IMPRESS WORKSHOP

Point and Diffusive emissions

Project outcomes and way forward

3 May 2016

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Point and Diffusive emissions

Innovative Measurements for Pollution Regulation in Emissions and area SourceS

Project outcomes and way forward

08:30	Registration	
09:00	Welcome and Introduction	*Rod Robinson, National Physical Laboratory*
09:10	Overview of European project IMPRESS: Metrology to underpin future regulation of industrial emissions	*Rod Robinson, National Physical Laboratory*
09:25	Monitoring of fugitive emissions: an industry perspective	*Pete Roberts, Conservation of Clean Air and Water in Europe (CONCAWE)*
09:55	Discussion: Regulatory perspective: how to leverage the outputs of the project	*Doug Wilson, Environment Agency*
10:20	***Coffee break***	
Concentration Measurement from Point (Stack) Emission Sources		
10:45	Investigation of accuracy of existing methods for stack concentration measurement and support for new CEN/TC 264 automatic standards	*Marc Coleman, National Physical Laboratory*
11:10	Description and capabilities of two new stack simulator facilities: The Particulate Simulator at NPL and the Gas Simulator at VSL	*Marc Coleman, National Physical Laboratory & Stefan Persijn, Dutch Metrology Institute (VSL)*
11:25	Laboratory and field testing of TDLAS and spectroscopic considerations in the application to both point (in-stack) and diffusive emission measurements	*Zhechao Qu, The National Metrology Institute of Germany (PTB)*
12:00	***Lunch & lab tours***	

National Physical Laboratory

Modelling Flow and Mass Emissions from Point (Stack) Emission Sources		
13:20	Model of flow in common stack configurations and results of an uncertainty study	*Jan Geršl, Czech Metrology Institute & Zeno Belligoli, TU Delft*
13:45	Modelling EN 14181 QAL2 calibration uncertainties and the associated implication for annualised mass emissions reporting	*Thomas Smith, National Physical Laboratory*
14:10	Physical limitations and timing error in annualized mass emission reporting	*Kianoosh Hadidi, Norwegian Metrology Service (JV)*
Diffuse Emission Measurements		
14:35	Model and field performance data for VOC measurements by IR camera	*John Korsman, Environmental Protection Agency of South Holland (DCMR) & Stefan Persijn, Dutch Metrology Institute (VSL)*
15:00	Description and capabilities of a novel controlled release facility (CRF) able to simulate diffuse emission sources	*Jon Helmore, National Physical Laboratory*
15:25	Field validation of open path techniques and support of CEN/TC 264/WG 38 *Determination of fugitive VOC emissions*	*Rod Robinson, NPL & Johan Mellqvist, Chalmers University of Technology*
15:50	***Coffee break***	
Future Work and Industry Feedback		
16:10	Scope of future EMPIR project IMPRESS 2 and Sulf-Norm	*Marc Coleman, National Physical Laboratory*
16:25	Open floor discussion: future challenges faced by the emissions monitoring industry	
17:00	Closing remarks	*Rod Robinson, National Physical Laboratory*

National Physical Laboratory

NPL Management Ltd - Commercial

Overview of European Project IMPRESS: Metrology to Underpin Future Regulation of Industrial Emissions

Rod Robinson

NPL 3rd May 2017

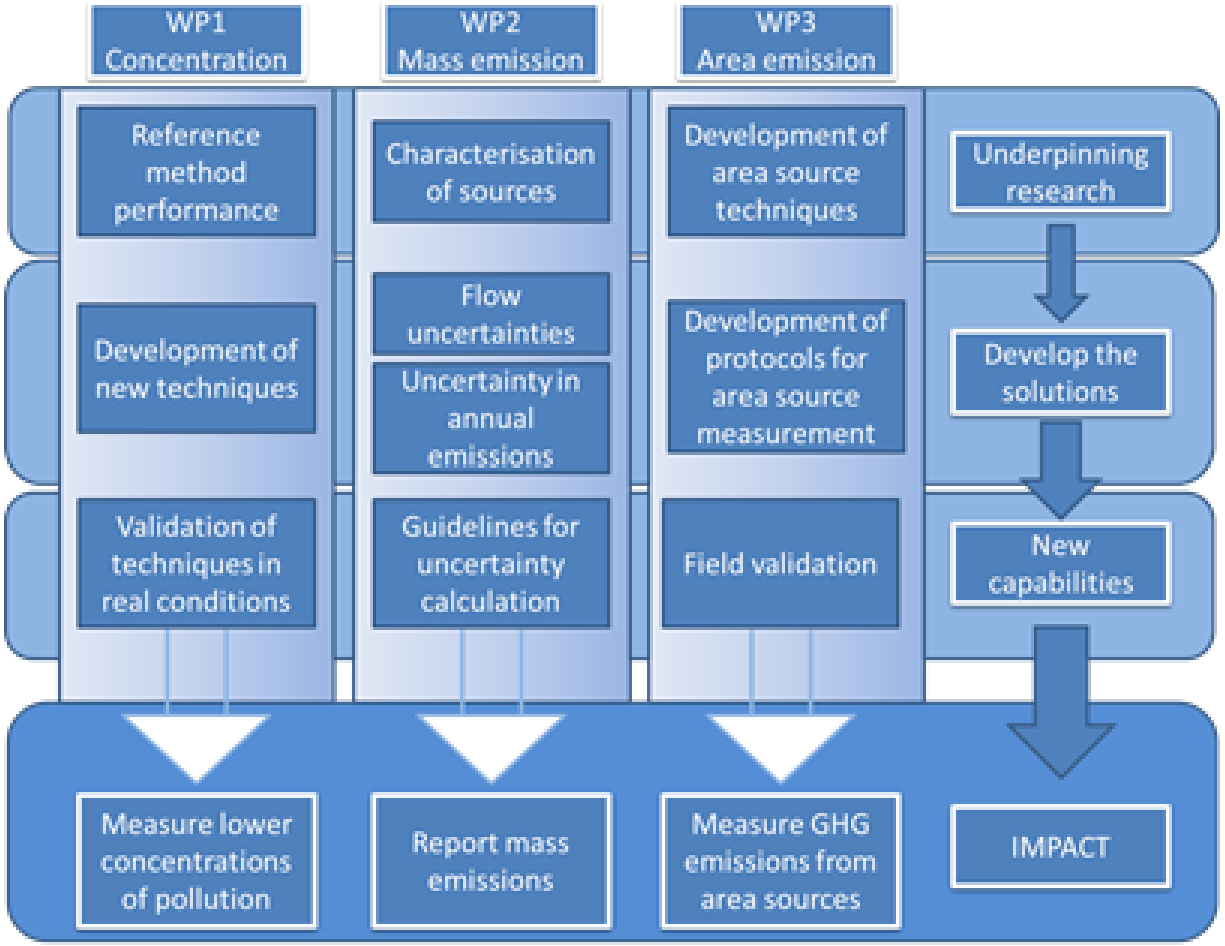
Motivation for IMPRESS (1)

- **IMPRESS is concerned with metrology to help monitor and reduce pollution from industrial sources in support of the Industrial Emissions Directive (IED – 2010/75/EU)**
- The IED replaced 7 prior directives bringing in stricter emission limits and formerly adopts Best Available Technique Reference (BREF) documents
- To enforce directives, and achieve traceability and comparability of data there is a need for both
  - Techniques (e.g. TDL), and
  - Measurement methods providing QA/QC of the techniques
- The Commission to support a directive will often provide a mandate to CEN to produce a Standard Reference Method (SRM)
  - An SRM is a validated standard that is passed into, or referred to, in member state legislation
  - In principle, the validation shows what emission limits are (or are not) enforceable

Motivation for IMPRESS (2)

- Across the IED and BREFs it adopts there are gaps in terms of capability of existing SRMs (originally developed for prior directives) and areas where there are no SRMs and insufficient technique validation
- This potentially compromises successful implementation of the IED which is projected to
  - Reduce premature deaths / years of life lost in Europe by 13 000 and 125 000 respectively
  - Save up to €28 billion p.a. (European Communities, COM(2007), 843 final)

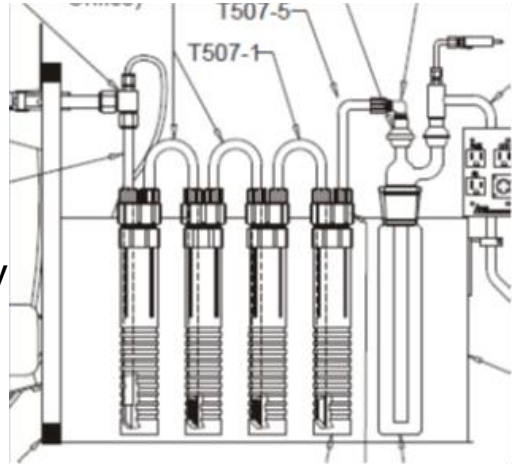
Project Structure



IMPRESS Consortium

WP1: Stack Concentration Measurement Issues

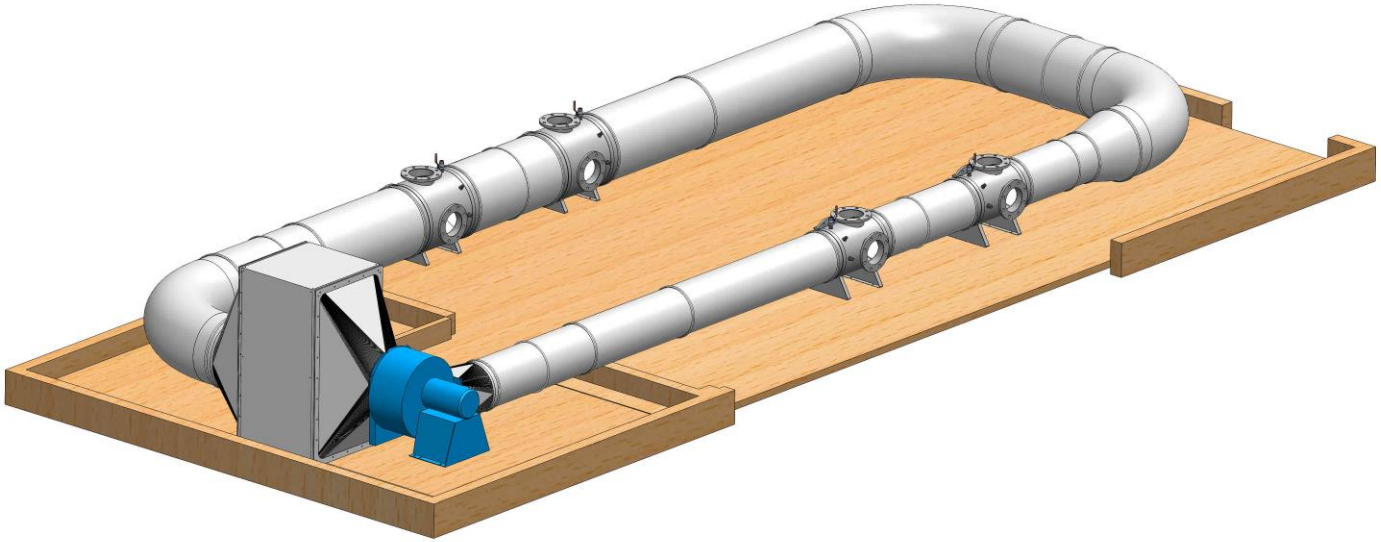
- Stack concentration measurement
  - e.g. original Commission mandated validation of SO_2 SRM (EN 14791) found an U_{95} of ±1.7 $mg.m^{-3}$ (k=2)
  - But, uncertainty requirement of the IED for LNG combustion processes is ±1 $mg.m^{-3}$
  - Process >100 MW require installation of an Automated Measuring System (AMS) for continuous monitoring of emissions
  - Must be type approved (EN 15267-3) and meet an uncertainty of 75% of directive requirement
  - AMSs must be calibrated via parallel SRM measurements
- Need to develop portable instrumental techniques and carry out validation work
- Need in support of instrumental techniques written methods to ensure QA/QC (standardised at CEN)
- Need national facilities to develop and test new approaches, and proficiency test accredited test laboratories performing existing and new SRMs



WP1 Achievements (Stack Concentration)

- Demonstrated portable FTIR + TGN M22 equivalent in accordance with CEN/TS 14793 to SRMs for CO, NO_x, SO_2, HCl and H_2O
  - Coleman, M.D., et al. JAWMA, 65:8 (2015) 1011-1019
- Creation of a European PT database
  - UK, Germany (HLNUG – collaborator), Netherlands
  - Analysis of test laboratory performance using SRMs and other techniques being carried out
- Development of facilities
  - Gas Stack Simulator at VSL built
  - Particulate Stack Simulator at NPL nearing completion
- Methods written for promulgation at CEN
  - FTIR based species independent method
  - SO_2 optical method

WP1 Achievements (Stack Concentration)

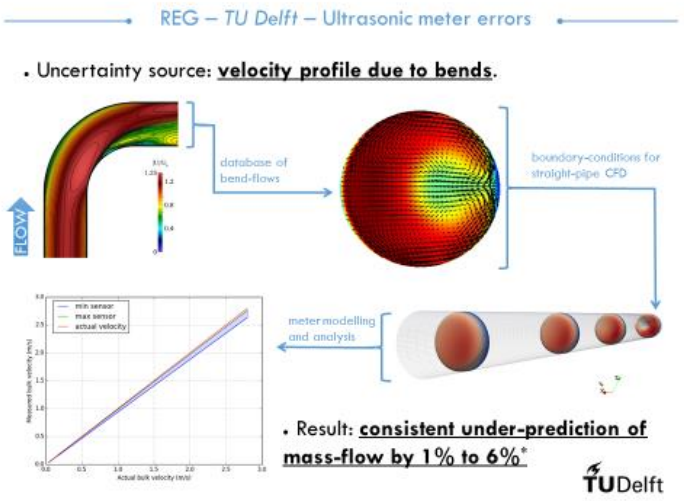


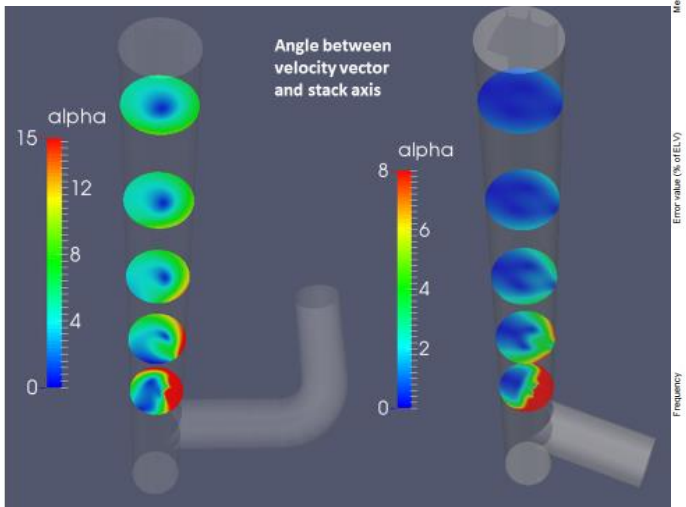
- Particle Simulator Facility
- 0.3m and 0.5m diameter sections
- 10m.s^{-1} velocity at 0.5m section
- 1µm - 8µm particle size
- 10's mg.m^{-3} down to <1 mg.m^{-3} concentrations

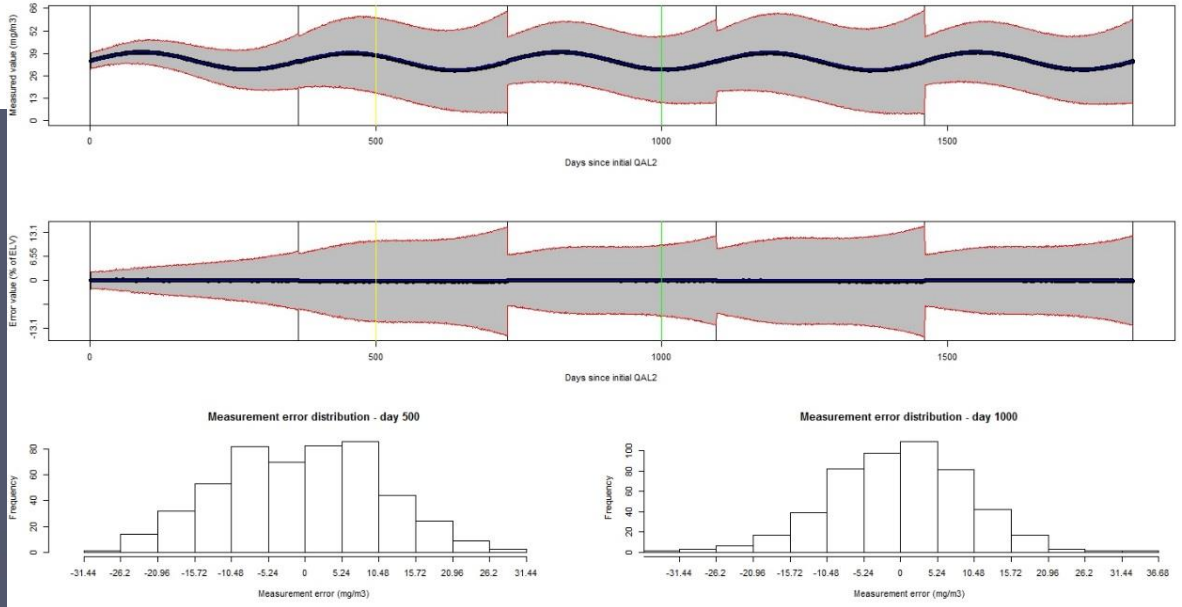
WP2 Achievements (Mass emissions)

- Collated industry flow measurement issues and data from NPL field campaigns.
- CFD flow modelling of specific industrially relevant cases including swirl.
- Computer model of stack emission monitoring instrument including full EN14818 quality control and calibration procedure concentration + flow.
- Uncertainty guidance and training

National Physical Laboratory

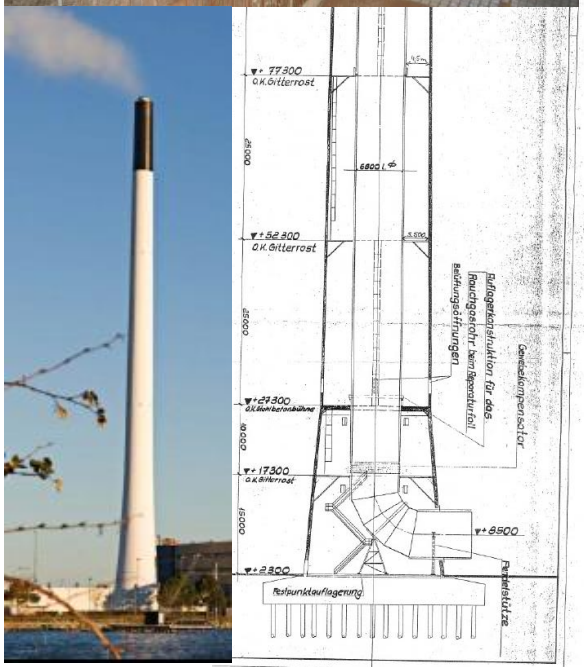






Objectives WP2 : Uncertainty of Flow and Annual Emissions

- Objectives
  - to address the challenges related to reporting annual mass emissions for complex processes and emission patterns.
  - determine uncertainties in annual emission figures.
- WP2 tasks are focussing on:
  - identification of challenging real world emission measurement scenarios, in particular flow measurement;
  - determination of the uncertainty of flow and concentration measurements for emission sources;
  - propagation of the uncertainties of instantaneous flow and concentration measurements into the uncertainty of the annual mass emission and the influence of sampling distribution to this uncertainty;
  - creation of an industry guidance document based on the simulations and the related statistical analysis for the identified typical annual mass emission measurement requirements.

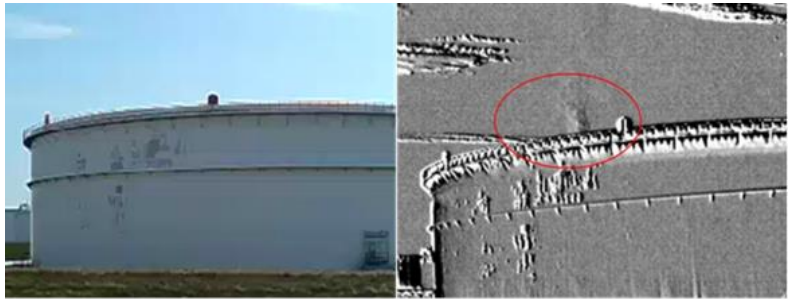


WP3: Area Source Measurement Issues

- Area sources (e.g. fugitive)
  - Regulations are currently based on modelled and calculated emissions (Landfill model – GasSim, AP 42 - TANKS – based on emissions factors)
  - Various studies have shown measured total-site emissions from refineries could be as much as a factor of 10 higher than calculated
  - Oil and gas industry BREF was published in 2015, plant operators have 4 years to demonstrate compliance
  - BREF requires fugitive emissions to be monitored by OGI techniques and real measurements to validate emissions (DIAL and SOF being listed)
- Need facilities (analogous to stack simulators) for technique / method development
  - Difficult as creating reference mixtures far more difficult for area than stack emission sources
- Need a CEN standardised method(s) (towards an SRM) for QA/QC of these techniques
  - Commission has provided a mandate underlining the importance in which they hold provision of a validated CEN standard

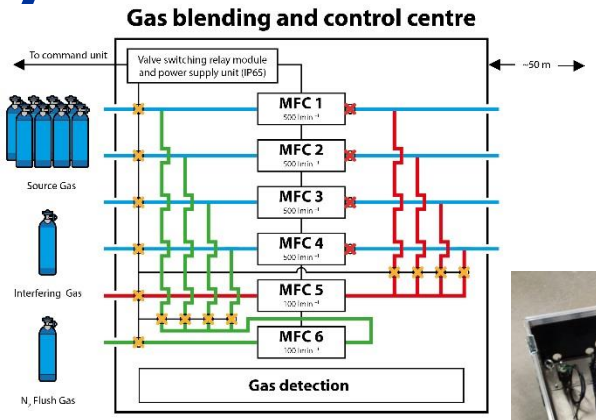
WP3 Achievements (Area Source Emissions)

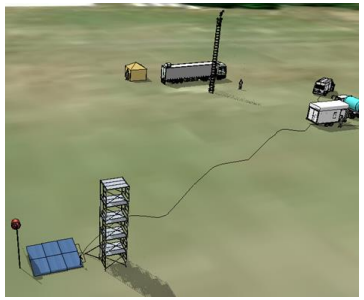
- Optical Gas Imaging (OGI) infrared camera for emission imaging
  - Camera lab test facility developed
  - Infrared camera response model developed
  - Field work in Netherlands carried out by VSL and DCMR
- Tuneable Diode Laser open path system
  - TDL system developed
  - Open path testing underway at PTB facility

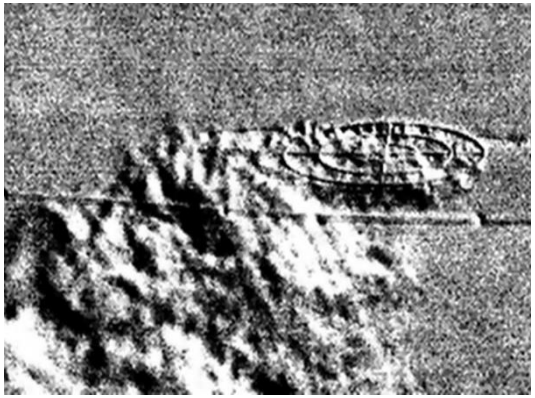


WP3 Achievements (Area Source Emissions)

- Novel, transportable Controlled Release Facility (CRF) able to simulate area emission sources
- High flow release rates comparable to small-medium industrial emissions: (1.1 – 55 $kg.h^{-1}$ for C_3H_8; 0.7 – 36 $kg.h^{-1}$ for CH_4; and 2 – 99 $kg.h^{-1}$ for CO_2)
- Gas can be released from up to four separate locations, and dispersion characteristics controlled by the use of different release nodes

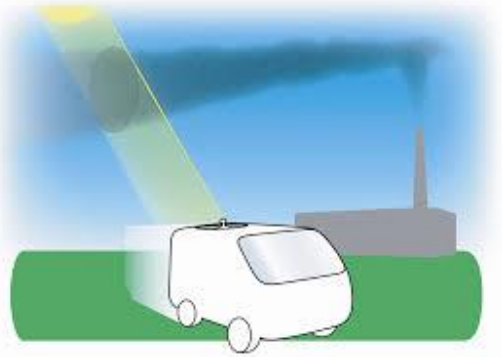






WP3 Achievements (Area Source Emissions

- Development of protocols for DIAL, SOF, TDL and IR camera
- Input into CEN WG38 – development of standard for fugitive emissions
- Validation of techniques
- CRF source nodes used to release propane while embedded within the structure of a cracking/reforming plant



WP4 Achievements (Impact)

- Significant standardisation impact at CEN/TC 264 Air Quality
  - WG38 'Determination of fugitive and diffuse VOC emissions' – Convenor
    - Now carrying out field validation of overarching standard covering open path optical techniques
  - WG16 'Emission monitoring reference methods'
    - Led promulgation of method for SO_2 by optical techniques
    - Published by CEN January 2017 (CEN/TS 17021)
  - WG36 'FTIR for emissions monitoring' – Convenor
    - Promulgation of FTIR method
    - TC264 Consultation about to be launched
  - WG9 'Quality assurance of emissions monitoring' – Convenor
    - Updated EN 14181 (calibration of permanently installed systems)
  - WG23 'Emission flow rate' – Co-convenor
    - Authored CEN Technical Report on implementation of flow SRM (EN 16911-1)
- For list of publications, reports, conference presentation slides and other technical downloads see website http://projects.npl.co.uk/impress/

Summary

- As project nears fruition we have achieved
  - WP1 Stack concentration
    - FTIR vs SRMs, PT evaluation of SRMs, Netherlands Gas Stack Simulator, UK Particulate Simulator
  - WP2 Flow
    - Model allowing probing of flow uncertainties, industry guidance document for annualised emissions uncertainty propagation
  - WP3 Area sources
    - NPL CRF, VSL IR camera test facility, field validation of a measurement method for DIAL, SOF, TDLAS, IR camera
  - WP4 Impact
    - New methods promulgated at CEN: SO_2, FTIR, AMS calibration, fugitive emissions
    - Various peer review publications, reports, conference presentations, e-training and other technical downloads. See http://projects.npl.co.uk/impress/
- Work will continue post May 2017 under
  - Sulf-Norm: SO_2 sampling from point sources
  - IMPRESS 2: Industrial point sources and urban biomass combustion

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