



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Federal Office of Civil Aviation FOCA  
**Aviation Policy and Strategy**



# Introduction of the First Particulate Matter Standard for Aircraft Engines

20th ETH Conference on Combustion Generated Nanoparticles  
June 16th 2016, Theo Rindlisbacher



# International Civil Aviation Organisation



2nd February 2016:

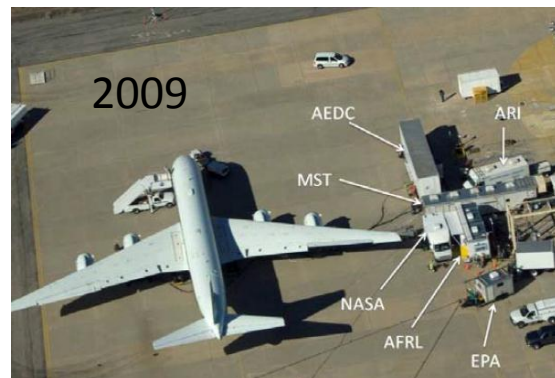
- **The ICAO Committee on Aviation Environmental Protection (CAEP) adopts the first particulate matter standard for aircraft engines**

[Members of CAEP: Argentina, Australia, Brazil, Canada, China, Egypt, France, Germany, India, Indonesia, Italy, Japan, Netherlands, Poland, Russian Federation, Singapore, South Africa, Spain, Sweden, Switzerland, Ukraine, United Arab Emirates, United Kingdom, United States]

- Final adoption expected by the **ICAO Council** in about one year: **New ICAO Annex 16 Volume II** and Environmental Technical Manual



# A Brief History, Starting 2004...







# A Brief History...



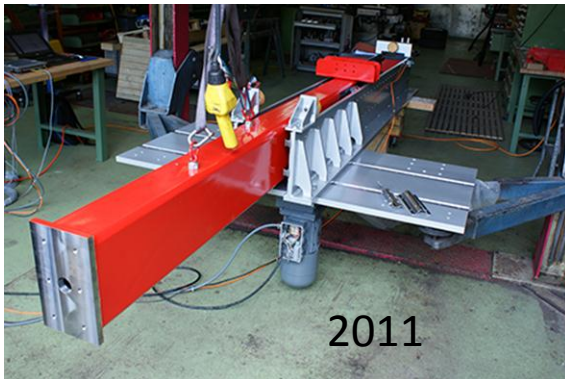
NPC Poster 2008



2009-2011



2010



2011



2011



2011



# A Brief History...





# Elements of the Standard



- Standard = Certification Requirement (includes the measurement methodology) **plus** Regulatory Level(s)
- Emissions concerned: **Non-volatile Particulate Matter** (nvPM)
- **Standardised Mass and Number** concentration measurement, conversion to emission indices EI (g/kg fuel, #/kg fuel)
- Mobility nvPM size cut (50% CE) at **10 nm** or lower
- Uses engine test procedure and exhaust probe from existing ICAO gaseous emission standard



- Enforcement of new Standard needs regulatory levels
- How derive regulatory levels without certified measurement data?
- How enforce certified measurements without regulatory levels?

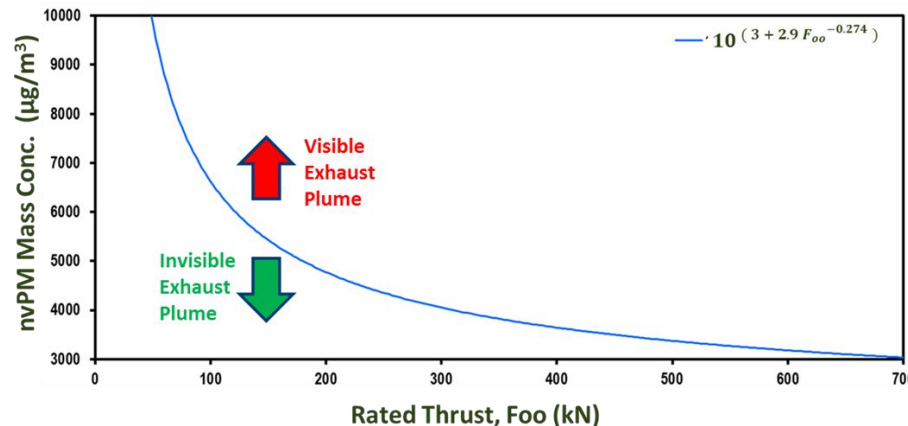




# Elements of the Standard



- Borrowed first nvPM regulatory limit from existing smoke number regulatory limit, which is used to suppress visible smoke. The smoke number is correlated to the nvPM mass concentration.
- Regulatory limit line for maximum nvPM mass concentration** was derived from Smoke Number limit line → No new stringency, engines passing current smoke number standard will pass new nvPM standard



$$\text{Regulatory limit concentration of } nvPM_{mass} = 10 \cdot (3 + 2.9 F_{oo}^{-0.274})$$



# Elements of the Standard



Important: **The Standard mandates reporting of certified values with a public health (and potentially climate) relevance:**

- nvPM mass and nvPM number EIs (g/kg fuel, #/kg fuel for the 4 points in the Landing and Take-Off Cycle (7, 30, 85, 100% thrust)
- Plus maximum nvPM Emission Index mass (g/kg fuel)
- Plus maximum nvPM Emission Index number (#/kg fuel)

## Applicability of the Standard:

- All turbofan engines > 26.7 kN rated thrust,  
**which are in production** from 1st January 2020  
and later.



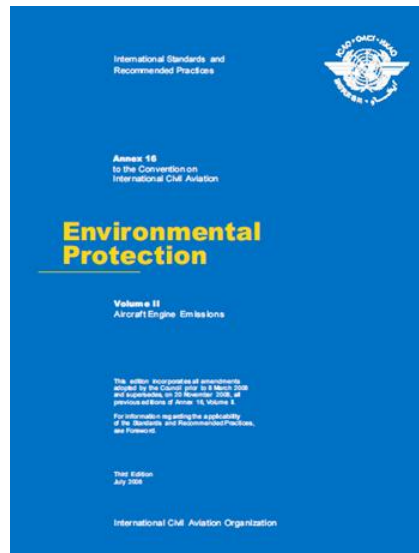




# Path to a Health Based Standard



- The nvPM emissions data of 24 selected representative engines are currently measured according to the new standard.
- Collection of data to develop the EI based (public health relevant) regulatory levels for nvPM mass and nvPM number.
- Public health based regulatory limits for nvPM mass and number are targeted for February 2019 (follow up standard).



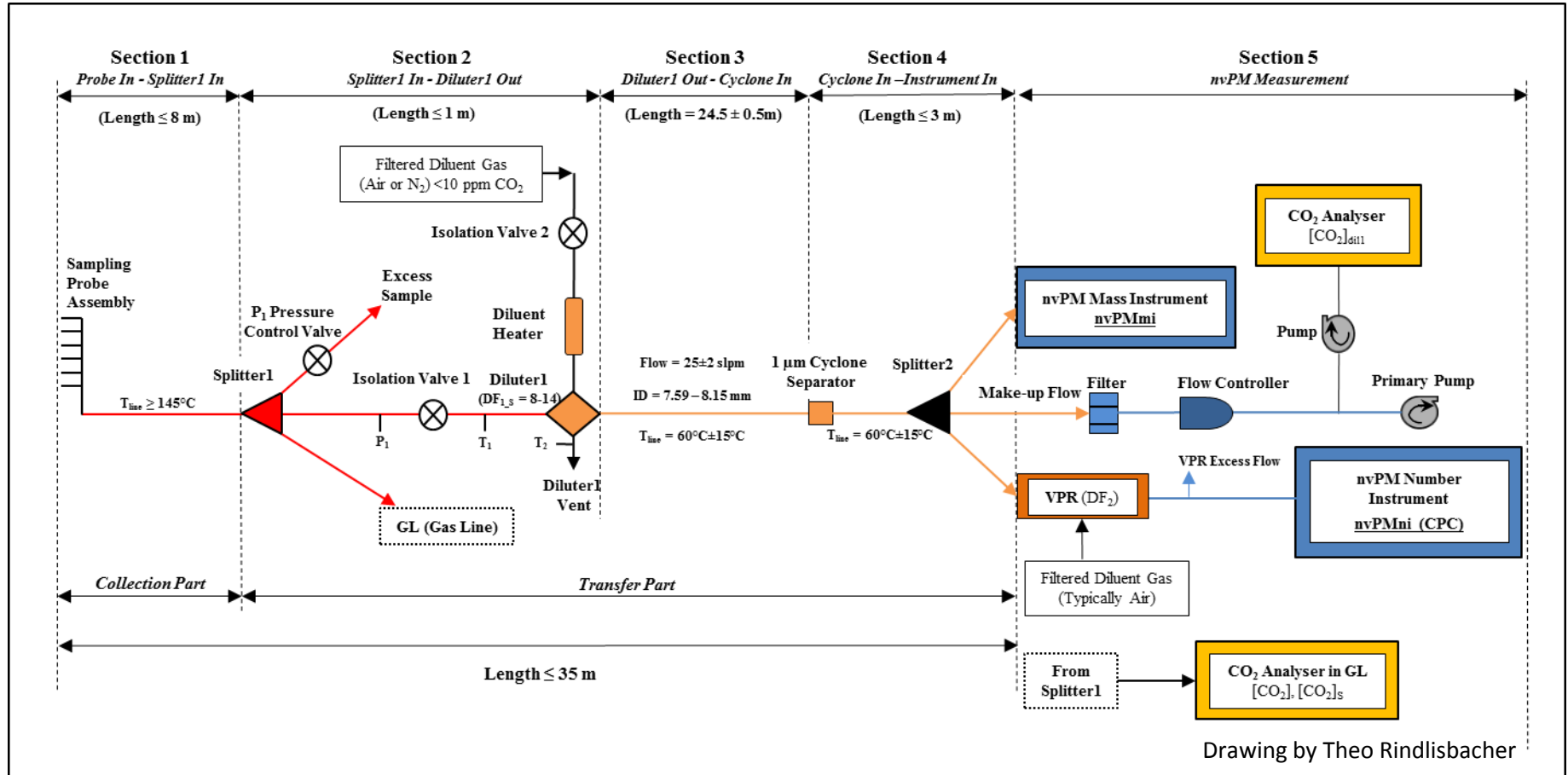


# Particle Loss Correction

- **Reported emission concentrations respectively emission factors are corrected for thermophoretic loss in the collection part** of the sampling system to balance out engine specific differences (from exhaust temperature profile).
- **Overall system particle loss correction factors are provided for modeling of engine exit plane emissions. The methodology will be published in ICAO Annex 16 Volume II Part IV and Appendix 8.**
- Part IV: Non-volatile Particulate Matter Assessment for Inventory and Modeling Purposes
- Appendix 8: Procedures for Estimating nvPM System Loss Corrections
- Tools developed by SAE-E31, standardised tool available by July 2016



# nvPM Measurement System Overview





# Thank you - Discussion

