SÜD-CHEMIE
Creating Performance Technology

CARB Verification of Catalyzed Diesel Particulate Filters For Emergency Generator Sets

Yinyan Huang, Zhongyuan Dang, Yongtaek Choi

Juan Andrade, Amiram Bar-Ilan

Süd-Chemie, Inc.

32 Fremont Street, Needham, MA 02494

Phone: (781) 444-5188 Fax: (781) 444-0130

ARB Verification Program - Six Phases

1. Baseline Engine Emissions Testing
2. Zero-hour Control Device Emissions Testing
3. Control Device Durability Testing (0 - 168 hr)
4. Post 168 hr Conditional Verification Emission Test
5. Control Device Durability Testing (168 - 500 hr)
6. Post 500 hr Control Device Emissions Testing

Emission Testing Protocol - ISO-8178B D2

Speed	**Rated speed – Constant 1,800 rpm**				
Mode	**1**	**2**	**3**	**4**	**5**
Load	**100%**	**75%**	**50%**	**25%**	**10%**
Weighting Factor	**0.05**	**0.25**	**0.3**	**0.3**	**0.1**

Example: E = 0.05 x (EM1) + 0.25 x (EM2) + 0.3 x (EM3) + 0.3 x (EM4) + 0.1 x (EM5)

Where:

- **E = overall emission factor of a given pollutant (lb/hp-hr or g/kW-hr)**
- **EMi = emission factor of given pollutant at Mode i**

SÜD-CHEMIE
Creating Performance Technology

ARB Recommended Durability Duty Cycles With Accelerated Cooling For Cold Starts

- ✓ **24 Cold Starts at idle for 30 min then cools for ~ 12 hours** **[12 hours]**

  (Simulating standby genset cold startup cycles)

- ✓ **72 hours at typical loads (25%, 65%, 80% load 24 hr each)** **[84 hours]**
- ✓ **24 Cold Starts at 30% Load for 30 min then cools for ~12 hours** **[96 hours]**

  (Simulating Pump Cold Start Cycles)

- ✓ **72 hours at typical loads (25%, 65%, 80% load 24 hr each)** **[168 hours]**
- ✓ ***Run the above durability cycles for three times to reach complete 500 hour cycle***

SÜD-CHEMIE
Creating Performance Technology

SC-cDPF Verification for Backup Genset/Pump

- **Engine: Make/Model/YR CATERPILLAR/3406C/2000, 14 Liter, 470 bhp @ 1800rpm**
- **Fuel: California Diesel "red dye" # 2, max. 500ppm Sulfur**
- **EnviCat 2051, 15" Dia x 15" L, 200cpsi**
- **Exhaust Temperature Profile (°C)**

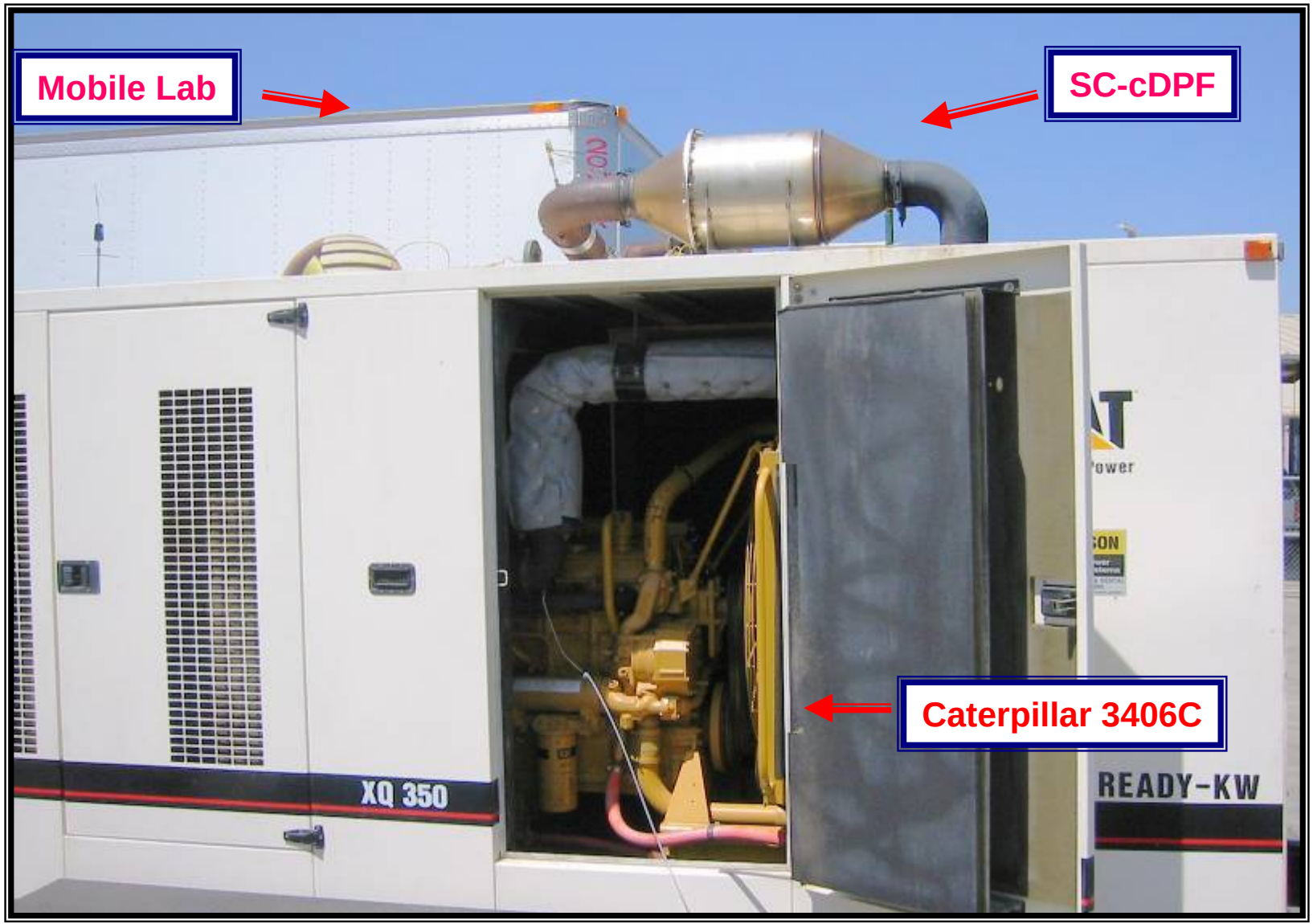
Model	1	2	3	4	5
Load	100%	75%	50%	25%	10%
Temp (°C)	602	553	492	403	326

SÜD-CHEMIE
Creating Performance Technology

Ce-Cert's HDD Mobile Lab

SÜD-CHEMIE
Creating Performance Technology

Test Engine & SC-cDPF Unit

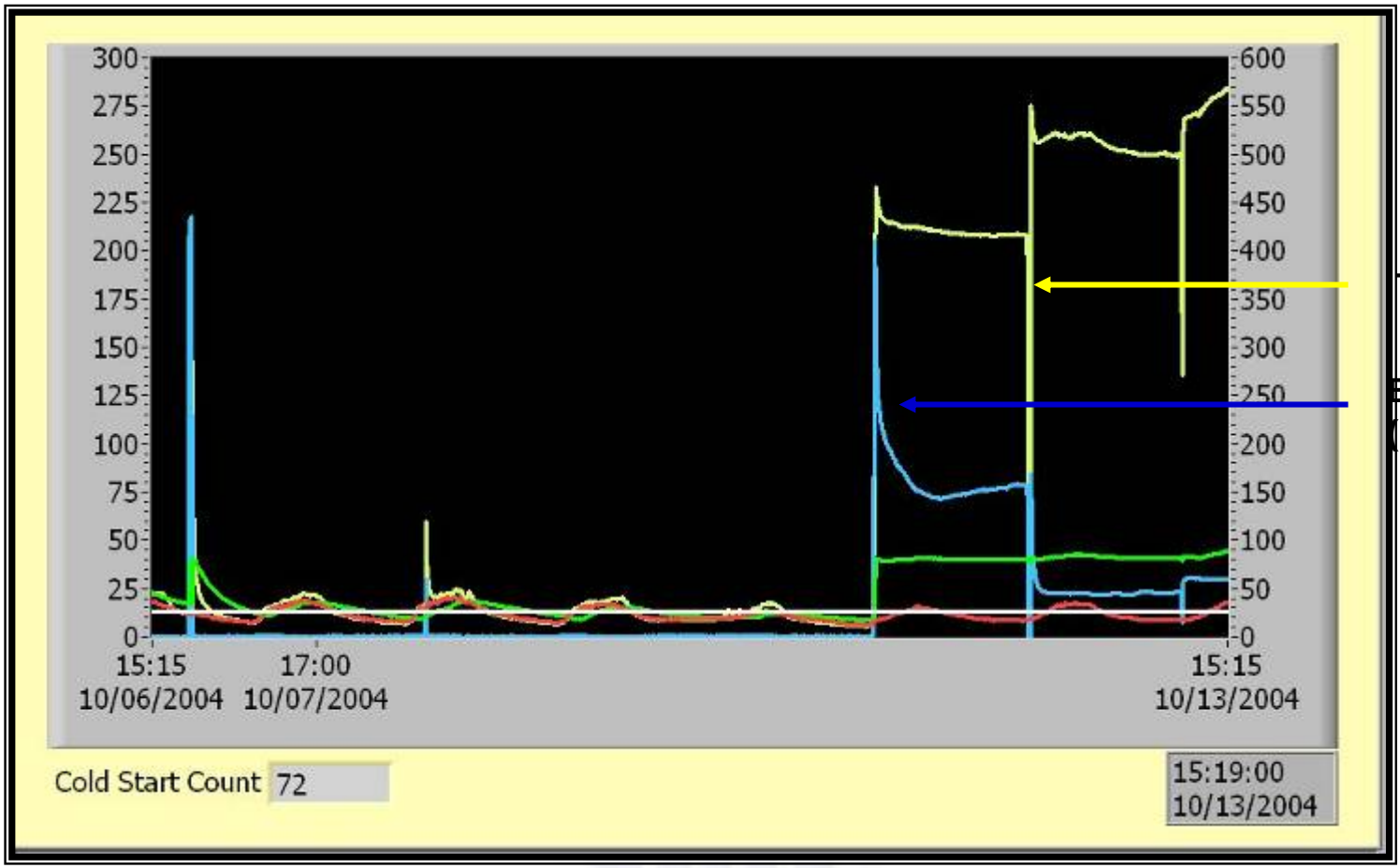


SÜD-CHEMIE
Creating Performance Technology

Triplicates Summary Weighted ISO 8178 D2

Test	THC	CO	NOx	NO_2/NOx	CO_2	PM2.5
0 Hr	81.2%	98.1%	1.3%	-1.1%	0.2%	98.5%
167 Hr	61.4%	>99%	-0.2%	-0.9%	-1.7%	98.6%
500 Hr	>99%	93%	-5.0%	0.9%	1.7%	99.4%

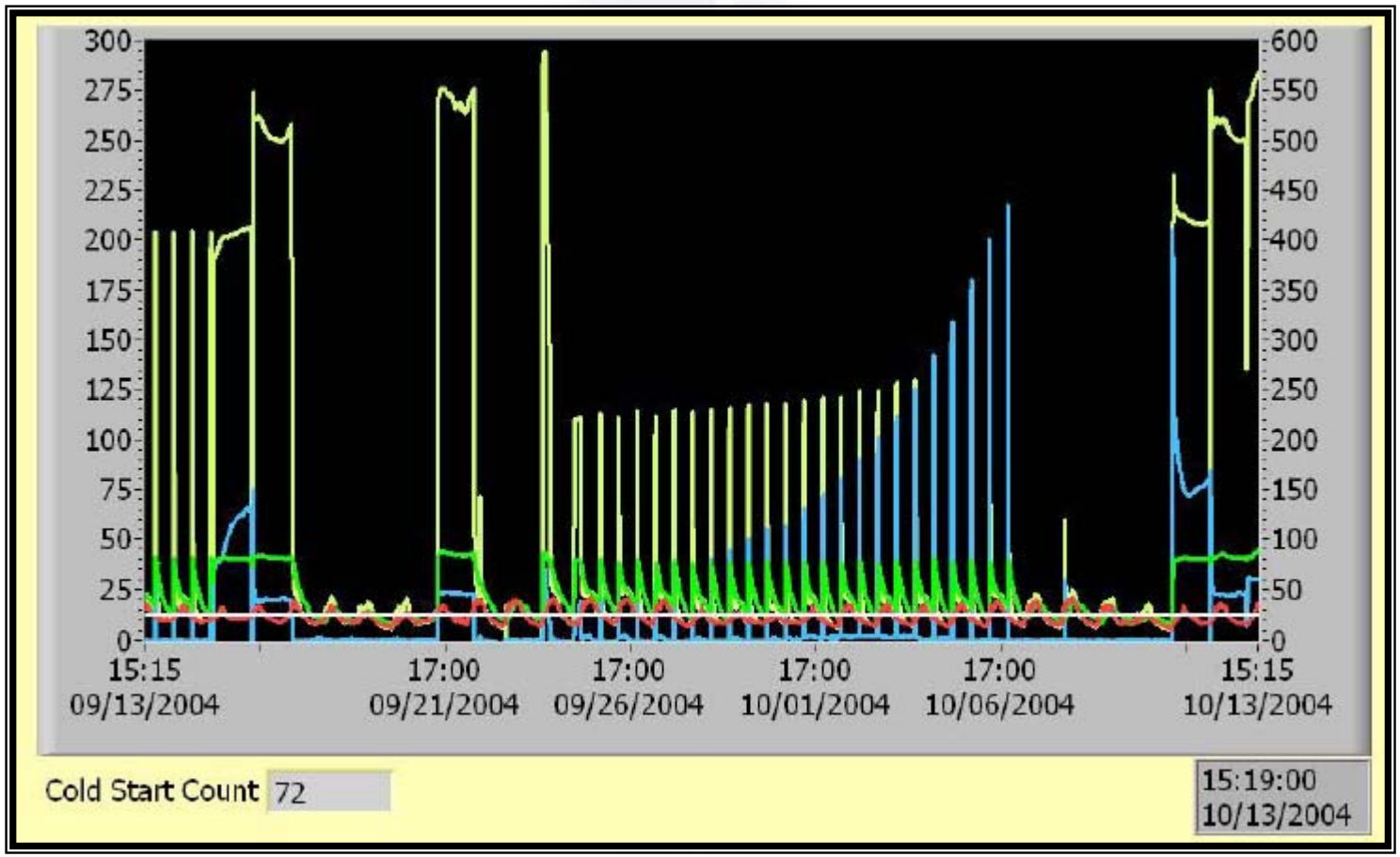
Durability - Loaded Tests



24hr at 25%, 24hr at 65% and 24hr at 80%

SÜD-CHEMIE
Creating Performance Technology

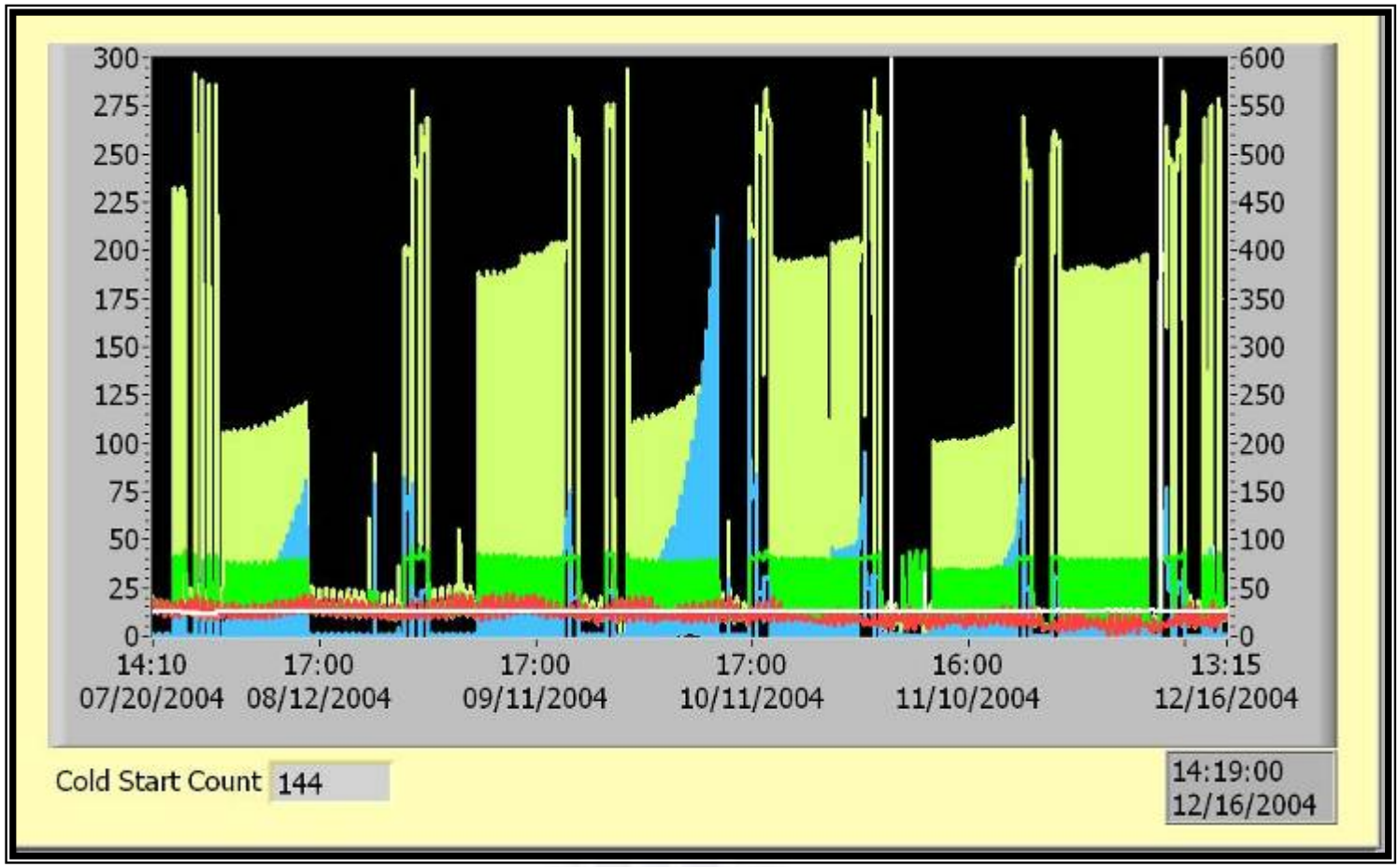
Durability of SC-DPF Verification



Idle cold starts after 167 hour emission testing

SÜD-CHEMIE
Creating Performance Technology

Complete 500 Hour Durability Data



500 hours of durability and emission testing operation
(72 idle cold starts and 72 colds starts at 30% load).

SÜD-CHEMIE
Creating Performance Technology

Conclusions

- **SC-cDPF - High efficiency for CO, HC and PM removal.**
- **SC-cDPF - Works well with high sulfur diesel fuel.**
- **SC-cDPF - Low NO_2 emission level.**
- **SC-cDPF - Can tolerate up to 12 hours cold starts.**
- **SC-cDPF - Complete passive regeneration under load.**
- **Additional testing for prime power generator verification is in progress.**