Institute of
Combustion Technology

Engine Emission Ground-Tests with Jet A-1 / Farnesane Blends

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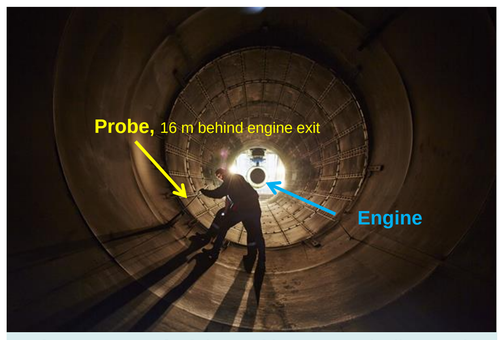
# Deutsche Lufthansa AG, + Lufthansa Technik, °Total, § Amyris

The use of renewable fuels like **Farnesane,** as a drop in fuel to conventional kerosene (Jet A-1) can help to reduce the CO_2 footprint of the aviation industry.
Farnesane (2,6,10-trimethyldodecane - $C_{15}H_{32}$) is produced by Amyris and Total from biomass through a combination of fermentation and hydroprocessing steps.
These engine ground tests evaluated the impact of the farnesane aviation grade, produced from sugarcane, on the engine performances and emissions.

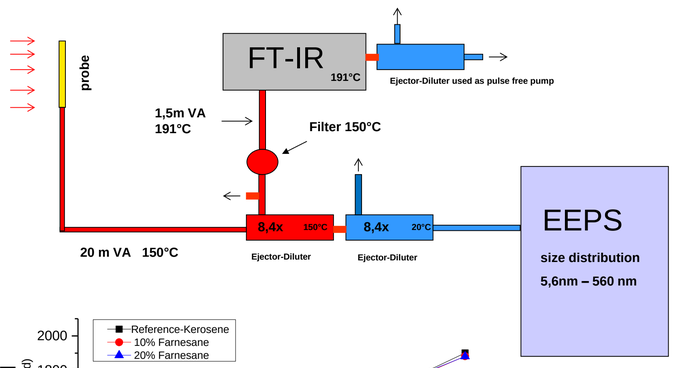
Structure of **Farnesane**
2,6,10-trimethyldodecane, $C_{15}H_{32}$

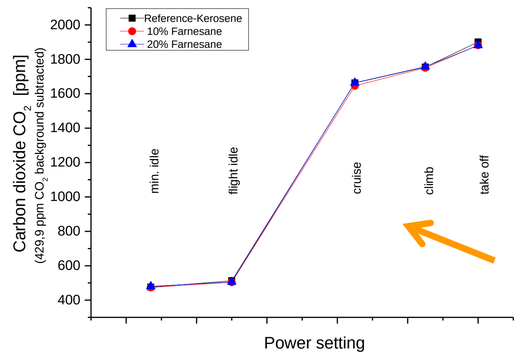


Exhaust tunnel of the Lufthansa Technik test rig

CFM56-5C4 engine, normally in service on an Airbus A340

Experimental Setup



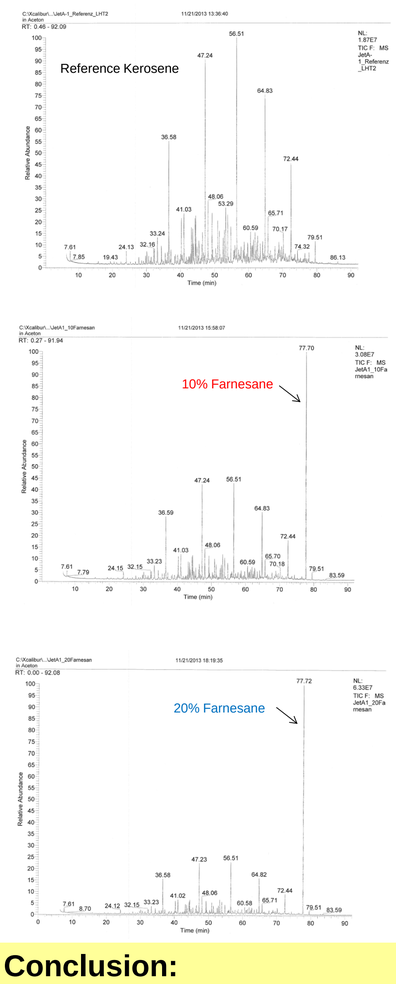


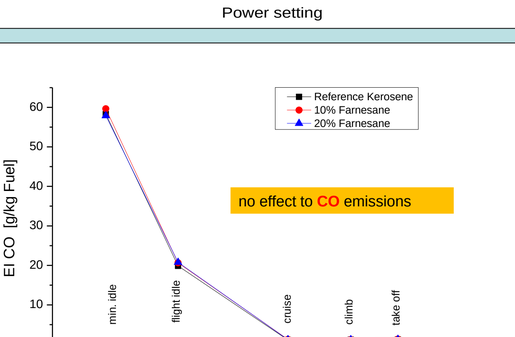
the CO_2 ***concentration*** measurements verify the reproducibility of engine power settings and probe sampling

Fuel Composition

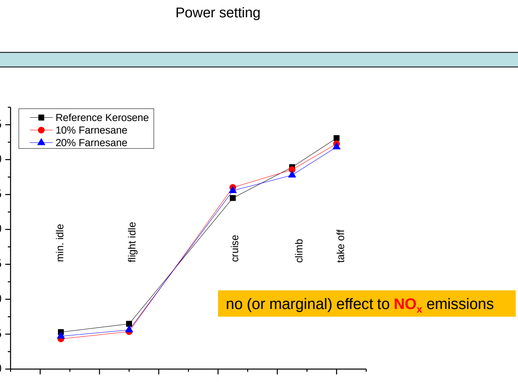
	Jet A-1 Reference Kerosene	Jet A-1 + 10% Farnesane	Jet A-1 + 20% Farnesane
Density kg / m³	793,2	791,5	789,4
Smoke Point [mm]	25	25	26
Aromatic Comp. Vol%	16,6	15,1	14,1
MJ/kg	43295	43376	43444

Fuel Blends



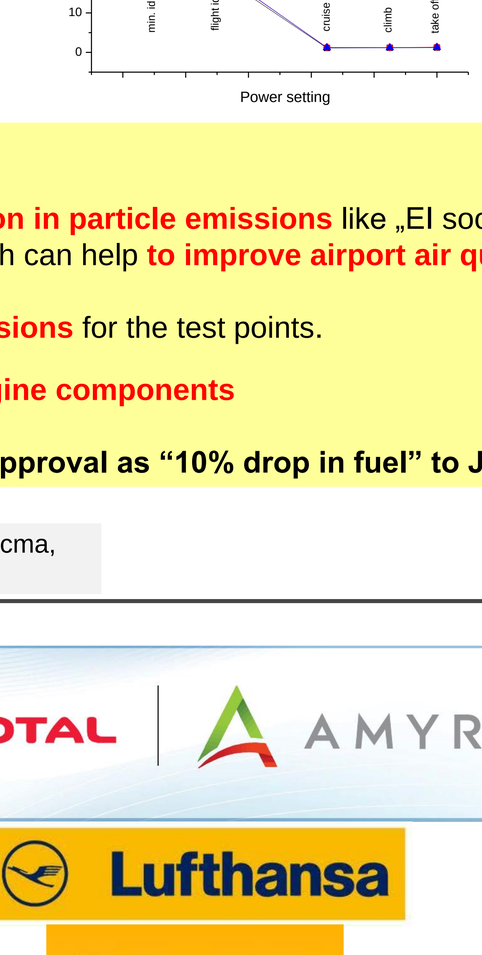


	Jet A-1		Jet A-1 + 10% Farnesane			Jet A-1 + 20% Farnesane		
Power setting	Reference Kerosene				EI Reduction in %			EI Reduction in %
%	EI Surface [m²/kg Fuel]		EI Surface [m²/kg Fuel]	%Ref.	to reference	EI Surface [m²/kg Fuel]	%Ref.	to reference
low idle	7	0.50	0.42	83.8	-16.2	0.38	75.8	-24.2
flight idle	30	0.36	0.31	84.8	-15.2	0.27	75.4	-24.6
"cruise"	65	3.56	3.56	99.9	-0.1	3.41	95.9	-4.1
climb out	85	4.21	4.07	96.7	-3.3	3.81	90.5	-9.5
take off	100	4.96	4.75	95.7	-4.3	4.45	89.7	-10.3



	Jet A-1		Jet A-1 + 10% Farnesane			Jet A-1 + 20% Farnesane		
Power setting	Reference-Kerosene				EI Reduction in %			EI Reduction in %
%	EI Soot Mass [mg/kg fuel]		EI Soot Mass [mg/kg fuel]	%Ref.	to reference	EI Soot Mass [mg/kg fuel]	%Ref.	to reference
low idle	7	6.1	5.5	89.6	-10.4	4.5	73.8	-26.2
flight idle	30	5.4	4.5	84.3	-15.7	4.1	75.2	-24.8
"cruise"	65	40.1	39.3	97.9	-2.1	38.2	95.2	-4.8
climb out	85	48.1	46.4	96.3	-3.7	43.5	90.4	-9.6
take off	100	58.9	55.2	93.7	-6.3	52.1	88.5	-11.5

Farnesane addition leads to a clear reduction in „EI soot mass“ and „EI surface“ , highest relative reduction at the low power settings „low idle =(TAXI)“ and „flight idle= (APPROACH)“



Farnesane addition results in a **clear effect of particle number reduction** , but it seems to be a **„saturation effect“**

no clear effect to particle diameter

no effect to CO emissions

no (or marginal) effect to NO_x emissions

Conclusion:

- Increasing **Farnesane** content results in a **corresponding reduction in particle emissions** like „EI soot mass“ and „EI soot surface“. Especially the reduction at TAXI and Approach can help **to improve airport air quality**
- Increasing **Farnesane** content show **no change in gaseous emissions** for the test points.
- Final inspection of the CFM56-5C4 engine showed **no harm to engine components**
- **Press release: Since June 16th 2014, farnesane has the ASTM approval as “10% drop in fuel” to Jet A-1**

The authors want to thank all contributors from Lufthansa, Lufthansa Technik, Snecma, Total, Amyris and DLR, making these measurements possible

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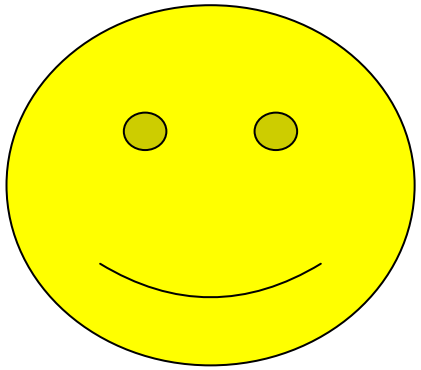

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