analog p/T-sensor

Mass flow calculation in ECU

Integrated Solution by systec Controls

Conventional solution

dp Sensor,
Bosch

Pitot probe,
Systec

p/T sensor

Daimler 900 / 4000 series, 2006

Superior: TFI4 Truckflow Sensor

„Truckflow Integrated“

Liebherr 2011

TFI4 Sensor

Mass flow equation

$$\dot{m} = K \cdot A_2 \cdot \varepsilon \cdot \sqrt{2\rho \cdot dp}$$

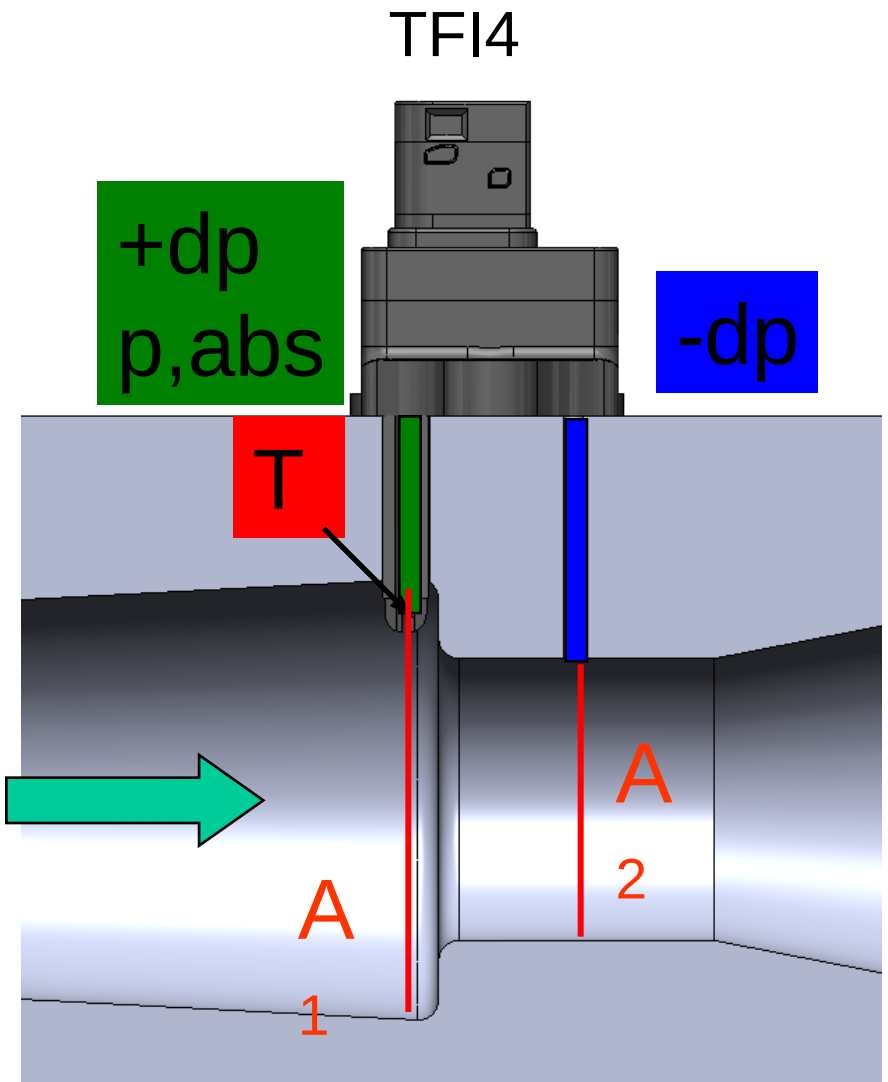
$$\rho = \frac{p_{abs}[Pa]}{R \cdot T[K]}$$

Calibration factors:

K = f (A1,A2,approach factor)

ε = f (venturi geometry)
density correction

Venturi nozzle: DIN EN ISO 5167-3



Reasons of Development
开发TFI4传感器原因

2001 Daimler looked for EGR-Sensor alternative
2001年戴姆勒寻求替代EGR测量的方案

- Robust >1 Million miles for US engines 可靠性超过1百万英里的美国发动机
- Low cost 低成本
- High accuracy for achieving EPA7/10 limit with fresh air measurement基于EPA7/10的高精度新鲜空气端测量

Problems with EGR sensors: EGR端测量的问题：

- dp-Sensordrift with Temperature and Moisture 不同温度湿度条件下的压差测量漂移
- dp-Sensor Deterioration over time (acids!) 压差测量随时间变差（酸性物质！）
- Soot layer on Venturi 文曲利管积碳污染
- Blockage of dp-lines 压差测量管道堵塞
- Freezing of dp-lines 压差测量管道结冰
- EGR Backflow can´t be detected 理论上测不到EGR回流

Accuracy >5%, in the field >15% insufficient for upcoming emission levels!

实验室误差>5%, 实际工况误差>15%，不能满足法规要求！

Reasons of Development
开发TFI4传感器原因

Required Accuracy 所需测量精度:

EGR Rate %	EGR accuracy %
10%	10%
20%	5%
30%	3.3%
40%	2.5%
50%	2%

Achieved Accuracy with Kavlico/Sensata:

Daimler: 5-10% at Testbed; >10% in field

使用Kavlico/Sensata，戴姆勒实验室精度5-10%，实际工况测量精度>10%.

Reasons of Development
开发TFI4传感器原因

Error by DP-Sensor drift: 由压差传感器产生的漂移误差

Sensor	EGR Flow [kg/h]	DP-Signal [mbar]	DP drift [mbar]	Mass Flow Error
Kavlico	180	192	7	1.8%
	18	4.5	7	60%
Sensata	180	192	2	0.5%
	18	4.5	2	20%
TFI4	180	192	0.2	0.05%
	18	4.5	0.2	2.2%

typical EGR Venturi with D=32mm Inlet and d=14mm Throat

Reasons of Development
开发TFI4传感器原因

Error by Soot layer on Venturi: 由积碳污染产生的误差

Soot layer Thickness 积碳厚度	Mass Flow Error
0.1mm	1.5%
0.3mm	4.4%
0.5mm	7.4%
1.0mm	15.2%

typical EGR Venturi with D=32mm Inlet and d=14mm Throat

Accuracy <5% for EGR unrealistic in field
EGR端在实际工况下无法达到5%精度

Systec Solution: TFI4 Sensor
因此开发TFI4传感器

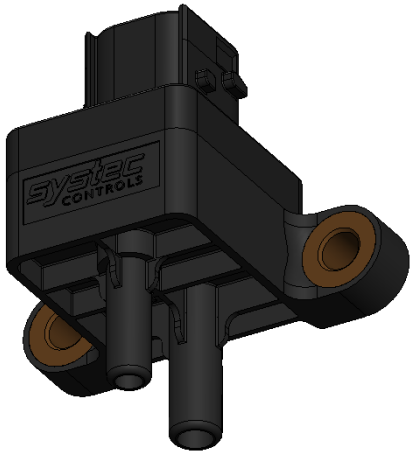
Heavy Duty 针对重载荷设计

TFI4

High accuracy精度 <2%
CAN Bus， CAN通讯

Flexible Positioning on engine
测量位置灵活

TFI4-2P



P/T-Sensor integrated
集成压力/温度传感器

Low calibration effort
标定成本低

ECU: Bosch EDC17 / Delphi OBD ready for EPA17
基于Bosch EDC17以及Delphi ECU的针对EPA17 的OBD功能

Development Partners for TFI4 合作伙伴

AVL

FEV

LIEBHERR

DAIMLER

BOSCH

博世 科技成就生活之美

MAGNA

DELPHI

Reasons for TFI4 客户选用TFI4原因

DAIMLER

Lower fuel consumption, Robustness 40000h / 1M Miles, better Engine Control (power)
降低油耗、可靠性好、发动机控制更佳

LIEBHERR

Robustness 15000h heavy off-road appl., low calibration effort (>100vehicles), dynamic hydraulic power control
可靠性好、标定成本低(超过100种车型），动态性能好

MAN

Better engine control (Power, lower fuel consumption) lower Adblue usage/ Fast substitution of HFM in Series
更佳的发动机控制（功率、低油耗）、优化Adblue、迅速替代HFM量产

Reasons for TFI4 客户选用TFI4原因

AGCO POWER

SAME DEUTZ-FAHR

Improved Adblue dosing, Exhaust Mass flow,
Lower fuel consumption, low calibration effort,
fast time to market (SOP)
Adblue控制优化、废气流量、降低油耗、标定成本低、量产应用开发快

JCB

Better engine control: high accuracy Fuel/Air Ratio;
⇒no DPF, no SCR for low power 4cyl engines Tier 3B, Tierf 4f(low power engines)
Low calibration effort => substitution of HFM in Series
更佳的发动机控制：高精度的燃料空气比：
=>无DPF，无SCR（低功率4缸机，Tier3B)
低标定成本=>量产代替HFM

Outlook from Bosch for China Engines 博世建议

System Strategy for CN6

Trucks & Buses

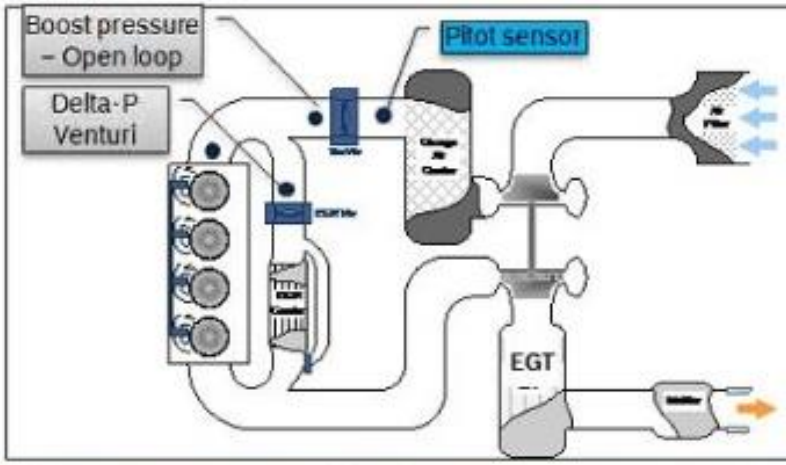
Proposed Air System in CN/建议的合适的空气系统

CN4 Solution

Open loop EGR control

- Calculate lambda for dynamic smoke limitation

→ No strong air mass measurement requirement, model air mass sufficient



CN6 Solution

Close Loop Control

- OBD monitoring
- Provide EGT exhaust ctrl, increase SCR efficiency
- Temp. control during DPF RGN
- Tolerance control for lifetime and fleet
- Realize EGR valve close loop control
- Calculate lambda for dynamic smoke limitation

→ Air mass measurement as additional option

Integrated SW functions for different air system

- Sensor after intercooler for fresh air - 2014
- Delta-p venturi for EGR mass - 2014
- Open loop with BPS for fresh air - 2013

SW synergies between CN4 and CN6 through SW switch for open/close loop

博世软件考虑了国六开闭环切换和向下兼容国四EGR方案

Trend for CNG engines 气体机趋势

CNG Bus Emissions Roadmap: from Euro III to Euro VI

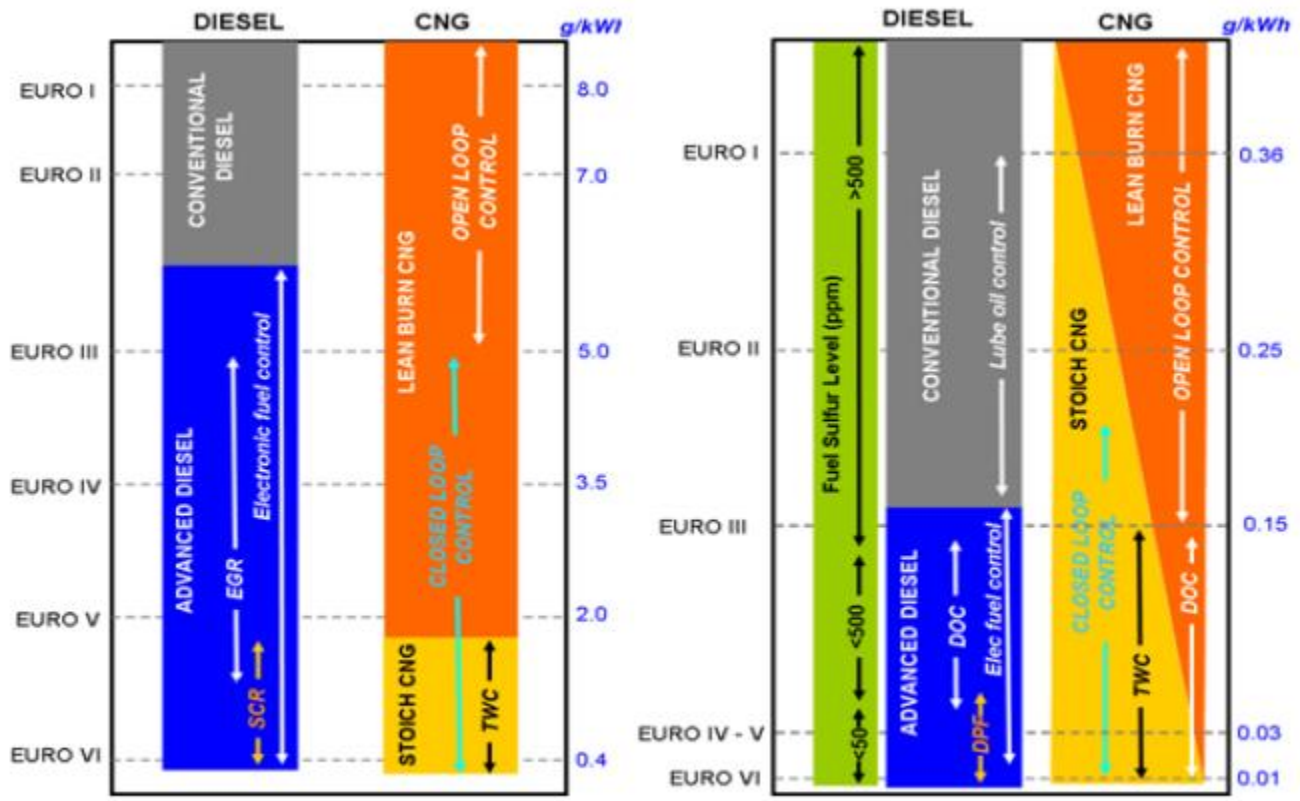


FIGURE 3. Technology evolution of heavy-duty engines to meet more stringent emission standards in the EU and the US

Trend: Diesel: EGR+SCR CNG: stoichiometric

趋势：柴油机 EGR+SCR，气体机：当量燃烧

Trend: Fresh air meas. has more benefit for next engines than EGR measuring

Diesel柴油机: EGR+**SCR**

TFI4 benefit vs. EGR-M. 新鲜空气端TFI4相对EGR测量比较

- high accuracy fuel/air ratio over lifetime of engine
  在长寿命内燃料空气比控制精度更高
- Robustness, long term stab. 可靠性更好
- Fast time to market 市场开发速度快
- Low calibration effort 更低的标定成本
- Improved Adblue dosing 更佳的Adblue成本控制

趋势：下一代发动机上新鲜空气测量比EGR端测量优势更大！

Trend: Fresh air meas. has more benefit for next engines than EGR measuring

CNG气体机: stoichiometric当量燃烧

TFI4 benefit: TFI4传感器优势：

- high accuracy fuel/air ratio 燃料空气比控制精度更高

=> lower fuel consumption 更低燃料消耗

- defined power output by improved CNG dosing 更优的燃料控制带来更佳的功率输出

趋势：下一代发动机上新鲜空气测量比EGR端测量优势更大！

Mass Flow Sensors and Trend
流量传感器发展历程和未来

1980 2006 2008 2009 2012 2015 2018

DDC:
EGR/Kavlico

EGR/Sensata HCM

?

Daimler:
Pitot/Systec/Bosch

Daimler:
Pitot/Systec/Sensata

Continental
quits Ultrasonic

Bosch
quits Ultrasonic

TFI4 Development
2007-2012

DAIMLER
LIEBHERR
AVL
MAGNA

Systec TFI4

Systec TFI4B

Bosch ?
Pitot sensor

In Series on 14 Engines 已经量产的TFI4项目

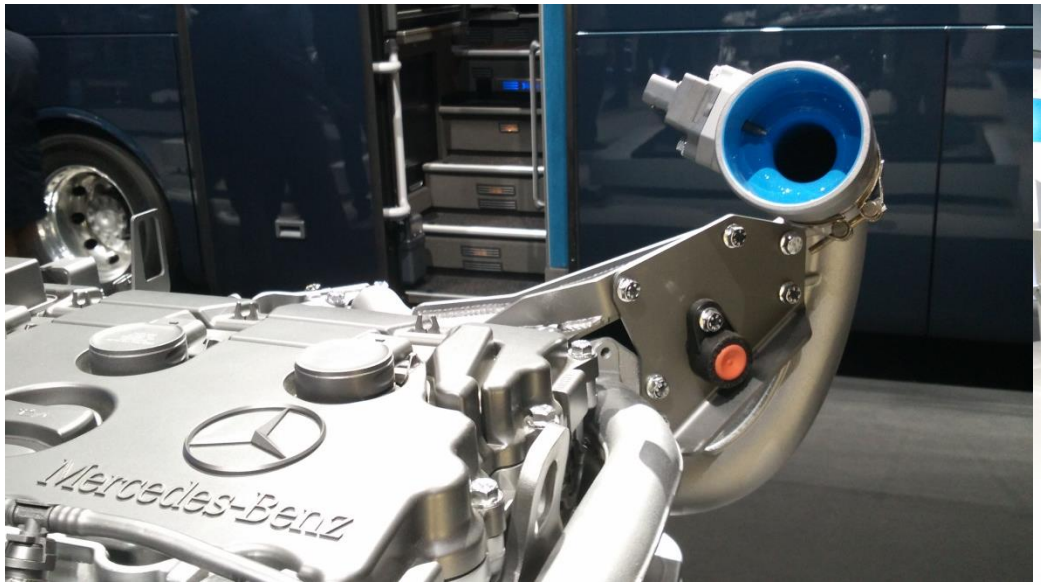
Company	Engine	Emission level	SOP	测量位置	Sensor
Daimler/DDC	MBE 900	EPA07	2006	增压前	mDC-H Pitot
Daimler/DDC	MBE 4000	EPA07	2006	增压前	mDC-B Pitot
Daimler	MDEG, 4cyl	Tier 3B	2012	中冷后	MDEG Truckflow
Daimler	MDEG, 6cyl	Tier 3B	2012	中冷后	MDEG Truckflow
Liebherr	D934	Tier 3B	2012	增压后	**TFI4**
Liebherr	D936	Tier 3B	2012	增压后	**TFI4**
Liebherr	D946	Tier 3B	2012	增压后	**TFI4**
Liebherr	D9508	Tier 3B	2012	增压后	**TFI4**
Agco sisu Power	6cyl. 66	Tier 4	2013	中冷后	**TFI4**
Agco sisu Power	6cyl. 84	Tier 4	2013	中冷后	**TFI4**
Agco sisu Power	6cyl. 98	Tier 4	2013	中冷后	**TFI4**
Agco sisu Power	7cyl. 98	Tier 4	2013	中冷后	**TFI4**
Agco sisu Power	4cyl 44	Tier 4	2014	中冷后	**TFI4**
Agco sisu Power	4cyl 49	Tier 4	2014	中冷后	**TFI4**

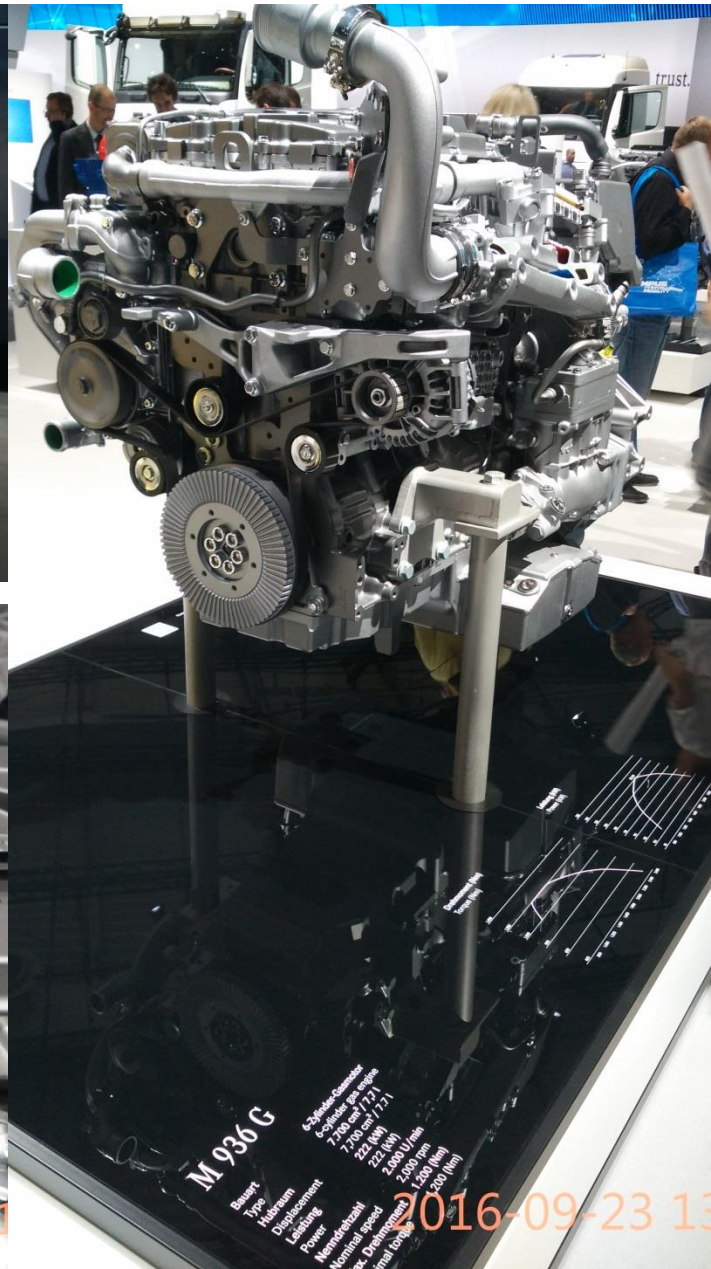
Next 15 engine series 正开发或即将量产TFI4项目

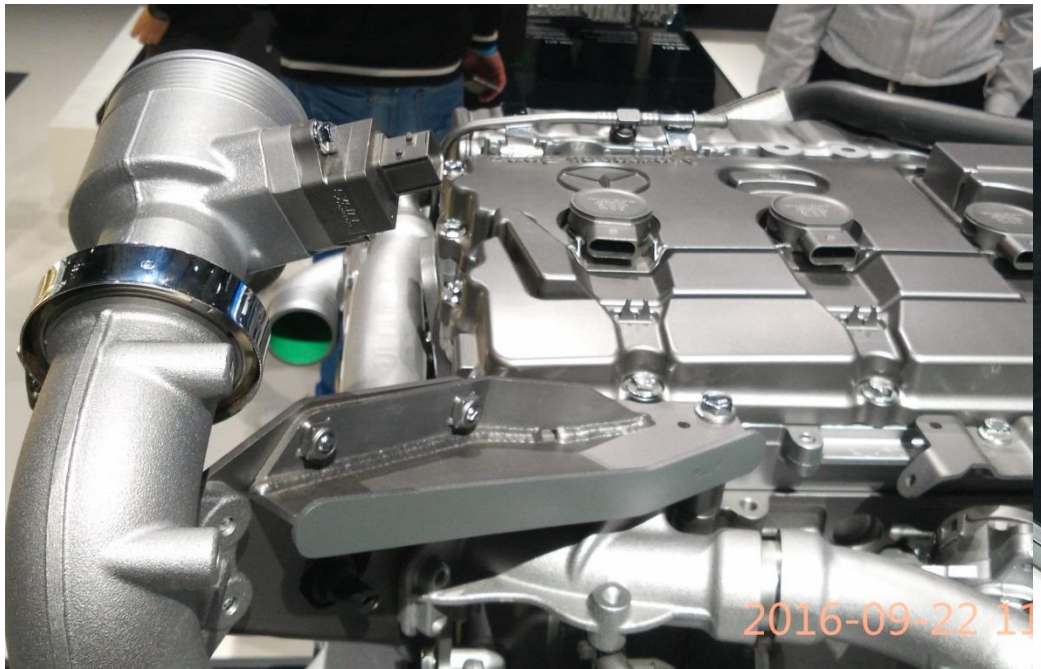
Company	Engines	Emission level	SOP	测量位置	Sensor
Daimler	MDEG CNG, HDEP CNG	Euro6	2015	中冷后	**TFI4**
Liebherr LMB	6G0002 CNG	Tier 4	2017	中冷后	**TFI4**
JCB	SEF 4cyl / 6cyl	Tier 4	2017	中冷后	**TFI4B**
Same Deutz Fahr	KE3, KE4	Tier 4	2016	增压前	**TFI4**
MTU Friedrichshafen	1600, 4000	Tier 4	2016	中冷后	**TFI4**
MTU Onsite Energy	4000 Bi-Fuel	Tier 4	2015	增压后	**TFI4**
MAN	D26, D38, D1515	Euro6	2018/19	中冷后	**TFI4B**
Achates Power	A48 opposed piston	EPA17	2017	**DP, EGR**	**TFI4B**
Isuzu	4cyl	Tier 4	2016	低压 **EGR**	**TFI4**

Daimler MDEG CNG engine M936 G

IAA Hannover 2016







systec CONTROLS

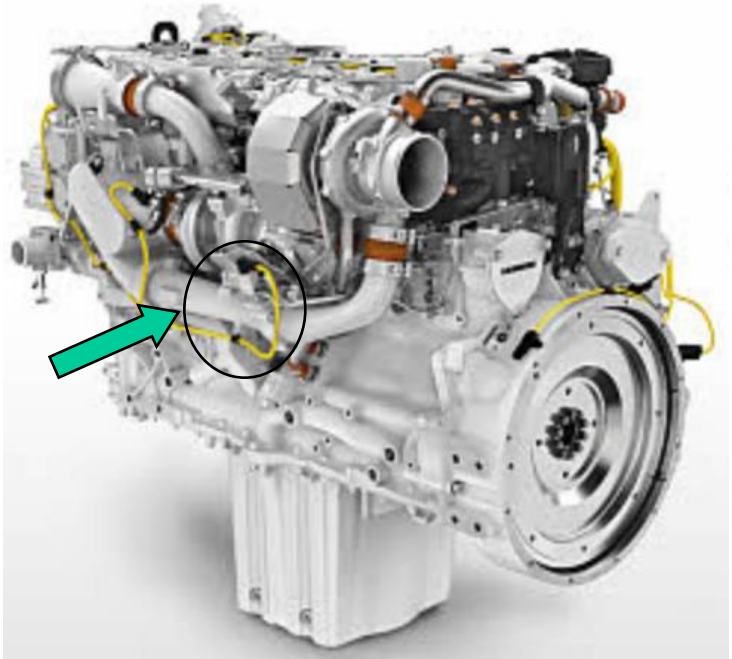
LIEBHERR

TFI4 on LMB IIIB/Tier 4i engines

LIEBHERR

D934 A7 DPF Tier IIIB/Tier 4i
7Liter, 200kW

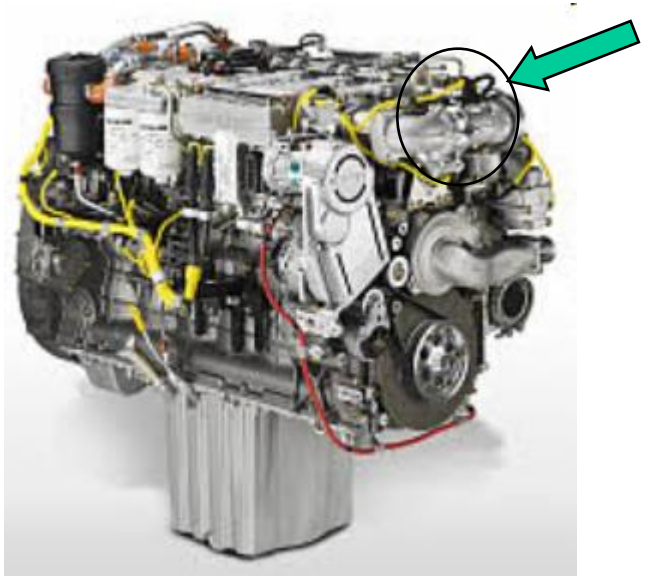
D936 A7 DPF Tier IIIB/Tier 4i
10.5Liter, 300kW



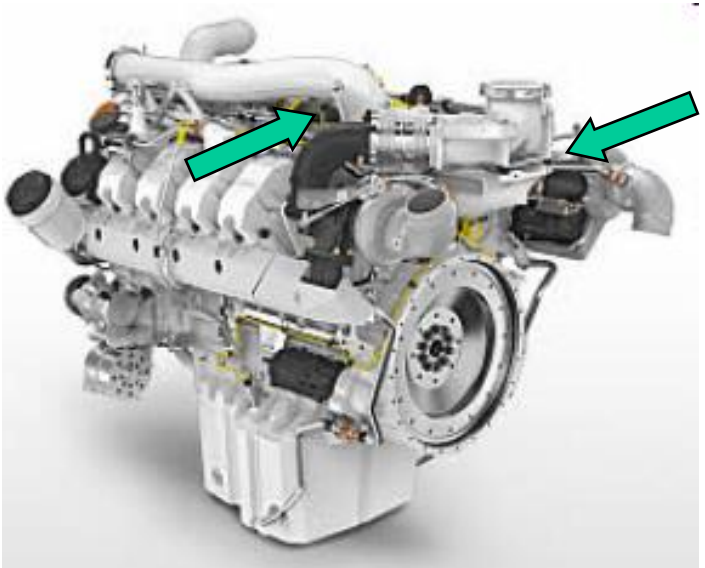
TFI4 on LMB IIIB engines

LIEBHERR

D946 A7 DPF Tier IIIB/tTier 4i
11.9Liter, 340kW



D9508 A7 Tier IIIB/tTier 4i
16.2Liter, 505kW



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AGCO

Challenger

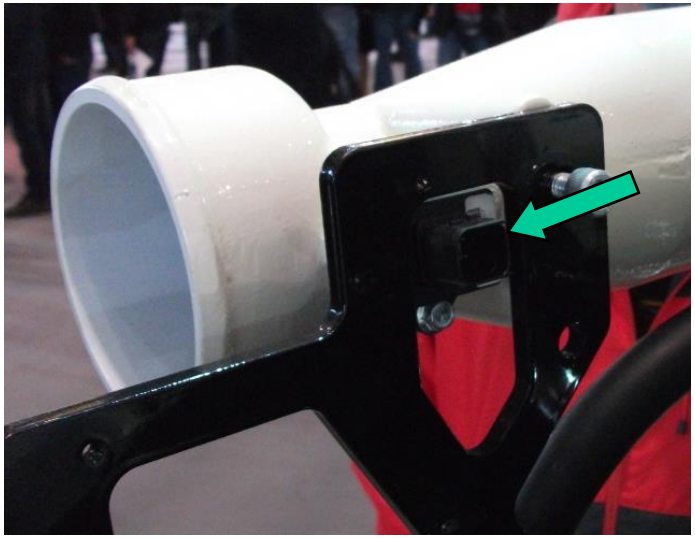
Fendt

Massey Ferguson

Valtra

TFI4 on AGCO Sisu Power 6cyl engine (Tier 4 final)

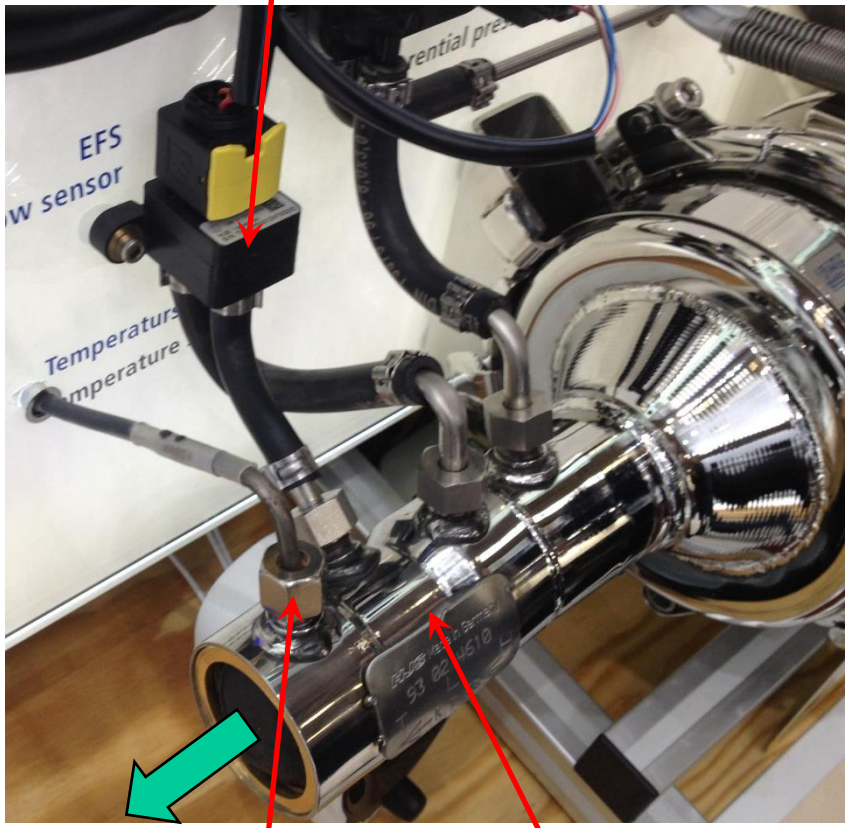
AGRITECHNICA 2013



HJS: Exhaust Flow Sensor „EFS“

HJS exhaust gas
After treatment system
(active control)

TFI4 2P Sensor
= „EFS“-Sensor



Bauma 2013

T-sensor „Venturi“

JCB

North America
Europe
Scandinavia
Russia & CIS
Middle East
India
Asia
Africa
Latin America
Oceania

systec CONTROLS

SAME DEUTZ-FAHR

DEUTZ FAHR | SAME | Lamborghini TRATTORI | Hürlimann | GREGOIRE | Lamborghini TRATTORI GREEN PRO

1600 / 4000 engines









Power Generator
Diesel / Gas / Bi-Fuel

MTU 4000 DS

50 Hz: 1550 - 3250 kVA
60 Hz: 1125 - 3250 kWe

MTU 1600 DS

50 Hz: 280 - 730 kVA
60 Hz: 210 - 600 kWe

www.achatespower.com

Opposed piston engine: saves 30% fuel, no cylinder heat/valves, less heat loss

F-DIESEL 合作伙伴联系方式

上海亚域动力工程有限公司

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电话：+86 21 3350 6361

传真：+86 21 3350 6269

邮箱：engineering@f-diesel.com

主页：www.f-diesel.com

TFI4