›› Knowledge Creates Progress

›› Airbag Emissions: The Quantification of Gases, Dust and Acoustics in Practice

› Demo-Report 20020930

› GWP Gesellschaft für Werkstoffprüfung mbH
› Georg-Wimmer-Ring 25, D-85604 Zorneding
› Tel. +49 (0) 8106 994 110 › Fax +49 (0) 8106 994 111
› Mail info@gwp.eu › Web www.gwp.eu

Deutscher Akkreditierungs Rat
DAR
DGA-PL-6358.05

GWP

Demo-Report 20020930

Airbag Emissions: The Quantification of Gases, Dust and Acoustics in Practice

Abstract

The emissions of restraint systems - gases, dust, and acoustics - are quantified in the industry using widely accepted methods like AKZV01, SAEJ1794, USCAR. This report shows some background of the used analytic methods and comments the given narrow specifications based on 8 years experience of emission tests.

We use pyrotechnical buckle pretensioners (PBP's) of one single lot as a probe for the evaluation of the different influences on the results. Nitrogen oxide is chosen as a key gaseous component and we demonstrate the influences of the experimental set up, humidity and pressure, on the resulting concentration. For dust analysis two methods are compared: Andersen-Impactor and Laser-Particle-Counter. The acoustic emissions are compared between car and chamber results.

Customer:	**Date**: 30.09.2002
GWP Marketing	**Reported by**: Dr. sc. nat. Julius A. Nickl
	Internal Verification: Tom Näke
	Pages: 8
Distribution:	**Status**: Demo-Bericht
DEMO Berichte GWP	**Order**: -

GWP Gesellschaft für Werkstoffprüfung mbH
Georg-Wimmer-Ring 25
D-85604 Zorneding/München
☎ +49 (0)8106 994 110
+49 (0)8106 994 111
www.gwp.eu

Geschäftsführer Dr. J. Nickl
HRB 53245 München
USt-ID DE 131179893
Steuer-Nr. 114/127/90067
info@gwp.eu

KRSK München-Starnberg
Konto 270 369 226
BLZ 702 501 50
SWIFT-BIC BYLADEM1KMS
IBAN DE21 7025 0150 0270 3692 26

Raiffeisenbank Zorneding eG
Konto 99 619
BLZ 701 696 19
SWIFT-BIC GENODEF1ZOR
IBAN DE06 7016 9619 0000 0996 19

Table of Content

1. Influences on the Gas Analysis: Example NOx

Since 10 years GWP examines gaseous airbag effluents. We developed a unique method for the on line analysis of 16 gaseous components, compare also the German AKZV01 since 1996, or other specifications like SAE1794 or USCAR. One example of the analytical subjective are reactive and “sticky” molecules like nitrogen oxide (NOx) or ammonia (NH3). They may react during the time of analysis over 30 minutes or adsorb due to their relatively high boiling points on walls, particles, and filters. Both mechanism change their initial concentration. Our method AV122G assures the measuring of the actual concentrations by special materials used, by heating the tubes, and filtering the gas in cascades before being analysed by CLD (NO and NO2 analysis), FT-IR, MS, and ND-IR.

Sometimes we have to comment the deviations of external results on gas concentrations from ignition to ignition and from series to series. We will show that especially for NO and NO2 the experimental conditions for ambient pressure, humidity, and type of tank should meet the given specifications in the methods: e.g. 23 °C, 50% relative humidity and pressure correction.

1.1 Influence of the Ambient Pressure

In case of measurements in small tanks, like 60 L or 146 L, the pressure before ignition can be varied in an easy way by filling the tank with compressed air or inert gas. Pressures over atmosphere have also the advantage that a gas flow can - after removal of airborne particles by suitable filtering- easily fed into an array of analytical devices. In picture 1 the drastic influence of the pressure to the resulting NOx concentration is shown. In this figure the relative NOx concentration generated by one PBP decreases with increasing pressure. This shows a strong adsorption or condensation of NOx molecules to walls and dust particles; this effect is enabled by the used water content of about 50 % relative humidity.

Other components like CO and H2 show other kinetics: the observed relative carbon monoxide concentration increases with increasing initial ambient pressure. Usually CO builds up at room temperature one monolayer of adsorbed molecules to metals (and oxides) and if this given capacity is filled all other added CO molecules are gaseous.

As a consequence the tank data on gas concentrations can not easily be extrapolated for vehicle results.

1.2 Influence of the Humidity

Humidity means water content of the air and a relative humidity of 50 % at e.g. 21 °C means an absolute water vapour concentration of about 1,22 vol%. Released reactive gases may change their chemical state by gaseous water or the adsorbed water film on walls and particles. For the examination of this effect we adjusted different concentrations of water (or humidity) before ignition of one PBP in a 60 L tank at 2 atm.

Picture 2 shows the influence of the variable humidity on the resulting gas concentrations. Due to the broad concentration range a logarithmic scale for the concentration is used.

Again NO2 shows a drastic dependency: with increasing water content the NO2 concentration decreases. Due to the reaction of NO2 with H2O to nitric acid (HNO3) predominately on wall and particle surfaces, NO2 is removed from the gas phase. NO shows a lower reactivity and thus also a lower adsorption on the walls or particles. The less reactive components CO and H2 alter on a lower scale. H2 may be produced by water reduction due to high combustion temperatures, like H2O + Red. -> H2 + Ox..

1.3 NO reaction kinetics in the 2,5 m3 chamber

Using the 2,5 m3 tank and a relative humidity of 50 % at 21 °C we released different amounts of pure, not diluted NO gas by blowing a certain flow and time into the chamber (no fan used). The resulting theoretical concentrations of NO were 500, 15ß, 100, 50 and 25 ppm. This procedure represents the initial gas output of a module or gas generator.

The experimentally observed kinetic of the NOx concentration is shown in picture 3. The overall decline of the sum of both nitrogen oxides is decreasing and decelerating steadily, top curve. Initially pure NO is “formed” but NO is rapidly consumed by e.g. NO2 formation or adsorption. NO2 is formed by NO oxidation and consumed by the mechanism discussed above again. (All methods report only mean gas concentration values over 20 or 30 minutes.)

How does the initial NO concentration influences the rate of the NO concentration? In picture 4 an interesting behaviour of the speed of the decline is observed: by increasing initial NO concentration a larger fraction is depleted. For this observation of a self catalysed diminishing process we have no model. Also this fact shows that simple linear extrapolation of gas concentrations to different volumes, or simultaneously ignited PBP’s is not recommended.

2. Dust Analysis

Particles generated by deployment are an important emission concerning passengers. This dust is an emission of most gas generators and has to be investigated according to the given methods. The determination of the total dust concentration (mg m^{-3}) often varies from ignition to ignition about 20 % and more. To exclude systematic and large statistic errors always complementary methods should be used simultaneously, like Andersen-Impactor plus total particulate filter.

A standard procedure for the measurement of the particle size distribution is using an Andersen impactor. Impaction means the acceleration of a gas and particles through a nozzle and the deflection on an opposite plate. On this plate heavy particles do not follow the gas path but impinge, or impact, on the plate. Variable gas speeds give variable impacted particles sizes, and the plates are evaluated by weight. A histogram of particle size vs. fraction mass results. Picture 5 shows the result of a standard dust concentration measurement by an Andersen Impactor. Particles with size over ca. 10 µm usually sediment fast due to gravitation, but small particles stay airborne much longer. Particles of an Andersen Impactor are useful for element analysis and for testing the morphology (fibers!).

In picture 6 the result of a comparable measurement to picture 5 by a laser particle counter is shown. There is a good correlation between these two complementary techniques: total dust content and, identification of the fraction size with most mass.

For the evaluation of the toxicity of the breathable fraction of the dust also the elemental composition is important. Element analysis of the collected dust has to be done using an ICP, AAS or other techniques , always requiring a certain mass of sample. The specifications of the methods for dust collecting result in a low mass for analysis. E.g. AKZV01, using a backup filter, 5 L min-1, 30 min, and 100 mg m-3 dust concentration

expected, will result a total of 15 mg collected dust. This requires extreme detection limits in the analysis methods of the elements like Pb, As, Cr, Ni ... Also the test on the acidity is difficult using such a low mass. Where applicable we collect by additional filters more dust material.

Generally the experimental set up has to be chosen carefully and should take the following into account: particle size distribution necessary?, sedimentation of particles, run time and flow of impactors, impactor capacity, recirculation of sample air, additional filters for more collected dust, filter capacity, requirements of the element and pH analysis.

3. Acoustics

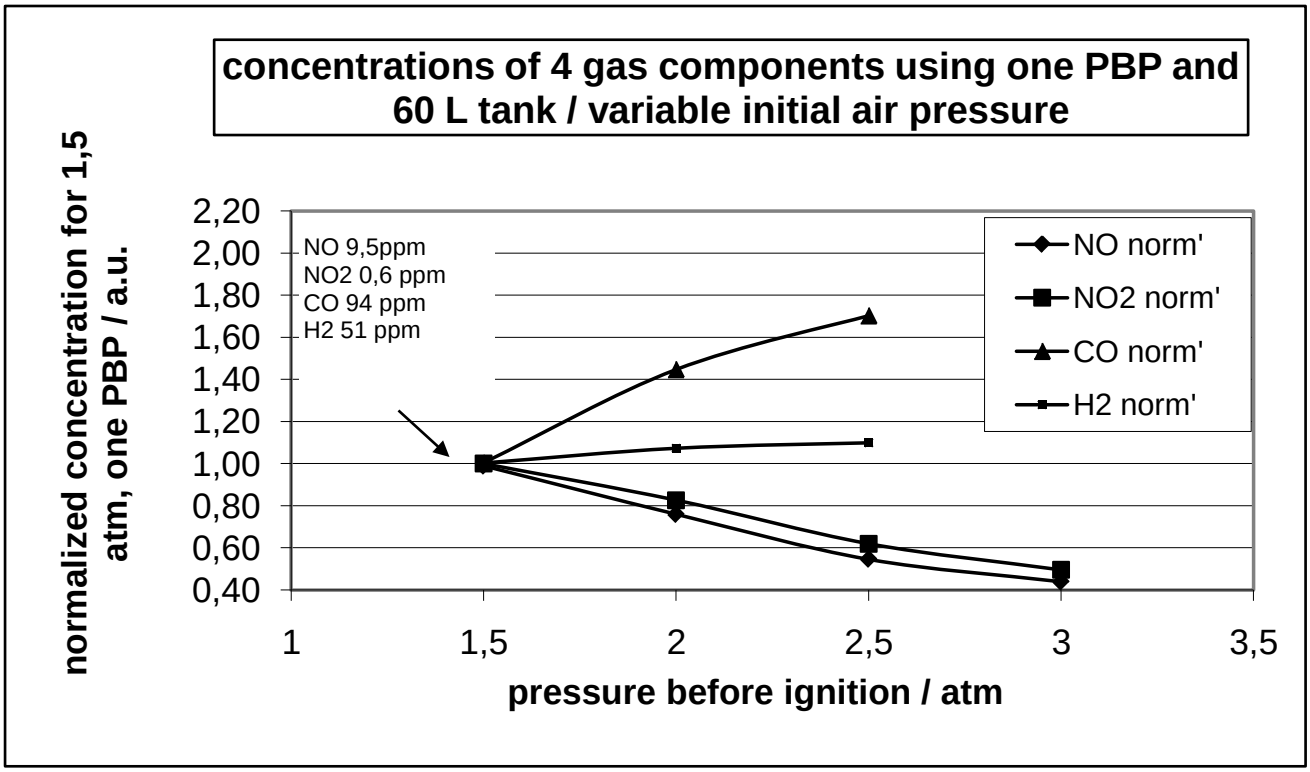
Acoustic measurements in airbag development are relatively new. One reason is that only rarely passengers involved in crashes with airbag deployment report about “loud” airbags; a crash itself reaches about 140 dB. The methods for emission tests, like AKZV01 of March 2002, or SAE J247, define a detailed method for the measurement using special equipment to record highly dynamic impulse noise. This method can be applied to vehicle measurements, compare also picture 7, and also to “chamber” measurements in an alpha cabin with low acoustic reflections, if no realistic vehicle is available. Gas and dust results can be extrapolated from chamber to vehicle under special conditions, but acoustic results may not be extrapolated due too many influencing and barely known parameters. Anyhow, “chamber” tests are necessary to get results in an early stage of a project.

The difficulty of the validation of the results is the second reason that acoustic measurements are a relatively new field of investigation. The US Army defined the Human Ear Model as a method for the reproducible validation of the complex function of an human ear. This model sums up many mechanisms in the ear and calculates one number in “auditory hazard units”. Thus the complex validation is reduced to an easily to handle result and a limit for the maximum expose can be defined, e.g. 500 ahu.

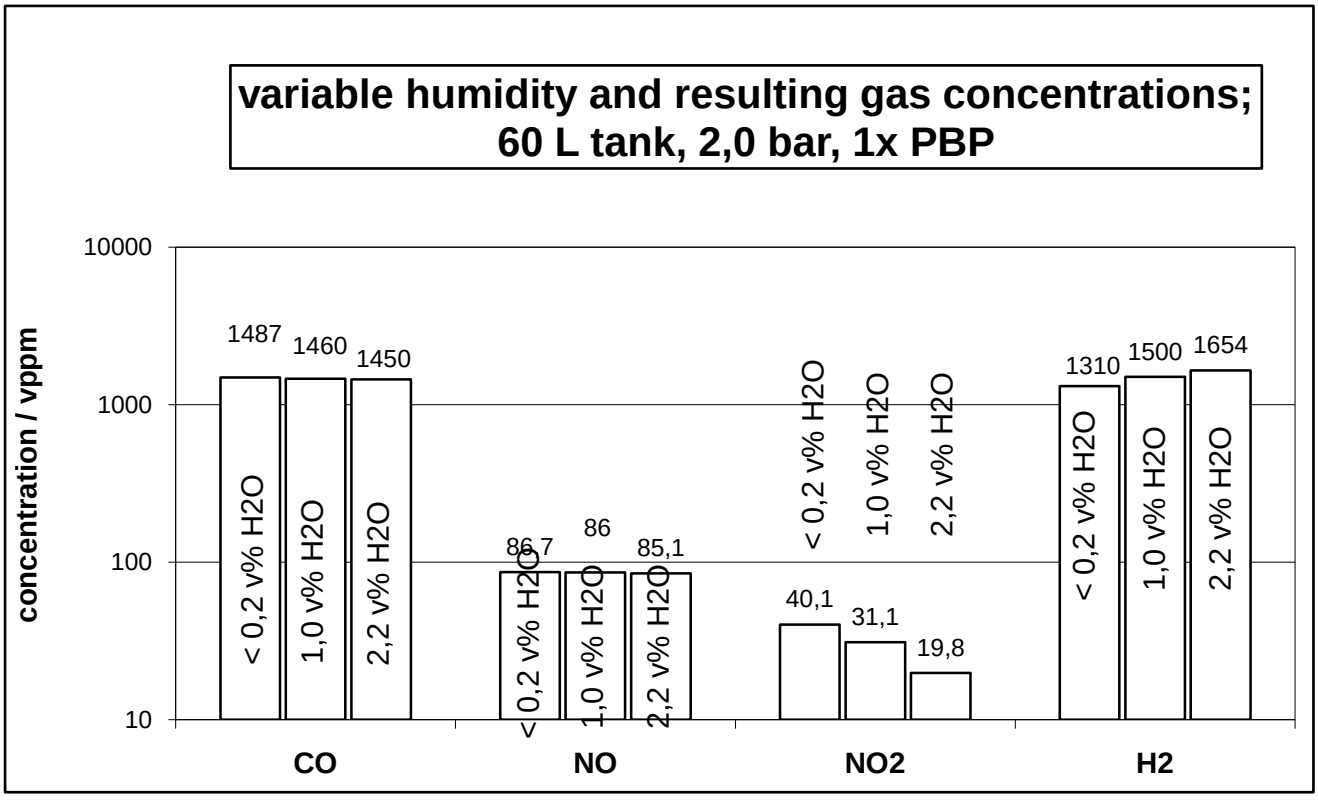
In this early stage we integrate all available acoustic data of our ca. 30 – 50 test series each year into a data base. We keep acoustic results on gas generators, modules, and complete crash configurations from alpha cabin tests as well as vehicle tests. The interpretation of this material may enable in the future a better insight in this field.

Zorneding, 30.09.2002

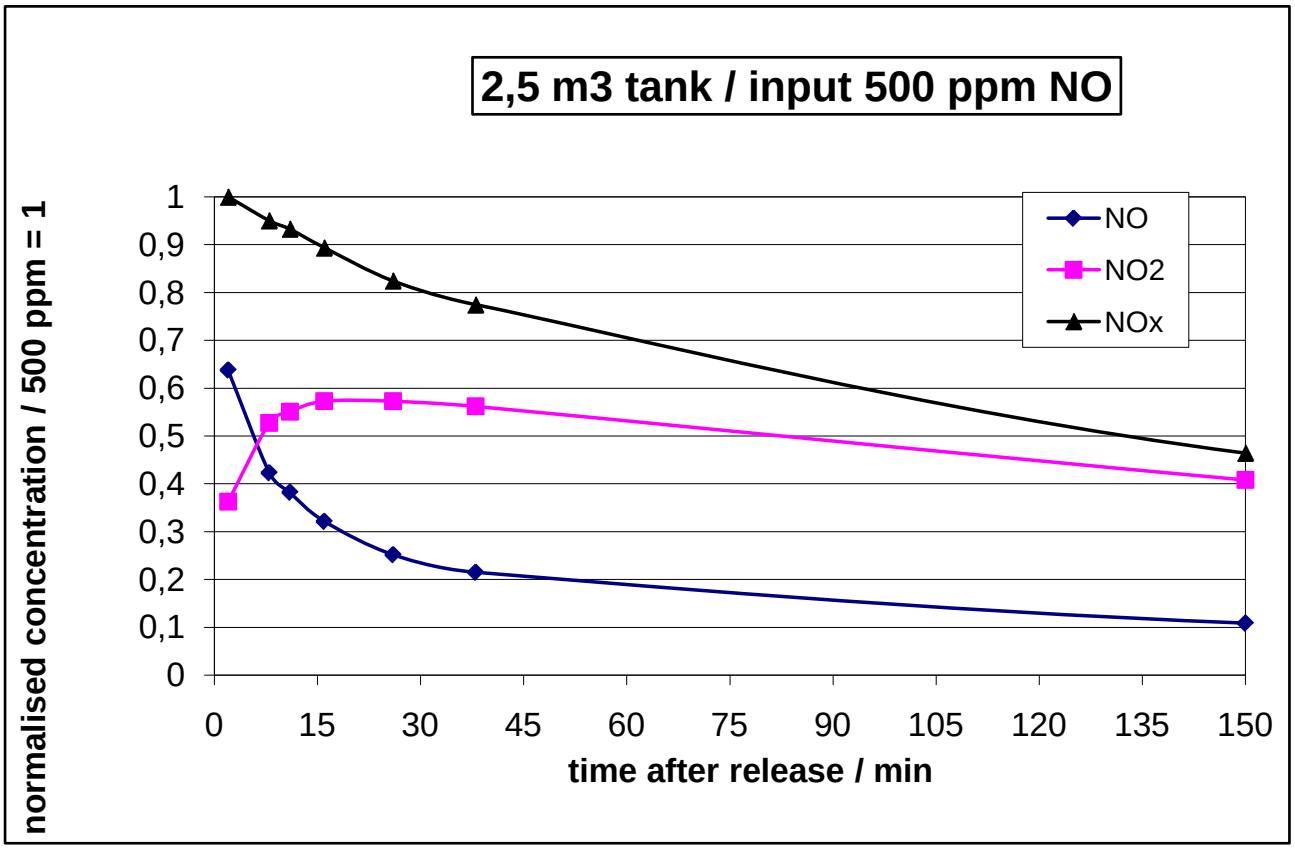
Dr. J. A. Nickl



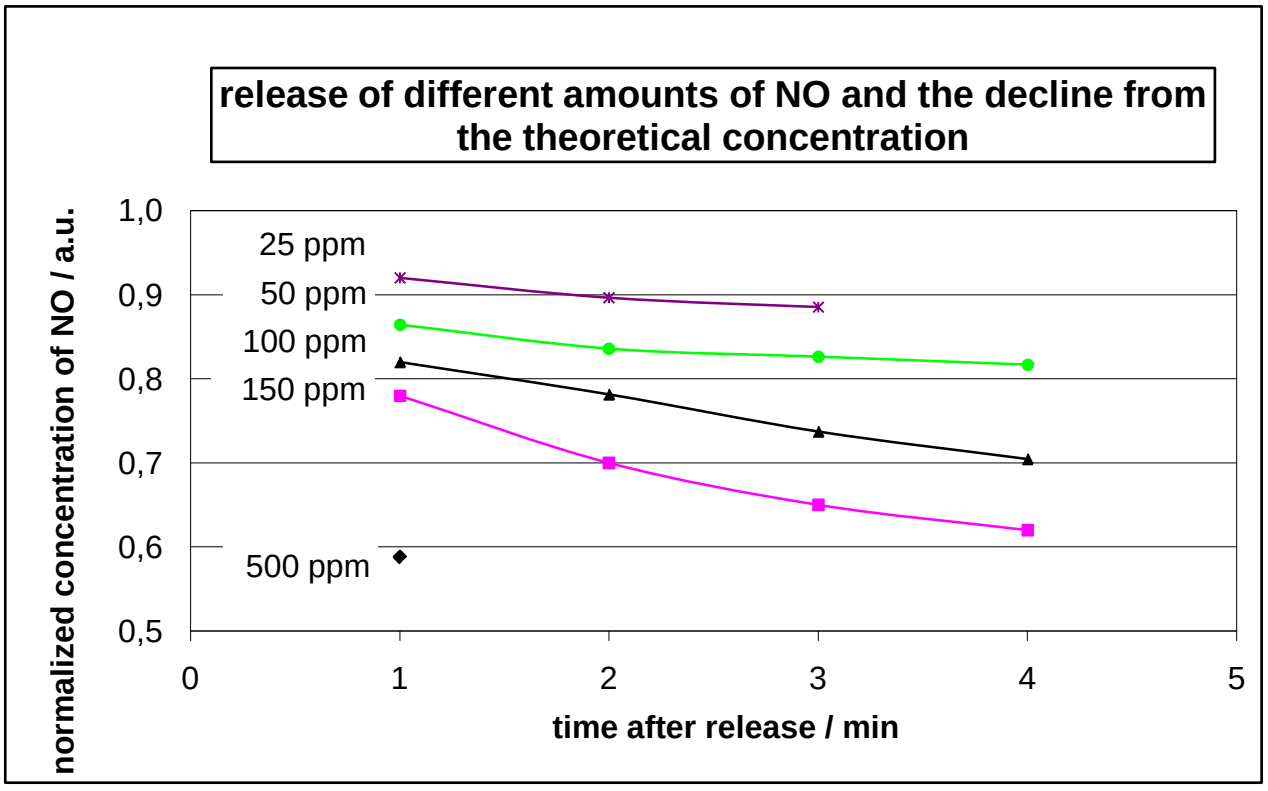
Picture 1: Influence of the initial ambient air pressure on the resulting gas concentrations per PBP. NO and NO2 diminish from the gas phase by raising pressure, while the relative CO concentration rises with initial pressure. Hydrogen (H2) is not strongly influenced.



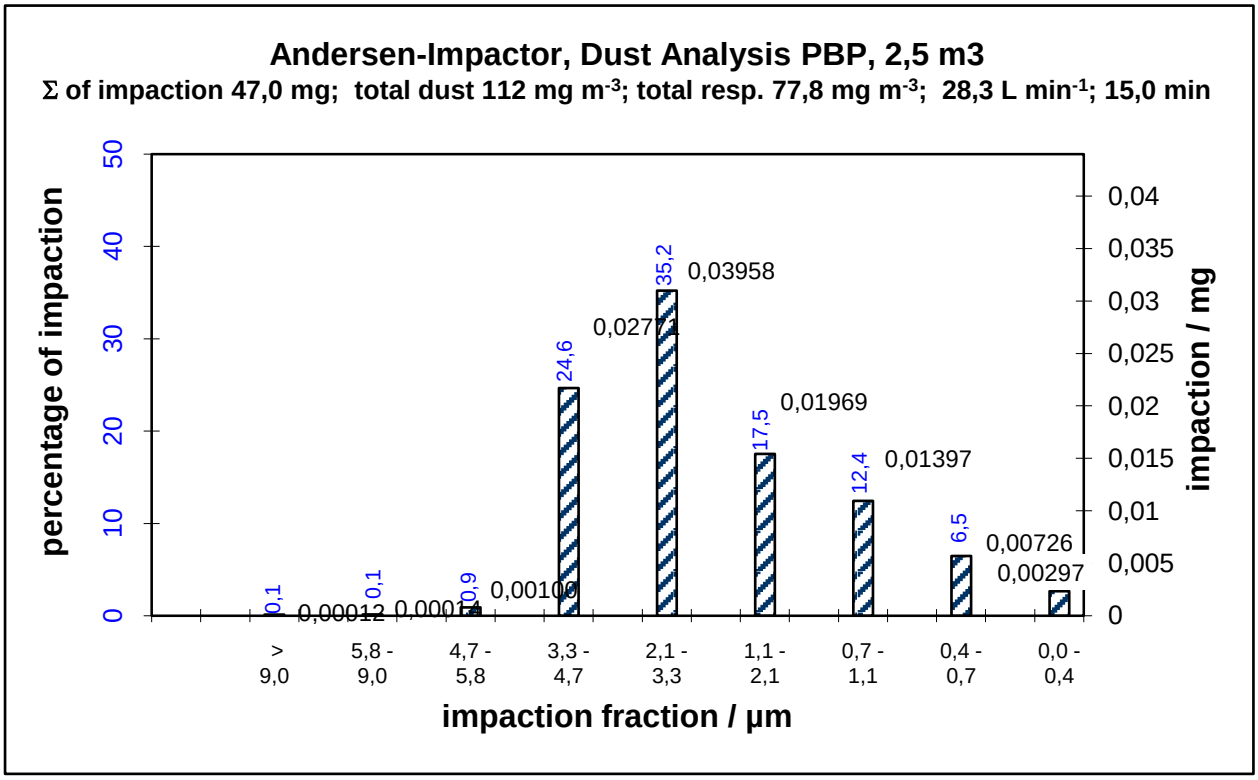
Picture 2: Influence of the initial water partial pressure, or humidity, on the resulting gas concentrations per PBP. CO and NO concentrations do not alter significantly, NO2 diminish from the gas phase by increasing humidity drastically, and H2 shows a positive dependence on the water content.



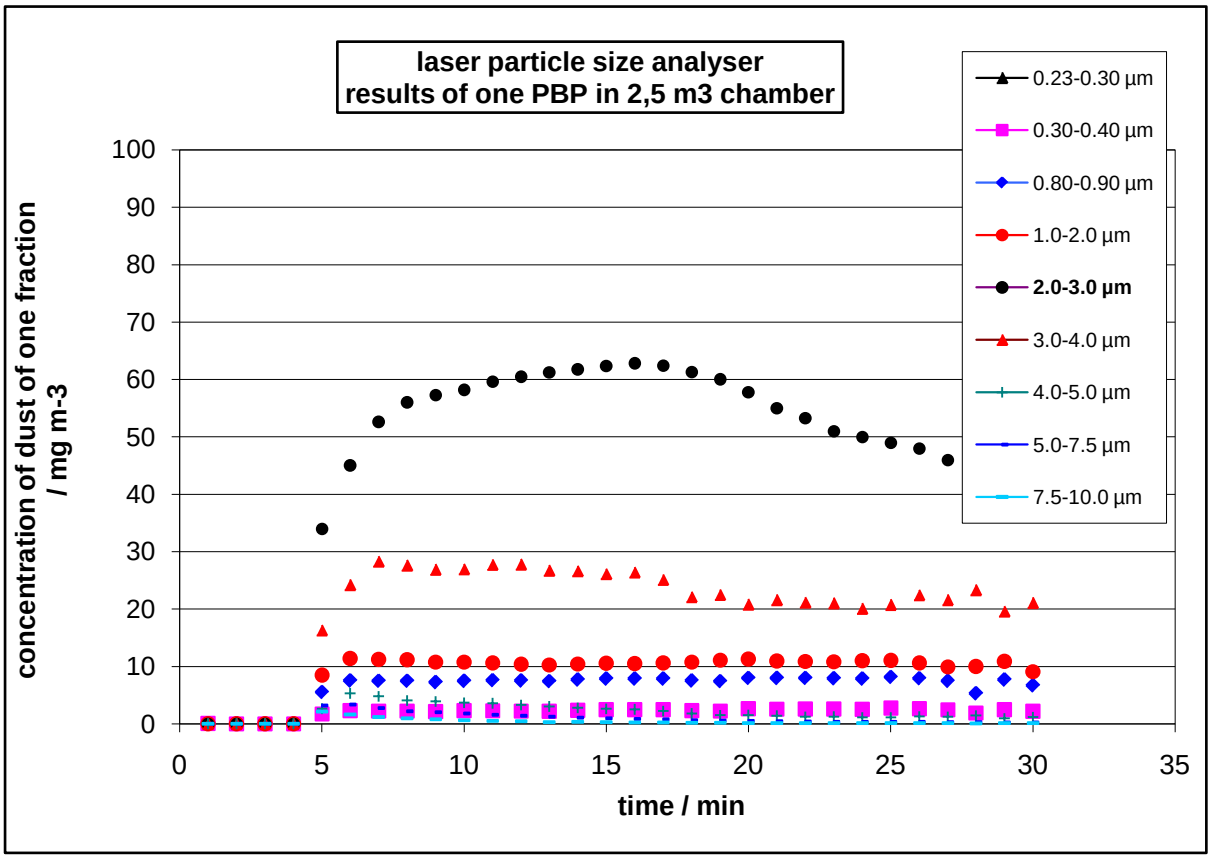
Picture 3: Reaction kinetics of released NO gas into a realistic chsmber (50 % rH, 21 °C)



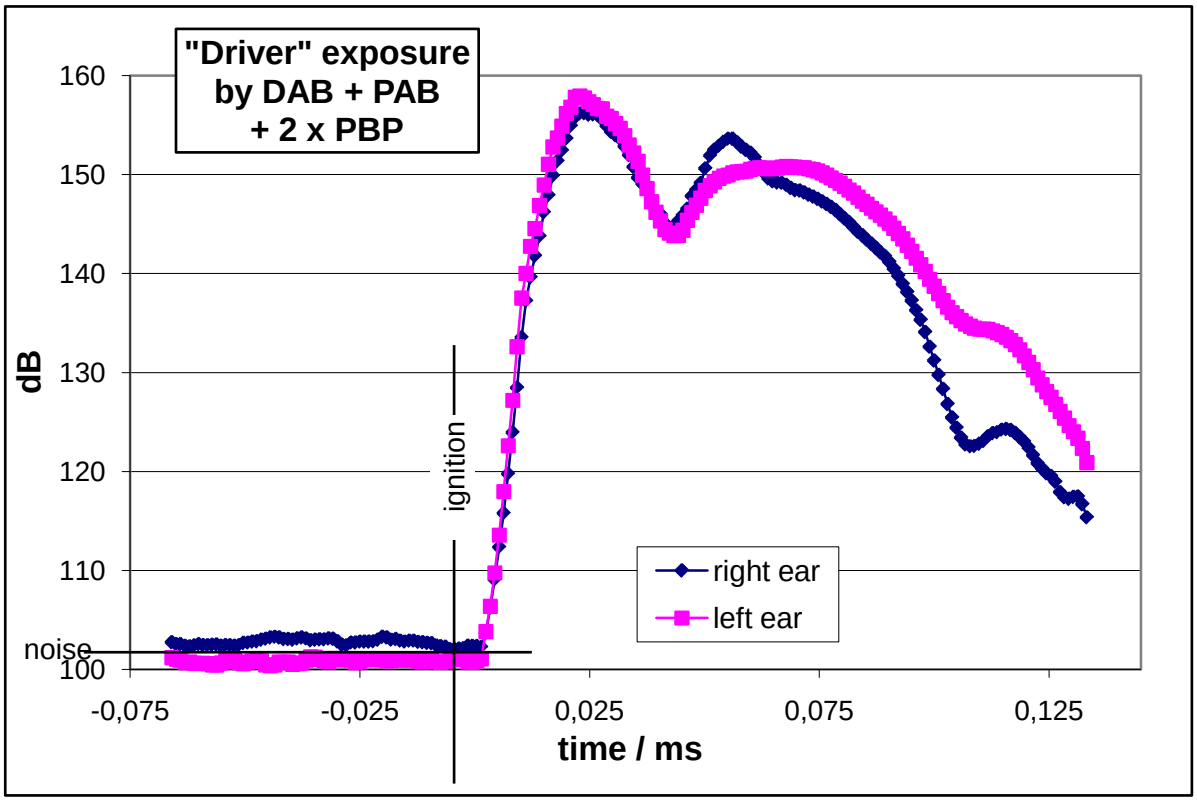
Picture 4: Similar to picture 3, but using different initial NO concentrations. The reaction kinetics of the NO decline is dependent of the initial concentration.



Picture 5: Andersen-Impactor result of one PBP in a 2,5 m3 chamber.



Picture 6: Laser particle counter result on the dust analysis of one PBP in a 2,5 m3 chamber. For the first 15 minutes after deployment there is a good correlation of Anderen results and laser results. After 15 minutes the bigger particles start to sediment.

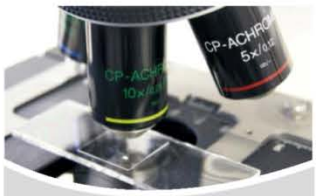


Picture 7: Acoustic measurement in a car using a complete front crash situation. Position of the microphones: driver ears. The „human ear model“ calculates an “auditory hazard” of about 486 unit.

›› Gesellschaft für Werkstoffprüfung mbH

› Analytik

› Werkstoffprüfung



› Materialografie

› Qualitätssicherung

› Schadensanalyse

› Entwicklung

› Laborservices

› Analytikum
› Chemie & Korrosionslabor
› Elektroniklabor
› Gaslabor
› Kunststofflabor
› Materialografie
› Mikroskopie REM/LIM
› Umweltsimulation
› Werkstatt
› Werkstoffprüfung
› Zerstörungsfreie Werkstoffprüfung

› Schadensanalyse

› Airbag
› Batterien
› Baustoffe
› Fraktographie
› Heterogene Katalyse
› Industrielle Prozesse und Produkte
› Korrosion
› Kunststoffe
› Medizintechnik
› Metallische Gefüge
› Oberflächentechnik
› Zerstörungsfreie Prüfung

› GWP Gesellschaft für Werkstoffprüfung mbH
› Georg-Wimmer-Ring 25, D-85604 Zorneding/München
› Tel. +49 (0) 8106 994 110 › Fax +49 (0) 8106 994 111
› Mail info@gwp.eu › Web www.gwp.eu

Deutscher Akkreditierungs Rat
DAR
DGA-PL-6358.05

GWP