K+S Aktiengesellschaft

New Occupational Exposure Limits – Challenges for the Potash and Rock Salt Mining Industry

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Technical Center – Mining

Kassel, March 20th 2019

New Occupational Exposure Limits

- Introduction
- Legal situation
- Underground Exposure
- Technical measures
- Occupational medicine
- Timeline
- Project organisation
- Outlook

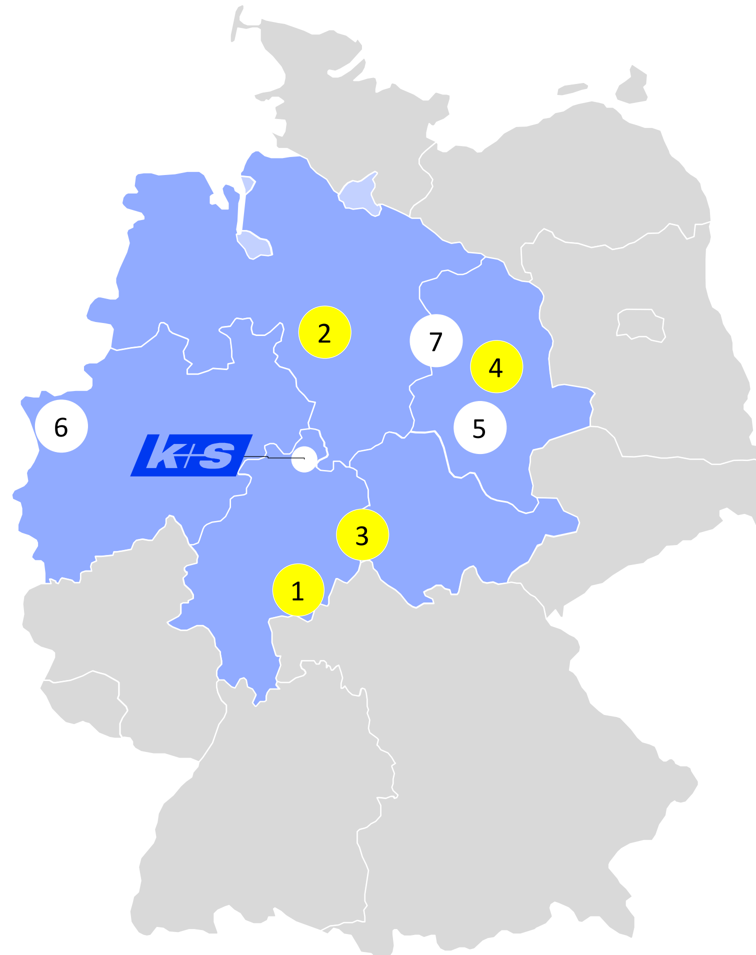
Our Underground Mines in Germany

1. Neuhof–Ellers
2. Sigmundshall
3. Werra
   - Hattorf-Wintershall
   - Unterbreizbach / Merkers
4. Zielitz

Potash

5. Bernburg
6. Borth
7. Braunschweig-Lüneburg

Salt



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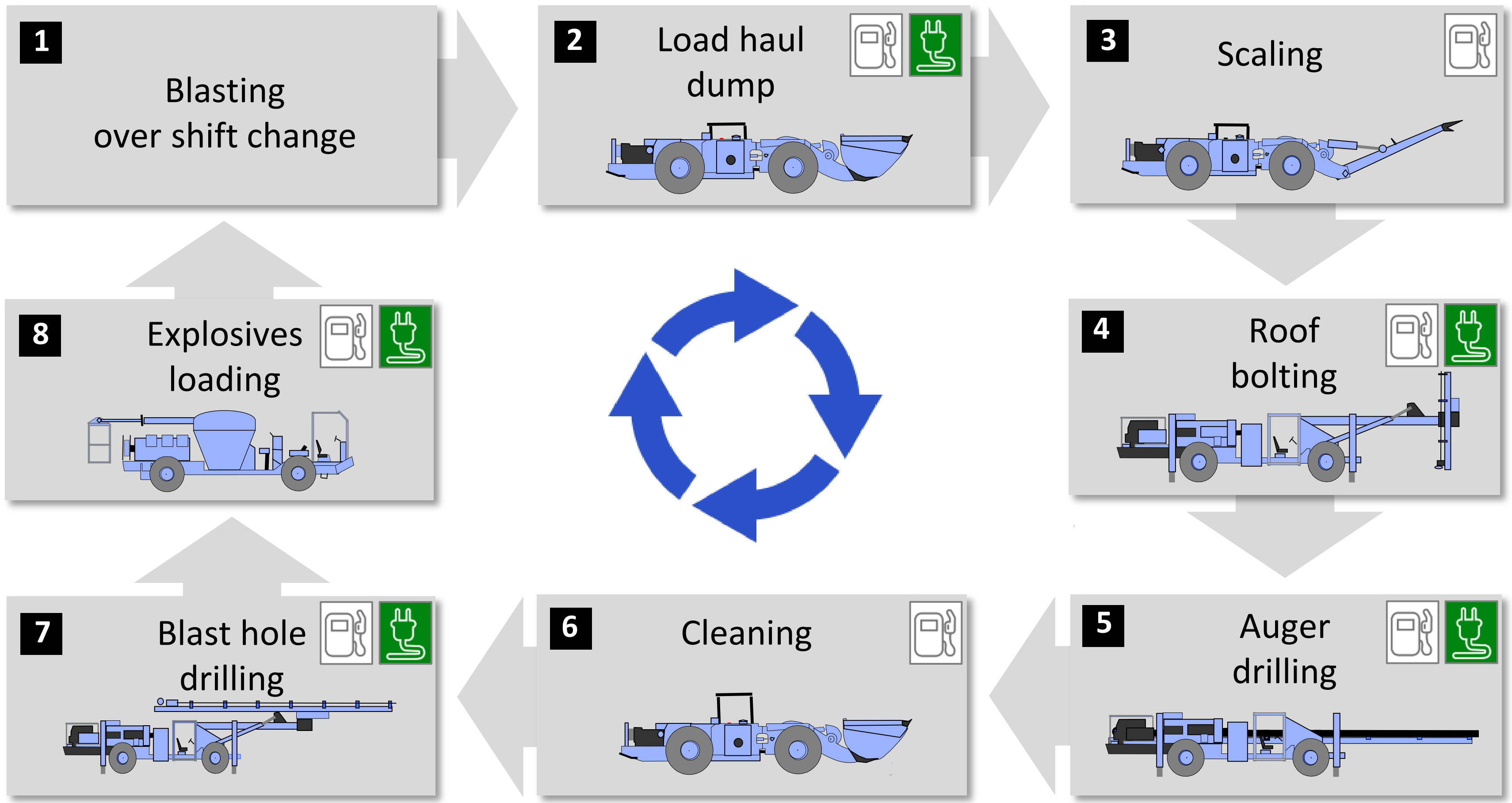
Drilling and Blasting

Core Process in Room-and-Pillar Mining Method

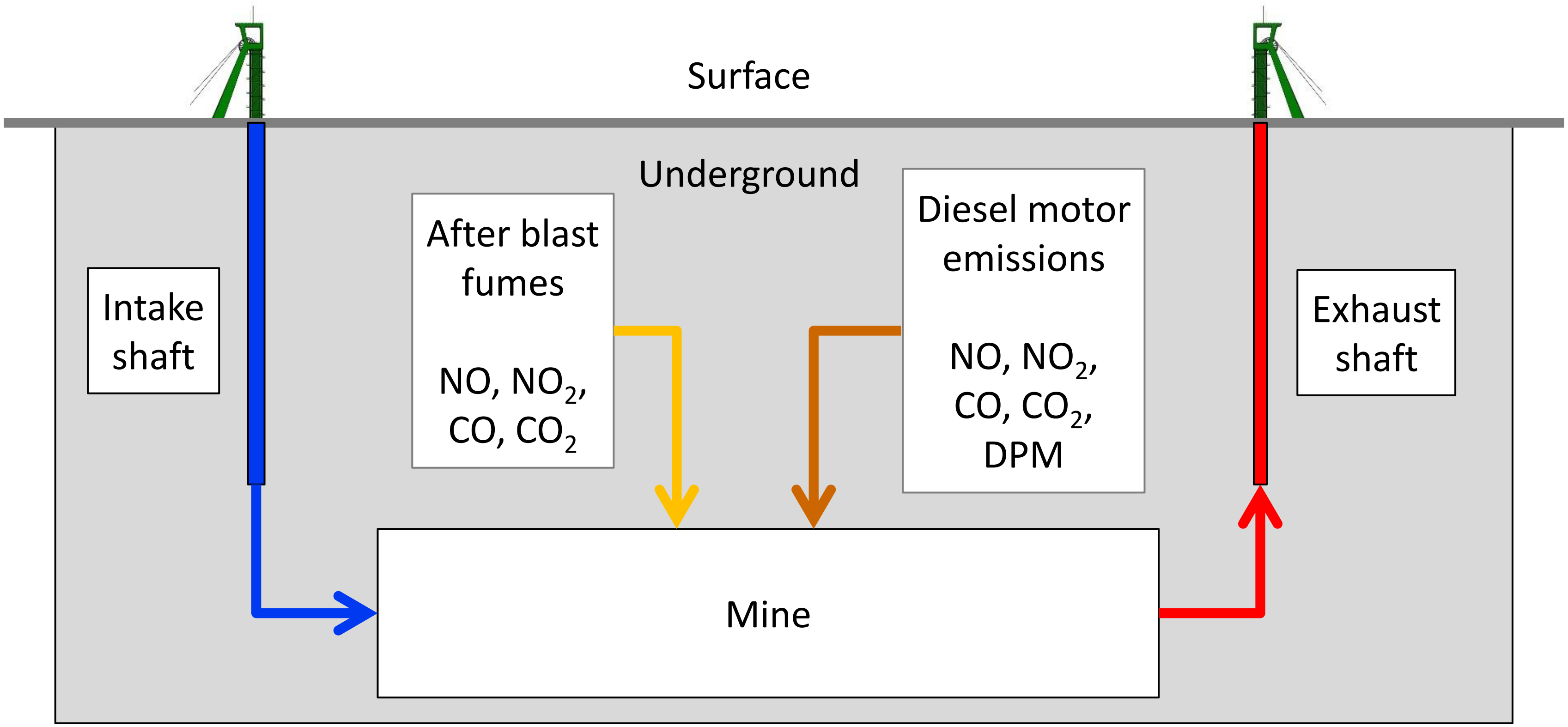
K+S in Germany	
Explosives	ANFO
Detonators	Electric




Mining Cycle with Drill and Blast



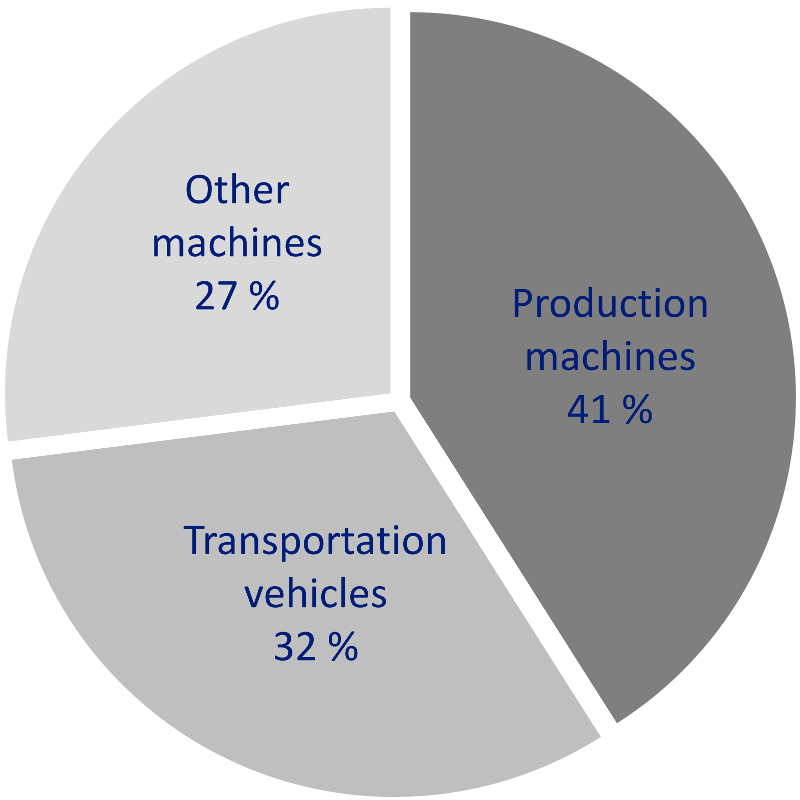
Mine Ventilation and Technical Emissions

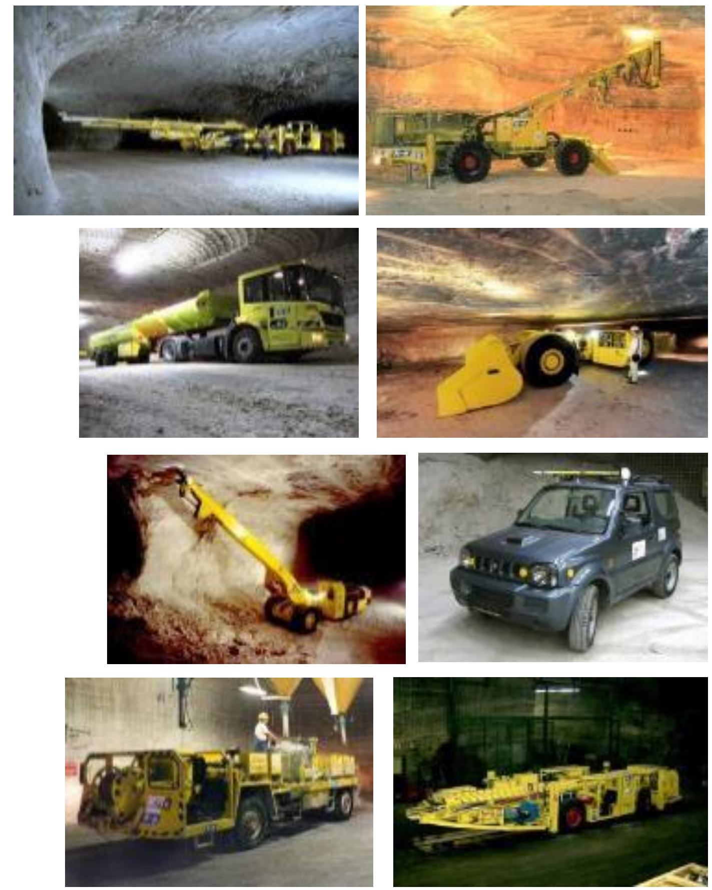


- Shaft are technical limits regarding ventilation air flow
- Blast emissions over shift change and during shifts
- Diesel motor emissions during shifts

Mobile Machines underground (GER)

Installed diesel power 200 MW in approx. 2,250 mobile machines

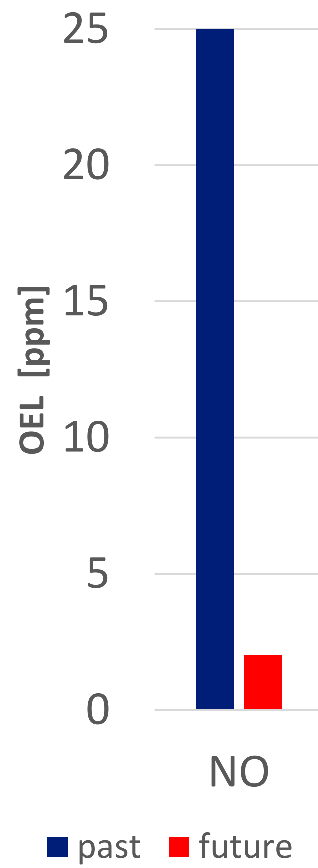


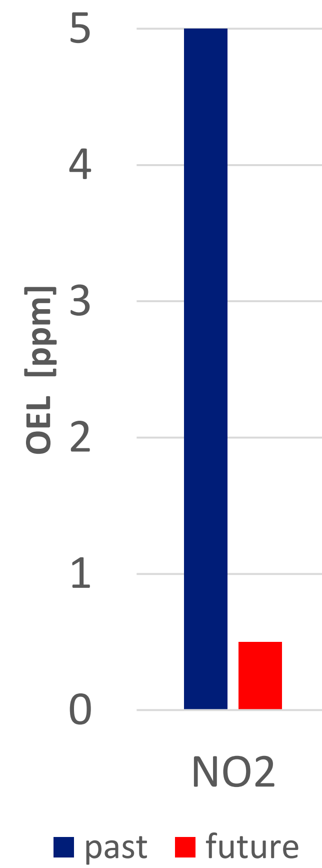


Occupational Exposure Limits (OEL)

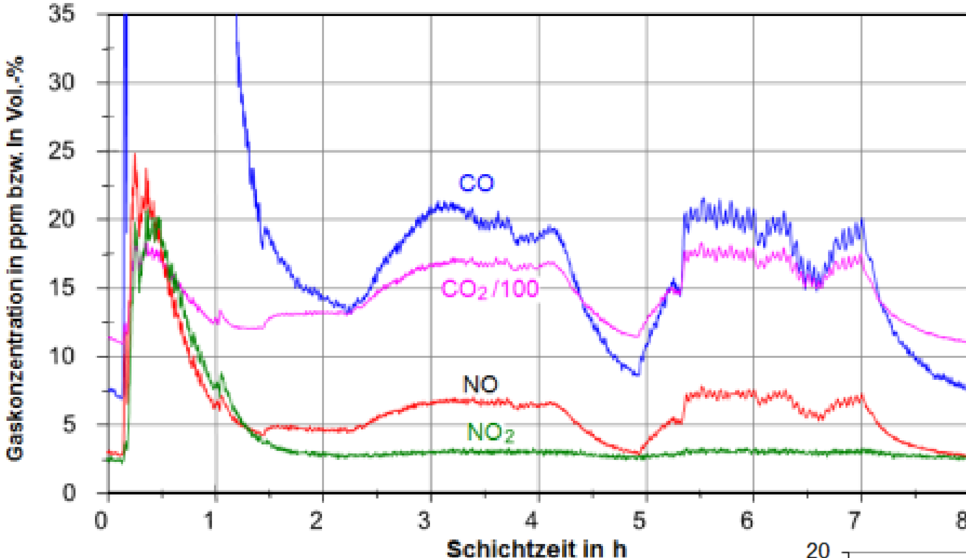
5 years transitional period for the mining industry – Reporting after 3 years

	Germany past	**Germany** today
Nitrogen oxide NO	(25 ppm)	2 ppm
Nitrogen dioxide NO_2	(5 ppm)	0.5 ppm
Diesel particulate matter (DPM)	300 µg/m³ EC	50 µg/m³ EC
Carbon monoxide CO	*30 ppm*	*(EU: 20 ppm)*



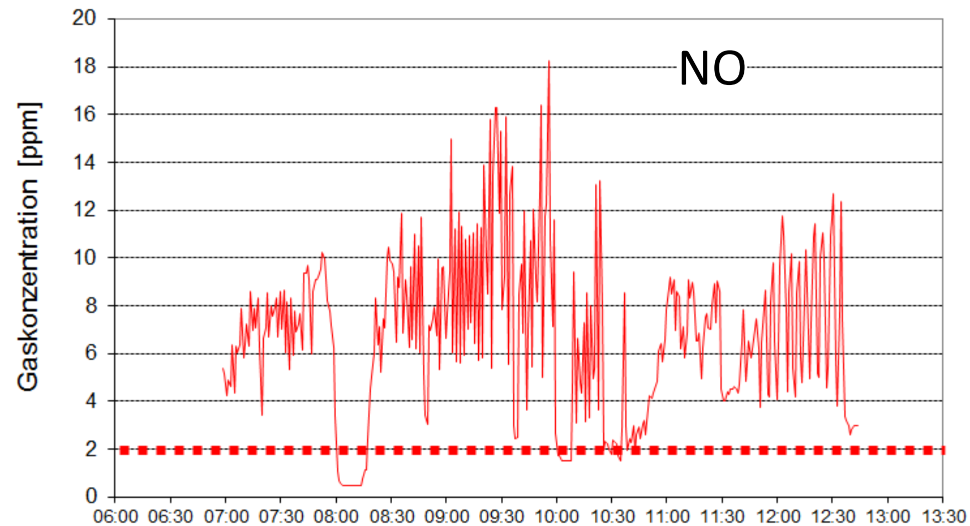


Measurements Underground

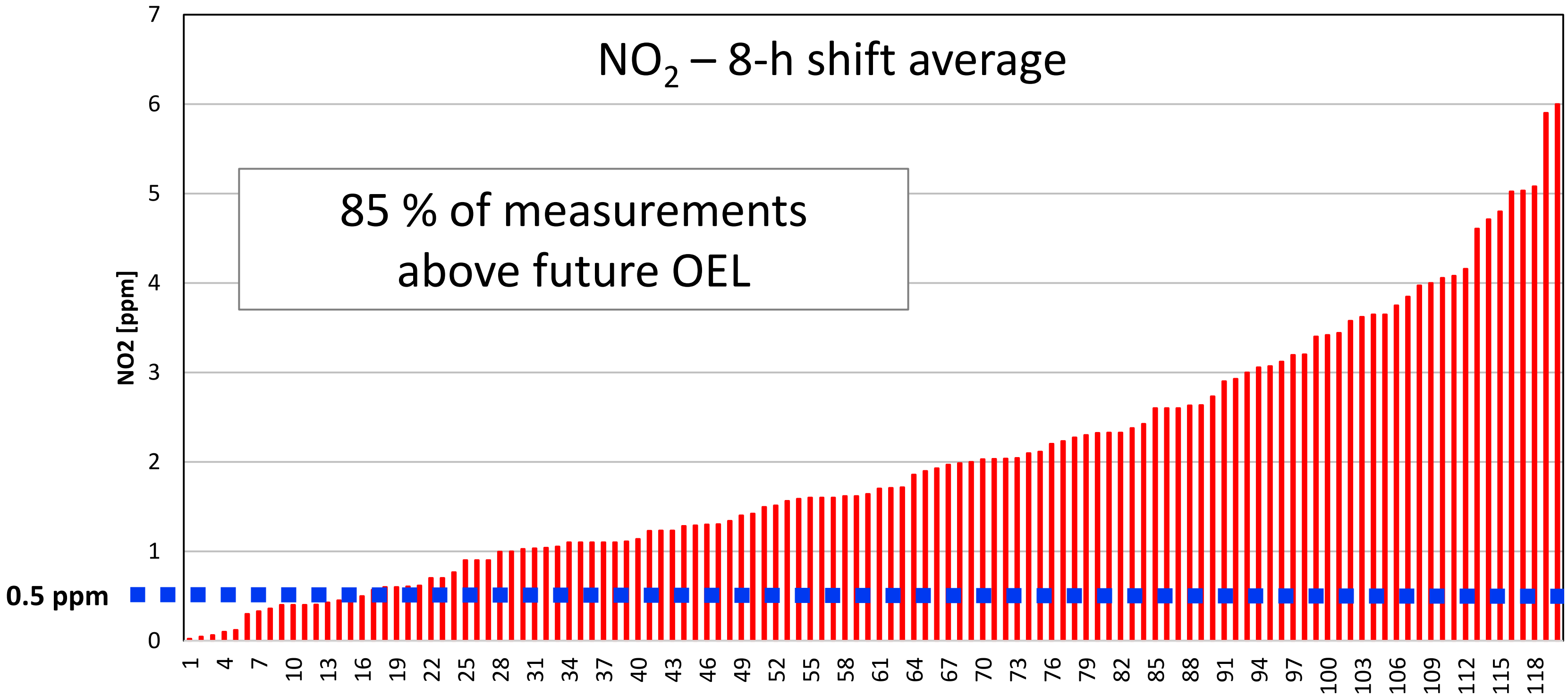


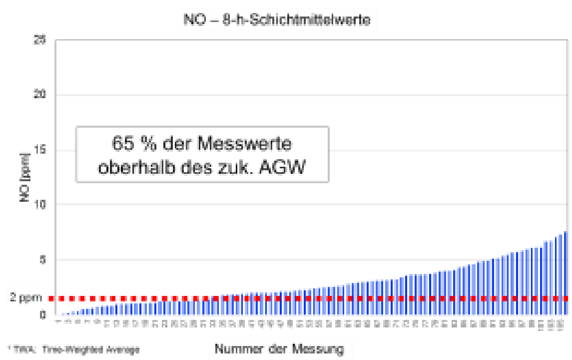
District or panel

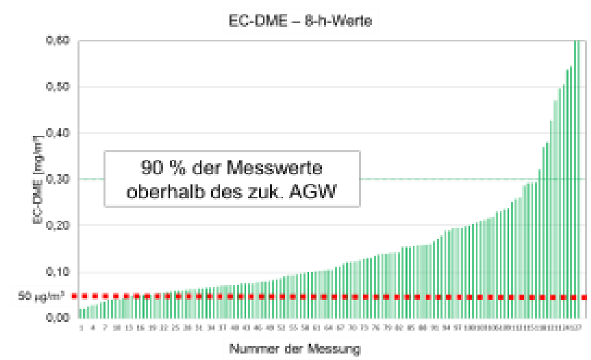
Workplace diesel LHD



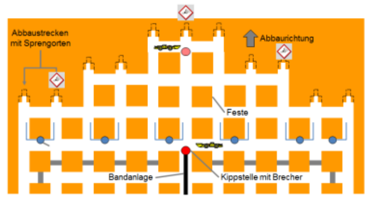
Exposure Measurements 2014







Package of Measures



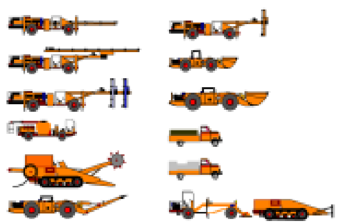
Diesel Motor Emissions

Mine Ventilation

Blast Fumes

Occupational Medicine

Package of Measures – Diesel Motor Emissions



Diesel Motor Emissions

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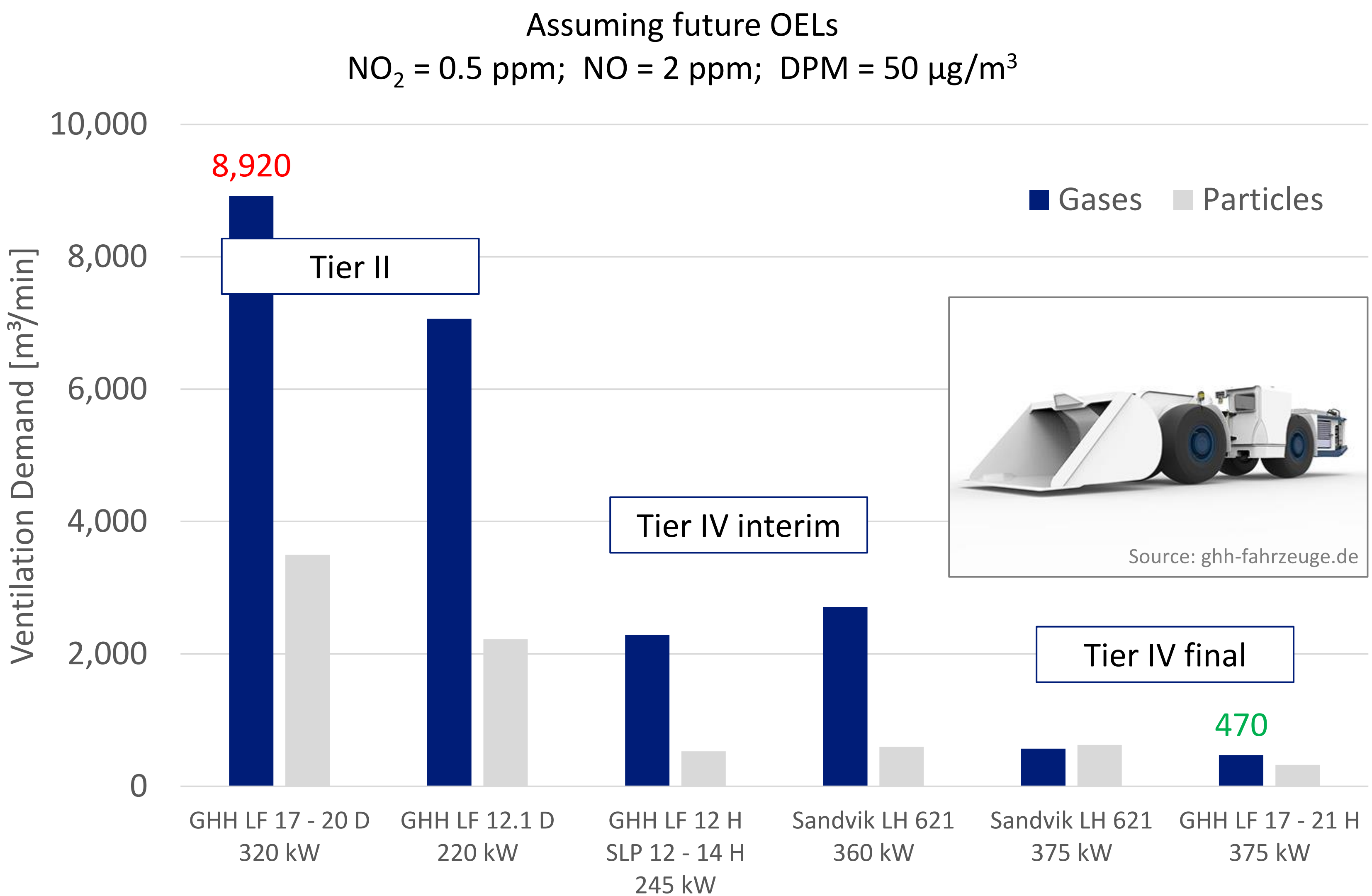
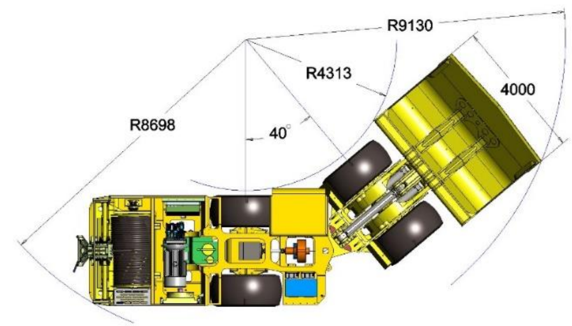
Diesel LHD Ventilation Demand

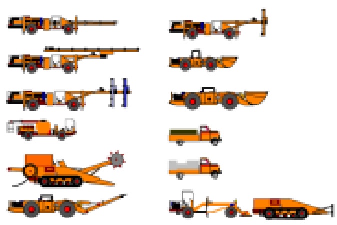


Technical Measures – Diesel Motor Emissions

- Conversion of mobile machine and vehicle fleet to latest motor technology Tier IV final / Euro 6
- Partially need for new machine development with according lead time and effort
- Electric drives for mobile machines and vehicles – where technically possible
- Capacities of suppliers
- Financial situation of mining industry regarding capital expenditures and operating cost
- Need for according transitional period



Package of Measures – Mine Ventilation



Diesel Motor Emissions

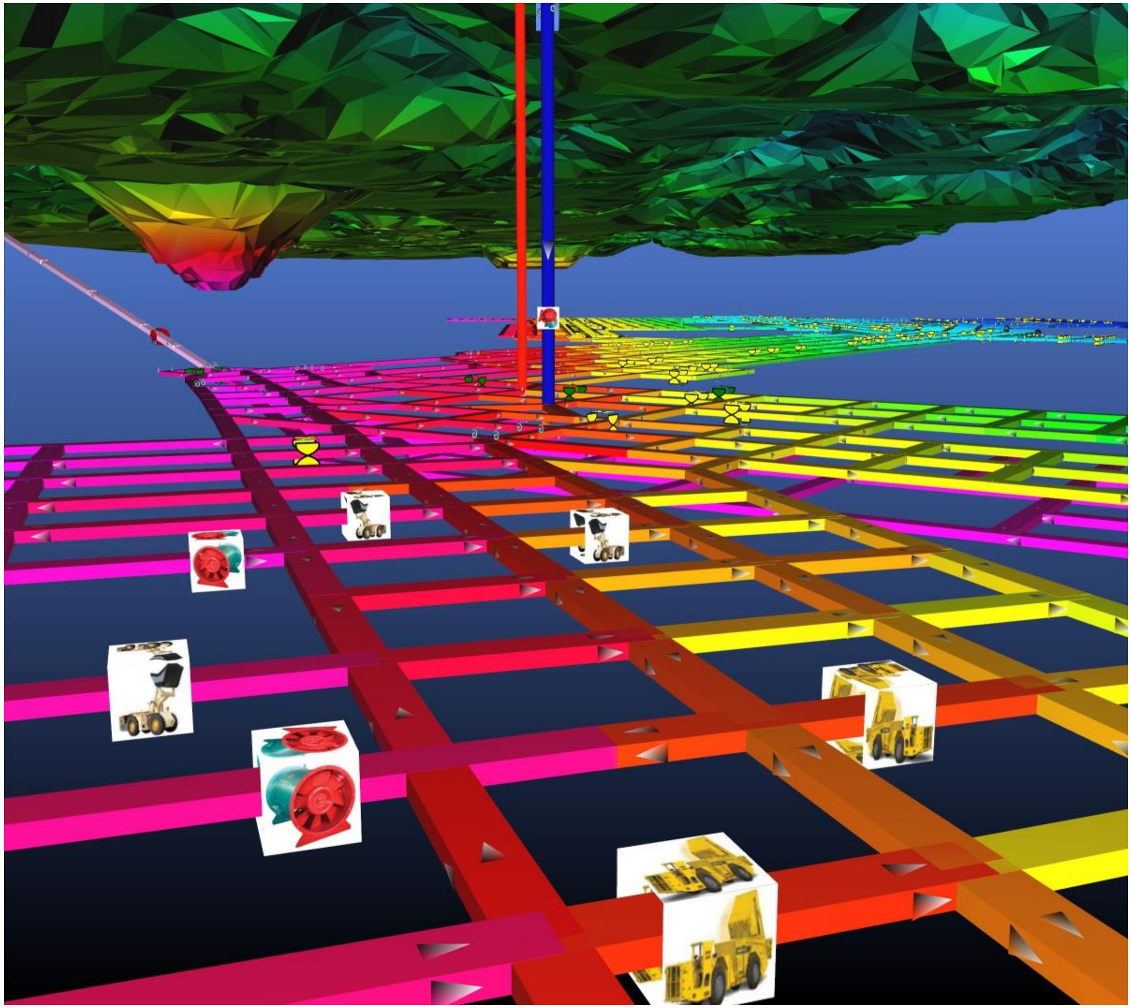
Mine Ventilation

Blast Fumes

Occupational Medicine

Mine Ventilation Challenges

- Fresh air / exhaust air
  - Losses
  - Dilution
- After blast fumes / diesel emissions
  - Dissemination
  - Diffusion
- Organization
  - Responsibility
  - Technical qualification



Source: ventsim.com

New Gas Measurement Techniques Underground

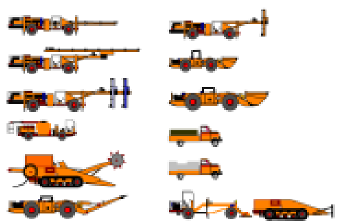
New gas measuring instruments:

- Mass spectrometer
- CO analyser (NDIR spectroscopy)
- Enclosure, air conditioning

Field of stationary application:

- Verification of Dräger sensors
- Emission measurements
- Blast fumes measurements

Package of Measures – After Blast Fumes



Diesel Motor Emissions

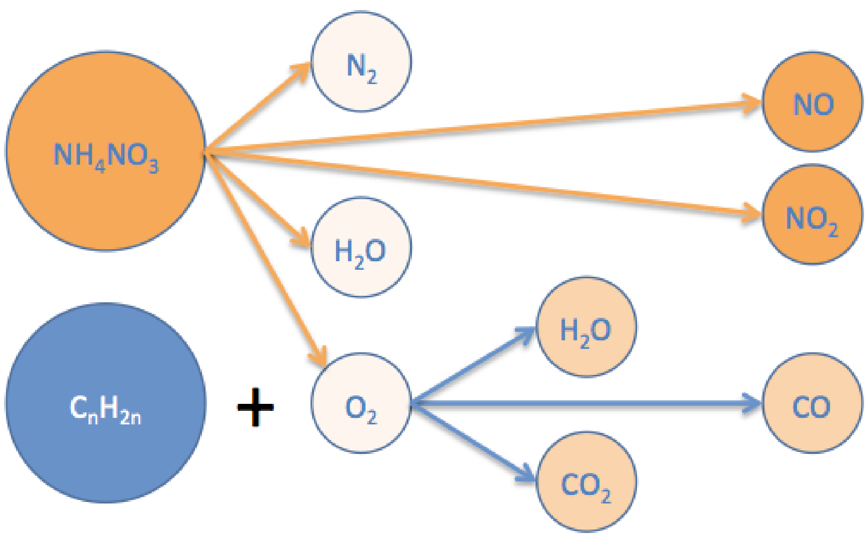
Mine Ventilation

Blast Fumes

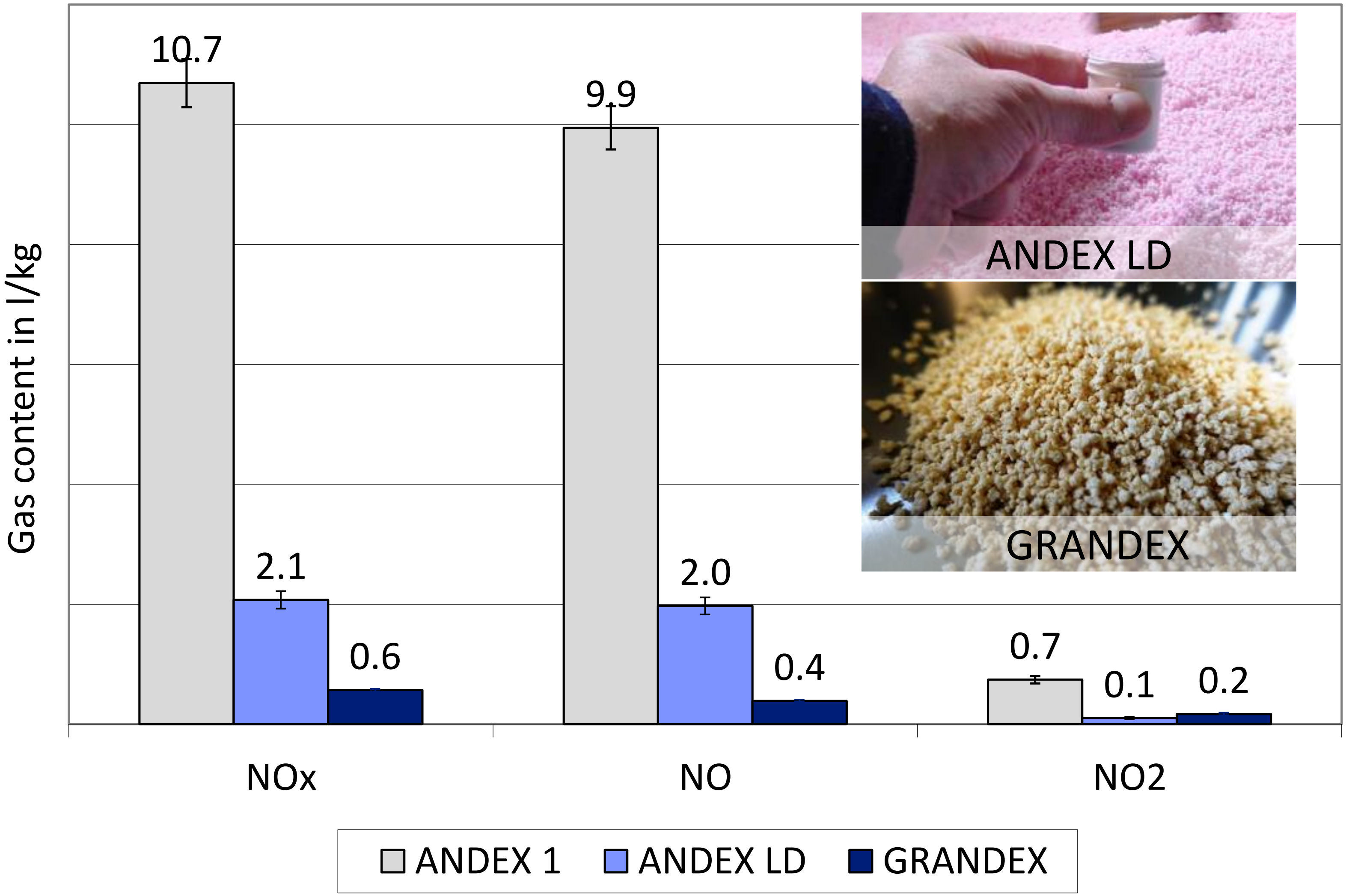
Occupational Medicine

Reduction of After Blast Fumes

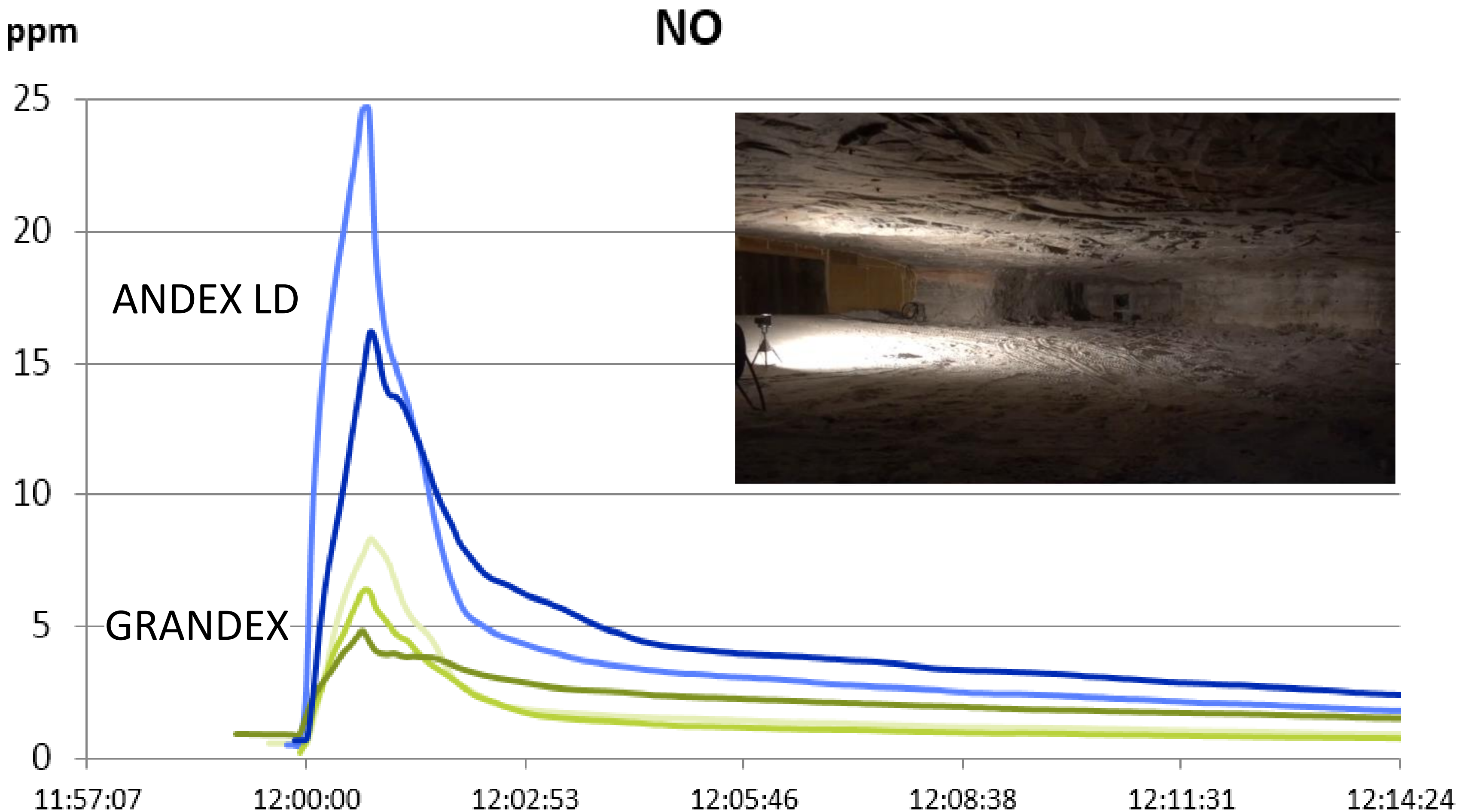
- MSW-CHEMIE GmbH – the explosives plant of the K+S Group
- ANFO production, explosives trading
- R+D project „low emission explosives“



Nitrogen Oxides in Blast Fumes (MSW)



Blast Fumes Comparison in Underground Tests



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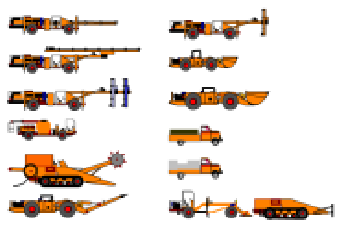
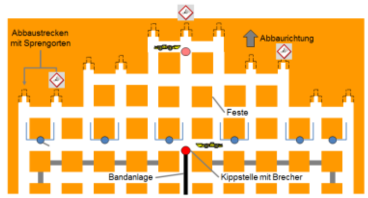
Package of Measures – Technical Measures CAPEX



Diesel Motor Emissions



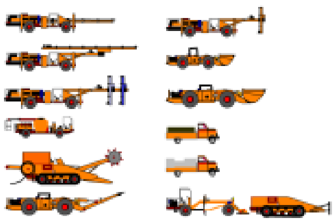
Mine Ventilation

Blast Fumes

Occupational Medicine

250 Mio. €

Package of Measures – Occupational Medicine



Diesel Motor Emissions

Mine Ventilation

Blast Fumes

Occupational Medicine

Occupational Medicine and Preventive Medical Care

Improvement of Knowledge Base

Occupational medical studies are rare and not of sufficient relevance with regard to current questions – therefore necessary:

- In-depth monitoring of exposure and health effects
- New health study (K+S study)
- Endowed professorship for occupational medicine and health care management

Health Study

Execution

- Comparison of health effects from different exposures (high, medium, low) on indicators (biomarkers e.g.) of employees
- Statistic validation by large sample – 1,250 individuals
- Medical examination before and after exposure / shift
- Individual-related measurement of exposure
- Realization in Zielitz and Werra mines

Project Organization

Sponsors – K+S Board of Directors

Steering Committee

Project Management

Work Packages

- Mobile Equipment
- Mine Ventilation
- Explosives
- Support Processes
- Measuring and Monitoring Concept
- Health Study and Preventive Care
- Communication
- Legislation and Work Safety
- Alternative Mining Methods

Timetable

<table>
<tr><th></th><th>Diesel Motor Emissions</th><th>Mine Ventilation</th><th>After Blast Fumes</th><th>Medical Care</th><th>Remarks</th></tr>
<tr><td>2016</td><td rowspan="7">Development of mobile machines

Introduction TIER VI final, EURO 6 by replacement / rebuild

Testing of electric driven vehicles and mobile machines underground</td><td>Basic evaluation and tests

New mobile analyzers development and tests</td><td rowspan="7">Development and testing of new low emission explosives

Conceptual design of new explosives manufacturing plant and logistics system</td><td rowspan="6">Study detailed design

Contracting

Health study

Medical examinations and exposure measurements underground

Upgrade of preventive medical care</td><td>Legal implementation of new OELs for nitrogen oxides</td></tr>
<tr><td>2017</td><td rowspan="5">Optimization of ventilation

Introduction of new mobile gas measuring instruments</td><td>… for DPM</td></tr>
<tr><td>2018</td><td></td></tr>
<tr><td>2019</td><td>Status report to legal bodies</td></tr>
<tr><td>2020</td><td></td></tr>
<tr><td>2021</td><td>Expiration of transitional period</td></tr>
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Summary

Compliance with future occupational exposure limits is a challenge for the mining industry.

K+S package of measures:

- TIER IV final and EURO 6 diesel motors
- Electric drives where applicable
- New low emission explosives
- Optimization of mine ventilation
- Optimization of processes underground including organisational customizations
- Upgrade of preventive medical care – extensive health study
- Allocation of according financial resources

Thank You for Your Attention

2021